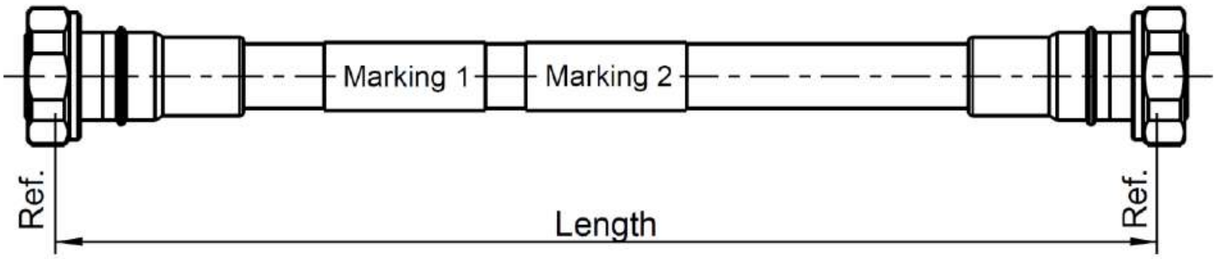
Technical Data Sheet

Rosenberger

1/2" JUMPER	7-16 MALE / 7-16 MALE	SLJ12RP-60M60M-X-00



Function Description

This part is a coaxial cable assembly for telecommunication equipment. It consists of 1/2" flexible coaxial cable with PE jacket and two 7-16 male connectors. The assembly is waterproof in mated condition and UV protected.

Available Variants

The assembly is available in lengths from 0.5 m to 10 m in intervals of 0.5 m. Different feet and inch lengths are available on request.

Assembly Parts

Connectors	7-16 male connectors plated with white bronze
Cable	S-Link 1/2"R, PE jacket
Marking 1	Direct print onto the cable or on wrapping label Marking includes manufacturer, part nr. & batch no.
Marking 2	Direct print onto the cable or on wrapping label Marking includes "Rosenberger factory made" Position in the middle of the cable
Bend Protection	Molding material TPE compound or anti-kink sleeve

Digitally signed by Cojocari Andrei
Date: 2022.09.12 09:19:35 EEST
Reason: MoldSign Signature
Location: Moldova

Rosenberger Hochfrequenztechnik GmbH & Co. KG
P.O.Box 1260 D-84526 Tittmoning Germany
www.rosenberger.de

Tel. : +49 8684 18-0
Email : info@rosenberger.de

Technical Data Sheet		**Rosenberger**
1/2" JUMPER	7-16 MALE / 7-16 MALE	**SLJ12RP-60M60M-X-00**

Electrical Data

Impedance	50 Ω		
Frequency	DC to 3.8 GHz		
Return loss	L ≤ 10 m	L > 10 m	L > 20 m
380 – 470 MHz	≥ 32 dB	≥ 30 dB	≥ 28 dB
600 – 960 MHz	≥ 32 dB	≥ 30 dB	≥ 28 dB
1.4 – 2.7 GHz	≥ 28 dB	≥ 26 dB	≥ 24 dB
3.4 – 3.8 GHz	≥ 23 dB	≥ 21 dB	≥ 19 dB
Insertion loss typ.			
DC – 1 GHz	≤ 0.08 dB/m (cable) + 0.01 dB * √f (GHz)		
1 – 2.2 GHz	≤ 0.13 dB/m (cable) + 0.01 dB * √f (GHz)		
2.2 – 2.7 GHz	≤ 0.15 dB/m (cable) + 0.01 dB * √f (GHz)		
2.7 – 3.8 GHz	≤ 0.16 dB/m (cable) + 0.01 dB * √f (GHz)		
Intermodulation (3rd order @ 2 x 20 W)	typ.	max.	
	≤ -120 dBm	≤ -117 dBm	
Relative Velocity of Propagation	88 %		
DC breakdown voltage	2500 V		

Mechanical Data

Coupling torque (recommended)	25 to 30 Nm
Spanner flat on coupling nut	32 mm
Cable diameter, jacket	16 mm typ.
Tensile strength	1100 N
Recommended hanger spacing	0.8 m
Minimum bend radius single	70 mm*
Minimum bend radius repeated	125 mm*

*Bending starts behind connector incl. the kink protection

Environmental Data

Operation temperature range	-40 °C to +85 °C
Installation temperature range	-25 °C to +60 °C
Degree of protection	IEC 60529, IP68 1 bar for 1 h (mated)
RoHS	compliant

For the installation of the electrotechnical equipment, particular electrotechnical expertise is required.

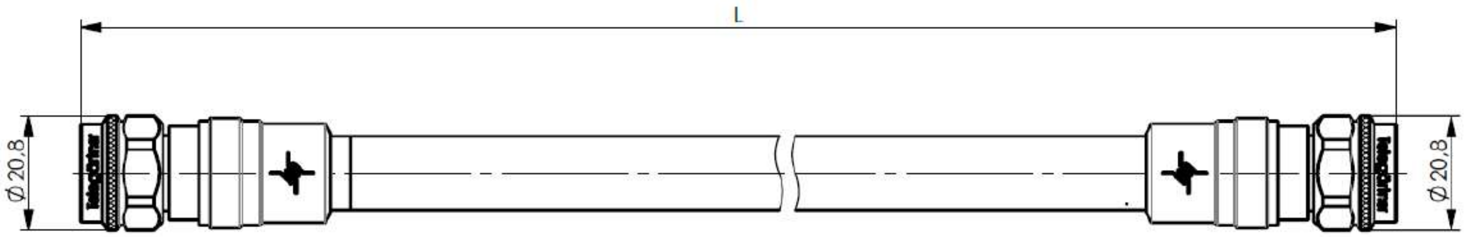
Draft	Date	Approved	Date	Rev.	Engineering change number	Name	Date
M. Wimmer	04.11.2013	Chr. Janßen	23.09.2020	f00	20-1927	B. Wollitzer	23.09.2020

Rosenberger Hochfrequenztechnik GmbH & Co. KG
P.O.Box 1260 D-84526 Tittmoning Germany
www.rosenberger.de

Tel. : +49 8684 18-0
Email : info@rosenberger.de

1/2" Flexible Jumper Cables

N m to N m Connectors, IP68



General	
Cable Type	1/2" Superflex Helically Corrugated
Outer Conductor	Copper
Centre Conductor	Copper-Clad Aluminium
Dielectric	Foam Polyethylene
Jacket	Black Polyethylene, Halogen Free
Connector Types	N male to N male
Outer Contact	Brass, Silver Plated
Centre Contact	Brass, Silver Plated
Coupling Nut	Brass Hex Nut, Telealloy Plated

Mechanical & Climatic Characteristics	
Sealing class	IP68 unmated, barrier sealed
Connector Gasket	Silicone
Connector Torque	4-6 Nm
Min. Bending Radius single	17 mm
Min. Bending Radius repeated	55 mm
Temperature Range (install.)	-40°C to +60°C
Temperature Range (op.)	-40°C to +85°C
Relative Humidity	0-100%
Water Tightness	IP68 tested under 25m head of water

Electrical Performance					
	450 MHz	900 MHz	1800 MHZ	2100 MHz	2700 MHz
Typical Return Loss	-32 dB	-32 dB	-30 dB	-30 dB	-28 dB
Typical Intermodulation (3rd Order)	-161 dBc	-161 dBc	-161 dBc	-161 dBc	-161 dBc
Attenuation (per 100 m) at 20°C (w/o connector)	7.59 dB	10.40 dB	16.00 dB	17.70 dB	21.50 dB

Typical insertion loss per connector <0.01 dB (0-3 GHz).

Mean Power Rating	600 W @ 800-1000 MHz 350 W @ 1000-2700 MHz
Impedance	50 Ohm (+/-1)
Velocity of propagation	83%

Length*	Type	Order Number
0.5 m	JMPS/0544K	L00010A1687
1 m	JMPS/1044K	L00010A1634
2 m	JMPS/2044K	L00011A0252
3 m	JMPS/3044K	L00012A0116
4 m	JMPS/4044K	L00013A0265
5 m	JMPS/5044K	L00013A0352
6 m	JMPS/6044K	L00014Q0083
7 m	JMPS/7044K	L00014Q0084
8 m	JMPS/8044K	L00014Q0085
9 m	JMPS/9044K	L00015Q0056
10 m	JMPS/10044K	L00015Q0057

*Standard lengths. Other lengths available on request.

Technical changes reserved.

Telegärtner
Karl Gärtner GmbH
Lerchenstraße 35
D-71144 Steinenbronn
Telefone: +49 (0) 71 57 / 1 25-0
Telefax: +49 (0) 71 57 / 1 25-5120
E-Mail: info@telegaertner.com
Web: www.telegaertner.com

7/8"-A

STANDARD

Cable type : *5228 A*

Reference : *EC5-50-A*

Cable with standard UV resistant PE jacket, halogen free according to IEC 60754

CHARACTERISTICS

Construction

• Inner conductor	
Material	**smooth copper tube**
Diameter *(mm) (in)*	**9.25 (0.36)**
• Dielectric	
Material	**gas-injected cellular polyethylene**
Diameter *(mm) (in)*	**23.5 (0.93)**
• Outer conductor	
Material	**corrugated copper tube**
Diameter *(mm) (in)*	**25 (0.98)**
• Outer sheath	
Thickness *(mm) (in)*	**1.4 (0.06)**
Diameter *(mm) (in)*	**27.8 (1.09)**

Mechanical characteristics

• Minimum bending radius	
a) single bending *(cm) (in)*	**10 (3.9)**
b) 15 repeated bends *(cm) (in)*	**25 (9.8)**
• Maximum pulling strength *(daN) (lb)*	**130 (292)**
• Recommended temperature range	
- Storage	**-70 to +85 °C (-94 to +185 °F)**
- Installation	**-40 to +60 °C (-40 to +140 °F)**
- Operation	**-55 to +85 °C (-67 to +185 °F)**
• Max. length per hoisting grip *(m) (ft)*	**70 (230)**
• Maximum hanger spacing *(m) (ft)*	**1.2 (3.9)**
• Flat plate crush res. *(kg/mm) (lb/in)*	**1.5 (87)**
• Bending moment *(Nm) (lb-ft)*	**10 (7.3)**
• Approximate weight *(kg/km) (lb/ft)*	**425 (0.288)**

Electrical characteristics

• Characteristic impedance *(Ω)*	**50 ± 1**
• Nominal capacity *(pF/m) (pF/ft)*	**75 (22.9)**
• Relative propagation velocity *(%)*	**89**
• Inductance *(µH/m) (µH/ft)*	**0.187 (0.057)**
• DC-resistance at 20°C (68°F)	
- inner conductor *(Ω/km) (Ω/1000ft)*	**1.65 (0.5)**
- outer conductor *(Ω/km) (Ω/1000ft)*	**1.31 (0.4)**
• RF peak voltage *(kV)*	**2.9**
• RF peak power *(kW)*	**86**
• Cut-off-frequency *(GHz)*	**5.1**
• Insulation resistance *(MΩ.km)*	**>> 5000**

• Attenuation[1] and power rating

Frequency *(MHz)*	Attenuation at 20°C (68° F) [2] *(dB/100m)*	*(dB/100ft)*	Mean power rating [3] *(kW)*
10	0.35	0.107	25.86
20	0.49	0.149	18.22
30	0.61	0.186	14.83
80	1.00	0.305	8.99
100	1.12	0.341	8.02
150	1.38	0.421	6.51
200	1.61	0.491	5.60
300	1.98	0.604	4.54
400	2.31	0.704	3.90
450	2.46	0.750	3.66
500	2.60	0.793	3.46
600	2.86	0.872	3.14
700	3.11	0.948	2.90
800	3.34	1.018	2.69
894	3.55	1.082	2.54
960	3.68	1.122	2.44
1000	3.77	1.149	2.39
1500	4.70	1.433	1.91
1700	5.04	1.537	1.79
1800	5.20	1.585	1.73
1880	5.33	1.625	1.69
2000	5.51	1.680	1.63
2170	5.77	1.759	1.56
2200	5.82	1.774	1.55
2300	5.96	1.817	1.51
2400	6.11	1.863	1.47
2500	6.25	1.905	1.44
2700	6.53	1.991	1.38
3000	6.93	2.113	1.30
4000	8.17	2.491	1.10
6000	-	-	-

[1] The attenuation can be approximated by the formula:

$$\alpha(f[MHz]) = A \cdot \sqrt{f[MHz]} + B \cdot f[MHz] \quad (dB/100m)$$

A = 0.109
B = 0.00032

[2] Nominal values

[3] Ambient temperature = 40°C (104°F); temperature of inner conductor = 100°C (212°F); VSWR = 1.0; no solar loading

ISO Certified Company KABELWERK EUPEN AG - Malmedyer Straße 9 - 4700 EUPEN - BELGIUM Tel.: +32(0) 87.59.70.00 - Fax : +32(0) 87.59.71.00 - http://www.eupen.com - e-mail: info@eupen.com

1/2"

STANDARD

Cable type : *5128*

Reference : *EC4-50*

Cable with standard UV resistant PE jacket, halogen free according to IEC 60754

CHARACTERISTICS

Construction

• Inner conductor	
Material	**copper clad aluminium wire**
Diameter *(mm) (in)*	**4.8 (0.19)**
• Dielectric	
Material	**gas-injected cellular polyethylene**
Diameter *(mm) (in)*	**12.4 (0.49)**
• Outer conductor	
Material	**corrugated copper tube**
Diameter *(mm) (in)*	**13.8 (0.54)**
• Outer sheath	
Thickness *(mm) (in)*	**1.1 (0.04)**
Diameter *(mm) (in)*	**16.0 (0.63)**

Mechanical characteristics

• Minimum bending radius	
a) single bending *(cm) (in)*	**7 (2.8)**
b) 15 repeated bends *(cm) (in)*	**12 (4.7)**
• Maximum pulling strength *(daN) (lb)*	**94 (211)**
• Recommended temperature range	
- Storage	**-70 to +85 °C (-94 to +185 °F)**
- Installation	**-40 to +60 °C (-40 to +140 °F)**
- Operation	**-55 to +85 °C (-67 to +185 °F)**
• Max. length per hoisting grip *(m) (ft)*	**70 (230)**
• Maximum hanger spacing *(m) (ft)*	**1 (3.3)**
• Flat plate crush res. *(kg/mm) (lb/in)*	**1.5 (87)**
• Bending moment *(Nm) (lb-ft)*	**3.4 (2.5)**
• Approximate weight *(kg/km) (lb/ft)*	**225 (0.152)**

Electrical characteristics

• Characteristic impedance *(Ω)*	**50 ± 1**
• Nominal capacity *(pF/m) (pF/ft)*	**76 (23.2)**
• Relative propagation velocity *(%)*	**88**
• Inductance *(µH/m) (µH/ft)*	**0.189 (0.058)**
• DC-resistance at 20°C (68°F)	
- inner conductor *(Ω/km) (Ω/1000ft)*	**1.48 (0.45)**
- outer conductor *(Ω/km) (Ω/1000ft)*	**2.14 (0.65)**
• RF peak voltage *(kV)*	**1.6**
• RF peak power *(kW)*	**25.6**
• Cut-off-frequency *(GHz)*	**9.8**
• Insulation resistance *(MΩ.km)*	**>> 5000**

• Attenuation[1] and power rating

Frequency	Attenuation at 20°C (68° F) [2]		Mean power rating [3]
(MHz)	*(dB/100m)*	*(dB/100ft)*	*(kW)*
10	0.67	0.204	11.79
20	0.95	0.290	8.31
30	1.17	0.357	6.77
80	1.92	0.585	4.11
100	2.15	0.655	3.67
150	2.65	0.808	2.98
200	3.07	0.936	2.57
300	3.79	1.155	2.08
400	4.41	1.345	1.79
450	4.69	1.430	1.68
500	4.96	1.512	1.59
600	5.46	1.665	1.45
700	5.92	1.805	1.33
800	6.36	1.939	1.24
894	6.74	2.055	1.17
960	7.01	2.137	1.13
1000	7.16	2.183	1.10
1500	8.91	2.716	0.89
1700	9.54	2.909	0.83
1800	9.85	3.003	0.80
1880	10.08	3.073	0.78
2000	10.43	3.180	0.76
2170	10.91	3.326	0.72
2200	10.99	3.351	0.72
2300	11.27	3.436	0.70
2400	11.54	3.518	0.68
2500	11.80	3.598	0.67
2700	12.32	3.756	0.64
3000	13.06	3.982	0.60
4000	15.36	4.683	0.51
6000	19.39	5.912	0.41

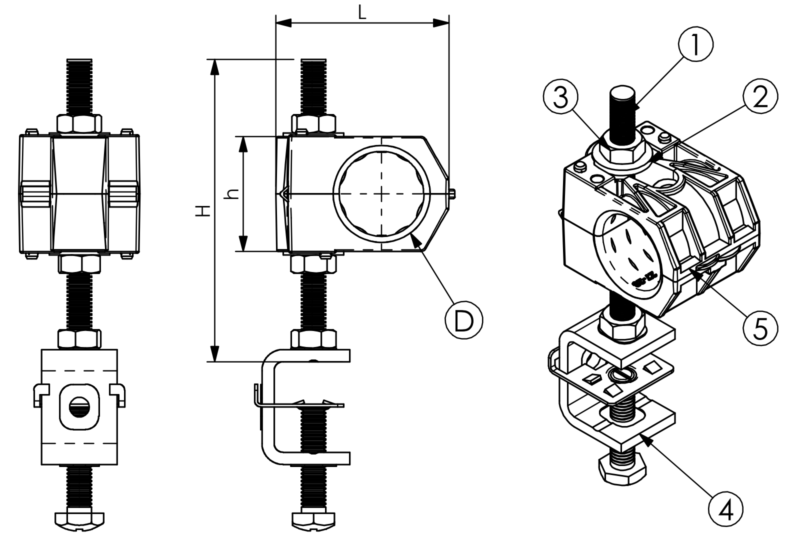
[1] The attenuation can be approximated by the formula:

$$\alpha(f[MHz]) = A \cdot \sqrt{f[MHz]} + B \cdot f[MHz] \quad (dB/100m)$$

A = 0.21
B = 0.00052

[2] Nominal values
[3] Ambient temperature = 40°C (104°F); temperature of inner conductor = 100°C (212°F); VSWR = 1.0; no solar loading

PRODUCT DATA SHEET



A) SPECIFICATIONS

1 *Stainless steel threaded bar BFI M8*
2 *Stainless steel flat Washer RPI 8/16*
3 *Stainless steel hexagonal nut DAI 8*
4 *Stainless steel MIM 8 clamp*
5 *SAM Single saddle P.P. U.V. resistant*

B) RESISTANCE TESTS

UV Test BS-ISO 105-B06
Vibration test conforming to UNI 60068-2-6
Operating temperature: -50°C +80°C

C) PACKAGING INFORMATION

Packing in boxes.
Label indicating:
product code, article, quantity,
production batch,
FIMO logo and figure.
(Customer code on request).

D) MOUNTING INSTRUCTIONS

On request

CODE	ARTICLE	ø D	L	h	H	WEIGHT
61 1572 0011	USC/ 1x11	10 - 11	44	75	21	102
61 1572 0014	USC/ 1x1/2"S (14)	13 - 14	50	75	27	105
61 1572 0012	USC/ 1x1/2" (17)	16 - 17	50	75	27	105
61 1572 0078	USC/ 1x7/8" (28)	27 - 28	59	100	38	132
61 1572 0114	USC/ 1x1.1/4" (40)	39 - 40	70	100	54	155
61 1572 0158	USC/ 1x1.5/8" (52)	50 - 52	80	125	66	155

RI	DATE	DR	DATE	AP
02				
01				
00	06/10/15	G.S.	06/10/15	A.V.
	1ST EMISSION			

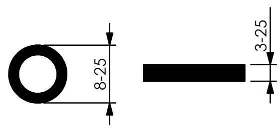
Description:

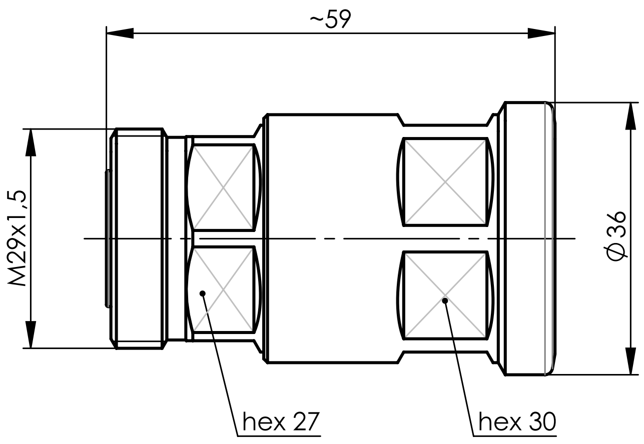
Cable Clamps type USO +MIM 8/25

FIMO
Setting Installation Standards

RoHS

Use: *Fixing of 1 cable on flat 3-25 and round ø 8-25.*





Mechanical characteristics	**Mechanische Eigenschaften**		
cables	Kabel		cable group / Kabelgruppe
		(b) (a)	G24(7/8"): RFA 7/8"-50, RFX 7/8"-50, LCF78-50JA, LDF5-50A, AVA5-50, 5228 7/8"-LD, 5228A 7/8"-LD, HPL 50-7/8, HFC 22D, FlexLine 7/8" R, Sucofeed_7/8, VXL5-50
			G52(7/8" Alu): RFA 7/8"-50 AL, HPL 50-7/8 AL, AL5-50
interface dimensions acc. to	Steckgesicht nach		IEC 61169-4
assembly instruction	Montageanleitung	(a)	B92
centre conductor	Innenleiter		clamp / Klemm
outer conductor	Außenleiter		clamp / Klemm
mating life	Steckzyklen		> 500
coupling torque	Kupplungsdrehmoment		25 - 35 Nm

Components	***Bauteile***	***Materials / Material***	***Finish / Oberfläche***
centre contact	Innenkontakt	copper alloy / Kupferleg.	Cu2Ag5
outer contact	Außenkontakt	brass / Messing	CuSnZn3 (d)
other metal parts	sonstige Metallteile	brass / Messing	Cu2Ni5
insulator	Isolierung	PE	
gasket	Dichtung	silicone / Silikon	

Electrical characteristics	**Elektrische Eigenschaften**		
impedance	Wellenwiderstand		50 Ω
frequency	Frequenz		0 - 3 GHz
return loss	Rückflussdämpfung		typ.: 40 dB (900 MHz), 37 dB (2.5 GHz)
insertion loss	Einfügedämpfung	(c)	1 GHz ≤0.03 dB; 2.2 GHz ≤0.10 dB; 3 GHz ≤0.13 dB
intermodulation	Intermodulation		IMP 3rd order <-112 dBm/-155 dBc (2x43 dBm (20 W) unmodulated test tones)
screen effectiveness	Schirmungsdämpfung		> 128 dB
working voltage	Betriebsspannung		2.7 kV
voltage proof	Prüfspannung		4 kV
insulation resistance	Isolationswiderstand		> 10 GΩ
power	Leistungsübertragung		1.8 kW / 1 GHz
contact resistance	Durchgangswiderstand		
centre contact	Innenkontakt		≤ 0.4 mΩ
outer contact	Außenkontakt		≤ 0.2 mΩ

Environmental	**Umgebung**	
operating temp.	Betriebstemperatur	-40°C / +85°C
protection class	Schutzklasse	IP 68 (IEC 60529)
RoHS compliant	RoHS konform	2002/95/EC

Änd./ rev. Index	Änderungs-Nr. / revision code	Datum/ date	Name/ name
d	29988	16.10.2018	HB
c	23160	12.09.2011	GB
b	23089	08.08.2011	MA
a	21002	17.07.2009	MA

	Datum/ *date*	Name/ *name*	Gewicht/ weight [g]
gez./ *drawn*	06.04.2009	PU	ca./approx. 150
gepr./ *appr.*	07.04.2009	BJ	

Maßstab/ *scale*: 1:1

Benennung/ *title*:

7-16 Straight Jack SIMFix® CA-Pro
7-16 Kabelbuchse SIMFix® CA-Pro

Telegärtner

untol. Maße/ *dim. without tolerances according to*

Unterl./*doc. type*: K

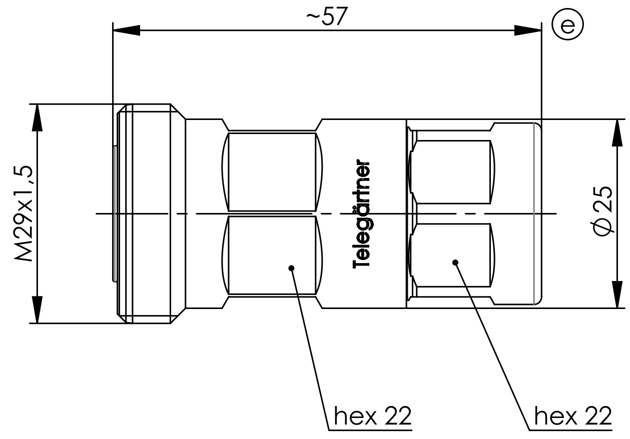
Zeichnungsnr./ *drawing no.*: J01121A0180

Ersatz für/ *replaces*

Maße/ *dimensions*: mm

Original : DIN A4

K.Gärtner GmbH D-71144 Steinenbronn Lerchenstrasse 35 Germany Phone: +49 7157/125-0 Fax: +49 7157/125-5120 www.telegaertner.com



Mechanical characteristics	**Mechanische Eigenschaften**	
cables	Kabel	G21(1/2"): RFA 1/2"-50, RFX 1/2"-50, (c) LCF 12-50 J, LDF4-50A, 5128 1/2"-LD, HPL 50-1/2, HFC 12D, FlexLine 1/2" R, Sucofeed_1/2
interface dimensions acc. to	Steckgesicht nach	IEC 61169-4
assembly instruction	Montageanleitung	(c) B90
centre conductor	Innenleiter	(b) clamp / klemm
outer conductor	Außenleiter	clamp / klemm
mating life	Steckzyklen	> 500
coupling torque	Kupplungsdrehmoment	25 - 35 Nm

Components	***Bauteile***	***Materials / Material***	***Finish / Oberfläche***
centre contact	Innenkontakt	copper alloy / Kupferleg.	Cu2Ag5
outer contact	Außenkontakt	brass / Messing	CuSnZn3 (f)
other metal parts	sonstige Metallteile	brass / Messing	Cu2Ni5
insulator	Isolierung	(e) Topas (COC)	
gasket	Dichtung	silicone / Silikon	

Electrical characteristics	**Elektrische Eigenschaften**	
impedance	Wellenwiderstand	50 Ω
frequency	Frequenz	0 - 3 GHz
return loss	Rückflussdämpfung	(a) typ.: 1 GHz - 40 dB; 2,5 GHz - 36 dB
insertion loss	Einfügedämpfung	(d) 1 GHz ≤ 0,03 dB; 2,2 GHz ≤ 0.1 dB; 3 GHz ≤ 0,13 dB
intermodulation	Intermodulation	IMP 3rd order <-112 dBm/-155 dBc (2x43 dBm (20 W) unmodulated test tones)
screen effectiveness	Schirmungsdämpfung	> 128 dB
working voltage	Betriebsspannung	≤ 2.7 kV_{eff} / 50 Hz
voltage proof	Prüfspannung	4 kV kV_{eff} / 50 Hz
insulation resistance	Isolationswiderstand	> 10 GΩ
power	Leistungsübertragung	≤ 1.8 kW / 1 GHz
contact resistance	Durchgangswiderstand	
centre contact	Innenkontakt	≤ 0.4 mΩ
outer contact	Außenkontakt	≤ 0.2 mΩ

Environmental	**Umgebung**	
operating temp.	Betriebstemperatur	-40°C / +85°C
protection class	Schutzklasse	IP 68 (IEC 60529)
RoHS compliant	RoHS konform	(c) 2002/95/EC

Änd./ *rev. Index*	Änderungs-Nr. / *revision code*	Datum/ *date*	Name/ *name*
f	29928	19.09.2018	HB
e	23907	25.05.2012	PU
d	23160	12.09.2011	GB
c	21002	08.07.2009	MA
b	19262	12.11.2007	VM
a	18257	25.10.2006	MA

	Datum/ *date*	Name/ *name*	Gewicht/ weight [g]
gez./ *drawn*	13.05.2008	BJ	
gepr./ *appr.*	26.08.2010	JA	ca./approx. 113

Maßstab/ *scale* 1:1

Benennung/ *title*

7-16 Straight Jack SIMFix®Pro

7-16 Kabelbuchse SIMFix®Pro

Telegärtner

untol. Maße/ *dim. without tolerances according to*

Unterl./*doc. type* K

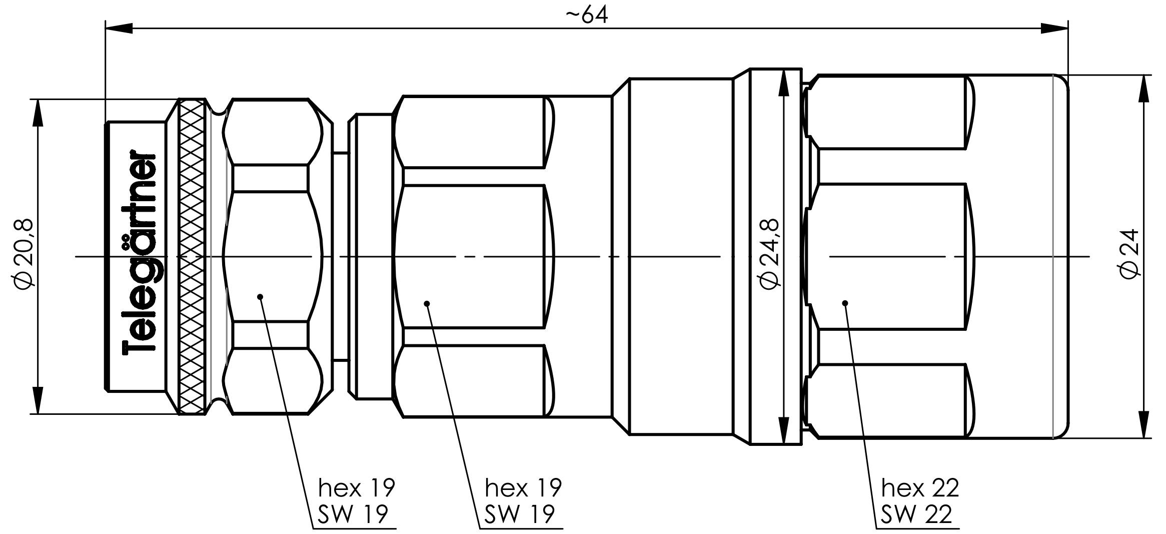
Zeichnungsnr./ *drawing no.* J01121G0136

Maße/ *dimensions*: mm

Original : DIN A4

Ersatz für/ *replaces* Zeichnung vom 21.01.2006

Blatt/ *sheet* 1 von/ *of* 1



Mechanical characteristics	**Mechanische Eigenschaften**	
cables	Kabel	cable group / Kabelgruppe G21 (1/2") 5128 1/2"-LD, Flexline 1/2" R, HFC 12D, HPL 50-1/2, LCF 12-50 J, LDF4-50A, RFA 1/2"-50, RFX 1/2"-50 , Sucofeed_1/2
interface dimensions acc. to	Steckgesicht nach	IEC 61169-16
assembly code	Montageanleitung	B90
centre conductor	Innenleiter	clamp / Klemm
outer conductor	Außenleiter	clamp / Klemm
mating life	Steckzyklen	>500
coupling torque	Kupplungsdrehmoment	4-6 Nm

Components	***Bauteile***	***Materials / Material***	***Finish / Oberfläche***
centre contact	Innenkontakt	copper alloy / Kupferleg.	Cu2Ag5
outer contact	Außenkontakt	brass / Messing	CuSnZn3 (a)
other metal parts	sonstige Metallteile	brass / Messing	Cu2Ni5, CuSnZn3
insulator	Isolierung	COC	
gasket	Dichtung	silicone / Silikon	

Electrical characteristics	**Elektrische Eigenschaften**	
impedance	Wellenwiderstand	50 Ω
frequency	Frequenz	0-3GHz
return loss	Rückflussdämpfung	typ.: 1 GHz - 40 dB; 2,5 GHz - 36 dB
insertion loss	Einfügedämpfung	1 GHz ≤0.09 dB; 2.2 GHz ≤0.13 dB; 3 GHz ≤0.18 dB
intermodulation	Intermodulation	IMP 3rd order < - 112 dBm/-155 dBc (2x43 dBm (20 W) unmodulated test tones)
screen effectiveness	Schirmungsdämpfung	> 100 dB
working voltage	Betriebsspannung	1 kV
voltage proof	Prüfspannung	2,5 kV
insulation resistance	Isolationswiderstand	> 5 GΩ
contact resistance	Durchgangswiderstand	
centre contact	Innenkontakt	≤ 1,5 mΩ
outer contact	Außenkontakt	≤ 1,0 mΩ
Environmental	**Umgebung**	
operating temp.	Betriebstemperatur	-40°C / +85°C
protection class	Schutzklasse	IP 68 (IEC 60529)
RoHS compliant	RoHS konform	2002/95/EC

Änd./ rev. Index	Änderungs-Nr. / revision code	Datum/ date	Name/ name
a	29928	19.09.2018	HB

	Datum/ date	Name/ name	Gewicht/ weight [g]
gez./ drawn	08.10.2012	GB	ca./approx.
gepr./ appr.	17.10.2012	PU	86

Maßstab/ scale: 2:1

Benennung/ title:

N Straight Plug SIMFix® Pro
N-Kabelstecker SIMFix® Pro

Telegärtner

untol. Maße/ dim. without tolerances according to

Unterl./doc. type: K

Zeichnungsnr./ drawing no.: J01020C0141

Maße/ dimensions: mm

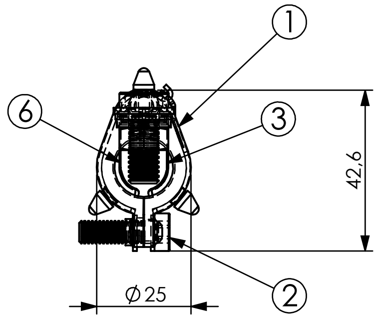
Original : DIN A4

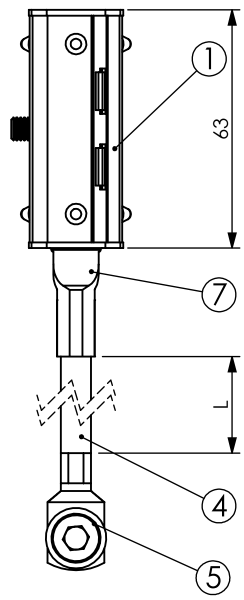
Ersatz für/ replaces: EWB10001-30

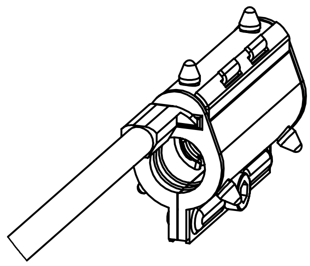
Blatt/ sheet 1 von/ of 1

 K.Gärtner GmbH D-71144 Steinenbronn Lerchenstrasse 35 Germany Phone: +49 7157/125-0 Fax: +49 7157/125-120 www.telegaertner.com

PRODUCT DATA SHEET







A) SPECIFICATIONS
1 *Shell: Stainless steel.*
2 *Hexagon socket head Screw: Stainless steel VCI 6x20*
3 *Gasket: Rubber EPDM.*
4 *16sqmm Connection cable: L=500 PE rigid copper cable.*
5 *Cable lug Ø8: Tinned copper. Including earthing screw kit (screw VCI 8x20; nut DAI 8, washers REG 8 + RPI 8/16).*
6 *Inner Contact: Tinned brass.*
7 *Contact bar: Tinned brass.*

B) RESISTANCE TESTS
Waterproof test:
IP 68 (FIMO Test according to IEC60529 normative).
Contact Resistance </= 1mOhm
Operating Temperature -40°C +85°C

C) PACKAGING INFORMATION
Packing in boxes.
Label indicating:
product code, article, quantity, production batch,
FIMO logo and figure.
(Customer code on request).

D) MOUNTING INSTRUCTIONS
IST 046

code	**6115409012**
article	**KMT 1/2" P E**

D	L		
16-17	500	10	0.2421kg

RI	DATE	DR	DATE	AP
02				
01				
00	17/12/2014	E.B.	17/12/2014	A.V.
	1ST EMISSION			

Description:
Grounding Kit

Use: *Earthing of coaxial cables.*

FIMO
Setting Installation Standards

RoHS

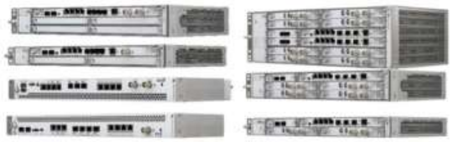
MINI-LINK 6600

MINI-LINK the Network Node
Building an efficient microwave backhaul network with end-to-end performance in mind; requires high node capacity, compact and modular building practice and advanced packet functionality. The microwave nodes also need to be capable of handling single hops as well as advanced hub sites for larger networks. By combining MINI-LINK outdoor units and indoor units, all network scenarios are supported with superior performance and lowest possible cost of ownership.
Ericsson is the market leader in microwave transmission and has over 40 years of microwave experience with more than 3.5 million radio units delivered to over 180 countries.

High Capacity Node and Radio Link
MINI-LINK 6600 is the high capacity indoor node in a split-mounted microwave system. It supports switching capacity up to 90 Gbps, multiple high capacity radio links with a capacity up to 2.5 Gbps. With high modulation schemes 8k QAM, XPIC, MIMO, Multi-band booster, wide channels like 112MHz and multiple 10G interfaces it ensures deployment flexibility and future readiness.

Advanced Packet Functionality
MINI-LINK 6600 has an integrated Ethernet switch/router supporting Customer and Provider mode switching, IP Routing and MPLS L3 VPN.

Flexible and modular building practice
In MINI-LINK 6600, compact nodes as well as modular nodes using plug-in units are available. This makes it easy to customize configurations. The full range of MINI-LINK outdoor units can easily be combined in many different ways:



traditional frequencies (6-42 GHz), V-band 60 GHz, E-band 70/80 GHz, single and dual carrier, Coax and Ethernet interface.

Efficient network migration
MINI-LINK 6600 support any network migration from one generation of Radio technology to next on the Road to 5G. There is a topology flexibility in MINI-LINK 6600 to build hop based, tree, stars or ring based topologies to best support the network need.

For cost efficient migration MINI-LINK 6600 is hop compatible with MINI-LINK TN. Upgrading to MINI-LINK 6600, the radio units, antennas, and cabling can be reused.

Technical specification MINI-LINK 6600

RADIO LINK 5-80 GHZ*	Using MINI-LINK 6363 up to 4096QAM: -1.4 Gbps 1+0 in 112 MHz (ETSI) -2.5 Gbps using 2+0 RLB in 112 MHz (ETSI) -1 Gbps 1+0 in 80 MHz (ANSI) -2 Gbps using 2+0 RLB in 80 MHz (ANSI) Using MINI-LINK 6363 80GHz up to 1024QAM -1.1 Gbps 1+0 in 125 MHz (ETSI) -2.2 Gbps 2+0 RLB in 125 MHz (ETSI)
RADIO LINK 60/70/80 GHZ*	1 Gbps over 200 MHz using MINI-LINK 6351 10 Gbps over 2000 MHz using MINI-LINK 6352
RADIO LINK	ATPC, Radio Link Bonding, XPIC, Adaptive Coding Modulation, Multi-layer Header Compression, Multi-band Booster, AES encryption over the hop, 4x4 MIMO
PROTECTION & CONFIGURATION	Up to 2+2 Hot standby and Space Diversity Up to 4+0 Radio Link Bonding (RLB) Up to 4+0 RLB using different CS combinations ERP, RSTP, SNCP Network protection MSP 1+1 Equipment protection
DIMENSIONS (H X W X D)	6651/3 44x444x171 mm, 1.7x17.6x6.8 inch 6651 44x444x240 mm, 1.7x17.6x9.4 inch 6654: 44x446x240 mm, 1.7x17.6x9.4 inch 6655: 66x446x240 mm, 2,6x17,6x9,4 inch 6691: 44x446x240 mm, 1.7x17.6x9.4 inch 6693: 66x446x240 mm, 2.6x17.2x9.4 inch 6694: 89x446x240 mm, 3.6x17.6x9.4 inch 6692: 133x446x240 mm, 5.2x17.5x9.4 inch
POWER SUPPLY	-48 V DC, Power redundancy
ENERGY EFFICIENCY	Traffic Aware Power Save
POWER CONSUMPTION (EXCLUDING RADIO)	6651/3: 30W 1+0 configuration 6651: 46W 1+0 configuration 6651/4: 64W 1+0 configuration 6654: 49W 1+0 configuration 6655: 57W 1+0 configuration 6691: 54W 1+0 configuration 6693: 52W 1+0 configuration 6694: 59W 1+0 configuration 6692: 64W 1+0 configuration
OPERATIONAL TEMPERATURE	-25°C to +65°C / -13F to +140F -25°C to +60°C / -13F to +131F (6651/3)
TRAFFIC INTERFACES	E1, CES SAToP, 10/100/1000 BASE-T IEEE802.3, Optical 1000BASE-SX/LX/ZX/BX, GE CWDM 10G BASE-LR/ER/ZR, 10GE DWDM
SYNCHRONIZATION	Sync E, 1588v2 (Telecom profile G.8275.1), NTP transparent, E1 and 2MHz, Frequency (G.8265.1), PTP monitoring IEEE1588v2.1 Annex M
SWITCHING/ROUTING	IEEE 802.1Q-2011 Customer & Provider Bridge, Bridge Virtual Interface, LAG/LACP, ERP, H-QoS, BNM, MAC Swap loopback, VRF, OSPF, eBGP, IS-IS, RSVP-TE FRR, RSVP-TE Path Protection, IP/MPLS L3 VPN, LDP, BFD, BGP FRR, MP-BGP, IPv4 ACL
OAM	Link OAM, Service OAM FM/PM, Y.1731, TWAMP reflector Light
DCN	DCN over VLAN, Routed DCN (OSPF) DCN over VLAN for L1 connection DCN over VRF (MPLS)
NETWORK MANAGEMENT	Supported by ENM, IP transport NMS, Service ON, Node GUI and CLI SNMP v3, SSH, RADIUS, TACACS+
STANDARDS & RECOMMENDATIONS	CEN/CENELEC, ETSI, ITU, IEC, IEEE, IETF

* For antennas and frequency bands, please see MINI-LINK outdoor datasheets

Ericsson AB
SE-417 56 Göteborg, Sweden
Telephone +46 10 719 00 00
www.ericsson.com

ERICSSON

MINI-LINK 6600 and MINI-LINK 6366

Release 1.17

Product Specification

Digitally signed by Cojocari Andrei
Date: 2021.10.27 16:44:24 EEST
Reason: MoldSign Signature
Location: Moldova

Copyright

Disclaimer

Contents

1 Introduction

MINI-LINK 6600 and MINI-LINK 6366 product family covers microwave nodes tailor made for different site needs spanning from simplest outdoor tail site to advanced split mounted aggregation site.

The following products are available:

— MINI-LINK 6651

— MINI-LINK 6691 with NPU 1002 or NPU1003 or NPU 1005

— MINI-LINK 6692 with NPU 1002 or NPU 1005

— MINI-LINK 6693 with NPU 1002 or NPU 1003 or NPU 1005

— MINI-LINK 6694 with NPU 1002 or NPU 1003 or NPU 1005

— MINI-LINK 6654 with PNM 1001 or PNM 1002

— MINI-LINK 6655 with PNM 1002

— MINI-LINK 6366

— MINI-LINK 6371

MINI-LINK 6651 is a compact 1RU node for tail sites.

MINI-LINK 6651/1 has a switch capacity of 14.5 Gbps and can connect one or two split mount radio links in one direction. It has 1 Gbps and 2.5 Gbps Ethernet interfaces on the front. It has forced cooling (fan unit).

MINI-LINK 6651/2 has a switch capacity of 14.5 Gbps and can connect one or two split mount radio links in two directions. It has 1 Gbps and 2.5 Gbps Ethernet interfaces on the front. It has forced cooling (fan unit).

MINI-LINK 6651/3 has a switch capacity of 14.5 Gbps and can connect one split mount radio link in one direction. It has 1 Gbps and 2.5 Gbps Ethernet interfaces on the front. It has convectional cooling (no fan).

MINI-LINK 6651/4 has a switch capacity of 47 Gbps and can connect one or two split mount radio links in two directions. It has 1 Gbps and 10 Gbps Ethernet interfaces on the front. Hierarchical Radio Link Bonding is supported. It has forced cooling (fan unit).

In this document, the notation MINI LINK 6651 will be used for generic specifications and parameters. The explicit notation MINI-LINK 6651/1, MINI-LINK 6651/2, MINI-LINK 6651/3 and MINI-LINK 6651/4 will be used where there are differences in the product versions.

MINI-LINK 6691 with NPU 1002 is a small flexible 1RU node for small aggregation hubs up to 4 radio links in a maximum of 4 radio directions. It has a switch capacity of 88 Gbps, where 38 Gbps can be used in this enclosure. It has 1 Gbps and 10 Gbps Ethernet interfaces on the front.

MINI-LINK 6691 with NPU 1003 is a small flexible 1RU node for small aggregation hubs up to 4 radio links in a maximum of 4 radio directions. It has a switch capacity of 45.5 Gbps, where 38 Gbps can be used in this enclosure. It has 1 Gbps and 10 Gbps Ethernet interfaces on the front.

MINI-LINK 6691 with NPU 1005 is a small flexible 1RU node for small aggregation hubs up to 4 radio links in a maximum of 4 radio directions. It has a switch capacity of 65.5 Gbps, where 43 Gbps can be used in this enclosure. It has 1 Gbps and 10 Gbps Ethernet interfaces on the front. Hierarchical Radio Link Bonding is supported.

MINI-LINK 6692 with NPU 1002 is a flexible 3RU node for large aggregation hubs up to 16 radio links in a maximum of 15 radio directions. It has a switch capacity of 88 Gbps, where 7.5 Gbps is reserved for future use. It has 1 Gbps and 10 Gbps Ethernet interfaces on the front. MINI-LINK 6692 supports redundant NPUs and PFUs.

MINI-LINK 6692 with NPU 1005 is a flexible 3RU node for large aggregation hubs up to 16 radio links in a maximum of 11 radio directions. It has a switch capacity of 65.5 Gbps, where the full capacity can be used in this enclosure. It has 1 Gbps and 10 Gbps Ethernet interfaces on the front. MINI-LINK 6692 supports redundant NPUs and PFUs. Hierarchical Radio Link Bonding is supported.

MINI-LINK 6693 with NPU 1002 is a flexible 1.5RU node for medium aggregation hubs up to 8 radio links in a maximum of 8 radio directions. It has a switch capacity of 88 Gbps, where 46.5 Gbps can be used in this enclosure and has 1 Gbps and 10 Gbps Ethernet interfaces on the front.

MINI-LINK 6693 with NPU 1003 is a flexible 1.5RU node for medium aggregation hubs up to 8 radio links in a maximum of 7 radio directions. It has a switch capacity of 45.5 Gbps, and the full capacity can be used in this enclosure. It has 1 Gbps and 10 Gbps Ethernet interfaces on the front.

MINI-LINK 6693 with NPU 1005 is a flexible 1.5RU node for medium aggregation hubs up to 8 radio links in a maximum of 7 radio directions. It has a switch capacity of 65.5 Gbps, where 55.5 Gbps can be used in this enclosure. It has 1 Gbps and 10 Gbps Ethernet interfaces on the front. Hierarchical Radio Link Bonding is supported.

MINI-LINK 6694 with NPU 1002 is a flexible 2RU node for medium aggregation hubs up to 8 radio links in a maximum of 8 radio directions. It has a switch capacity of 88 Gbps where 59.5 Gbps can be used in this enclosure. It has 1 Gbps and 10 Gbps Ethernet interfaces on the front. MINI-LINK 6694 supports redundant NPUs and PFUs.

MINI-LINK 6694 with NPU 1003 is a flexible 2RU node for medium aggregation hubs up to 8 radio links in a maximum of 7 radio directions. It has a switch capacity of 45.5 Gbps and the full capacity can be used in this enclosure. It has 1

Gbps and 10 Gbps Ethernet interfaces on the front. MINI-LINK 6694 supports redundant PFUs. Redundant NPU with NPU 1003 is not possible.

MINI-LINK 6694 with NPU 1005 is a flexible 2RU node for medium aggregation hubs up to 8 radio links in a maximum of 7 radio directions. It has a switch capacity of 65.5 Gbps where 55.5 can be used in this enclosure. It has 1 Gbps and 10 Gbps Ethernet interfaces on the front. MINI-LINK 6694 supports redundant NPUs and PFUs. Hierarchical Radio Link Bonding is supported.

MINI-LINK 6654 with PNM 1001 is a small flexible 1RU node for medium aggregation hubs up to 5 radio links in a maximum of 5 radio directions. It has a switch capacity of 36.5 Gbps, and the full capacity can be used in this enclosure. It has 1 Gbps and 10 Gbps Ethernet interfaces on the front.

MINI-LINK 6654 with PNM 1002 is a small flexible 1RU node for medium aggregation hubs up to 6 radio links in a maximum of 6 radio directions. It has a switch capacity of 39 Gbps, and the full capacity can be used in this enclosure. It has 1 Gbps and 10 Gbps Ethernet interfaces on the front.

MINI-LINK 6655 with PNM 1002 is a small flexible 1.5RU node for medium aggregation hubs up to 10 radio links in a maximum of 8 radio directions. It has a switch capacity of 44 Gbps, and the full capacity can be used in this enclosure. It has 1 Gbps and 10 Gbps Ethernet interfaces on the front.

MINI-LINK 6366 is an all-outdoor compact node. It has a switch capacity of 9.5 Gbps and can connect one or two radio units. It has 1 Gbps and 2.5 Gbps Ethernet interfaces on the front. In this document, the notation MINI LINK 6366 will be used for generic specifications and parameters. The explicit notation MINI-LINK 6366/1 and MINI-LINK 6366/4 will be used where there are differences in the product versions.

MINI-LINK 6371 is an all-outdoor compact node. It has a switch capacity of 36 Gbps and can connect one or two radio units, in two directions. It has 1 Gbps and 10 Gbps Ethernet interfaces on the front. Hierarchical Radio Link Bonding is supported.

1.1 Scope

This product specification defines the basic conditions, characteristics and performance of the MINI-LINK 6600, MINI-LINK 6366, and MINI-LINK 6371 Network Elements.

For more information about supported features please see

47/221 02-HRA 901 20/11 Technical Description MINI-LINK 6600,

49/221 02-HRA 901 20/13 Technical Description MINI-LINK 6366, and

4/221 02-HRA 901 20/18 Technical Description MINI-LINK 6300.

2 Ethernet Characteristics

For more information about supported features please see

47/221 02-HRA 901 20/11 Technical Description MINI-LINK 6600 and 49/221 02-HRA 901 20/13 Technical Description MINI-LINK 6366.

For relations between Frame ID and corresponding Channel Separation support, see also Channel Separation to Frame ID Relation on page 73.

2.1 Traffic Capacity

Capacity characteristics for Ethernet depend on hardware configuration, selected physical mode and assigned Ethernet traffic capacity. Measured values are typical, not guaranteed.

Measurements are done according to RFC 2544.

2.1.1 Layer 1 Line Interface Capacity for ETSI

Data for standard Frame ID's (256, 257, 258, 259, 260, 261, and 303) can be found in revision BT of this document.

Table 1 Layer 1 Line Interface Capacity for ETSI

Physical mode			Layer 1 Line Interface Capacity [Mbps]							
CS [MHz] (Frame ID)	Modulation	Frame size [bytes] / Air Interface Capacity [Mbps]	64	128	256	512	1024	1280	1518	9216
7 (356)	4QAM S	8	10.8	9.8	8.9	8.8	8.8	8.8	8.8	8.8
	4QAM	10	12.7	11.5	10.1	10.3	10.4	10.3	10.3	10.3
	16QAM S	18	22.6	19.9	18.4	18.2	17.9	17.6	17.6	17.7
	16QAM	21	26.4	23.2	20.4	21.3	21	21	20.9	20.7
	32QAM	26	33.1	29.6	27.8	26.9	26.4	26.3	26.2	26.1
	64QAM	33	41.6	37.1	34.9	33.7	33.1	33	33	32.7
	128QAM	39	49.2	44	41.3	40	39.2	39.1	39	38.7
	256QAM	45	56.8	50.8	47.6	46.1	45.3	45.1	45	44.7
	512QAM	51	64.4	57.5	54	52.3	51.3	51.2	51	50.6
	1024QAM	56	71.2	63.7	59.8	57.8	56.8	56.6	56.5	56

Physical mode			Layer 1 Line Interface Capacity [Mbps]							
CS [MHz] (Frame ID)	Modulation	Frame size [bytes] / Air Interface Capacity [Mbps]	64	128	256	512	1024	1280	1518	9216
13.75 14 (357)	4QAM S	19	23.3	20.8	19.5	18.9	18.6	18.5	18.4	18.3
	4QAM	22	27.2	24.3	22.9	22.1	2.7	21.6	21.6	21.4
	16QAM S	37	47	42	39.4	38.1	37.5	37.3	37.2	37
	16QAM	43	54.3	49.1	46.1	44.6	43.8	43.6	43.5	43.2
	32QAM	54	69	61.7	58	56	55	54.8	54.7	54.3
	64QAM	68	86.4	77.3	72.7	70.2	69	68.7	68.6	68
	128QAM	81	102.3	91.5	86	83	81.6	81.3	81.1	80.5
	256QAM	93	118.1	105.6	99.2	95.9	94.2	93.9	93.7	92.9
	512QAM	105	133.8	119.7	112.5	108.7	106.8	106.4	106.2	105.3
	1024QAM	117	148.2	132.5	124.5	120.3	118.2	117.8	117.5	116.6
	2048QAM	121	154	137.8	129.5	125.3	123	122.6	122.4	121.2
	2048QAM L	127	161.9	144.8	136.1	131.5	129.2	128.7	128.5	127.4
27.5 28 (358)	4QAM S	37	47.1	42.1	39.5	38.3	37.6	37.5	37.4	37.1
	4QAM	44	55	49.2	46.2	44.7	43.9	43.7	43.7	43.3
	16QAM S	75	94.6	84.7	79.4	76.8	75.5	75.2	75.1	74.5
	16QAM	87	110.4	98.8	92.9	89.7	88.1	87.8	87.6	86.9
	32QAM	109	138.7	124.1	116.6	112.8	110.8	110.4	110.2	109.1
	64QAM	137	173.8	155.5	146.1	141.2	138.6	138.2	137.9	136.8
	128QAM	162	205.4	183.8	172.8	167.1	164	163.4	163	161.7
	256QAM	186	237.2	212.2	199.4	192.9	189.5	188.8	188.4	186.7
	512QAM	211	268.9	240.5	226	218.6	214.8	214.1	213.6	211.6
	1024QAM	234	297.5	266.2	250.1	242	237.6	236.9	236.4	234.2
	2048QAM	243	309.4	276.7	260	251.6	247.1	246.3	245.8	243.5
	2048QAM L	256	325.2	290.9	273.4	264.5	259.7	258.9	258.4	255.9
	4096QAM	264	336	300.6	282.4	273.3	268.4	267.5	267	264.3
	4096QAM L	276	351.9	314.8	295.8	286.1	281	280.1	279.5	276.9
	8192QAM	284	361.1	323	303.5	293.7	288.7	287.7	287.1	284.4

Physical mode			Layer 1 Line Interface Capacity [Mbps]							
CS [MHz] (Frame ID)	Modulation	Frame size [bytes]	64	128	256	512	1024	1280	1518	9216
		Air Interface Capacity [Mbps]								
40 (359)	4QAM S	53	67.5	60.4	56.7	54.9	53.9	53.7	53.6	53.1
	4QAM	62	78.8	70.5	66.2	64.1	62.9	62.7	62.6	62
	16QAM S	107	135.4	121.1	113.8	110.1	108.1	107.8	107.6	106.5
	16QAM	124	158	141.4	132.8	128.5	126.2	125.8	125.5	124.4
	32QAM	156	198.3	177.4	166.7	161.3	158.4	157.9	157.5	156.1
	64QAM	196	248.6	222.4	208.9	202.1	198.5	197.9	197.5	195.6
	128QAM	231	293.8	262.9	247	239	234.7	233.9	233.5	231.3
	256QAM	267	339.1	303.4	285.1	275.8	270.9	270	269.4	266.9
	512QAM	302	384.4	343.9	323.1	312.6	307	306	305.4	302.5
	1024QAM	335	425.4	380.4	357.6	345.9	339.8	338.6	338	334.8
	2048QAM	348	441.8	395.2	371.3	359.3	352.9	351.7	351	347.7
	2048QAM L	366	464.9	415.9	390.8	378.1	371.3	370.1	369.4	365.9
	4096QAM	378	480.3	429.7	403.7	390.6	383.7	382.4	381.6	378
	4096QAM L	395	499.9	450	422.8	409	401.7	400.4	399.6	395.8
	8192QAM	406	516.6	462.1	434.3	420.2	413.1	411.7	410.8	406.6
55 56 62.5 (360)	4QAM S	75	95.7	85.6	80.4	77.8	76.4	76.2	76	75.3
	4QAM	88	111.7	99.9	93.9	90.8	89.2	88.9	88.7	87.9
	16QAM S	151	191.8	171.6	161.2	156	153.2	152.7	152.1	150.9
	16QAM	176	223.8	199.7	188.1	182	178.6	177.9	177.6	176.1
	32QAM	221	280.8	251.2	236	228.3	224.3	223.5	223.1	221
	64QAM	277	351.9	314.8	295.8	286.2	281.1	280.2	279.6	277
	128QAM	327	416	372.1	349.7	338.3	332.3	331.2	330.5	327.4
	256QAM	377	480	429.4	403.5	390.4	383.4	382.2	381.4	377.8
	512QAM	427	544	486.6	457.3	442.4	434.5	433.1	432.2	428.1
	1024QAM	473	601.8	538.4	505.9	489.5	480.7	479.2	478.2	473.7
	2048QAM	492	625.7	559.8	526	508.9	499.8	498.2	497.2	492.5
	2048QAM L	517	657.7	588.4	552.9	534.9	525.3	523.6	522.6	517.6
	4096QAM	534	679.5	607.9	571.2	552.6	542.8	541	539.9	534.8
	4096QAM L	559	711.5	636.5	598.1	578.7	568.3	566.5	565.3	560

Physical mode			Layer 1 Line Interface Capacity [Mbps]							
CS [MHz] (Frame ID)	Modulation	Frame size [bytes] / Air Interface Capacity [Mbps]	64	128	256	512	1024	1280	1518	9216
80 (403)	4QAM S	108	137.5	123	115.6	111.8	109.8	109.5	109.2	108.2
	4QAM	126	160.5	143.6	134.9	130.5	128.2	127.8	127.5	126.3
	16QAM S	217	275.4	246.4	231.5	224	220	219.3	218.8	216.7
	16QAM	253	321.4	287.5	270.2	261.4	256.7	255.9	255.3	252.9
	32QAM	317	403.1	360.7	338.9	327.9	322	321	320.3	317.3
	64QAM	397	504.4	451.2	423.9	410.1	402.8	401.5	400.7	396.9
	128QAM	469	597.2	534.3	502	485.7	477	475.5	474.5	470.1
	256QAM	542	689.2	616.5	579.4	560.5	550.5	548.7	547.6	542.4
	512QAM	614	781.1	698.8	656.7	635.3	623.9	621.9	620.6	614.8
	1024QAM	679	863.4	772.2	725.8	702.1	689.6	687.3	685.9	679.5
	2048QAM	706	898.6	803.6	755.4	730.8	717.8	715.5	714	707.2
	2048QAM L	742	943.2	843.8	792.9	767.1	753.4	750.9	749.4	742.3
	4096QAM	767	973.5	870.8	818.3	791.6	777.5	774.9	773.4	766.1
	4096QAM L	803	1020.9	913.2	858.2	830.3	816.3	813.5	811.7	803.9
110 112 125 (361 404)	4QAM S	151	191.6	171.4	161	155.8	153	152.5	152.2	150.8
	4QAM	176	223.6	200	187.9	181.8	178.6	178	177.6	175.9
	16QAM S	302	383.5	343.1	322.4	311.9	306.4	305.4	304.7	301.8
	16QAM	352	447.5	400.4	376.2	364	357.5	356.3	355.6	352.2
	32QAM	441	561.3	502.2	471.9	456.5	448.4	446.9	446	441.8
	64QAM	553	703.5	629.4	591.4	572.1	561.9	560.1	559	553.7
	128QAM	654	831.5	743.8	699	676.2	664.2	662	660.7	654.4
	256QAM	754	956.7	855.9	804.3	778	764.2	761.7	760	753
	512QAM	855	1085	966.5	908.2	878.7	862.9	860	858.5	850.3
	1024QAM	946	1201	1068	1009	974.8	957.7	952.6	952.2	943.3
	2048QAM	983	1248	1110	1048	1012	994.8	990.8	990.1	980.2
	2048QAM L	1033	1311	1167	1102	1063	1043	1041	1040	1030
	4096QAM	1068	1356	1206	1139	1100	1078	1076	1075	1065

2.1.2 Layer 1 Line Interface Capacity ANSI

Data for standard Frame ID's (262, 263, 264, 265, 266, 267, and 268) can be found in revision BT of this document.

Table 2 Layer 1 Line Interface Capacity ANSI

Physical mode			Layer 1 Line Interface Capacity [Mbps]							
CS [MHz] Frame ID	Modulation	Frame size [bytes] / Air Interface Capacity [Mbps]	64	128	256	512	1024	1280	1518	9216
10 (362)	4QAM S	13	16	14.1	13.2	12.8	12.6	12.5	12.5	12.4
	4QAM	15	18.4	16.5	15.5	15	14.7	14.7	14.6	14.5
	16QAM S	25	31.8	28.4	26.7	25.8	25.4	25.3	25.2	25
	16QAM	29	37.1	33.2	31.2	30.2	29.7	29.6	29.5	29.2
	32QAM	37	46.7	41.7	39.2	37.9	37.3	37.1	37.1	36.7
	64QAM	46	58.5	52.4	49.2	47.6	46.7	46.6	46.5	46.1
	128QAM	55	69.2	61.9	58.2	56.3	55.3	55.1	55	54.5
	256QAM	63	79.9	71.5	67.2	65	63.8	63.6	63.5	62.9
	512QAM	71	90.6	81.1	76.2	73.7	72.4	72.2	72	71.3
	1024QAM	79	110.3	89.7	84.3	81.6	80.1	79.9	79.7	78.9
20 (363)	4QAM S	26	33.1	29.6	27.8	26.9	26.4	26.4	26.3	26.1
	4QAM	31	38.7	34.6	32.5	31.5	30.9	30.8	30.7	30.4
	16QAM S	53	66.6	59.6	56	54.2	53.2	53	52.9	52.4
	16QAM	61	77.8	69.6	65.4	63.3	62.1	61.9	61.8	61.2
	32QAM	77	97.7	87.4	82.1	79.4	78	77.8	77.6	76.9
	64QAM	97	122.5	109.6	103	99.6	97.8	97.5	97.3	96.4
	128QAM	114	144.8	129.6	121.7	117.8	115.7	115.3	115.1	114
	256QAM	132	176.2	149.6	140.5	136	133.5	133.1	132.8	131.6
	512QAM	149	189.5	169.5	159.3	154.1	151.4	150.9	150.6	149.2
	1024QAM	165	209.7	187.6	176.3	170.6	167.5	167	166.6	165.1
	2048QAM	172	218.1	195.1	183.3	177.3	174.2	173.6	173.3	171.6
	2048QAM L	180	229.3	205.1	192.7	186.4	183.1	182.5	182.1	180.4

Physical mode			Layer 1 Line Interface Capacity [Mbps]							
CS [MHz] Frame ID	Modulation	Frame size [bytes] / Air Interface Capacity [Mbps]	64	128	256	512	1024	1280	1518	9216
28 (371)	4QAM S	37	47.1	42.1	39.5	38.3	37.6	37.5	37.4	37.1
	4QAM	44	55	49.2	46.2	44.7	43.9	43.7	43.7	43.3
	16QAM S	75	94.6	84.7	79.4	76.8	75.5	75.2	75.1	74.5
	16QAM	87	110.4	98.8	92.9	89.7	88.1	87.8	87.6	86.9
	32QAM	109	138.7	124.1	116.6	112.8	110.8	110.4	110.2	109.1
	64QAM	137	173.8	155.5	146.1	141.2	138.6	138.2	137.9	136.8
	128QAM	162	205.4	183.8	172.8	167.1	164	163.4	163	161.7
	256QAM	186	237.2	212.2	199.4	192.9	189.5	188.8	188.4	186.7
	512QAM	211	268.9	240.5	226	218.6	214.8	214.1	213.6	211.6
	1024QAM	234	297.5	266.2	250.1	242	237.6	236.9	236.4	234.2
	2048QAM	243	309.4	276.7	260	251.6	247.1	246.3	245.8	243.5
	2048QAM L	256	325.2	290.9	273.4	264.5	259.7	258.9	258.4	255.9
	4096QAM	264	336	300.6	282.4	273.3	268.4	267.5	267	264.3
	4096QAM L	276	351.9	314.8	295.8	286.1	281	280.1	279.5	276.9
30 (364)	4QAM S	40	50.4	45.1	42.4	41	40.3	40.1	40.1	39.7
	4QAM	47	58.9	52.7	49.5	47.9	47	46.9	46.8	46.4
	16QAM S	80	101.3	90.6	85.1	82.4	80.9	80.6	80.5	79.7
	16QAM	93	118.3	105.8	99.4	96.2	94.4	94.1	94	93.1
	32QAM	117	148.4	132.8	124.8	120.7	118.6	118.2	117.9	116.8
	64QAM	147	186.1	166.5	156.4	151.3	148.6	148.1	147.8	146.4
	128QAM	173	220	196.8	184.9	178.9	175.7	175.1	174.8	173.1
	256QAM	200	251	224.6	211	204.1	200.5	199.8	199.4	197.6
	512QAM	226	287.8	257.5	241.9	234.1	229.9	229.1	228.7	226.5
	1024QAM	251	318.5	284.9	267.7	259	254.4	253.6	253.1	250.7
	2048QAM	261	331.2	296.2	278.4	269.3	264.5	263.6	263.1	260.6
	2048QAM L	274	348.1	311.4	292.6	283.1	278.1	277.1	276.6	274
	4096QAM	283	359.7	321.8	302.4	292.5	287.3	286.4	285.8	283.1
	4096QAM L	296	376.6	336.9	316.6	306.3	300.8	299.9	299.3	296.4
	8192QAM	304	387	346.1	325.3	314.7	309.4	308.3	307.7	304.7

Physical mode			Layer 1 Line Interface Capacity [Mbps]							
CS [MHz] Frame ID	Modulation	Frame size [bytes] / Air Interface Capacity [Mbps]	64	128	256	512	1024	1280	1518	9216
40 (365)	4QAM S	54	68	60.9	57.2	55.3	54.3	54.2	54	53.5
	4QAM	63	79.4	71.1	66.8	64.6	63.4	63.2	63.1	62.5
	16QAM S	108	136.5	122.1	114.7	111	109	108.7	108.4	107.4
	16QAM	126	159.3	142.5	133.9	129.6	127.3	126.8	126.6	125.4
	32QAM	157	199.9	178.8	168.1	162.5	159.7	159.2	158.8	157.3
	64QAM	197	250.6	224.2	210.7	203.8	200.2	199.5	199.1	197.2
	128QAM	233	296.2	265	249	240.9	236.6	235.9	235.4	233.2
	256QAM	269	341.9	305.9	287.4	278.1	273.1	272.2	271.6	269.1
	512QAM	305	387.6	346.7	325.8	315.2	309.6	308.5	307.9	305
	1024QAM	337	428.9	383.6	360.5	348.8	342.5	341.4	340.7	337.5
	2048QAM	351	445.9	398.9	374.8	362.6	356.1	355	354.3	350.9
	2048QAM L	369	468.7	419.3	394	381.2	374.4	373.2	372.4	368.9
	4096QAM	381	484.3	433.2	407.1	393.8	386.8	385.6	384.8	381.1
	4096QAM L	399	504.4	451.2	423.9	410.1	402.8	401.5	400.7	396.9
	8192QAM	409	520.9	465.9	437.9	423.6	416.5	415.1	414.2	410
50 (366)	4QAM S	68	85.5	76.5	71.8	69.6	68.3	68.1	68	67.3
	4QAM	79	99.9	89.3	83.9	81.2	79.8	79.5	79.3	78.6
	16QAM S	135	171.5	153.4	144.1	139.4	137	136.5	136.2	134.9
	16QAM	158	200	179	168.2	162.7	159.8	159.3	159	157.5
	32QAM	198	251	224.6	211	204.1	200.5	199.8	199.4	197.6
	64QAM	248	314.7	281.5	264.5	255.9	251.3	250.5	250	247.7
	128QAM	293	372	332.8	312.7	302.5	297.1	296.1	295.5	292.7
	256QAM	338	429.2	384	360.8	349.1	342.9	341.7	341	337.8
	512QAM	383	486.5	435.2	409	395.7	388.6	387.3	386.6	382.9
	1024QAM	423	538.4	481.6	452.6	437.8	430	428.6	427.6	423.7
	2048QAM	440	559.7	500.7	470.5	455.2	447.1	445.6	444.7	440.5
	2048QAM L	463	588.4	526.3	494.6	478.5	470	468.4	467.5	463.1
	4096QAM	478	607.9	543.8	511	494.4	485.6	484	483	478.4
	4096QAM L	500	636.4	569.5	535.1	517.7	508.5	506.8	505.8	501

Physical mode			Layer 1 Line Interface Capacity [Mbps]							
CS [MHz] Frame ID	Modulation	Frame size [bytes] / Air Interface Capacity [Mbps]	64	128	256	512	1024	1280	1518	9216
56 (373)	4QAM S	75	95.7	85.6	80.4	77.8	76.4	76.2	76.0	75.3
	4QAM	88	111.7	99.9	93.9	90.8	89.2	88.9	88.7	87.9
	16QAM S	151	191.8	171.6	161.2	156	153.2	152.7	152.1	150.9
	16QAM	176	223.8	199.7	188.1	182	178.6	177.9	177.6	176.1
	32QAM	221	280.8	251.2	236	228.3	224.3	223.5	223.1	221
	64QAM	277	351.9	314.8	295.8	286.2	281.1	280.2	279.6	277
	128QAM	327	416	372.1	349.7	338.3	332.3	331.2	330.5	327.4
	256QAM	377	480	429.4	403.5	390.4	383.4	382.2	381.4	377.8
	512QAM	427	544	486.6	457.3	442.4	434.5	433.1	432.2	428.1
	1024QAM	473	601.8	538.4	505.9	489.5	480.7	479.2	478.2	473.7
	2048QAM	492	625.7	559.8	526	508.9	499.8	498.2	497.2	492.5
	2048QAM L	517	657.7	588.4	552.9	534.9	525.3	523.6	522.6	517.6
	4096QAM	534	679.5	607.9	571.2	552.6	542.8	541	539.9	534.8
	4096QAM L	559	711.5	636.5	598.1	578.7	568.3	566.5	565.3	560
60 (367)	4QAM S	81	102.8	92	86.4	83.6	82.1	81.8	81.7	80.9
	4QAM	95	120	107.4	100.9	97.6	95.9	95.5	95.4	94.5
	16QAM S	162	206.1	184.4	173.2	167.6	164.6	164.1	163.7	162.2
	16QAM	189	240.5	215.1	202.2	195.6	192.1	191.5	191.1	189.3
	32QAM	237	301.7	269.9	253.6	245.4	241	240.2	239.7	237.5
	64QAM	297	378.2	338.3	317.9	307.6	302.1	301.1	300.5	297.6
	128QAM	352	447	399.9	375.8	363.5	357.1	355.9	355.2	351.8
	256QAM	406	515.8	461.5	433.6	419.5	412	410.7	409.9	406
	512QAM	460	584.7	523.1	491.5	475.5	467	465.5	464.6	460.2
	1024QAM	509	647	578.8	543.9	526.2	516.8	515.1	514	509.2
	2048QAM	529	672.7	601.8	565.4	547	537.3	535.5	534.5	529.4
	2048QAM L	556	707.1	632.1	594.4	575	564.8	562.9	561.8	556.5
	4096QAM	574	730.6	653.6	614.1	594.1	583.5	581.6	580.5	575
	4096QAM L	601	759.2	679.1	638.1	617.4	606.4	604.4	603.2	597.5

Physical mode			Layer 1 Line Interface Capacity [Mbps]							
CS [MHz] Frame ID	Modulation	Frame size [bytes] / Air Interface Capacity [Mbps]	64	128	256	512	1024	1280	1518	9216
80 (368)	4QAM S	108	137.5	123	115.6	111.8	109.8	109.5	109.2	108.2
	4QAM	126	160.5	143.6	134.9	130.5	128.2	127.8	127.5	126.3
	16QAM S	217	275.4	246.4	231.5	224	220	219.3	218.8	216.7
	16QAM	253	321.4	287.5	270.2	261.4	256.7	255.9	255.3	252.9
	32QAM	317	403.1	360.7	338.9	327.9	322	321	320.3	317.3
	64QAM	397	504.4	451.2	423.9	410.1	402.8	401.5	400.7	396.9
	128QAM	469	597.2	534.3	502	485.7	477	475.5	474.5	470.1
	256QAM	542	689.2	616.5	579.4	560.5	550.5	548.7	547.6	542.4
	512QAM	614	781.1	698.8	656.7	635.3	623.9	621.9	620.6	614.8
	1024QAM	679	863.4	772.2	725.8	702.1	689.6	687.3	685.9	679.5
	2048QAM	706	898.6	803.6	755.4	730.8	717.8	715.5	714	707.2
	2048QAM L	742	943.2	843.8	792.9	767.1	753.4	750.9	749.4	742.3
	4096QAM	767	973.5	870.8	818.3	791.6	777.5	774.9	773.4	766.1
	4096QAM L	803	1020	913.2	858.2	830.3	816.3	813.5	811.7	804
112 (374)	4QAM S	151	191.6	171.4	161	155.8	153	152.5	152.2	150.8
	4QAM	176	223.6	200	187.9	181.8	178.6	178	177.6	175.9
	16QAM S	302	383.5	343.1	322.4	311.9	306.4	305.4	304.7	301.8
	16QAM	352	447.5	400.4	376.2	364	357.5	356.3	355.6	352.2
	32QAM	441	561.3	502.2	471.9	456.5	448.4	446.9	446	441.8
	64QAM	553	703.5	629.4	591.4	572.1	561.9	560.1	559	553.7
	128QAM	654	831.5	743.8	699	676.2	664.2	662	660.7	654.4
	256QAM	754	956.7	855.9	804.3	778	764.2	761.7	760	753
	512QAM	855	1085	966.5	908.2	878.7	862.9	860	858.5	850.3
	1024QAM	946	1201	1068	1009	974.8	957.7	945.9	945.3	943.3
	2048QAM	983	1248	1110	1048	1012	994.8	990.8	990.1	980.2
	2048QAM L	1033	1311	1167	1102	1063	1043	1041	1040	1030
	4096QAM	1068	1356	1206	1139	1100	1078	1076	1075	1065

2.1.3 Layer 2 Line Interface Capacity

L2 = L1 x (packet size) / (packet size +20)

2.2 Traffic Latency

Latency characteristics for Ethernet depend on hardware configuration, selected physical mode and assigned Ethernet traffic capacity. Measured values are typical, not guaranteed.

Measurements are done according to RFC 2544.

2.2.1 Traffic Latency for ETSI

The table below shows latency values for low latency Frame ID’s.

Values for standard Frame ID’s (256, 257, 258, 259, 260, 261 and 303) can be found in revision BT of this document.

Table 3 Traffic Latency for ETSI

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
7 (356)	4QAM S	64	766	750	840
		128	825	810	860
		256	946	930	980
		512	1204	1170	1210
		1024	1639	1630	1670
		1280	1896	1860	1900
		1518	2115	2080	2120
		9216	9185	9160	9200
7 (356)	4QAM	64	752	730	920
		128	799	780	840
		256	896	880	930
		512	1101	1090	1120
		1024	1510	1480	1520
		1280	1716	1680	1720
		1518	1904	1880	1910
		9216	7917	7910	7940

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
7 (356)	16QAM S	64	709	698	725
		128	736	728	754
		256	795	788	816
		512	917	900	980
		1024	1152	1140	1170
		1280	1272	1260	1290
		1518	1388	1370	1390
		9216	4914	4900	4980
7 (356)	16QAM	64	698	690	713
		128	722	716	738
		256	776	770	790
		512	875	870	890
		1024	1081	1070	1090
		1280	1180	1170	1190
		1518	1279	1273	1290
		9216	4314	4290	4360
7 (356)	32QAM	64	686	681	700
		128	707	702	720
		256	751	745	762
		512	832	827	840
		1024	994	990	1002
		1280	1076	1070	1080
		1518	1157	1148	1163
		9216	3580	3570	3630
7 (356)	64QAM	64	680	673	688
		128	694	690	705
		256	730	720	740
		512	796	793	803
		1024	924	922	933
		1280	992	980	1000
		1518	1054	1051	1062
		9216	3013	3000	3030

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
7 (356)	128QAM	64	673	669	682
		128	686	683	696
		256	716	713	724
		512	773	770	780
		1024	886	881	891
		1280	941	939	949
		1518	995	992	1001
		9216	2652	2640	2680
7 (356)	256QAM	64	669	665	676
		128	681	678	689
		256	707	700	720
		512	757	750	760
		1024	853	852	859
		1280	902	900	920
		1518	951	947	956
		9216	2395	2380	2420
7 (356)	512QAM	64	665	662	672
		128	678	674	684
		256	696	690	701
		512	745	740	750
		1024	829	828	836
		1280	874	872	880
		1518	917	915	922
		9216	2198	2190	2220
7 (356)	1024QAM	64	664	661	670
		128	674	671	680
		256	695	692	701
		512	737	735	741
		1024	815	813	820
		1280	854	852	859
		1518	891	889	896
		9216	2056	2051	2059

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
13.75 14 (357)	4QAM S	64	391	384	413
		128	423	410	480
		256	482	470	550
		512	597	580	660
		1024	821	810	890
		1280	940	920	1000
		1518	1043	1030	1050
		9216	4482	4460	4540
13.75 14 (357)	4QAM	64	391	370	460
		128	411	400	429
		256	460	450	510
		512	559	550	610
		1024	752	740	800
		1280	848	840	910
		1518	943	930	950
		9216	3869	3860	3930
13.75 14 (357)	16QAM S	64	366	350	410
		128	379	373	402
		256	407	400	440
		512	466	460	500
		1024	581	570	610
		1280	642	630	670
		1518	699	690	704
		9216	2428	2420	2460
13.75 14 (357)	16QAM	64	358	353	382
		128	371	367	396
		256	398	390	420
		512	448	440	470
		1024	548	540	570
		1280	600	590	620
		1518	648	642	655
		9216	2140	2130	2160

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
13.75 14 (357)	32QAM	64	353	349	378
		128	364	360	386
		256	384	380	400
		512	426	420	450
		1024	506	505	515
		1280	549	547	554
		1518	588	585	593
		9216	1791	1780	1810
13.75 14 (357)	64QAM	64	349	345	374
		128	357	354	373
		256	376	374	380
		512	409	407	424
		1024	475	472	493
		1280	508	506	528
		1518	539	536	544
		9216	1510	1508	1514
13.75 14 (357)	128QAM	64	346	343	367
		128	354	350	370
		256	369	368	374
		512	398	397	414
		1024	454	452	467
		1280	485	482	490
		1518	510	508	515
		9216	1342	1337	1343
13.75 14 (357)	256QAM	64	355	340	370
		128	353	349	358
		256	365	360	370
		512	391	389	393
		1024	440	439	443
		1280	467	464	469
		1518	490	488	492
		9216	1218	1214	1230

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
13.75 14 (357)	512QAM	64	354	346	357
		128	349	347	355
		256	362	360	392
		512	385	384	388
		1024	428	427	431
		1280	454	451	455
		1518	473	471	475
		9216	1123	1120	1134
13.75 14 (357)	1024QAM	64	352	346	357
		128	347	345	355
		256	363	362	380
		512	381	379	383
		1024	420	419	423
		1280	443	442	445
		1518	459	458	461
		9216	1054	1052	1065
13.75 14 (357)	2048QAM	64	350	345	354
		128	348	345	354
		256	361	360	378
		512	379	377	383
		1024	418	417	420
		1280	439	437	441
		1518	457	456	460
		9216	1030	1027	1035
13.75 14 (357)	2048QAM L	64	349	344	359
		128	346	344	351
		256	358	356	360
		512	378	376	380
		1024	415	413	417
		1280	435	433	437
		1518	452	450	454
		9216	1000	998	1010

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
27.5 28 (358)	4QAM S	64	217	213	240
		128	232	228	255
		256	262	258	284
		512	322	318	345
		1024	437	432	456
		1280	498	492	518
		1518	553	549	567
		9216	2292	2289	2312
27.5 28 (358)	4QAM	64	213	209	236
		128	225	222	249
		256	252	248	275
		512	303	300	327
		1024	403	398	424
		1280	455	450	477
		1518	502	498	519
		9216	1995	1992	2014
27.5 28 (358)	16QAM S	64	202	200	226
		128	210	208	226
		256	228	225	243
		512	259	257	274
		1024	319	318	335
		1280	351	348	367
		1518	380	378	392
		9216	1285	1283	1301
27.5 28 (358)	16QAM	64	201	198	221
		128	208	205	232
		256	222	220	235
		512	250	249	263
		1024	303	301	316
		1280	331	328	344
		1518	356	355	367
		9216	1141	1139	1155

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
27.5 28 (358)	32QAM	64	198	196	220
27.5 28 (358)	32QAM	128	204	202	223
27.5 28 (358)	32QAM	256	224	210	240
27.5 28 (358)	32QAM	512	239	238	265
27.5 28 (358)	32QAM	1024	282	281	293
27.5 28 (358)	32QAM	1280	305	303	316
27.5 28 (358)	32QAM	1518	326	325	334
27.5 28 (358)	32QAM	9216	967	966	979
27.5 28 (358)	64QAM	64	195	193	211
27.5 28 (358)	64QAM	128	201	199	217
27.5 28 (358)	64QAM	256	216	214	237
27.5 28 (358)	64QAM	512	231	229	252
27.5 28 (358)	64QAM	1024	266	265	274
27.5 28 (358)	64QAM	1280	286	284	294
27.5 28 (358)	64QAM	1518	303	301	309
27.5 28 (358)	64QAM	9216	829	828	838
27.5 28 (358)	128QAM	64	202	196	220
27.5 28 (358)	128QAM	128	199	198	213
27.5 28 (358)	128QAM	256	221	207	226
27.5 28 (358)	128QAM	512	225	224	242
27.5 28 (358)	128QAM	1024	256	255	263
27.5 28 (358)	128QAM	1280	273	272	280
27.5 28 (358)	128QAM	1518	288	287	294
27.5 28 (358)	128QAM	9216	745	744	752
27.5 28 (358)	256QAM	64	205	196	217
27.5 28 (358)	256QAM	128	198	196	210
27.5 28 (358)	256QAM	256	216	204	222
27.5 28 (358)	256QAM	512	221	220	236
27.5 28 (358)	256QAM	1024	249	248	254
27.5 28 (358)	256QAM	1280	265	263	270
27.5 28 (358)	256QAM	1518	278	276	282
27.5 28 (358)	256QAM	9216	684	682	691

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
27.5 28 (358)	512QAM	64	204	199	213
		128	197	196	208
		256	214	203	219
		512	219	218	231
		1024	244	242	248
		1280	258	256	262
		1518	271	269	275
		9216	637	636	643
27.5 28 (358)	1024QAM	64	202	198	211
		128	203	198	213
		256	211	202	215
		512	216	215	228
		1024	239	238	243
		1280	253	251	256
		1518	264	262	267
		9216	603	602	608
27.5 28 (358)	2048QAM	64	202	198	210
		128	202	198	212
		256	211	202	215
		512	216	215	227
		1024	238	237	242
		1280	251	250	255
		1518	262	261	265
		9216	591	589	596
27.5 28 (358)	2048QAM L	64	201	197	209
		128	202	198	211
		256	211	201	214
		512	215	214	225
		1024	236	235	240
		1280	249	248	253
		1518	259	258	260
		9216	576	575	581

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
27.5 28 (358)	4096QAM	64	201	197	208
		128	203	197	210
		256	210	201	213
		512	214	213	224
		1024	235	234	238
		1280	247	246	251
		1518	258	256	260
		9216	566	565	571
27.5 28 (358)	4096QAM L	64	200	197	208
		128	204	197	209
		256	208	202	212
		512	213	212	223
		1024	234	233	237
		1280	246	245	249
		1518	256	254	258
		9216	554	553	559
27.5 28 (358)	81926QAM	64	200	197	208
		128	203	198	210
		256	210	202	214
		512	214	213	223
		1024	234	233	237
		1280	245	244	249
		1518	255	254	257
		9216	548	546	552
40 (359)	4QAM S	64	162	159	186
		128	173	170	195
		256	195	192	217
		512	234	235	260
		1024	320	318	343
		1280	363	360	385
		1518	403	400	420
		9216	1630	1628	1653

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
40 (359)	4QAM	64	159	156	183
		128	168	166	187
		256	187	185	206
		512	225	223	243
		1024	296	293	314
		1280	333	330	352
		1518	367	365	383
		9216	1433	1432	1454
40 (359)	16QAM S	64	152	150	177
		128	158	156	178
		256	171	168	195
		512	194	192	204
		1024	238	236	248
		1280	261	259	271
		1518	283	281	290
		9216	939	936	948
40 (359)	16QAM	64	159	152	177
		128	156	154	174
		256	179	165	191
		512	187	186	211
		1024	226	225	235
		1280	247	245	256
		1518	265	264	272
		9216	838	835	847
40 (359)	32QAM	64	156	151	176
		128	153	151	167
		256	175	161	181
		512	180	179	198
		1024	212	210	218
		1280	229	228	236
		1518	247	243	250
		9216	715	714	724

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
40 (359)	64QAM	64	158	152	169
		128	151	150	167
		256	169	158	174
		512	174	173	188
		1024	200	199	205
		1280	215	214	220
		1518	228	227	232
		9216	619	618	626
40 (359)	128QAM	64	156	152	165
		128	157	152	167
		256	166	156	170
		512	170	169	182
		1024	194	193	198
		1280	207	206	211
		1518	218	217	221
		9216	560	559	566
40 (359)	256QAM	64	154	151	162
		128	157	151	164
		256	163	155	166
		512	168	167	178
		1024	189	187	192
		1280	201	199	204
		1518	211	210	213
		9216	517	516	522
40 (359)	512QAM	64	153	150	159
		128	155	150	161
		256	161	155	166
		512	165	164	174
		1024	184	183	187
		1280	196	195	199
		1518	205	204	207
		9216	484	483	489

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
40 (359)	1024QAM	64	152	149	158
		128	156	149	159
		256	160	154	163
		512	164	163	171
		1024	182	181	184
		1280	192	191	195
		1518	201	200	203
		9216	461	460	465
40 (359)	2048QAM	64	153	150	158
		128	155	149	159
		256	159	154	163
		512	164	162	171
		1024	181	180	183
		1280	191	190	194
		1518	200	199	201
		9216	453	451	456
40 (359)	2048QAM L	64	152	149	157
		128	155	149	158
		256	159	153	163
		512	163	162	170
		1024	180	179	182
		1280	190	189	192
		1518	198	197	200
		9216	442	441	446
40 (359)	4096QAM	64	153	149	157
		128	154	149	157
		256	158	153	162
		512	163	162	169
		1024	179	178	181
		1280	189	188	191
		1518	197	196	198
		9216	436	435	439

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
40 (359)	4096QAM L	64	152	149	156
		128	154	149	157
		256	158	153	161
		512	162	161	168
		1024	178	177	180
		1280	188	186	190
		1518	195	194	196
		9216	427	426	430
40 (359)	8192QAM	64	152	149	155
		128	153	148	156
		256	157	152	161
		512	162	161	168
		1024	177	176	179
		1280	187	186	189
		1518	195	194	195
		9216	422	421	425
55 56 62.5 (360)	4QAM S	64	122	119	144
		128	130	127	144
		256	146	144	149
		512	177	175	187
		1024	236	234	251
		1280	269	266	283
		1518	296	294	299
		9216	1185	1181	1189
55 56 62.5 (360)	4QAM	64	120	117	146
		128	127	124	140
		256	141	139	153
		512	168	166	181
		1024	219	217	232
		1280	247	244	260
		1518	272	269	274
		9216	1035	1034	1041

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
55 56 62.5 (360)	16QAM S	64	130	120	142
		128	119	117	127
		256	131	127	147
		512	146	145	153
		1024	178	177	186
		1280	196	195	203
		1518	211	210	217
		9216	684	683	688
55 56 62.5 (360)	16QAM	64	126	119	138
		128	118	116	125
		256	131	124	143
		512	142	140	147
		1024	170	169	176
		1280	187	185	192
		1518	199	198	204
		9216	613	612	617
55 56 62.5 (360)	32QAM	64	123	118	131
		128	124	118	133
		256	132	122	136
		512	136	135	141
		1024	160	159	164
		1280	174	172	178
		1518	185	183	188
		9216	527	526	533
55 56 62.5 (360)	64QAM	64	119	116	127
		128	122	116	128
		256	128	119	129
		512	132	131	136
		1024	152	151	175
		1280	164	162	167
		1518	173	172	176
		9216	459	458	464

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
55 56 62.5 (360)	128QAM	64	115	110	121
		128	121	116	124
		256	121	115	125
		512	125	118	129
		1024	130	128	133
		1280	147	146	150
		1518	158	156	160
		9216	166	164	168
55 56 62.5 (360)	256QAM	64	119	115	122
		128	120	114	123
		256	124	118	128
		512	128	126	135
		1024	144	142	146
		1280	153	152	155
		1518	161	159	162
		9216	388	386	391
55 56 62.5 (360)	512QAM	64	119	114	122
		128	120	114	122
		256	123	118	126
		512	127	126	129
		1024	141	140	143
		1280	150	149	152
		1518	156	155	158
		9216	365	363	368
55 56 62.5 (360)	1024QAM	64	117	114	120
		128	118	114	121
		256	121	117	125
		512	129	124	131
		1024	139	138	141
		1280	148	146	149
		1518	154	152	155
		9216	349	347	351

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
55 56 62.5 (360)	2048QAM	64	117	114	120
		128	118	114	121
		256	121	117	124
		512	127	123	130
		1024	138	137	140
		1280	147	146	148
		1518	153	151	154
		9216	342	341	345
55 56 62.5 (360)	2048QAM L	64	116	113	119
		128	117	113	120
		256	120	117	124
		512	128	123	129
		1024	138	136	139
		1280	146	145	147
		1518	152	150	153
		9216	335	333	338
55 56 62.5 (360)	4096QAM	64	116	113	119
		128	117	113	120
		256	121	117	124
		512	125	123	129
		1024	137	136	138
		1280	145	144	146
		1518	151	149	152
		9216	331	329	333
55 56 62.5 (360)	4096QAM L	64	117	114	119
		128	117	114	120
		256	120	117	123
		512	128	123	129
		1024	137	136	138
		1280	145	143	146
		1518	150	149	151
		9216	325	323	327

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
80 (403)	4QAM S	64	98	96	119
		128	103	102	123
		256	120	110	140
		512	145	135	155
		1024	183	181	193
		1280	206	204	216
		1518	227	225	235
		9216	875	874	887
80 (403)	4QAM	64	105	98	123
		128	101	100	119
		256	120	110	136
		512	133	131	156
		1024	171	169	179
		1280	191	190	200
		1518	210	208	214
		9216	773	771	783
80 (403)	16QAM S	64	103	97	112
		128	97	95	111
		256	110	102	117
		512	118	116	130
		1024	142	141	146
		1280	156	155	160
		1518	168	166	171
		9216	529	527	535
80 (403)	16QAM	64	101	97	109
		128	101	97	111
		256	111	101	113
		512	114	113	125
		1024	136	135	140
		1280	149	148	153
		1518	159	158	161
		9216	479	478	484

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
80 (403)	32QAM	64	98	95	105
		128	101	95	106
		256	106	100	111
		512	111	110	119
		1024	129	128	132
		1280	140	139	143
		1518	149	148	151
		9216	419	418	424
80 (403)	64QAM	64	98	95	102
		128	100	95	102
		256	103	99	107
		512	108	106	114
		1024	124	123	126
		1280	133	132	135
		1518	141	140	142
		9216	372	371	375
80 (403)	128QAM	64	97	94	100
		128	98	94	101
		256	102	98	104
		512	107	105	111
		1024	120	119	122
		1280	129	128	131
		1518	136	135	137
		9216	343	342	346
80 (403)	256QAM	64	96	94	98
		128	97	93	100
		256	100	97	103
		512	108	104	109
		1024	118	117	119
		1280	126	125	127
		1518	132	131	133
		9216	322	321	324

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
80 (403)	512QAM	64	95	93	97
		128	96	94	98
		256	99	96	101
		512	107	103	108
		1024	116	115	117
		1280	124	123	125
		1518	131	130	132
		9216	306	305	308
80 (403)	1024QAM	64	95	92	96
		128	96	93	98
		256	98	96	100
		512	106	102	107
		1024	115	114	118
		1280	122	121	123
		1518	128	127	128
		9216	295	294	296
80 (403)	2048QAM	64	94	93	96
		128	95	93	97
		256	98	96	100
		512	105	102	106
		1024	114	113	115
		1280	121	120	122
		1518	127	126	127
		9216	291	289	292
80 (403)	2048QAM L	64	94	92	95
		128	95	93	97
		256	98	96	99
		512	105	102	106
		1024	114	113	116
		1280	120	120	121
		1518	126	125	127
		9216	286	284	287

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
80 (403)	4096QAM	64	94	92	95
		128	95	93	96
		256	97	95	99
		512	105	102	106
		1024	113	112	116
		1280	120	119	123
		1518	125	124	126
		9216	282	281	284
80 (403)	4096QAM L	64	94	92	95
		128	95	93	96
		256	97	95	99
		512	104	102	453
		1024	113	112	116
		1280	120	119	122
		1518	125	124	125
		9216	278	277	279
110 112 125 (361 404)	4QAM S	64	92	80	105
		128	82	80	96
		256	96	89	111
		512	109	107	116
		1024	141	139	149
		1280	159	157	166
		1518	174	172	180
		9216	649	648	653
110 112 125 (361 404)	4QAM	64	88	81	101
		128	88	83	102
		256	98	87	105
		512	105	103	110
		1024	133	131	138
		1280	149	147	154
		1518	162	160	167
		9216	575	574	578

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
110 112 125 (361 404)	16QAM S	64	83	78	89
		128	83	78	89
		256	90	81	93
		512	93	92	96
		1024	112	111	115
		1280	123	122	126
		1518	132	130	134
		9216	400	399	404
110 112 125 (361 404)	16QAM	64	82	78	86
		128	82	78	87
		256	87	80	90
		512	92	90	94
		1024	108	107	110
		1280	118	117	120
		1518	126	125	128
		9216	364	363	368
110 112 125 (361 404)	32QAM	64	80	77	83
		128	81	77	84
		256	84	80	88
		512	90	87	95
		1024	103	102	105
		1280	112	111	114
		1518	118	117	120
		9216	322	321	325
110 112 125 (361 404)	64QAM	64	78	75	81
		128	80	76	82
		256	82	79	85
		512	89	85	91
		1024	99	98	100
		1280	107	106	108
		1518	112	111	114
		9216	288	287	290

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
110 112 125 (361 404)	128QAM	64	77	75	79
		128	78	75	80
		256	81	78	83
		512	88	84	89
		1024	97	96	100
		1280	104	103	105
		1518	109	108	110
		9216	268	266	269
110 112 125 (361 404)	256QAM	64	76	75	78
		128	77	75	78
		256	80	78	82
		512	86	83	88
		1024	95	94	98
		1280	102	100	103
		1518	106	105	107
		9216	253	251	254
110 112 125 (361 404)	512QAM	64	76	74	77
		128	76	75	78
		256	79	77	81
		512	86	84	87
		1024	93	92	96
		1280	100	99	103
		1518	104	103	105
		9216	241	240	242
110 112 125 (361 404)	1024QAM	64	75	74	77
		128	76	74	77
		256	78	77	80
		512	85	82	86
		1024	92	91	95
		1280	99	98	102
		1518	103	102	104
		9216	233	231	234

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
110 112 125 (361)	2048QAM	64	75	74	76
		128	76	74	77
		256	79	77	80
		512	85	83	86
		1024	92	91	95
		1280	98	97	101
		1518	103	101	103
		9216	230	228	231
110 112 125 (361)	2048QAM L	64	75	74	76
		128	76	74	77
		256	78	77	80
		512	85	83	85
		1024	92	91	94
		1280	98	97	100
		1518	102	101	102
		9216	226	225	227
110 112 125 (361)	4096QAM	64	75	74	76
		128	75	74	76
		256	78	77	80
		512	84	82	85
		1024	91	90	94
		1280	97	96	98
		1518	101	100	102
		9216	224	222	225

2.2.2 Traffic Latency for ANSI

The table below shows the latency values for low latency Frame ID’s.

Values for standard Frame ID’s (262, 263, 264, 265, 266, 267 and 268) can be found in revision BT of this document.

Table 4 Traffic Latency for ANSI

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
10 (362)	4QAM S	64	567	540	730
		128	609	580	730
		256	730	700	830
		512	936	900	1030
		1024	1341	1260	1380
		1280	1512	1440	1560
		1518	1532	1490	1570
		9216	6665	6640	6700
10 (362)	4QAM	64	556	530	670
		128	584	570	690
		256	684	650	770
		512	859	830	930
		1024	1202	1170	1240
		1280	1363	1340	1400
		1518	1367	1340	1410
		9216	5757	5730	5790
10 (362)	16QAM S	64	521	500	540
		128	541	520	590
		256	590	570	610
		512	687	672	701
		1024	876	840	920
		1280	967	930	990
		1518	1002	992	1020
		9216	3590	3570	3600
10 (362)	16QAM	64	514	500	580
		128	532	521	550
		256	570	558	587
		512	651	630	700
		1024	818	790	850
		1280	894	860	930
		1518	930	920	980
		9216	3148	3136	3163

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
10 (362)	32QAM	64	504	496	525
		128	519	511	540
		256	547	542	571
		512	613	600	650
		1024	728	717	746
		1280	791	776	805
		1518	840	830	870
		9216	2619	2612	2635
10 (362)	64QAM	64	496	491	520
		128	509	503	532
		256	536	520	560
		512	585	570	610
		1024	682	670	710
		1280	737	720	760
		1518	769	760	790
		9216	2201	2197	2214
10 (362)	128QAM	64	493	487	516
		128	506	498	526
		256	524	510	570
		512	567	560	590
		1024	651	640	670
		1280	695	680	720
		1518	725	721	741
		9216	1948	1941	1955
10 (362)	256QAM	64	490	485	514
		128	498	490	530
		256	517	510	560
		512	554	540	570
		1024	628	622	642
		1280	667	660	680
		1518	693	691	707
		9216	1761	1756	1768

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
10 (362)	512QAM	64	488	483	512
		128	497	490	520
		256	514	500	550
		512	547	542	553
		1024	611	604	615
		1280	645	642	654
		1518	669	667	681
		9216	1619	1615	1625
10 (362)	1024QAM	64	487	482	511
		128	494	480	520
		256	509	495	530
		512	537	532	552
		1024	598	592	613
		1280	629	623	642
		1518	653	650	663
		9216	1514	1511	1521
20 (363)	4QAM S	64	287	279	308
		128	315	300	360
		256	356	340	410
		512	452	420	500
		1024	626	590	670
		1280	720	680	760
		1518	764	740	810
		9216	3238	3228	3256
20 (363)	4QAM	64	283	274	303
		128	300	292	321
		256	339	327	356
		512	415	400	460
		1024	571	550	600
		1280	647	620	660
		1518	684	670	730
		9216	2804	2798	2822

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
20 (363)	16QAM S	64	267	261	279
		128	279	270	320
		256	299	290	350
		512	346	330	370
		1024	433	423	442
		1280	480	460	500
		1518	508	503	524
		9216	1775	1771	1784
20 (363)	16QAM	64	263	259	288
		128	272	268	293
		256	290	287	300
		512	330	325	338
		1024	405	398	415
		1280	447	439	454
		1518	474	469	485
		9216	1568	1563	1574
20 (363)	32QAM	64	258	256	284
		128	267	260	290
		256	283	280	300
		512	315	310	321
		1024	371	368	378
		1280	404	399	411
		1518	430	427	436
		9216	1315	1312	1321
20 (363)	64QAM	64	266	258	287
		128	262	260	287
		256	276	270	300
		512	302	298	316
		1024	351	346	365
		1280	376	371	390
		1518	397	394	401
		9216	1115	1113	1120

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
20 (363)	128QAM	64	265	257	285
		128	259	257	281
		256	271	269	283
		512	294	291	305
		1024	337	332	348
		1280	358	354	369
		1518	376	373	379
		9216	994	991	997
20 (363)	256QAM	64	262	255	272
		128	258	256	276
		256	269	266	278
		512	288	286	298
		1024	325	322	335
		1280	344	341	355
		1518	361	359	364
		9216	905	903	908
20 (363)	512QAM	64	266	258	282
		128	259	256	275
		256	269	266	284
		512	286	283	295
		1024	319	316	322
		1280	337	334	341
		1518	351	349	357
		9216	839	835	840
20 (363)	1024QAM	64	267	258	280
		128	258	255	277
		256	271	264	285
		512	283	281	291
		1024	313	311	321
		1280	329	327	338
		1518	343	341	347
		9216	789	786	791

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
20 (363)	2048QAM	64	266	258	279
		128	260	255	277
		256	266	264	283
		512	281	279	289
		1024	311	309	318
		1280	327	325	335
		1518	340	338	344
		9216	773	769	774
20 (363)	2048QAM L	64	265	257	277
		128	262	259	278
		256	267	263	282
		512	280	279	287
		1024	309	307	316
		1280	324	322	331
		1518	337	335	339
		9216	750	747	752
28 (371)	4QAM S	64	217	213	240
		128	232	228	255
		256	262	258	284
		512	322	318	345
		1024	437	432	456
		1280	498	492	518
		1518	553	549	567
		9216	2292	2289	2312
28 (371)	4QAM	64	213	209	236
		128	225	222	249
		256	252	248	275
		512	303	300	327
		1024	403	398	424
		1280	455	450	477
		1518	502	498	519
		9216	1995	1992	2014

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
28 (371)	16QAM S	64	202	200	226
		128	210	208	226
		256	228	225	243
		512	259	257	274
		1024	319	318	335
		1280	351	348	367
		1518	380	378	392
		9216	1285	1283	1301
28 (371)	16QAM	64	201	198	221
		128	208	205	232
		256	222	220	235
		512	250	249	263
		1024	303	301	316
		1280	331	328	344
		1518	356	355	367
		9216	1141	1139	1155
28 (371)	32QAM	64	198	196	220
		128	204	202	223
		256	224	210	240
		512	239	238	265
		1024	282	281	293
		1280	305	303	316
		1518	326	325	334
		9216	967	966	979
28 (371)	64QAM	64	195	193	211
		128	201	199	217
		256	216	214	237
		512	231	229	252
		1024	266	265	274
		1280	286	284	294
		1518	303	301	309
		9216	829	828	838

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
28 (371)	128QAM	64	202	196	220
		128	199	198	213
		256	221	207	226
		512	225	224	242
		1024	256	255	263
		1280	273	272	280
		1518	288	287	294
		9216	745	744	752
28 (371)	256QAM	64	205	196	217
		128	198	196	210
		256	216	204	222
		512	221	220	236
		1024	249	248	254
		1280	265	263	270
		1518	278	276	282
		9216	684	682	691
28 (371)	512QAM	64	204	199	213
		128	197	196	208
		256	214	203	219
		512	219	218	231
		1024	244	242	248
		1280	258	256	262
		1518	271	269	275
		9216	637	636	643
28 (371)	1024QAM	64	202	198	211
		128	203	198	213
		256	211	202	215
		512	216	215	228
		1024	239	238	243
		1280	253	251	256
		1518	264	262	267
		9216	603	602	608

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
28 (371)	2048QAM	64	202	198	210
		128	202	198	212
		256	211	202	215
		512	216	215	227
		1024	238	237	242
		1280	251	250	255
		1518	262	261	265
		9216	591	589	596
28 (371)	2048QAM L	64	201	197	209
		128	202	198	211
		256	211	201	214
		512	215	214	225
		1024	236	235	240
		1280	249	248	253
		1518	259	258	260
		9216	576	575	581
28 (371)	4096QAM	64	201	197	208
		128	203	197	210
		256	210	201	213
		512	214	213	224
		1024	235	234	238
		1280	247	246	251
		1518	258	256	260
		9216	566	565	571
28 (371)	4096QAM L	64	200	197	208
		128	204	197	209
		256	208	202	212
		512	213	212	223
		1024	234	233	237
		1280	246	245	249
		1518	256	254	258
		9216	554	553	559

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
30 (364)	4QAM S	64	204	200	226
		128	219	214	241
		256	247	243	266
		512	302	299	322
		1024	411	406	428
		1280	467	462	485
		1518	519	515	534
		9216	2147	2144	2166
30 (364)	4QAM	64	200	197	224
		128	212	209	236
		256	237	234	253
		512	288	280	310
		1024	378	375	397
		1280	427	420	450
		1518	471	467	475
		9216	1869	1867	1874
30 (364)	16QAM S	64	190	188	212
		128	198	196	212
		256	214	211	228
		512	244	241	258
		1024	300	299	315
		1280	331	329	345
		1518	258	356	360
		9216	1207	1205	1209
30 (364)	16QAM	64	188	186	200
		128	195	193	207
		256	213	200	240
		512	235	233	240
		1024	285	283	290
		1280	311	310	317
		1518	335	333	337
		9216	1073	1071	1079

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
30 (364)	32QAM	64	196	189	214
		128	192	190	201
		256	211	202	228
		512	225	224	234
		1024	266	265	270
		1280	288	286	297
		1518	307	306	309
		9216	911	909	916
30 (364)	64QAM	64	192	187	207
		128	189	187	203
		256	213	197	219
		512	217	216	224
		1024	250	249	258
		1280	269	267	276
		1518	285	284	290
		9216	782	781	790
30 (364)	128QAM	64	189	186	207
		128	187	186	200
		256	206	195	213
		512	212	211	218
		1024	241	240	247
		1280	258	256	264
		1518	272	271	274
		9216	703	702	296
30 (364)	256QAM	64	194	187	203
		128	186	185	205
		256	204	193	209
		512	208	207	222
		1024	235	234	240
		1280	249	248	255
		1518	262	261	266
		9216	646	644	652

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
30 (364)	512QAM	64	192	186	201
		128	192	188	203
		256	200	191	120
		512	206	205	218
		1024	230	229	234
		1280	243	242	248
		1518	255	254	258
		9216	602	601	608
30 (364)	1024QAM	64	190	186	198
		128	191	187	200
		256	200	190	203
		512	208	198	211
		1024	226	225	230
		1280	238	237	242
		1518	249	248	251
		9216	570	569	575
30 (364)	2048QAM	64	190	186	198
		128	192	186	199
		256	199	190	202
		512	203	202	213
		1024	225	223	228
		1280	237	236	240
		1518	247	246	249
		9216	559	558	564
30 (364)	2048QAM L	64	189	185	197
		128	191	186	198
		256	198	189	202
		512	202	201	212
		1024	223	222	226
		1280	235	234	238
		1518	245	244	247
		9216	545	544	550

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
30 (364)	4096QAM	64	189	185	196
		128	191	186	197
		256	197	189	202
		512	201	200	211
		1024	222	221	225
		1280	233	232	237
		1518	243	242	245
		9216	536	535	541
30 (364)	4096QAM L	64	189	185	195
		128	192	186	197
		256	196	189	200
		512	201	200	210
		1024	221	219	223
		1280	232	231	235
		1518	241	240	243
		9216	525	523	529
30 (364)	8192QAM	64	188	185	195
		128	191	185	196
		256	196	189	200
		512	200	199	209
		1024	220	218	222
		1280	231	230	321
		1518	240	239	242
		9216	518	517	522
40 (365)	4QAM S	64	161	158	185
		128	172	169	194
		256	194	191	216
		512	237	235	258
		1024	319	316	340
		1280	362	358	383
		1518	401	398	404
		9216	1630	1628	1653

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
40 (365)	4QAM	64	158	155	182
		128	168	165	1186
		256	186	184	205
		512	223	221	242
		1024	294	292	313
		1280	331	329	350
		1518	365	362	380
		9216	1423	1421	1443
40 (365)	16QAM S	64	151	149	176
		128	157	155	178
		256	173	160	190
		512	193	192	203
		1024	237	235	247
		1280	260	258	271
		1518	281	280	290
		9216	931	930	943
40 (365)	16QAM	64	158	152	176
		128	155	153	172
		256	172	164	190
		512	186	185	209
		1024	225	223	233
		1280	246	244	254
		1518	264	263	271
		9216	832	830	841
40 (365)	32QAM	64	155	151	169
		128	152	151	167
		256	171	160	181
		512	179	178	198
		1024	211	209	217
		1280	228	227	235
		1518	243	242	249
		9216	711	710	719

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
40 (365)	64QAM	64	158	151	168
		128	151	149	167
		256	168	157	173
		512	178	164	180
		1024	199	198	205
		1280	214	213	219
		1518	227	226	231
		9216	615	614	622
40 (365)	128QAM	64	155	151	164
		128	156	152	166
		256	164	155	169
		512	169	168	181
		1024	193	192	197
		1280	206	205	126
		1518	217	216	220
		9216	557	556	563
40 (365)	256QAM	64	153	150	161
		128	155	150	163
		256	162	154	167
		512	167	166	177
		1024	188	187	198
		1280	200	199	203
		1518	210	209	212
		9216	514	513	520
40 (365)	512QAM	64	153	150	160
		128	155	150	161
		256	161	153	165
		512	165	164	174
		1024	184	183	187
		1280	195	194	198
		1518	204	203	207
		9216	482	481	486

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
40 (365)	1024QAM	64	151	149	157
		128	155	149	158
		256	159	153	163
		512	163	162	171
		1024	181	180	184
		1280	192	191	194
		1518	200	199	202
		9216	459	457	337
40 (365)	2048QAM	64	152	149	157
		128	154	149	158
		256	159	153	162
		512	163	162	170
		1024	180	179	183
		1280	191	190	193
		1518	199	198	201
		9216	450	449	454
40 (365)	2048QAM L	64	152	149	157
		128	153	149	158
		256	158	153	162
		512	162	161	169
		1024	179	178	181
		1280	189	188	192
		1518	197	196	198
		9216	440	439	444
40 (365)	4096QAM	64	152	149	156
		128	154	149	157
		256	158	153	161
		512	162	161	169
		1024	179	177	181
		1280	188	187	190
		1518	196	195	197
		9216	434	432	189

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
40 (365)	4096QAM L	64	152	148	155
		128	153	149	156
		256	157	152	161
		512	162	160	168
		1024	178	176	179
		1280	187	186	121
		1518	195	194	196
		9216	425	424	428
40 (365)	8192QAM	64	152	148	155
		128	152	149	156
		256	157	152	160
		512	161	160	167
		1024	177	176	179
		1280	186	185	188
		1518	194	193	195
		9216	420	419	423
50 (366)	4QAM S	64	133	129	158
		128	142	138	161
		256	160	150	200
		512	195	190	215
		1024	264	256	281
		1280	300	292	315
		1518	327	322	336
		9216	1331	1327	1337
50 (366)	4QAM	64	131	127	156
		128	138	130	160
		256	153	140	175
		512	184	180	201
		1024	242	237	252
		1280	272	267	283
		1518	298	294	305
		9216	1163	1161	1168

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
50 (366)	16QAM S	64	133	127	150
		128	129	127	147
		256	139	137	142
		512	158	156	168
		1024	194	192	204
		1280	215	211	224
		1518	230	227	232
		9216	763	761	766
50 (366)	16QAM	64	136	127	143
		128	128	125	148
		256	139	137	156
		512	153	151	161
		1024	185	183	187
		1280	203	200	210
		1518	216	214	218
		9216	682	678	684
50 (366)	32QAM	64	133	126	144
		128	130	127	142
		256	139	131	145
		512	147	146	149
		1024	173	171	176
		1280	188	186	195
		1518	200	198	202
		9216	582	579	584
50 (366)	64QAM	64	130	125	138
		128	131	125	139
		256	137	129	140
		512	142	141	144
		1024	164	163	166
		1280	177	175	182
		1518	187	185	189
		9216	504	502	506

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
50 (366)	128QAM	64	128	125	135
		128	130	124	135
		256	136	127	139
		512	140	138	144
		1024	159	158	163
		1280	170	169	174
		1518	180	177	182
		9216	456	453	459
50 (366)	256QAM	64	128	124	133
		128	128	123	133
		256	134	126	137
		512	138	136	146
		1024	155	154	158
		1280	165	164	169
		1518	173	172	175
		9216	422	419	425
50 (366)	512QAM	64	127	123	130
		128	128	123	131
		256	132	127	135
		512	136	135	143
		1024	152	151	156
		1280	161	160	164
		1518	168	167	170
		9216	395	393	398
50 (366)	1024QAM	64	127	123	129
		128	127	123	131
		256	131	126	135
		512	135	133	141
		1024	150	148	152
		1280	158	157	161
		1518	165	164	167
		9216	376	374	379

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
50 (366)	2048QAM	64	126	123	129
		128	127	122	130
		256	130	126	134
		512	135	133	141
		1024	149	148	151
		1280	158	156	160
		1518	164	163	165
		9216	369	368	372
50 (366)	2048QAM L	64	126	123	128
		128	127	122	130
		256	130	126	133
		512	137	133	140
		1024	148	147	150
		1280	157	155	159
		1518	163	161	164
		9216	361	359	364
50 (366)	4096QAM	64	125	122	128
		128	126	122	129
		256	130	126	133
		512	136	132	139
		1024	147	146	149
		1280	156	155	158
		1518	162	161	163
		9216	356	354	358
50 (366)	4096QAM L	64	125	122	127
		128	126	122	129
		256	129	125	132
		512	136	132	138
		1024	147	145	149
		1280	155	154	157
		1518	161	159	162
		9216	348	347	351

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
56 (373)	4QAM S	64	122	119	144
		128	130	127	144
		256	146	144	149
		512	177	175	187
		1024	236	234	251
		1280	269	266	283
		1518	296	294	299
		9216	1185	1181	1189
56 (373)	4QAM	64	120	117	146
		128	127	124	140
		256	141	139	153
		512	168	166	181
		1024	219	217	232
		1280	247	244	260
		1518	272	269	274
		9216	1035	1034	1041
56 (373)	16QAM S	64	130	120	142
		128	119	117	127
		256	131	127	147
		512	146	145	153
		1024	178	177	186
		1280	196	195	203
		1518	211	210	217
		9216	684	683	688
56 (373)	16QAM	64	126	119	138
		128	118	116	125
		256	131	124	143
		512	142	140	147
		1024	170	169	176
		1280	187	185	192
		1518	199	198	204
		9216	613	612	617

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
56 (373)	32QAM	64	123	118	131
		128	124	118	133
		256	132	122	136
		512	136	135	141
		1024	160	159	164
		1280	174	172	178
		1518	185	183	188
		9216	527	526	533
56 (373)	64QAM	64	119	116	127
		128	122	116	128
		256	128	119	129
		512	132	131	136
		1024	152	151	175
		1280	164	162	167
		1518	173	172	176
		9216	459	458	464
56 (373)	128QAM	64	115	110	121
		128	121	116	124
		256	121	115	125
		512	125	118	129
		1024	130	128	133
		1280	147	146	150
		1518	158	156	160
		9216	166	164	168
56 (373)	256QAM	64	119	115	122
		128	120	114	123
		256	124	118	128
		512	128	126	135
		1024	144	142	146
		1280	153	152	155
		1518	161	159	162
		9216	388	386	391

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
56 (373)	512QAM	64	119	114	122
		128	120	114	122
		256	123	118	126
		512	127	126	129
		1024	141	140	143
		1280	150	149	152
		1518	156	155	158
		9216	365	363	368
56 (373)	1024QAM	64	117	114	120
		128	118	114	121
		256	121	117	125
		512	129	124	131
		1024	139	138	141
		1280	148	146	149
		1518	154	152	155
		9216	349	347	351
56 (373)	2048QAM	64	117	114	120
		128	118	114	121
		256	121	117	124
		512	127	123	130
		1024	138	137	140
		1280	147	146	148
		1518	153	151	154
		9216	342	341	345
56 (373)	2048QAM L	64	116	113	119
		128	117	113	120
		256	120	117	124
		512	128	123	129
		1024	138	136	139
		1280	146	145	147
		1518	152	150	153
		9216	335	333	338

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
56 (373)	4096QAM	64	116	113	119
		128	117	113	120
		256	121	117	124
		512	125	123	129
		1024	137	136	138
		1280	145	144	146
		1518	151	149	152
		9216	331	329	333
56 (373)	4096QAM L	64	117	114	119
		128	117	114	120
		256	120	117	123
		512	128	123	129
		1024	137	136	138
		1280	145	143	146
		1518	150	149	151
		9216	325	323	327
60 (367)	4QAM S	64	115	112	140
		128	125	120	150
		256	139	130	159
		512	169	164	180
		1024	225	220	242
		1280	257	252	271
		1518	281	276	288
		9216	1127	1124	1132
60 (367)	4QAM	64	123	116	144
		128	120	117	145
		256	134	130	160
		512	160	156	174
		1024	209	204	223
		1280	236	230	248
		1518	256	253	264
		9216	988	985	991

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
60 (367)	16QAM S	64	123	113	132
		128	114	111	127
		256	124	120	130
		512	139	137	147
		1024	169	167	177
		1280	186	184	194
		1518	200	198	202
		9216	654	651	656
60 (367)	16QAM	64	120	112	129
		128	118	114	132
		256	126	118	133
		512	135	133	141
		1024	161	159	168
		1280	176	174	183
		1518	188	187	190
		9216	585	584	588
60 (367)	32QAM	64	115	111	125
		128	117	112	126
		256	119	115	130
		512	129	128	141
		1024	152	150	157
		1280	164	163	170
		1518	175	173	180
		9216	503	501	506
60)367)	64QAM	64	114	110	121
		128	116	110	122
		256	120	113	125
		512	125	124	129
		1024	144	143	148
		1280	155	144	160
		1518	164	162	168
		9216	438	435	441

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
60 (367)	128QAM	64	113	109	118
		128	114	109	118
		256	119	113	123
		512	123	122	131
		1024	139	138	143
		1280	150	148	153
		1518	157	156	160
		9216	398	396	401
60 (367)	256QAM	64	113	109	116
		128	114	109	117
		256	117	112	121
		512	123	120	128
		1024	137	135	140
		1280	146	144	148
		1518	153	151	155
		9216	370	368	373
60 (367)	512QAM	64	112	108	115
		128	113	108	116
		256	116	112	119
		512	122	119	126
		1024	134	133	137
		1280	142	141	145
		1518	149	147	151
		9216	348	346	351
60 (367)	1024QAM	64	111	108	113
		128	112	108	114
		256	115	111	118
		512	120	118	124
		1024	132	131	134
		1280	140	139	142
		1518	146	145	148
		9216	332	331	335

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
60 (367)	2048QAM	64	111	108	113
		128	111	108	114
		256	114	111	118
		512	120	117	124
		1024	131	130	133
		1280	139	138	141
		1518	145	144	147
		9216	326	325	329
60 (367)	2048QAM L	64	110	107	113
		128	111	107	113
		256	114	111	117
		512	121	117	123
		1024	131	129	135
		1280	139	137	141
		1518	144	143	145
		9216	320	318	323
60 (367)	4096QAM	64	110	108	112
		128	111	107	113
		256	114	111	117
		512	119	117	123
		1024	130	129	132
		1280	138	137	140
		1518	143	142	144
		9216	315	314	318
60 (367)	4096QAM L	64	110	107	112
		128	110	107	113
		256	113	110	116
		512	119	116	122
		1024	130	128	134
		1280	137	136	139
		1518	142	141	143
		9216	310	308	312

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
80 (368)	4QAM S	64	105	96	125
		128	101	98	123
		256	113	110	122
		512	136	133	149
		1024	180	176	192
		1280	203	199	211
		1518	223	219	231
		9216	872	870	877
80 (368)	4QAM	64	103	95	121
		128	98	96	118
		256	109	100	120
		512	130	127	140
		1024	168	164	178
		1280	188	184	199
		1518	205	204	213
		9216	768	767	772
80 (368)	16QAM S	64	100	95	110
		128	101	95	111
		256	109	99	115
		512	114	112	120
		1024	138	136	144
		1280	151	150	158
		1518	163	161	168
		9216	516	514	520
80 (368)	16QAM	64	98	94	107
		128	100	93	107
		256	106	97	111
		512	111	109	116
		1024	132	131	137
		1280	144	143	149
		1518	154	153	157
		9216	466	464	469

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
80 (368)	32QAM	64	98	93	103
		128	99	92	103
		256	102	95	106
		512	107	106	116
		1024	125	124	129
		1280	136	134	139
		1518	144	142	147
		9216	404	402	408
80 (368)	64QAM	64	98	94	100
		128	99	94	102
		256	103	98	106
		512	107	105	113
		1024	122	121	123
		1280	132	130	134
		1518	138	137	139
		9216	358	357	362
80 (368)	128QAM	64	94	91	97
		128	95	91	98
		256	98	94	101
		512	103	101	108
		1024	116	115	119
		1280	125	123	126
		1518	131	130	133
		9216	327	325	329
80 (368)	256QAM	64	95	93	97
		128	96	93	98
		256	99	96	103
		512	105	102	108
		1024	116	115	118
		1280	124	123	126
		1518	130	129	131
		9216	308	316	311

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
80 (368)	512QAM	64	95	92	96
		128	95	93	98
		256	98	96	101
		512	105	102	107
		1024	115	113	116
		1280	122	121	123
		1518	127	126	128
		9216	292	291	294
80 (368)	1024QAM	64	94	92	95
		128	95	92	96
		256	98	95	100
		512	105	101	106
		1024	113	112	117
		1280	120	119	122
		1518	125	124	126
		9216	281	279	283
80 (368)	2048QAM	64	94	92	95
		128	94	93	96
		256	98	95	100
		512	104	101	105
		1024	113	111	116
		1280	120	119	121
		1518	124	123	125
		9216	276	275	277
80 (368)	2048QAM L	64	91	89	92
		128	91	89	93
		256	94	92	96
		512	101	98	103
		1024	110	108	113
		1280	116	115	117
		1518	121	120	122
		9216	269	267	270

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
80 (368)	4096QAM	64	93	92	94
		128	94	92	95
		256	97	95	99
		512	104	100	105
		1024	112	110	115
		1280	119	118	120
		1518	123	122	124
		9216	268	267	270
80 (368)	4096QAM L	64	94	92	95
		128	95	93	96
		256	97	95	99
		512	104	102	453
		1024	113	112	116
		1280	120	119	122
		1518	125	124	125
		9216	278	277	279
112 (374)	4QAM S	64	92	80	105
		128	82	80	96
		256	96	89	111
		512	109	107	116
		1024	141	139	149
		1280	159	157	166
		1518	174	172	180
		9216	649	648	653
112 (374)	4QAM	64	88	81	101
		128	88	83	102
		256	98	87	105
		512	105	103	110
		1024	133	131	138
		1280	149	147	154
		1518	162	160	167
		9216	575	574	578

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
112 (374)	16QAM S	64	83	78	89
		128	83	78	89
		256	90	81	93
		512	93	92	96
		1024	112	111	115
		1280	123	122	126
		1518	132	130	134
		9216	400	399	404
112 (374)	16QAM	64	82	78	86
		128	82	78	87
		256	87	80	90
		512	92	90	94
		1024	108	107	110
		1280	118	117	120
		1518	126	125	128
		9216	364	363	368
112 (374)	32QAM	64	80	77	83
		128	81	77	84
		256	84	80	88
		512	90	87	95
		1024	103	102	105
		1280	112	111	114
		1518	118	117	120
		9216	322	321	325
112 (374)	64QAM	64	78	75	81
		128	80	76	82
		256	82	79	85
		512	89	85	91
		1024	99	98	100
		1280	107	106	108
		1518	112	111	114
		9216	288	287	290

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
112 (374)	128QAM	64	77	75	79
		128	78	75	80
		256	81	78	83
		512	88	84	89
		1024	97	96	100
		1280	104	103	105
		1518	109	108	110
		9216	268	266	269
112 (374)	256QAM	64	76	75	78
		128	77	75	78
		256	80	78	82
		512	86	83	88
		1024	95	94	98
		1280	102	100	103
		1518	106	105	107
		9216	253	251	254
112 (374)	512QAM	64	76	74	77
		128	76	75	78
		256	79	77	81
		512	86	84	87
		1024	93	92	96
		1280	100	99	103
		1518	104	103	105
		9216	241	240	242
112 (374)	1024QAM	64	75	74	77
		128	76	74	77
		256	78	77	80
		512	85	82	86
		1024	92	91	95
		1280	99	98	102
		1518	103	102	104
		9216	233	231	234

Physical mode		Frame size [bytes]	Latency [µs]		
CS [MHz] (Frame ID)	Modulation		Average	Minimum	Maximum
112 (374)	2048QAM	64	75	74	76
		128	76	74	77
		256	79	77	80
		512	85	83	86
		1024	92	91	95
		1280	98	97	101
		1518	103	101	103
		9216	230	228	231
112 (374)	2048QAM L	64	75	74	76
		128	76	74	77
		256	78	77	80
		512	85	83	85
		1024	92	91	94
		1280	98	97	100
		1518	102	101	102
		9216	226	225	227
112 (374)	4096QAM	64	75	74	76
		128	75	74	76
		256	78	77	80
		512	84	82	85
		1024	91	90	94
		1280	97	96	98
		1518	101	100	102
		9216	224	222	225

2.3 Radio Link Bonding

Radio Link Bonding enables transparent transport of Ethernet frames over a number of parallel Packet Links.

Table 5 Radio Link Bonding

Radio Link bonding	MMU 1002 MMU 1004	MMU 1001	MINI-LINK 6651(1)	MINI-LINK 6366 MINI-LINK 6371	PNM 1002
Max number of bonded links	4	2	2	2	2
Max capacity for bonded links	2.5 Gbit/s	2.5 Gbit/s	2.5 Gbit/s	2.5 Gbit/s	2.5 Gbit/s

(1) Not applicable for MINI-LINK 6651/3

Protection and bonding do not add additional overhead, nor any latency compared to a 1+0 configuration.

The latency for a bonded hop will be determined by the slowest member in the bonding group.

2.4 Hierarchical Radio Link Bonding

With Hierarchical Radio Link Bonding (hRLB) there is a possibility to increase both the number of bonded links and the aggregated capacity for bonded links. hRLB is supported with NPU 1005 and MMU 1002 or MMU 1004. MINI-LINK 6651/4 and MINI-LINK 6371 also support hRLB.

Table 6 hRLB capacity

	NPU 1005	MINI-LINK 6651/4 and MINI-LINK 6371
hRLB capacity in total	10 Gbps	17 Gbps
Maximum hRLB group capacity	10 Gbps	10 Gbps
Maximum number of hRLB groups	2	2
Maximum number of hRLB members in total, per group	4	2
Maximum number of carriers in total	16	6(1)

(1) Figure includes 2 AOD carriers per group. hRLB is only possible together with AOD.

2.4.1 Link Efficiency and Capacity

The hRLB capacity is 7.5 Mpps. Considering RFC2544 throughput test with 64, 128 bytes frames the 10Gbps capacity should not be expected.

If two hRLB groups are configured the hRLB capacity is 4 Mpps per group. Considering RFC2544 throughput test with 64, 128, 256 bytes frames the 10Gbps capacity should not be expected

The utilization of an hRLB link compared to an ordinary link depends on the Ethernet frame size, and it is around 99%. In a typical mobile backhaul or Internet traffic (IMIX 7/4/1) it is recommended to plan with the hRLB group interface capacity value.

2.4.2 Latency

The latency on an hRLB link depends on the latency of all its members, that is the latency of the configured Radio Links. It is recommended to plan with worst case latency which is the value for the link with highest latency and an additional delay. This additional delay is typically in the range of 30 µsec depending on the configuration.

In a steady state the hRLB algorithm ensures that traffic flows are distributed among the hRLB members in a way to optimize the average latency of the traffic flows. This means that the link with highest latency will not determine the latency of all flows.

3 Radio Link

For relations between Frame ID and corresponding Channel Separation support, see Channel Separation to Frame ID Relation on page 73.

3.1 Channel Separation to Frame ID Relation

The tables below show the relationship between Channel Separation and corresponding Frame ID.

Data for standard Frame ID's (256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 303, 1256, 1257, 1258, 1259, 1260, 1261, 1262, 1263, 1264, 1265, 1266, 1267, 1268, and 1303) can be found in revision BT of this document.

Table 7 Channel Separation to Frame ID Relation - ETSI

ETSI	Frame ID	Frame ID	Frame ID	Frame ID	Frame ID
Channel Separation	Single Carrier	Carrier Aggregation	XPIC	2x2 MIMO	4x4 MIMO
7 MHz	356		1356		
13.75 MHz	357		1357		
14 MHz	357		1357		
27.5 MHz	358	358	1358	2358	2358
28 MHz	358	358	1358	2358	2358
40 MHz	359	359	1359		
55 MHz	360	360	1360	2360	2360
56 MHz	360	360	1360	2360	2360
62.5 MHz	360		1360		
80 MHz	403		1403		
110 MHz	361	361	1361		
112 MHz	361	361	1361		
125 MHz	361		1361		
220 MHz(1)		404			
224 MHz(2)		404			

(1) For CS 220 MHz, Carrier Aggregation with 2x110 MHz shall be configured and FFID 404 shall be used to fulfill CS 220 MHz requirements.

(2) For CS 224 MHz, Carrier Aggregation with 2x112 MHz shall be configured and FFID 404 shall be used to fulfill CS 224 MHz requirements.

Table 8 Channel Separation to Frame ID Relation - ANSI

ANSI	Frame ID	Frame ID	Frame ID	Frame ID	Frame ID
Channel Separation	Single Carrier	Carrier Aggregation	XPIC	2x2 MIMO	4x4 MIMO
10 MHz	362		1362		
20 MHz	363		1363		
28 MHz	371		1371		
30 MHz	364	364	1364	2364	2364
40 MHz	365	365	1365	2365	2365
50 MHz	366	366	1366		
56 MHz	373		1373		
60 MHz	367	367	1367		
80 MHz	368	368	1368		
112 MHz	374		1374		

3.2 Radio Frequencies

3.2.1 Radio Frequencies

Within the restrictions of channel arrangement and sub-band ranging imposed by the different Radio Unit the channel frequency can be selected from the O&M system.

Frequency band and sub range, as well as lowest, highest and selected center frequency is readable from the O&M system.

The operating center frequency can be set in steps of 0.005, 0.010, 0.025, or 0.250 MHz depending on sub-band, frequency band and Radio Unit.

For Radio Units with SW configurable duplex distance, the distance between transmitter and receiver shall always comply with regulatory requirements. The most common duplex distances can be found after each sub-band table.

The Radio Units are produced for frequency bands, sub ranges and channel plans according to the tables in the following chapters.

Note: For the MINI-LINK 6364 product family, a limitation of a maximum of 1000 frequency shifts applies for full performance and capacity fulfillment.

3.2.2 CS Dependence

Lower and upper frequencies in below tables state the edges for respective sub-band. The given frequency edge shall therefore be compensated for actual CS according below. (CS= 7, 14, 28, 40, 56, 80, and 112 MHz for ETSI and 5, 10, 20, 30, 40, 50, 60, and 80 MHz for ANSI)

Lowest user frequency = Tx or Rx Lower edge + CS/2

Highest user frequency = Tx or Rx Higher edge — CS/2

3.2.3 RAU2 X

3.2.3.1 RAU2 X 5 GHz Band

Table 9 RAU2 X 5 HP

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
11	300	4400.00	4570.00	170.00	4700.00	4870.00	170.00	ETSI
15	300	4700.00	4870.00	170.00	4400.00	4570.00	170.00	ETSI
12	300	4530.00	4700.00	170.00	4830.00	5000.00	170.00	ETSI
16	300	4830.00	5000.00	170.00	4530.00	4700.00	170.00	ETSI
A11		4400.00	4570.00	170.00	4700.00	4870.00	170.00	ETSI
A15		4700.00	4870.00	170.00	4400.00	4570.00	170.00	ETSI
A12		4530.00	4700.00	170.00	4830.00	5000.00	170.00	ETSI
A16		4830.00	5000.00	170.00	4530.00	4700.00	170.00	ETSI

Sub-band 1x is valid for CS 7, 14, 28, 40, and 56 MHz.

Sub-band A1x (Duplex 300 and 312 MHz) is valid for CS 7, 14, 28, 40, and 56 MHz.

3.2.3.2 RAU2 X 6 GHz Lower Band

Table 10 RAU2 X 6L [HP]

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
11	252.04	5925.000	6020.250	95.25	6177.050	6272.300	95.25	ETSI/ANSI
15	252.04	6177.050	6272.300	95.25	5925.000	6020.250	95.25	ETSI/ANSI
12	252.04	6018.000	6110.250	92.25	6270.050	6362.300	92.25	ETSI/ANSI
16	252.04	6270.050	6362.300	92.25	6018.000	6110.250	92.25	ETSI/ANSI
13	252.04	6078.500	6173.250	94.75	6330.550	6425.300	94.75	ETSI/ANSI

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
17	252.04	6330.550	6425.300	94.75	6078.500	6173.250	94.75	ETSI/ANSI
14	252.04	5989.675	6048.975	59.30	6241.725	6301.025	59.30	ETSI/ANSI
18	252.04	6241.725	6301.025	59.30	5989.675	6048.975	59.30	ETSI/ANSI
A11		5925.000	6020.250	95.250	6177.050	6277.000	99.950	ETSI/ANSI
A15		6177.050	6277.000	99.950	5925.000	6020.250	95.250	ETSI/ANSI
A12		6018.000	6110.250	92.250	6270.050	6362.300	92.250	ETSI/ANSI
A16		6270.050	6362.300	92.250	6018.000	6110.250	92.250	ETSI/ANSI
A13		6078.500	6173.250	94.750	6330.550	6425.300	94.750	ETSI/ANSI
A17		6330.550	6425.300	94.750	6078.500	6173.250	94.750	ETSI/ANSI
A14		5989.675	6048.975	59.300	6241.725	6301.025	59.300	ETSI/ANSI
A18		6241.725	6301.025	59.300	5989.675	6048.975	59.300	ETSI/ANSI
A51		5925.000	6020.250	95.250	6177.050	6277.000	99.950	ANSI
A55		6177.050	6277.000	99.950	5925.000	6020.250	95.250	ANSI
A52		6011.000	6110.250	99.250	6270.050	6362.300	92.250	ANSI
A56		6270.050	6362.300	92.250	6011.000	6110.250	99.250	ANSI
A53		6078.500	6173.250	94.750	6330.550	6425.300	94.750	ANSI
A57		6330.550	6425.300	94.750	6078.500	6173.250	94.750	ANSI
A54		5989.675	6048.975	59.300	6241.725	6301.025	59.300	ANSI
A58		6241.725	6301.025	59.300	5989.675	6048.975	59.300	ANSI

Sub-band 1x is valid for CS 7, 14, 28/29.65, and 56/59.3 MHz.

Sub-band 1x is valid for CS 9.88/10, 20, 29.65/30, 40, 50, and 59.3/60 MHz.

Sub-band A1x (Duplex 240, 252.04, 260, and 266 MHz) is valid for CS 7, 14, 28/29.65, and 56/59.3 MHz.

Sub-band A1x (Duplex 252.04 MHz) are valid for CS 9.88/10, 20, 29.65/30, 40, 50, and 59.3/60 MHz.

Sub-band A5x (Duplex 252.04 MHz) are valid for CS 9.88/10, 20, 29.65/30, 40, 50, and 59.3/60 MHz.

3.2.3.3 RAU2 X 6 GHz Upper Band

Table 11 RAU2 X 6U [HP]

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
21	340	6430.00	6565.00	135.00	6770.00	6905.00	135.00	ETSI/ANSI
25	340	6770.00	6905.00	135.00	6430.00	6565.00	135.00	ETSI/ANSI
22	340	6550.00	6685.00	135.00	6890.00	7025.00	135.00	ETSI/ANSI
26	340	6890.00	7025.00	135.00	6550.00	6685.00	135.00	ETSI/ANSI

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
23	340	6635.00	6765.00	130.00	6975.00	7105.00	130.00	ETSI/ANSI
27	340	6975.00	7105.00	130.00	6635.00	6765.00	130.00	ETSI/ANSI
24	340	6520.00	6600.00	80.00	6860.00	6940.00	80.00	ETSI/ANSI
28	340	6860.00	6940.00	80.00	6520.00	6600.00	80.00	ETSI/ANSI
A21		6430.000	6565.000	135.000	6770.000	6905.000	135.000	ETSI/ANSI
A25		6770.000	6905.000	135.000	6430.000	6565.000	135.000	ETSI/ANSI
A22		6550.000	6685.000	135.000	6890.000	7025.000	135.000	ETSI/ANSI
A26		6890.000	7025.000	135.000	6550.000	6685.000	135.000	ETSI/ANSI
A23		6635.000	6765.000	130.000	6975.000	7105.000	130.000	ETSI/ANSI
A27		6975.000	7105.000	130.000	6635.000	6765.000	130.000	ETSI/ANSI
A24		6520.000	6600.000	80.000	6860.000	6940.000	80.000	ETSI/ANSI
A28		6860.000	6940.000	80.000	6520.000	6600.000	80.000	ETSI/ANSI
31	160	6540.00	6602.50	62.50	6700.00	6762.50	62.50	ANSI
35	160	6700.00	6762.50	62.50	6540.00	6602.50	62.50	ANSI
32	160	6597.50	6657.50	60.00	6757.50	6817.50	60.00	ANSI
36	160	6757.50	6817.50	60.00	6597.50	6657.50	60.00	ANSI
33	160	6650.00	6710.00	60.00	6810.00	6870.00	60.00	ANSI
37	160	6810.00	6870.00	60.00	6650.00	6710.00	60.00	ANSI
A31		6540.000	6610.000	70.000	6700.000	6770.000	70.000	ANSI
A35		6700.000	6770.000	70.000	6540.000	6610.000	70.000	ANSI
A32		6597.500	6657.500	60.000	6757.500	6817.500	60.000	ANSI
A36		6757.500	6817.500	60.000	6597.500	6657.500	60.000	ANSI
A33		6640.000	6710.000	70.000	6800.000	6870.000	70.000	ANSI
A37		6800.000	6870.000	70.000	6640.000	6710.000	70.000	ANSI
A41		6523.750	6626.250	102.500	6773.750	6876.250	102.500	ANSI
A45		6773.750	6876.250	102.500	6523.750	6626.250	102.500	ANSI

Sub-band 2x is valid for 7, 14, 28/30, 40, and 56/60 MHz.

Sub-band 2x is valid for CS 10, 20, 30, 40, and 50 MHz.

Sub-band A2x (Duplex 340 MHz) is valid for CS 7, 14, 28/30, 40, and 56/60 MHz.

Sub-band A2x (Duplex 340 MHz) is valid for CS 10, 20, 30, 40, and 50 MHz.

Sub-band 3x is valid for CS 10, 20, 30, 40, and 50 MHz.

Sub-band A3x (Duplex 160 and 170 MHz) are valid for CS 10, 20, 30, 40, and 50 MHz.

3.2.3.4 RAU2 X 7 GHz Band

Table 12 RAU2 X 7 [HP]

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
01	196	7107.00	7163.00	56.00	7303.00	7359.00	56.00	ETSI
05	196	7303.00	7359.00	56.00	7107.00	7163.00	56.00	ETSI
02	196	7163.00	7219.00	56.00	7359.00	7415.00	56.00	ETSI
06	196	7359.00	7415.00	56.00	7163.00	7219.00	56.00	ETSI
03	196	7191.00	7247.00	56.00	7387.00	7443.00	56.00	ETSI
07	196	7387.00	7443.00	56.00	7191.00	7247.00	56.00	ETSI
11	154	7428.00	7484.00	56.00	7582.00	7638.00	56.00	ETSI
15	154	7582.00	7638.00	56.00	7428.00	7484.00	56.00	ETSI
12	154	7456.00	7512.00	56.00	7610.00	7666.00	56.00	ETSI
16	154	7610.00	7666.00	56.00	7456.00	7512.00	56.00	ETSI
13	154	7484.00	7540.00	56.00	7638.00	7694.00	56.00	ETSI
17	154	7638.00	7694.00	56.00	7484.00	7540.00	56.00	ETSI
14	154	7512.00	7568.00	56.00	7666.00	7722.00	56.00	ETSI
18	154	7666.00	7722.00	56.00	7512.00	7568.00	56.00	ETSI
21	245	7426.50	7513.75	87.25	7671.50	7758.75	87.25	ETSI
25	245	7671.50	7758.75	87.25	7426.50	7513.75	87.25	ETSI
22	245	7482.25	7569.75	87.50	7727.25	7814.75	87.50	ETSI
26	245	7727.25	7814.75	87.50	7482.25	7569.75	87.50	ETSI
23	245	7510.25	7597.75	87.50	7755.25	7842.75	87.50	ETSI
27	245	7755.25	7842.75	87.50	7510.25	7597.75	87.50	ETSI
24	245	7566.25	7653.75	87.50	7566.25	7653.75	87.50	ETSI
28	245	7811.25	7898.75	87.50	7566.25	7653.75	87.50	ETSI
31	161	7124.50	7184.00	59.50	7285.50	7345.00	59.50	ETSI
35	161	7285.50	7345.00	59.50	7124.50	7184.00	59.50	ETSI
32	161	7152.50	7212.00	59.50	7313.50	7373.00	59.50	ETSI
36	161	7313.50	7373.00	59.50	7152.50	7212.00	59.50	ETSI
33	161	7180.50	7240.00	59.50	7341.50	7401.00	59.50	ETSI
37	161	7341.50	7401.00	59.50	7180.50	7240.00	59.50	ETSI
34	161	7208.50	7268.00	59.50	7369.50	7429.00	59.50	ETSI
38	161	7369.50	7429.00	59.50	7208.50	7268.00	59.50	ETSI
41	161	7424.50	7484.00	59.50	7585.50	7645.00	59.50	ETSI
45	161	7585.50	7645.00	59.50	7424.50	7484.00	59.50	ETSI
42	161	7449.50	7512.00	62.50	7610.50	7673.00	62.50	ETSI
46	161	7610.50	7673.00	62.50	7449.50	7512.00	62.50	ETSI
43	161	7477.50	7540.00	62.50	7638.50	7701.00	62.50	ETSI
47	161	7638.50	7701.00	62.50	7477.50	7540.00	62.50	ETSI
44	161	7505.50	7568.00	62.50	7666.50	7729.00	62.50	ETSI
48	161	7666.50	7729.00	62.50	7505.50	7568.00	62.50	ETSI

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
51	168	7107.00	7163.00	56.00	7275.00	7331.00	56.00	ETSI
55	168	7275.00	7331.00	56.00	7107.00	7163.00	56.00	ETSI
52	168	7135.00	7191.00	56.00	7303.00	7359.00	56.00	ETSI
56	168	7303.00	7359.00	56.00	7135.00	7191.00	56.00	ETSI
53	168	7163.00	7219.00	56.00	7331.00	7387.00	56.00	ETSI
57	168	7331.00	7387.00	56.00	7163.00	7219.00	56.00	ETSI
54	168	7191.00	7247.00	56.00	7359.00	7415.00	56.00	ETSI
58	168	7359.00	7415.00	56.00	7191.00	7247.00	56.00	ETSI
61	168	7414.00	7470.00	56.00	7582.00	7638.00	56.00	ETSI
65	168	7582.00	7638.00	56.00	7414.00	7470.00	56.00	ETSI
62	168	7442.00	7498.00	56.00	7610.00	7666.00	56.00	ETSI
66	168	7610.00	7666.00	56.00	7442.00	7498.00	56.00	ETSI
63	168	7470.00	7526.00	56.00	7638.00	7694.00	56.00	ETSI
67	168	7638.00	7694.00	56.00	7470.00	7526.00	56.00	ETSI
64	168	7498.00	7554.00	56.00	7666.00	7722.00	56.00	ETSI
68	168	7666.00	7722.00	56.00	7498.00	7554.00	56.00	ETSI
71	154	7128.00	7184.00	56.00	7282.00	7338.00	56.00	ETSI
75	154	7282.00	7338.00	56.00	7128.00	7184.00	56.00	ETSI
72	154	7156.00	7212.00	56.00	7310.00	7366.00	56.00	ETSI
76	154	7310.00	7366.00	56.00	7156.00	7212.00	56.00	ETSI
73	154	7184.00	7240.00	56.00	7338.00	7394.00	56.00	ETSI
77	154	7338.00	7394.00	56.00	7184.00	7240.00	56.00	ETSI
74	154	7212.00	7268.00	56.00	7366.00	7422.00	56.00	ETSI
78	154	7366.00	7422.00	56.00	7212.00	7268.00	56.00	ETSI
81	161	7249.50	7309.00	59.50	7410.50	7470.00	59.50	ETSI
85	161	7410.50	7470.00	59.50	7249.50	7309.00	59.50	ETSI
82	161	7277.50	7337.00	59.50	7438.50	7498.00	59.50	ETSI
86	161	7438.50	7498.00	59.50	7277.50	7337.00	59.50	ETSI
83	161	7305.50	7365.00	59.50	7466.50	7526.00	59.50	ETSI
87	161	7466.50	7526.00	59.50	7305.50	7365.00	59.50	ETSI
84	161	7333.50	7393.00	59.50	7494.50	7554.00	59.50	ETSI
88	161	7494.50	7554.00	59.50	7333.50	7393.00	59.50	ETSI
91	168	7443.00	7499.00	56.00	7611.00	7667.00	56.00	ETSI
95	168	7611.00	7667.00	56.00	7443.00	7499.00	56.00	ETSI
92	168	7471.00	7527.00	56.00	7639.00	7695.00	56.00	ETSI
96	168	7639.00	7695.00	56.00	7471.00	7527.00	56.00	ETSI
93	168	7499.00	7555.00	56.00	7667.00	7723.00	56.00	ETSI
97	168	7667.00	7723.00	56.00	7499.00	7555.00	56.00	ETSI
94	168	7527.00	7583.00	56.00	7695.00	7751.00	56.00	ETSI
98	168	7695.00	7751.00	56.00	7527.00	7583.00	56.00	ETSI
101	175	7125.00	7170.00	45.00	7300.00	7345.00	45.00	ANSI
105	175	7300.00	7345.00	45.00	7125.00	7170.00	45.00	ANSI
102	175	7155.00	7195.00	40.00	7330.00	7370.00	40.00	ANSI

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
106	175	7330.00	7370.00	40.00	7155.00	7195.00	40.00	ANSI
103	175	7180.00	7225.00	45.00	7355.00	7400.00	45.00	ANSI
107	175	7355.00	7400.00	45.00	7180.00	7225.00	45.00	ANSI
104	175	7210.00	7250.00	40.00	7385.00	7425.00	40.00	ANSI
108	175	7385.00	7425.00	40.00	7210.00	7250.00	40.00	ANSI
111	150	7425.00	7480.00	55.00	7575.00	7630.00	55.00	ANSI
115	150	7575.00	7630.00	55.00	7425.00	7480.00	55.00	ANSI
112	150	7460.00	7515.00	55.00	7610.00	7665.00	55.00	ANSI
116	150	7610.00	7665.00	55.00	7460.00	7515.00	55.00	ANSI
113	150	7515.00	7555.00	40.00	7665.00	7705.00	40.00	ANSI
117	150	7665.00	7705.00	40.00	7515.00	7555.00	40.00	ANSI
114	150	7545.00	7575.00	30.00	7695.00	7725.00	30.00	ANSI
118	150	7695.00	7725.00	30.00	7545.00	7575.00	30.00	ANSI
132	269	7505.00	7533.00	28.00	7774.00	7802.00	28.00	ETSI
136	269	7774.00	7802.00	28.00	7505.00	7533.00	28.00	ETSI
A01		7107.000	7163.000	56.00	7303.000	7359.000	56.00	ETSI
A05		7303.000	7359.000	56.00	7107.000	7163.000	56.00	ETSI
A02		7163.000	7219.000	56.00	7359.000	7415.000	56.00	ETSI
A06		7359.000	7415.000	56.00	7163.000	7219.000	56.00	ETSI
A03		7191.000	7247.000	56.00	7387.000	7443.000	56.00	ETSI
A07		7387.000	7443.000	56.00	7191.000	7247.000	56.00	ETSI
A11		7414.000	7485.000	71.00	7575.000	7645.000	70.00	ETSI/ANSI
A15		7575.000	7645.000	70.00	7414.000	7485.000	71.00	ETSI/ANSI
A12		7442.000	7515.000	73.00	7610.000	7673.000	63.00	ETSI/ANSI
A16		7610.000	7673.000	63.00	7442.000	7515.000	73.00	ETSI/ANSI
A13		7470.000	7540.000	70.00	7638.000	7701.000	63.00	ETSI/ANSI
A17		7638.000	7701.000	63.00	7470.000	7540.000	70.00	ETSI/ANSI
A14		7498.000	7568.000	70.00	7665.000	7729.000	64.00	ETSI/ANSI
A18		7665.000	7729.000	64.00	7498.000	7568.000	70.00	ETSI/ANSI
A21		7426.500	7513.750	87.25	7671.500	7758.750	87.25	ETSI
A25		7671.500	7758.750	87.25	7426.500	7513.750	87.25	ETSI
A22		7482.250	7569.750	87.50	7727.250	7814.750	87.50	ETSI
A26		7727.250	7814.750	87.50	7482.250	7569.750	87.50	ETSI
A23		7510.250	7597.750	87.50	7755.250	7842.750	87.50	ETSI
A27		7755.250	7842.750	87.50	7510.250	7597.750	87.50	ETSI
A24		7566.250	7653.750	87.50	7811.250	7898.750	87.50	ETSI
A28		7811.250	7898.750	87.50	7566.250	7653.750	87.50	ETSI
A31		7107.000	7184.000	77.00	7275.000	7345.000	70.00	ETSI/ANSI
A35		7275.000	7345.000	70.00	7107.000	7184.000	77.00	ETSI/ANSI
A32		7135.000	7212.000	77.00	7303.000	7373.000	70.00	ETSI/ANSI
A36		7303.000	7373.000	70.00	7135.000	7212.000	77.00	ETSI/ANSI
A33		7163.000	7240.000	77.00	7331.000	7401.000	70.00	ETSI/ANSI
A37		7331.000	7401.000	70.00	7163.000	7240.000	77.00	ETSI/ANSI

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
A34		7191.000	7268.000	77.00	7359.000	7429.000	70.00	ETSI/ANSI
A38		7359.000	7429.000	70.00	7191.000	7268.000	77.00	ETSI/ANSI
A81		7249.500	7309.000	59.50	7410.500	7470.000	59.50	ETSI
A85		7410.500	7470.000	59.50	7249.500	7309.000	59.50	ETSI
A82		7277.500	7337.000	59.50	7438.500	7498.000	59.50	ETSI
A86		7438.500	7498.000	59.50	7277.500	7337.000	59.50	ETSI
A83		7305.500	7365.000	59.50	7466.500	7526.000	59.50	ETSI
A87		7466.500	7526.000	59.50	7305.500	7365.000	59.50	ETSI
A84		7333.500	7393.000	59.50	7494.500	7554.000	59.50	ETSI
A88		7494.500	7554.000	59.50	7333.500	7393.000	59.50	ETSI
A94		7527.000	7583.000	56.00	7695.000	7751.000	56.00	ETSI/ANSI
A98		7695.000	7751.000	56.00	7527.000	7583.000	56.00	ETSI/ANSI

Sub-band 0x, 1x, 2x, 3x, 4x, 5x, 6x, 7x, 8x, 9x, and 13x are valid for CS 7, 14, 28, and 56 MHz.

Sub-band 10x is valid for CS 10, 20, 30, and 40 MHz.

Sub-band 111, 112, 115, and 116 are valid for CS 10, 20, 30, 40, and 50 MHz.

Sub-band 114 and 118 are valid for CS 10, 20, and 30 MHz.

Sub-band A0x (Duplex 196 MHz), A2x (Duplex 245 and 269 MHz), and A8x (Duplex 161 MHz) are valid for CS 7, 14, 28, and 56 MHz.

Sub-band A1x (Duplex 154, 161, and 168 MHz), A3x (Duplex 154, 161, and 168 MHz), and A9x (Duplex 168 MHz) are valid for CS 7, 14, 28, and 56 MHz.

Sub-band A1x (Duplex 150 MHz), A3x (Duplex 175 MHz), and A9x (Duplex 150 MHz) are valid for CS 10, 20, 30, 40, and 50 MHz.

3.2.3.5 RAU2 X 8 GHz Band

Table 13 RAU2 X 8 [HP]

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
11	311.32	7718.050	7807.000	88.950	8029.375	8118.325	88.950	ETSI
15	311.32	8029.375	8118.325	88.950	7718.050	7807.000	88.950	ETSI
12	311.32	7777.350	7866.300	88.950	8088.675	8177.625	88.950	ETSI
16	311.32	8088.675	8177.625	88.950	7777.350	7866.300	88.950	ETSI
13	311.32	7821.825	7910.775	88.950	8133.150	8222.100	88.950	ETSI
17	311.32	8133.150	8222.100	88.950	7821.825	7910.775	88.950	ETSI
14	311.32	7881.125	7970.075	88.950	8192.450	8281.400	88.950	ETSI

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
18	311.32	8192.450	8281.400	88.950	7881.125	7970.075	88.950	ETSI
21	126	8282.50	8324.50	42.00	8408.50	8450.50	42.00	ETSI
25	126	8408.50	8450.50	42.00	8282.50	8324.50	42.00	ETSI
23	126	8324.50	8366.50	42.00	8450.50	8492.50	42.00	ETSI
27	126	8450.50	8492.50	42.00	8324.50	8366.50	42.00	ETSI
31	119	8286.00	8328.00	42.00	8405.00	8447.00	42.00	ETSI
35	119	8405.00	8447.00	42.00	8286.00	8328.00	42.00	ETSI
33	119	8328.00	8370.00	42.00	8447.00	8489.00	42.00	ETSI
37	119	8447.00	8489.00	42.00	8328.00	8370.00	42.00	ETSI
41	119	8279.00	8321.00	42.00	8398.00	8440.00	42.00	ETSI
45	119	8398.00	8440.00	42.00	8279.00	8321.00	42.00	ETSI
42	119	8307.00	8349.00	42.00	8426.00	8468.00	42.00	ETSI
46	119	8426.00	8468.00	42.00	8307.00	8349.00	42.00	ETSI
43	119	8335.00	8377.00	42.00	8454.00	8496.00	42.00	ETSI
47	119	8454.00	8496.00	42.00	8335.00	8377.00	42.00	ETSI
51	126	8279.00	8321.00	42.00	8405.00	8447.00	42.00	ETSI
55	126	8405.00	8447.00	42.00	8279.00	8321.00	42.00	ETSI
52	126	8307.00	8349.00	42.00	8433.00	8475.00	42.00	ETSI
56	126	8433.00	8475.00	42.00	8307.00	8349.00	42.00	ETSI
53	126	8328.00	8370.00	42.00	8454.00	8496.00	42.00	ETSI
57	126	8454.00	8496.00	42.00	8328.00	8370.00	42.00	ETSI
61	266	7905.00	8010.00	105.00	8171.00	8276.00	105.00	ETSI
65	266	8171.00	8276.00	105.00	7905.00	8010.00	105.00	ETSI
62	266	7968.00	8073.00	105.00	8234.00	8339.00	105.00	ETSI
66	266	8234.00	8339.00	105.00	7968.00	8073.00	105.00	ETSI
63	266	8031.00	8136.00	105.00	8297.00	8402.00	105.00	ETSI
67	266	8297.00	8402.00	105.00	8031.00	8136.00	105.00	ETSI
71	311.32	7718.050	7836.650	118.600	8029.375	8147.975	118.600	ETSI
75	311.32	8029.375	8147.975	118.600	7718.050	7836.650	118.600	ETSI
72	311.32	7777.350	7881.125	103.775	8088.675	8192.450	103.775	ETSI
76	311.32	8088.675	8192.450	103.775	7777.350	7881.125	103.775	ETSI
73	311.32	7851.475	7970.075	118.600	8162.800	8281.400	118.600	ETSI
77	311.32	8162.800	8281.400	118.600	7851.475	7970.075	118.600	ETSI
81	300	7725.00	7805.00	80.00	8025.00	8105.00	80.00	ANSI
85	300	8025.00	8105.00	80.00	7725.00	7805.00	80.00	ANSI
82	300	7785.00	7865.00	80.00	8085.00	8165.00	80.00	ANSI
86	300	8085.00	8165.00	80.00	7785.00	7865.00	80.00	ANSI
83	300	7835.00	7910.00	75.00	8135.00	8210.00	75.00	ANSI
87	300	8135.00	8210.00	75.00	7835.00	7910.00	75.00	ANSI
84	300	7895.00	7965.00	70.00	8195.00	8265.00	70.00	ANSI
88	300	8195.00	8265.00	70.00	7895.00	7965.00	70.00	ANSI
91	208	8050.00	8134.00	84.00	8258.00	8342.00	84.00	ETSI
95	208	8258.00	8342.00	84.00	8050.00	8134.00	84.00	ETSI

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
92	208	8106.00	8190.00	84.00	8314.00	8398.00	84.00	ETSI
96	208	8314.00	8398.00	84.00	8106.00	8190.00	84.00	ETSI
93	208	8162.00	8246.00	84.00	8370.00	8454.00	84.00	ETSI
97	208	8370.00	8454.00	84.00	8162.00	8246.00	84.00	ETSI
101	310	7905.00	8017.00	112.00	8215.00	8327.00	112.00	ETSI
105	310	8215.00	8327.00	112.00	7905.00	8017.00	112.00	ETSI
102	310	7989.00	8101.00	112.00	8299.00	8411.00	112.00	ETSI
106	310	8299.00	8411.00	112.00	7989.00	8101.00	112.00	ETSI
103	310	8073.00	8185.00	112.00	8383.00	8495.00	112.00	ETSI
107	310	8383.00	8495.00	112.00	8073.00	8185.00	112.00	ETSI
111	310	7725.00	7837.00	112.00	8035.00	8147.00	112.00	ETSI
115	310	8035.00	8147.00	112.00	7725.00	7837.00	112.00	ETSI
112	310	7777.00	7881.00	104.00	8087.00	8191.00	104.00	ETSI
116	310	8087.00	8191.00	104.00	7777.00	7881.00	104.00	ETSI
113	310	7851.00	7965.00	114.00	8161.00	8275.00	114.00	ETSI
117	310	8161.00	8275.00	114.00	7851.00	7965.00	114.00	ETSI
121	148.5	7744.75	7793.75	49.00	7893.25	7942.25	49.00	ETSI
125	148.5	7893.25	7942.25	49.00	7744.75	7793.75	49.00	ETSI
122	148.5	7779.75	7828.75	49.00	7928.25	7977.25	49.00	ETSI
126	148.5	7928.25	7977.25	49.00	7779.75	7828.75	49.00	ETSI
131	148.25	7744.75	7793.75	49.00	7893.00	7942.00	49.00	ETSI
135	148.25	7893.00	7942.00	49.00	7744.75	7793.75	49.00	ETSI
132	148.25	7779.75	7828.75	49.00	7928.00	7977.00	49.00	ETSI
136	148.25	7928.00	7977.00	49.00	7779.75	7828.75	49.00	ETSI
A01		7744.750	7793.750	49.000	7893.000	7942.250	49.250	ETSI
A05		7893.000	7942.250	49.250	7744.750	7793.750	49.000	ETSI
A02		7779.750	7828.750	49.000	7928.000	7977.250	49.250	ETSI
A06		7928.000	7977.250	49.250	7779.750	7828.750	49.000	ETSI
A11		7718.050	7837.000	118.950	8025.000	8147.975	122.975	ETSI/ANSI
A15		8025.000	8147.975	122.975	7718.050	7837.000	118.950	ETSI/ANSI
A12		7777.000	7910.775	133.775	8085.000	8222.100	137.100	ETSI/ANSI
A16		8085.000	8222.100	137.100	7777.000	7910.775	133.775	ETSI/ANSI
A14		7835.000	7970.075	135.075	8135.000	8281.400	146.400	ETSI/ANSI
A18		8135.000	8281.400	146.400	7835.000	7970.075	135.075	ETSI/ANSI
A21		8279.000	8328.000	49.000	8405.000	8450.500	45.500	ETSI
A25		8405.000	8450.500	45.500	8279.000	8328.000	49.000	ETSI
A23		8324.500	8370.000	45.500	8447.000	8492.500	45.500	ETSI
A27		8447.000	8492.500	45.500	8324.500	8370.000	45.500	ETSI
A41		8279.000	8321.000	42.000	8398.000	8440.000	42.000	ETSI
A45		8398.000	8440.000	42.000	8279.000	8321.000	42.000	ETSI
A42		8307.000	8349.000	42.000	8426.000	8475.000	49.000	ETSI
A46		8426.000	8475.000	49.000	8307.000	8349.000	42.000	ETSI
A43		8328.000	8377.000	49.000	8454.000	8496.000	42.000	ETSI

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
A47		8454.000	8496.000	42.000	8328.000	8377.000	49.000	ETSI
A61		7905.000	8017.000	112.000	8171.000	8327.000	156.000	ETSI
A65		8171.000	8327.000	156.000	7905.000	8017.000	112.000	ETSI
A62		7968.000	8073.000	105.000	8234.000	8339.000	105.000	ETSI
A66		8234.000	8339.000	105.000	7968.000	8073.000	105.000	ETSI
A63		7989.000	8136.000	147.000	8297.000	8411.000	114.000	ETSI
A67		8297.000	8411.000	114.000	7989.000	8136.000	147.000	ETSI
A64		8073.000	8185.000	112.000	8383.000	8495.000	112.000	ETSI
A68		8383.000	8495.000	112.000	8073.000	8185.000	112.000	ETSI
A91		8050.000	8134.000	84.000	8258.000	8342.000	84.000	ETSI
A95		8258.000	8342.000	84.000	8050.000	8134.000	84.000	ETSI
A92		8106.000	8190.000	84.000	8314.000	8398.000	84.000	ETSI
A96		8314.000	8398.000	84.000	8106.000	8190.000	84.000	ETSI
A93		8162.000	8246.000	84.000	8370.000	8454.000	84.000	ETSI
A97		8370.000	8454.000	84.000	8162.000	8246.000	84.000	ETSI

Sub-band 1x is valid for CS 7, 14, 28/29.65, and 56/59.3 MHz.

Sub-band 2x, 3x, 12x, and 13x are valid for 7, 14, and 28/29.65 MHz.

Sub-band 4x and 5x, are valid for CS 7, 14, and 28/29.65 MHz.

Sub-band 6x, 7x, 9x, 10x, and 11x are valid for CS 7, 14, 28/29.65, and 56/59.3 MHz.

Sub-band 8x is valid for CS 10, 20, 30, 40, and 50 MHz.

Sub-band A0x (Duplex 148.25 and 148.5 MHz), A2x and A4x (Duplex 119 and 126 MHz) are valid for CS 7, 14, and 28/29.65 MHz.

Sub-band A1x (Duplex 283.5, 310, and 311.32 MHz), A6x (Duplex 266 and 310 MHz), and A9x (Duplex 208 MHz) are valid for CS 7, 14, 28/29.65, and 56/59.3 MHz.

Sub-band A1x (Duplex 300 MHz) is valid for CS 10, 20, 30, 40, and 50 MHz.

3.2.3.6 RAU2 X 10 GHz Band

Table 14 RAU2 X 10 [HP]

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
11	65	10550.00	10570.00	20.00	10615.00	10635.00	20.00	ANSI
15	65	10615.00	10635.00	20.00	10550.00	10570.00	20.00	ANSI

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
12	65	10565.00	10585.00	20.00	10630.00	10650.00	20.00	ANSI
16	65	10630.00	10650.00	20.00	10565.00	10585.00	20.00	ANSI
13	65	10580.00	10600.00	20.00	10645.00	10665.00	20.00	ANSI
17	65	10645.00	10665.00	20.00	10580.00	10600.00	20.00	ANSI
14	65	10595.00	10615.00	20.00	10660.00	10680.00	20.00	ANSI
18	65	10660.00	10680.00	20.00	10595.00	10615.00	20.00	ANSI
21	91	10500.50	10528.50	28.00	10591.50	10619.50	28.00	ETSI
25	91	10591.50	10619.50	28.00	10500.50	10528.50	28.00	ETSI
22	91	10528.50	10556.50	28.00	10619.50	10647.50	28.00	ETSI
26	91	10619.50	10647.50	28.00	10528.50	10556.50	28.00	ETSI
23	91	10556.50	10584.50	28.00	10647.50	10675.50	28.00	ETSI
27	91	10647.50	10675.50	28.00	10556.50	10584.50	28.00	ETSI
31	350	10125.00	10300.00	175.00	10475.00	10650.00	175.00	ETSI
35	350	10475.00	10650.00	175.00	10125.00	10300.00	175.00	ETSI
41	168	10308.00	10420.00	112.00	10476.00	10588.00	112.00	ETSI
45	168	10476.00	10588.00	112.00	10308.00	10420.00	112.00	ETSI
51	350	10130.00	10186.00	56.00	10480.00	10536.00	56.00	ETSI
55	350	10480.00	10536.00	56.00	10130.00	10186.00	56.00	ETSI
52	350	10144.00	10200.00	56.00	10494.00	10550.00	56.00	ETSI
56	350	10494.00	10550.00	56.00	10144.00	10200.00	56.00	ETSI
71	350	10000.00	10189.00	189.00	10350.00	10539.00	189.00	ETSI
75	350	10350.00	10539.00	189.00	10000.00	10189.00	189.00	ETSI
72	350	10125.00	10330.00	205.00	10475.00	10680.00	205.00	ETSI
76	350	10475.00	10680.00	205.00	10125.00	10330.00	205.00	ETSI
A11		10550.00	10570.00	20.00	10615.00	10635.00	20.00	ANSI
A15		10615.00	10635.00	20.00	10550.00	10570.00	20.00	ANSI
A12		10565.00	10585.00	20.00	10630.00	10650.00	20.00	ANSI
A16		10630.00	10650.00	20.00	10565.00	10585.00	20.00	ANSI
A13		10580.00	10600.00	20.00	10645.00	10665.00	20.00	ANSI
A17		10645.00	10665.00	20.00	10580.00	10600.00	20.00	ANSI
A14		10595.00	10615.00	20.00	10660.00	10680.00	20.00	ANSI
A18		10660.00	10680.00	20.00	10595.00	10615.00	20.00	ANSI
A21		10500.50	10528.50	28.00	10591.50	10619.50	28.00	ETSI
A25		10591.50	10619.50	28.00	10500.50	10528.50	28.00	ETSI
A22		10528.50	10556.50	28.00	10619.50	10647.50	28.00	ETSI
A26		10619.50	10647.50	28.00	10528.50	10556.50	28.00	ETSI
A23		10556.50	10584.50	28.00	10647.50	10675.50	28.00	ETSI
A27		10647.50	10675.50	28.00	10556.50	10584.50	28.00	ETSI
A41		10308.00	10420.00	112.00	10476.00	10588.00	112.00	ETSI
A45		10476.00	10588.00	112.00	10308.00	10420.00	112.00	ETSI
A51		10130.00	10186.00	56.00	10480.00	10536.00	56.00	ETSI
A55		10480.00	10536.00	56.00	10130.00	10186.00	56.00	ETSI
A52		10144.00	10200.00	56.00	10494.00	10550.00	56.00	ETSI

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
A56		10494.00	10550.00	56.00	10144.00	10200.00	56.00	ETSI
A71		10000.00	10189.00	189.00	10350.00	10539.00	189.00	ETSI
A75		10350.00	10539.00	189.00	10000.00	10189.00	189.00	ETSI
A72		10125.00	10330.00	205.00	10475.00	10680.00	205.00	ETSI
A76		10475.00	10680.00	205.00	10125.00	10330.00	205.00	ETSI

Sub-band 1x is valid for CS 10 and 20 MHz.

Sub-band 2x is valid for 7, 14, and 28 MHz.

Sub-band 3x, 4x, and 5x are valid for 7, 14, 28, and 56 MHz.

Sub-band A1x (Duplex 65 MHz) is valid for CS 10 and 20 MHz.

Sub-band A2x (Duplex 91 MHz) is valid for CS 7, 14, and 28 MHz.

Sub-band A4x (Duplex 168 MHz), A5x and A7x (Duplex 350 MHz) are valid for CS 7, 14, 28, and 56 MHz.

3.2.3.7 RAU2 X 11 GHz Band

Table 15 RAU2 X 11 [HP]

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
11	530	10695.00	10855.00	160.00	11225.00	11385.00	160.00	ETSI
15	530	11225.00	11385.00	160.00	10695.00	10855.00	160.00	ETSI
12	530	10835.00	11035.00	200.00	11365.00	11565.00	200.00	ETSI
16	530	11365.00	11565.00	200.00	10835.00	11035.00	200.00	ETSI
13	530	11015.00	11175.00	160.00	11545.00	11705.00	160.00	ETSI
17	530	11545.00	11705.00	160.00	11015.00	11175.00	160.00	ETSI
21	490	10695.00	10875.00	180.00	11185.00	11365.00	180.00	ETSI/ANSI
25	490	11185.00	11365.00	180.00	10695.00	10875.00	180.00	ETSI/ANSI
22	490	10855.00	11055.00	200.00	11345.00	11545.00	200.00	ETSI/ANSI
26	490	11345.00	11545.00	200.00	10855.00	11055.00	200.00	ETSI/ANSI
23	490	11035.00	11195.00	160.00	11525.00	11685.00	160.00	ETSI/ANSI
27	490	11525.00	11685.00	160.00	11035.00	11195.00	160.00	ETSI/ANSI
A01		10695.00	10875.00	180.00	11185.00	11385.00	200.00	ETSI/ANSI
A05		11185.00	11385.00	200.00	10695.00	10875.00	180.00	ETSI/ANSI
A02		10835.00	11055.00	220.00	11345.00	11565.00	220.00	ETSI/ANSI
A06		11345.00	11565.00	220.00	10835.00	11055.00	220.00	ETSI/ANSI
A03		11015.00	11200.00	185.00	11525.00	11705.00	180.00	ETSI/ANSI
A07		11525.00	11705.00	180.00	11015.00	11200.00	185.00	ETSI/ANSI

Sub-band 1x and 2x are valid for 7, 14, 28, 40, and 56 MHz.

Sub-band 2x is valid for CS 10, 20, 30, 40, and 50 MHz.

Sub-band A0x (Duplex 490 and 530 MHz) is valid for CS 7, 14, 28, 40, and 56 MHz.

Sub-band A0x (Duplex 490 and 500 MHz) is valid for CS 10, 20, 30, 40, and 50 MHz.

3.2.3.8 RAU2 X 13 GHz Band

Table 16 RAU2 X 13 [HP]

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
11	266	12751.00	12835.00	84.00	13017.00	13101.00	84.00	ETSI/ANSI
15	266	13017.00	13101.00	84.00	12751.00	12835.00	84.00	ETSI/ANSI
12	266	12821.00	12905.00	84.00	13087.00	13171.00	84.00	ETSI/ANSI
16	266	13087.00	13171.00	84.00	12821.00	12905.00	84.00	ETSI/ANSI
13	266	12891.00	12975.00	84.00	13157.00	13241.00	84.00	ETSI/ANSI
17	266	13157.00	13241.00	84.00	12891.00	12975.00	84.00	ETSI/ANSI
14	266	12863.00	12919.00	56.00	13129.00	13185.00	56.00	ETSI/ANSI
18	266	13129.00	13185.00	56.00	12863.00	12919.00	56.00	ETSI/ANSI
42	266	12807.00	12891.00	84.00	13073.00	13157.00	84.00	ETSI/ANSI
46	266	13073.00	13157.00	84.00	12807.00	12891.00	84.00	ETSI/ANSI
A01		12751.00	12863.00	112.00	13017.00	13129.00	112.00	ETSI/ANSI
A05		13017.00	13129.00	112.00	12751.00	12863.00	112.00	ETSI/ANSI
A02		12807.00	12905.00	98.00	13073.00	13171.00	98.00	ETSI/ANSI
A06		13073.00	13171.00	98.00	12807.00	12905.00	98.00	ETSI/ANSI
A03		12863.00	12975.00	112.00	13129.00	13241.00	112.00	ETSI/ANSI
A07		13129.00	13241.00	112.00	12863.00	12975.00	112.00	ETSI/ANSI

Note: FCC part 101.147(p)(2) frequency range begins at 12700.00 MHz.

Sub-band 1x and 4x are valid for 7, 14, 28, and 56 MHz.

Sub-band 1x and 4x are valid for CS 10, 20, 30, 40, and 50 MHz.

Sub-band A0x (Duplex 266 MHz) is valid for 7, 14, 28, and 56 MHz.

Sub-band A0x (Duplex 225 and 266 MHz) is valid for CS 10, 20, 30, 40, and 50 MHz.

For RAU2 X/Xu 13 [HP] CS=12.5 MHz and 25 MHz (10 MHz in a 12.5 MHz CS and 20 MHz in a 25 MHz CS) are supported.

3.2.3.9 RAU2 X 15 GHz Band

Table 17 RAU2 X 15 [HP]

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
11	735	14499.25	14613.00	113.75	15234.25	15348.00	113.75	ETSI
18	735	15234.25	15348.00	113.75	14499.25	14613.00	113.75	ETSI
12	315	14604.25	14732.00	127.75	14919.25	15047.00	127.75	ETSI
15	315	14919.25	15047.00	127.75	14604.25	14732.00	127.75	ETSI
13	315	14709.25	14828.50	119.25	15024.25	15143.50	119.25	ETSI
16	315	15024.25	15143.50	119.25	14709.25	14828.50	119.25	ETSI
14	315	14814.25	14933.50	119.25	15129.25	15248.50	119.25	ETSI
17	315	15129.25	15248.50	119.25	14814.25	14933.50	119.25	ETSI
21	420	14495.75	14620.00	124.25	14915.75	15040.00	124.25	ETSI
25	420	14915.75	15040.00	124.25	14495.75	14620.00	124.25	ETSI
22	420	14607.75	14732.00	124.25	15027.75	15152.00	124.25	ETSI
26	420	15027.75	15152.00	124.25	14607.75	14732.00	124.25	ETSI
23	420	14719.75	14837.00	117.25	15139.75	15257.00	117.25	ETSI
27	420	15139.75	15257.00	117.25	14719.75	14837.00	117.25	ETSI
24	420	14817.75	14928.00	110.25	15237.75	15348.00	110.25	ETSI
28	420	15237.75	15348.00	110.25	14817.75	14928.00	110.25	ETSI
43	644	14495.75	14700.50	204.75	15139.75	15344.50	204.75	ETSI
49	644	15139.75	15344.50	204.75	14495.75	14700.50	204.75	ETSI
51	475	14700.00	14800.00	100.00	15175.00	15275.00	100.00	ANSI
53	475	15175.00	15275.00	100.00	14700.00	14800.00	100.00	ANSI
52	475	14775.00	14875.00	100.00	15250.00	15350.00	100.00	ANSI
54	475	15250.00	15350.00	100.00	14775.00	14875.00	100.00	ANSI
55	475	14500.00	14620.00	120.00	14975.00	15095.00	120.00	ANSI
57	475	14975.00	15095.00	120.00	14500.00	14620.00	120.00	ANSI
56	475	14600.00	14720.00	120.00	15075.00	15195.00	120.00	ANSI
58	475	15075.00	15195.00	120.00	14600.00	14720.00	120.00	ANSI
61	728	14495.75	14620.00	124.25	15223.75	15348.00	124.25	ETSI
68	728	15223.75	15348.00	124.25	14495.75	14620.00	124.25	ETSI
62	308	14614.75	14735.50	120.75	14922.75	15043.50	120.75	ETSI
65	308	14922.75	15043.50	120.75	14614.75	14735.50	120.75	ETSI
63	308	14698.75	14819.50	120.75	15006.75	15127.50	120.75	ETSI
66	308	15006.75	15127.50	120.75	14698.75	14819.50	120.75	ETSI
64	308	14810.75	14931.50	120.75	15118.75	15239.50	120.75	ETSI
67	308	15118.75	15239.50	120.75	14810.75	14931.50	120.75	ETSI
80	490	14397.75	14522.00	124.25	14887.75	15012.00	124.25	ETSI
85	490	14887.75	15012.00	124.25	14397.75	14522.00	124.25	ETSI
81	490	14481.75	14606.00	124.25	14971.75	15096.00	124.25	ETSI
86	490	14971.75	15096.00	124.25	14481.75	14606.00	124.25	ETSI

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
82	490	14565.75	14690.00	124.25	15055.75	15180.00	124.25	ETSI
87	490	15055.75	15180.00	124.25	14565.75	14690.00	124.25	ETSI
83	490	14649.75	14774.00	124.25	15139.75	15264.00	124.25	ETSI
88	490	15139.75	15264.00	124.25	14649.75	14774.00	124.25	ETSI
84	490	14733.75	14858.00	124.25	15223.75	15348.00	124.25	ETSI
89	490	15223.75	15348.00	124.25	14733.75	14858.00	124.25	ETSI
92	322	14627.00	14739.00	112.00	14949.00	15061.00	112.00	ETSI
95	322	14949.00	15061.00	112.00	14627.00	14739.00	112.00	ETSI
93	322	14711.00	14823.00	112.00	15033.00	15145.00	112.00	ETSI
96	322	15033.00	15145.00	112.00	14711.00	14823.00	112.00	ETSI
94	322	14795.00	14907.00	112.00	15117.00	15229.00	112.00	ETSI
97	322	15117.00	15229.00	112.00	14795.00	14907.00	112.00	ETSI
A01		14495.75	14774.00	278.25	15055.75	15348.00	292.25	ETSI
A05		15055.75	15348.00	292.25	14495.75	14774.00	278.25	ETSI
A02		14604.25	14739.00	134.75	14919.25	15061.00	141.75	ETSI
A06		14919.25	15061.00	141.75	14604.25	14739.00	134.75	ETSI
A03		14698.75	14828.50	129.75	15006.75	15145.00	138.25	ETSI
A07		15006.75	15145.00	138.25	14698.75	14828.50	129.75	ETSI
A04		14795.00	14933.50	138.50	15117.00	15248.50	131.50	ETSI
A08		15117.00	15248.50	131.50	14795.00	14933.50	138.50	ETSI
A11		14397.75	14660.00	262.25	14887.75	15130.00	242.25	ETSI/ANSI
A15		14887.75	15130.00	242.25	14397.75	14660.00	262.25	ETSI/ANSI
A12		14600.00	14732.00	132.00	15027.75	15195.00	167.25	ETSI/ANSI
A16		15027.75	15195.00	167.25	14600.00	14732.00	132.00	ETSI/ANSI
A13		14700.00	14928.00	228.00	15139.75	15350.00	210.25	ETSI/ANSI
A17		15139.75	15350.00	210.25	14700.00	14928.00	228.00	ETSI/ANSI

Sub-band 1x, 2x, 6x, 8x, and 9x are valid for CS 7, 14, 28, and 56 MHz.

Sub-band 5x are valid for CS 10, 20, 30, 40, and 50 MHz.

Sub-band A0x (Duplex 308, 315, 322, 490, 644, 728, and 735 MHz) and A1x (Duplex 420, 470, and 490 MHz) are valid for CS 7, 14, 28, and 56 MHz.

Sub-band A1x (Duplex 420, 470, and 490 MHz) are valid for CS 7, 14, 28, and 56 MHz.

Sub-band A1x (Duplex 475 MHz) is valid for CS 10, 20, 30, 40, and 50 MHz.

3.2.3.10 RAU2 X 18 GHz Band

Table 18 RAU2 X 18 [HP]

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
11	1010	17706.50	18009.50	303.00	18716.50	19019.50	303.00	ETSI
15	1010	18716.50	19019.50	303.00	17706.50	18009.50	303.00	ETSI
12	1010	17933.50	18236.50	303.00	18943.50	19246.50	303.00	ETSI
16	1010	18943.50	19246.50	303.00	17933.50	18236.50	303.00	ETSI
13	1010	18153.50	18456.50	303.00	19163.50	19466.50	303.00	ETSI
17	1010	19163.50	19466.50	303.00	18153.50	18456.50	303.00	ETSI
14	1010	18373.50	18676.50	303.00	19383.50	19686.50	303.00	ETSI
18	1010	19383.50	19686.50	303.00	18373.50	18676.50	303.00	ETSI
21	340	18580.00	18670.00	90.00	18920.00	19010.00	90.00	ANSI
25	340	18920.00	19010.00	90.00	18580.00	18670.00	90.00	ANSI
22	340	18655.00	18745.00	90.00	18995.00	19085.00	90.00	ANSI
26	340	18995.00	19085.00	90.00	18655.00	18745.00	90.00	ANSI
23	340	18730.00	18830.00	100.00	19070.00	19170.00	100.00	ANSI
27	340	19070.00	19170.00	100.00	18730.00	18830.00	100.00	ANSI
24	340	18820.00	18920.00	100.00	19160.00	19260.00	100.00	ANSI
28	340	19160.00	19260.00	100.00	18820.00	18920.00	100.00	ANSI
31	1560	17700.00	18003.00	303.00	19260.00	19563.00	303.00	ANSI
35	1560	19260.00	19563.00	303.00	17700.00	18003.00	303.00	ANSI
32	1560	17837.00	18140.00	303.00	19397.00	19700.00	303.00	ANSI
36	1560	19397.00	19700.00	303.00	17837.00	18140.00	303.00	ANSI
41	1008	17720.50	18009.50	289.00	18728.50	19017.50	289.00	ETSI
45	1008	18728.50	19017.50	289.00	17720.50	18009.50	289.00	ETSI
42	1008	17935.50	18236.50	301.00	18943.50	19244.50	301.00	ETSI
46	1008	18943.50	19244.50	301.00	17935.50	18236.50	301.00	ETSI
43	1008	18155.50	18456.50	301.00	19163.50	19464.50	301.00	ETSI
47	1008	19163.50	19464.50	301.00	18155.50	18456.50	301.00	ETSI
44	1008	18375.50	18672.50	297.00	19383.50	19680.50	297.00	ETSI
48	1008	19383.50	19680.50	297.00	18375.50	18672.50	297.00	ETSI
71	1010	17706.50	18009.50	303.00	18716.50	19019.50	303.00	ETSI
75	1010	18716.50	19019.50	303.00	17706.50	18009.50	303.00	ETSI
72	1010	17933.50	18236.50	303.00	18943.50	19246.50	303.00	ETSI
76	1010	18943.50	19246.50	303.00	17933.50	18236.50	303.00	ETSI
73	1010	18153.50	18456.50	303.00	19163.50	19466.50	303.00	ETSI
77	1010	19163.50	19466.50	303.00	18153.50	18456.50	303.00	ETSI
74	1010	18373.50	18676.50	303.00	19383.50	19686.50	303.00	ETSI
78	1010	19383.50	19686.50	303.00	18373.50	18676.50	303.00	ETSI
A11		17706.50	18236.50	530.00	18600.00	19246.50	646.50	ANSI
A15		18600.00	19246.50	646.50	17706.50	18236.50	530.00	ANSI

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
A13		18002.25	18676.50	674.25	19094.75	19686.50	591.75	ANSI
A17		19094.75	19686.50	591.75	18002.25	18676.50	674.25	ANSI
A21		18580.00	18670.00	90.00	18920.00	19010.00	90.00	ANSI
A25		18920.00	19010.00	90.00	18580.00	18670.00	90.00	ANSI
A22		18655.00	18745.00	90.00	18995.00	19085.00	90.00	ANSI
A26		18995.00	19085.00	90.00	18655.00	18745.00	90.00	ANSI
A23		18730.00	18830.00	100.00	19070.00	19170.00	100.00	ANSI
A27		19070.00	19170.00	100.00	18730.00	18830.00	100.00	ANSI
A24		18820.00	18920.00	100.00	19160.00	19260.00	100.00	ANSI
A28		19160.00	19260.00	100.00	18820.00	18920.00	100.00	ANSI
A31		17700.00	18140.00	440.00	19260.00	19700.00	440.00	ANSI
A35		19260.00	19700.00	440.00	17700.00	18140.00	440.00	ANSI

Sub-band 1x, 4x, and 7x are valid for CS 7, 13.75/14, 27.5/28, and 55/56 MHz.

Sub-band 2x and 3x are valid for CS 7, 13.75/14, 27.5/28, and 55/56 MHz.

Sub-band 2x and 3x are valid for CS 10, 20, 30, 40, and 50 MHz.

Sub-band A1x (Duplex 1008 and 1010 MHz), A2x (Duplex 340 MHz), and A3x (Duplex 1560 MHz) are valid for CS 7, 13.75/14, 27.5/28, and 55/56 MHz.

Sub-band A1x (Duplex 1160 MHz), A2x (Duplex 340 MHz), and A3x (Duplex 1560 MHz) are valid for CS 10, 20, 30, 40, and 50 MHz.

3.2.3.11 RAU2 X 23 GHz Band

Table 19 RAU2 X 23 [HP]

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
72	1008	22100.00	22400.00	300.00	23108.00	23408.00	300.00	ETSI
73	1008	23108.00	23408.00	300.00	22100.00	22400.00	300.00	ETSI
74	1008	22217.75	22540.25	322.50	23225.75	23548.25	322.50	ETSI
75	1008	23225.75	23548.25	322.50	22217.75	22540.25	322.50	ETSI
76	1008	22002.75	22316.25	313.50	23010.75	23324.25	313.50	ETSI
78	1008	23010.75	23324.25	313.50	22002.75	22316.25	313.50	ETSI
77	1008	22274.00	22590.75	316.75	23282.00	23598.75	316.75	ETSI
79	1008	23282.00	23598.75	316.75	22274.00	22590.75	316.75	ETSI
81	1200	21218.25	21523.25	305.00	22418.25	22723.25	305.00	ETSI/ANSI
85	1200	22418.25	22723.25	305.00	21218.25	21523.25	305.00	ETSI/ANSI

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
82	1200	21494.75	21824.75	330.00	22694.75	23024.75	330.00	ETSI/ANSI
86	1200	22694.75	23024.75	330.00	21494.75	21824.75	330.00	ETSI/ANSI
83	1200	21796.25	22145.25	349.00	22996.25	23345.25	349.00	ETSI/ANSI
87	1200	22996.25	23345.25	349.00	21796.25	22145.25	349.00	ETSI/ANSI
84	1200	22094.75	22400.00	305.25	23294.75	23600.00	305.25	ETSI/ANSI
88	1200	23294.75	23600.00	305.25	22094.75	22400.00	305.25	ETSI/ANSI
91	1232	21224.00	21532.25	308.25	22456.00	22764.25	308.25	ETSI/ANSI
95	1232	22456.00	22764.25	308.25	21224.00	21532.25	308.25	ETSI/ANSI
92	1232	21503.75	21812.25	308.50	22735.75	23044.25	308.50	ETSI/ANSI
96	1232	22735.75	23044.25	308.50	21503.75	21812.25	308.50	ETSI/ANSI
93	1232	21784.00	22092.25	308.25	23016.00	23324.25	308.25	ETSI/ANSI
97	1232	23016.00	23324.25	308.25	21784.00	22092.25	308.25	ETSI/ANSI
94	1232	22049.75	22363.25	313.50	23281.75	23595.25	313.50	ETSI/ANSI
98	1232	23281.75	23595.25	313.50	22049.75	22363.25	313.50	ETSI/ANSI
101	1050	21950.25	22263.75	313.50	23000.25	23313.75	313.50	ETSI
103	1050	23000.25	23313.75	313.50	21950.25	22263.75	313.50	ETSI
102	1050	22235.25	22538.25	303.00	23285.25	23588.25	303.00	ETSI
104	1050	23285.25	23588.25	303.00	22235.25	22538.25	303.00	ETSI
111	1200	21200.00	21523.25	323.25	22400.00	22723.25	323.25	ETSI
115	1200	22400.00	22723.25	323.25	21200.00	21523.25	323.25	ETSI
A01		21200.00	21824.75	624.75	22400.00	23044.25	644.25	ETSI/ANSI
A05		22400.00	23044.25	644.25	21200.00	21824.75	624.75	ETSI/ANSI
A02		21784.00	22600.00	816.00	22996.25	23600.00	603.75	ETSI/ANSI
A06		22996.25	23600.00	603.75	21784.00	22600.00	816.00	ETSI/ANSI

Sub-band 7x, 8x, 9x, 10x, and 11x are valid for CS 7, 14, 28, and 56 MHz.

Sub-band 8x and 9x are valid for CS 10, 20, 30, 40, and 50 MHz.

Sub-band A0x (Duplex 1008, 1050, 1200, and 1232 MHz) is valid for CS 7, 14, 28, and 56 MHz.

Sub-band A0x (Duplex 1200 and 1232 MHz) is valid for CS 10, 20, 30, 40, and 50 MHz.

3.2.3.12 RAU2 X 24 GHz Band

Table 20 RAU2 X 24

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
41	800	24250.00	24450.00	200.00	25050.00	25250.00	200.00	ANSI
45	800	25050.00	25250.00	200.00	24250.00	24450.00	200.00	ANSI
A41		24250.00	24450.00	200.00	25050,00	25250,00	200.00	ANSI
A45		25050.00	25250.00	200.00	24250,00	24450,00	200.00	ANSI

Sub-band 4x is valid for CS 10, 20, 30, 40, and 50 MHz.

Sub-band A4x (Duplex 800 MHz) is valid for CS 10, 20, 30, 40, and 50 MHz.

3.2.3.13 RAU2 X 26 GHz Band

Table 21 RAU2 X 26

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
51	1008	24549.00	24885.00	336.00	25557.00	25893.00	336.00	ETSI
55	1008	25557.00	25893.00	336.00	24549.00	24885.00	336.00	ETSI
52	1008	24829.00	25165.00	336.00	25837.00	26173.00	336.00	ETSI
56	1008	25837.00	26173.00	336.00	24829.00	25165.00	336.00	ETSI
53	1008	25109.00	25445.00	336.00	26117.00	26453.00	336.00	ETSI
57	1008	26117.00	26453.00	336.00	25109.00	25445.00	336.00	ETSI
A01		24549.00	25165.00	616.00	25557.00	26173.00	616.00	ETSI
A05		25557.00	26173.00	616.00	24549.00	25165.00	616.00	ETSI
A02		24883.25	25469.00	585.75	25891.25	26477.00	585.75	ETSI
A06		25891.25	26477.00	585.75	24883.25	25469.00	585.75	ETSI

Sub-band 5x is valid for CS 7, 14, 28, and 56 MHz.

Sub-band A0x (Duplex 1008 MHz) is valid for CS 7, 14, 28, and 56 MHz.

3.2.3.14 RAU2 X 28 GHz Band

Table 22 RAU2 X 28

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
31	420	27505.00	27701.00	196.00	27925.00	28121.00	196.00	ANSI
33	420	27925.00	28121.00	196.00	27505.00	27701.00	196.00	ANSI
32	420	27701.00	27925.00	224.00	28121.00	28345.00	224.00	ANSI
34	420	28121.00	28345.00	224.00	27701.00	27925.00	224.00	ANSI
41	1008	27548.50	27884.50	336.00	28556.50	28892.50	336.00	ETSI
45	1008	28556.50	28892.50	336.00	27548.50	27884.50	336.00	ETSI
42	1008	27828.50	28164.50	336.00	28836.50	29172.50	336.00	ETSI
46	1008	28836.50	29172.50	336.00	27828.50	28164.50	336.00	ETSI
43	1008	28108.50	28444.50	336.00	29116.50	29452.50	336.00	ETSI
47	1008	29116.50	29452.50	336.00	28108.50	28444.50	336.00	ETSI
51	450	27500.00	27700.00	200.00	27950.00	28150.00	200.00	ANSI
53	450	27950.00	28150.00	200.00	27500.00	27700.00	200.00	ANSI
52	450	27700.00	27900.00	200.00	28150.00	28350.00	200.00	ANSI
54	450	28150.00	28350.00	200.00	27700.00	27900.00	200.00	ANSI
A01		27548.50	27996.50	448.00	28556.50	29004.50	448.00	ETSI
A05		28556.50	29004.50	448.00	27548.50	27996.50	448.00	ETSI
A02		27996.50	28444.50	448.00	29004.50	29452.50	448.00	ETSI
A06		29004.50	29452.50	448.00	27996.50	28444.50	448.00	ETSI
A03		27828.50	28276.50	448.00	28836.50	29284.50	448.00	ETSI
A07		28836.50	29284.50	448.00	27828.50	28276.50	448.00	ETSI
A11		27500.00	27701.00	201.00	27925.00	28150.00	225.00	ANSI
A15		27925.00	28150.00	225.00	27500.00	27701.00	201.00	ANSI
A12		27700.00	27925.00	225.00	28121.00	28350.00	229.00	ANSI
A16		28121.00	28350.00	229.00	27700.00	27925.00	225.00	ANSI

Sub-band 3x and 5x are valid for CS 10, 20, 30, 40, and 50 MHz.

Sub-band 4x is valid for CS 7, 14, 28, and 56 MHz.

Sub-band A0x (Duplex 1008 MHz) is valid for CS 7, 14, 28, and 56 MHz.

Sub-band A1x (Duplex 420 and 450 MHz) is valid for CS 10, 20, 30, 40, and 50 MHz.

3.2.3.15 RAU2 X 32 GHz Band

Table 23 RAU2 X 32

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
11	812	31815.00	32095.00	280.00	32627.00	32907.00	280.00	ETSI
15	812	32627.00	32907.00	280.00	31815.00	32095.00	280.00	ETSI
12	812	32053.00	32333.00	280.00	32865.00	33145.00	280.00	ETSI
16	812	32865.00	33145.00	280.00	32053.00	32333.00	280.00	ETSI
13	812	32291.00	32599.00	308.00	33103.00	33411.00	308.00	ETSI
17	812	33103.00	33411.00	308.00	32291.00	32599.00	308.00	ETSI
A11		31815.00	32207.00	392.00	32627.00	33019.00	392.00	ETSI
A15		32627.00	33019.00	392.00	31815.00	32207.00	392.00	ETSI
A12		32053.00	32333.00	280.00	32865.00	33145.00	280.00	ETSI
A16		32865.00	33145.00	280.00	32053.00	32333.00	280.00	ETSI
A13		32207.00	32599.00	392.00	33019.00	33411.00	392.00	ETSI
A17		33019.00	33411.00	392.00	32207.00	32599.00	392.00	ETSI

Sub-band 1x is valid for CS 7, 14, 28, and 56 MHz.

Sub-band A1x (Duplex 812 MHz) is valid for CS 7, 14, 28, and 56 MHz.

3.2.3.16 RAU2 X 38 GHz Band

Table 24 RAU2 X 38

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
11	1260	37058.00	37339.75	281.75	38318.00	38599.75	281.75	ETSI
15	1260	38318.00	38599.75	281.75	37058.00	37339.75	281.75	ETSI
12	1260	37338.00	37619.75	281.75	38598.00	38879.75	281.75	ETSI
16	1260	38598.00	38879.75	281.75	37338.00	37619.75	281.75	ETSI
13	1260	37618.00	37899.75	281.75	38878.00	39159.75	281.75	ETSI
17	1260	38878.00	39159.75	281.75	37618.00	37899.75	281.75	ETSI
14	1260	37898.00	38179.75	281.75	39158.00	39439.75	281.75	ETSI
18	1260	39158.00	39439.75	281.75	37898.00	38179.75	281.75	ETSI
23	1260	37758.00	38039.75	281.75	39018.00	39299.75	281.75	ETSI
27	1260	39018.00	39299.75	281.75	37758.00	38039.75	281.75	ETSI
31	700	38600.00	38800.00	200.00	39300.00	39500.00	200.00	ANSI
35	700	39300.00	39500.00	200.00	38600.00	38800.00	200.00	ANSI
32	700	38770.00	38970.00	200.00	39470.00	39670.00	200.00	ANSI
36	700	39470.00	39670.00	200.00	38770.00	38970.00	200.00	ANSI
33	700	38930.00	39130.00	200.00	39630.00	39830.00	200.00	ANSI

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
37	700	39630.00	39830.00	200.00	38930.00	39130.00	200.00	ANSI
34	700	39100.00	39300.00	200.00	39800.00	40000.00	200.00	ANSI
38	700	39800.00	40000.00	200.00	39100.00	39300.00	200.00	ANSI
A11		37058.00	37619.75	561.75	38318.00	38879.75	561.75	ETSI
A15		38318.00	38879.75	561.75	37058.00	37619.75	561.75	ETSI
A12		37618.00	38179.75	561.75	38878.00	39439.75	561.75	ETSI
A16		38878.00	39439.75	561.75	37618.00	38179.75	561.75	ETSI
A31		38600.00	38800.00	200.00	39300.00	39500.00	200.00	ANSI
A35		39300.00	39500.00	200.00	38600.00	38800.00	200.00	ANSI
A32		38770.00	38970.00	200.00	39470.00	39670.00	200.00	ANSI
A36		39470.00	39670.00	200.00	38770.00	38970.00	200.00	ANSI
A33		38930.00	39130.00	200.00	39630.00	39830.00	200.00	ANSI
A37		39630.00	39830.00	200.00	38930.00	39130.00	200.00	ANSI
A34		39100.00	39300.00	200.00	39800.00	40000.00	200.00	ANSI
A38		39800.00	40000.00	200.00	39100.00	39300.00	200.00	ANSI

Sub-band 1x and 2x are valid for CS 7, 14, 28, and 56 MHz.

Sub-band 3x is valid for CS 10, 20, 30, 40, and 50 MHz for ANSI.

Sub-band A1x (Duplex 1260 MHz) is valid for CS 7, 14, 2, and 56 MHz.

Sub-band A3x (Duplex 700 MHz) is valid for CS 10, 20, 30, 40, and 50 MHz.

3.2.3.17 RAU2 X 42 GHz Band

Table 25 RAU2 X 42

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
11	1500	40522.00	40830.00	308.00	42022.00	42330.00	308.00	ETSI
15	1500	42022.00	42330.00	308.00	40522.00	40830.00	308.00	ETSI
12	1500	40774.00	41054.00	280.00	42274.00	42554.00	280.00	ETSI
16	1500	42274.00	42554.00	280.00	40774.00	41054.00	280.00	ETSI
21	1500	40998.00	41278.00	280.00	42498.00	42778.00	280.00	ETSI
25	1500	42498.00	42778.00	280.00	40998.00	41278.00	280.00	ETSI
22	1500	41222.00	41502.00	280.00	42722.00	43002.00	280.00	ETSI
26	1500	42722.00	43002.00	280.00	41222.00	41502.00	280.00	ETSI
31	1500	41446.00	41726.00	280.00	42946.00	43226.00	280.00	ETSI
35	1500	42946.00	43226.00	280.00	41446.00	41726.00	280.00	ETSI
32	1500	41670.00	41964.00	294.00	43170.00	43464.00	294.00	ETSI
36	1500	43170.00	43464.00	294.00	41670.00	41964.00	294.00	ETSI
A01		40522.00	41054.00	532.00	42022.00	42554.00	532.00	ETSI

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
A05		42022.00	42554.00	532.00	40522.00	41054.00	532.00	ETSI
A02		40998.00	41502.00	504.00	42498.00	43002.00	504.00	ETSI
A06		42498.00	43002.00	504.00	40998.00	41502.00	504.00	ETSI
A03		41446.00	41964.00	518.00	42946.00	43464.00	518.00	ETSI
A07		42946.00	43464.00	518.00	41446.00	41964.00	518.00	ETSI

Sub-band 1x, 2x, and 3x are valid for CS 7, 14, 28, and 56 MHz.

Sub-band A0x (Duplex 1500 MHz) is valid for CS 7, 14, 28, and 56 MHz.

3.2.4 MINI-LINK 6363

3.2.4.1 MINI-LINK 6363 6 GHz Lower Band

Table 26 MINI-LINK 6363 6L

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
11L		5925.000	6020.250	95.250	6177.050	6277.000	99.950	ETSI/ANSI
11H		6177.050	6277.000	99.950	5925.000	6020.250	95.250	ETSI/ANSI
12L		6011.000	6110.250	99.250	6270.050	6362.300	92.250	ETSI/ANSI
12H		6270.050	6362.300	92.250	6011.000	6110.250	99.250	ETSI/ANSI
13L		6078.500	6173.250	94.750	6330.550	6425.300	94.750	ETSI/ANSI
13H		6330.550	6425.300	94.750	6078.500	6173.250	94.750	ETSI/ANSI
14L		5989.325	6049.350	60.025	6241.350	6301.375	60.025	ETSI/ANSI
14H		6241.350	6301.375	60.025	5989.325	6049.350	60.025	ETSI/ANSI
51L		5925.000	6020.250	95.250	6177.050	6277.000	99.950	ANSI
51H		6177.050	6277.000	99.950	5925.000	6020.250	95.250	ANSI
52L		6011.000	6110.250	99.250	6270.050	6362.300	92.250	ANSI
52H		6270.050	6362.300	92.250	6011.000	6110.250	99.250	ANSI
53L		6078.500	6173.250	94.750	6330.550	6425.300	94.750	ANSI
53H		6330.550	6425.300	94.750	6078.500	6173.250	94.750	ANSI
54L		5989.330	6049.330	60.000	6241.370	6301.370	60.000	ANSI
54H		6241.370	6301.370	60.000	5989.330	6049.330	60.000	ANSI

Sub-band 1xL/H (Duplex 240, 252.04, 260, and 266 MHz) is valid for CS 7, 14, 28/29.65, and 56/59.3 MHz.

Sub-band 1xL/H (Duplex 252.04 MHz) are valid for CS 9.88/10, 20, 29.65/30, 40, 50, and 59.3/60 MHz.

Sub-band 5xL/H (Duplex 252.04 MHz) are valid for CS 9.88/10, 20, 29.65/30, 40, 50, and 59.3/60 MHz.

3.2.4.2 MINI-LINK 6363 6 GHz Upper Band

Table 27 MINI-LINK 6363 6U

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
21L		6430.000	6565.000	135.000	6770.000	6905.000	135.000	ETSI/ANSI
21H		6770.000	6905.000	135.000	6430.000	6565.000	135.000	ETSI/ANSI
22L		6550.000	6685.000	135.000	6890.000	7025.000	135.000	ETSI/ANSI
22H		6890.000	7025.000	135.000	6550.000	6685.000	135.000	ETSI/ANSI
23L		6635.000	6765.000	130.000	6975.000	7105.000	130.000	ETSI/ANSI
23H		6975.000	7105.000	130.000	6635.000	6765.000	130.000	ETSI/ANSI
24L		6520.000	6600.000	80.000	6860.000	6940.000	80.000	ETSI/ANSI
24H		6860.000	6940.000	80.000	6520.000	6600.000	80.000	ETSI/ANSI
31L		6540.000	6610.000	70.000	6700.000	6770.000	70.000	ANSI
31H		6700.000	6770.000	70.000	6540.000	6610.000	70.000	ANSI
32L		6597.500	6657.500	60.000	6757.500	6817.500	60.000	ANSI
32H		6757.500	6817.500	60.000	6597.500	6657.500	60.000	ANSI
33L		6640.000	6710.000	70.000	6800.000	6870.000	70.000	ANSI
33H		6800.000	6870.000	70.000	6640.000	6710.000	70.000	ANSI

Sub-band 2xL/H (Duplex 340 MHz) is valid for CS 7, 14, 28/30, 40, and 56/60 MHz.

Sub-band 2xL/H (Duplex 340 MHz) is valid for CS 10, 20, 30, 40, and 50 MHz.

Sub-band 3xL/H (Duplex 160 and 170 MHz) are valid for CS 10, 20, 30, 40, and 50 MHz.

3.2.4.3 MINI-LINK 6363 7 GHz Band

Table 28 MINI-LINK 6363 7

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
01L		7107.000	7163.000	56.00	7303.000	7359.000	56.00	ETSI
01H		7303.000	7359.000	56.00	7107.000	7163.000	56.00	ETSI
02L		7163.000	7219.000	56.00	7359.000	7415.000	56.00	ETSI
02H		7359.000	7415.000	56.00	7163.000	7219.000	56.00	ETSI
03L		7191.000	7247.000	56.00	7387.000	7443.000	56.00	ETSI
03H		7387.000	7443.000	56.00	7191.000	7247.000	56.00	ETSI

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
11L		7414.000	7485.000	71.00	7575.000	7645.000	70.00	ETSI/ANSI
11H		7575.000	7645.000	70.00	7414.000	7485.000	71.00	ETSI/ANSI
12L		7442.000	7515.000	73.00	7610.000	7673.000	63.00	ETSI/ANSI
12H		7610.000	7673.000	63.00	7442.000	7515.000	73.00	ETSI/ANSI
13L		7470.000	7540.000	70.00	7638.000	7701.000	63.00	ETSI/ANSI
13H		7638.000	7701.000	63.00	7470.000	7540.000	70.00	ETSI/ANSI
14L		7498.000	7568.000	70.00	7665.000	7729.000	64.00	ETSI/ANSI
14H		7665.000	7729.000	64.00	7498.000	7568.000	70.00	ETSI/ANSI
21L		7426.500	7513.750	87.250	7671.500	7758.750	87.250	ETSI
21H		7671.500	7758.750	87.250	7426.500	7513.750	87.250	ETSI
22L		7482.250	7569.750	87.500	7727.250	7814.750	87.500	ETSI
22H		7727.250	7814.750	87.500	7482.250	7569.750	87.500	ETSI
23L		7510.250	7597.750	87.500	7755.250	7842.750	87.500	ETSI
23H		7755.250	7842.750	87.500	7510.250	7597.750	87.500	ETSI
24L		7566.250	7653.750	87.500	7811.250	7898.750	87.500	ETSI
24H		7811.250	7898.750	87.500	7566.250	7653.750	87.500	ETSI
31L		7107.000	7184.000	77.00	7275.000	7345.000	70.00	ETSI/ANSI
31H		7275.000	7345.000	70.00	7107.000	7184.000	77.00	ETSI/ANSI
32L		7135.000	7212.000	77.00	7303.000	7373.000	70.00	ETSI/ANSI
32H		7303.000	7373.000	70.00	7135.000	7212.000	77.00	ETSI/ANSI
33L		7163.000	7240.000	77.00	7331.000	7401.000	70.00	ETSI/ANSI
33H		7331.000	7401.000	70.00	7163.000	7240.000	77.00	ETSI/ANSI
34L		7191.000	7268.000	77.00	7359.000	7429.000	70.00	ETSI/ANSI
34H		7359.000	7429.000	70.00	7191.000	7268.000	77.00	ETSI/ANSI
81L		7249.500	7309.000	59.50	7410.500	7470.000	59.50	ETSI
81H		7410.500	7470.000	59.50	7249.500	7309.000	59.50	ETSI
82L		7277.500	7337.000	59.50	7438.500	7498.000	59.50	ETSI
82H		7438.500	7498.000	59.50	7277.500	7337.000	59.50	ETSI
83L		7305.500	7365.000	59.50	7466.500	7526.000	59.50	ETSI
83H		7466.500	7526.000	59.50	7305.500	7365.000	59.50	ETSI
84L		7333.500	7393.000	59.50	7494.500	7554.000	59.50	ETSI
84H		7494.500	7554.000	59.50	7333.500	7393.000	59.50	ETSI
94L		7527.000	7583.000	56.00	7695.000	7751.000	56.00	ETSI/ANSI
94H		7695.000	7751.000	56.00	7527.000	7583.000	56.00	ETSI/ANSI

Sub-band 0xL/H (Duplex 196 MHz), 2xL/H (Duplex 245 and 269 MHz), 8xL/H (Duplex 161 MHz) are valid for CS 7, 14, 28, and 56 MHz.

Sub-band 1xL/H (Duplex 154, 161, and 168 MHz), 3xL/H (Duplex 154, 161, and 168 MHz), 9xL/H (Duplex 168 MHz) are valid for CS 7, 14, 28, and 56 MHz.

Sub-band 1xL/H (Duplex 150 MHz), 3xL/H (Duplex 175 MHz), and 9xL/H (Duplex 150 MHz) are valid for CS 10, 20, 30, 40, and 50 MHz.

3.2.4.4 MINI-LINK 6363 8 GHz Band

Table 29 MINI-LINK 6363 8

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
01L		7744.750	7793.750	49.000	7893.000	7942.250	49.250	ETSI
01H		7893.000	7942.250	49.250	7744.750	7793.750	49.000	ETSI
02L		7779.750	7828.750	49.000	7928.000	7977.250	49.250	ETSI
02H		7928.000	7977.250	49.250	7779.750	7828.750	49.000	ETSI
11L		7718.050	7837.250	119.200	8016.500	8147.975	131.475	ETSI/ANSI
11H		8016.500	8147.975	131.475	7718.050	7837.250	119.200	ETSI/ANSI
12L		7777.000	7910.775	133.775	8085.000	8222.100	137.100	ETSI/ANSI
12H		8085.000	8222.100	137.100	7777.000	7910.775	133.775	ETSI/ANSI
14L		7835.000	7970.075	135.075	8135.000	8281.400	146.400	ETSI/ANSI
14H		8135.000	8281.400	146.400	7835.000	7970.075	135.075	ETSI/ANSI
21L		8279.000	8328.000	49.000	8405.000	8450.500	45.500	ETSI
21H		8405.000	8450.500	45.500	8279.000	8328.000	49.000	ETSI
23L		8324.500	8370.000	45.500	8447.000	8492.500	45.500	ETSI
23H		8447.000	8492.500	45.500	8324.500	8370.000	45.500	ETSI
41L		8279.000	8321.000	42.000	8398.000	8440.000	42.000	ETSI
41H		8398.000	8440.000	42.000	8279.000	8321.000	42.000	ETSI
42L		8307.000	8349.000	42.000	8426.000	8475.000	49.000	ETSI
42H		8426.000	8475.000	49.000	8307.000	8349.000	42.000	ETSI
43L		8328.000	8377.000	49.000	8454.000	8496.000	42.000	ETSI
43H		8454.000	8496.000	42.000	8328.000	8377.000	49.000	ETSI
61L		7905.000	8017.000	112.000	8171.000	8327.000	156.000	ETSI
61H		8171.000	8327.000	156.000	7905.000	8017.000	112.000	ETSI
62L		7968.000	8073.000	105.000	8234.000	8339.000	105.000	ETSI
62H		8234.000	8339.000	105.000	7968.000	8073.000	105.000	ETSI
63L		7989.000	8136.000	147.000	8290.000	8411.000	121.000	ETSI
63H		8290.000	8411.000	121.000	7989.000	8136.000	147.000	ETSI
64L		8073.000	8185.000	112.000	8383.000	8495.000	112.000	ETSI
64H		8383.000	8495.000	112.000	8073.000	8185.000	112.000	ETSI
91L		8050.000	8134.000	84.000	8258.000	8342.000	84.000	ETSI
91H		8258.000	8342.000	84.000	8050.000	8134.000	84.000	ETSI
92L		8106.000	8190.000	84.000	8314.000	8398.000	84.000	ETSI
92H		8314.000	8398.000	84.000	8106.000	8190.000	84.000	ETSI
93L		8162.000	8246.000	84.000	8370.000	8454.000	84.000	ETSI
93H		8370.000	8454.000	84.000	8162.000	8246.000	84.000	ETSI

Sub-band 0xL/H (Duplex 148.25 and 148.5 MHz), 2xL/H and 4xL/H (Duplex 119 and 126 MHz) are valid for CS 7, 14, and 28/29.65 MHz.

Sub-band 1xL/H (Duplex 283.5, 310, and 311.32 MHz), 6xL/H (Duplex 266 and 310 MHz), and 9xL/H (Duplex 208 MHz) are valid for CS 7, 14, 28/29.65, and 56/59.3 MHz.

Sub-band 1xL/H (Duplex 300 and 310 MHz) is valid for CS 10, 20, 30, 40, and 50 MHz.

3.2.4.5 MINI-LINK 6363 10 GHz Band

Table 30 MINI-LINK 6363 10

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
21L		10500.50	10528.50	28.00	10591.50	10619.50	28.00	ETSI
21H		10591.50	10619.50	28.00	10500.50	10528.50	28.00	ETSI
22L		10528.50	10556.50	28.00	10619.50	10647.50	28.00	ETSI
22H		10619.50	10647.50	28.00	10528.50	10556.50	28.00	ETSI
23L		10556.50	10584.50	28.00	10647.50	10675.50	28.00	ETSI
23H		10647.50	10675.50	28.00	10556.50	10584.50	28.00	ETSI
41L		10308.00	10420.00	112.00	10476.00	10588.00	112.00	ETSI
41H		10476.00	10588.00	112.00	10308.00	10420.00	112.00	ETSI
71L		10000.00	10189.00	189.00	10350.00	10539.00	189.00	ETSI
71H		10350.00	10539.00	189.00	10000.00	10189.00	189.00	ETSI
72L		10125.00	10330.00	205.00	10475.00	10680.00	205.00	ETSI
72H		10475.00	10680.00	205.00	10125.00	10330.00	205.00	ETSI

Sub-band 2xL/H (Duplex 91 MHz) is valid for CS 7, 14, and 28 MHz.

Sub-band 4xL/H (Duplex 168 MHz) and 7xL/H (Duplex 350 MHz) are valid for CS 7, 14, 28, and 56 MHz.

3.2.4.6 MINI-LINK 6363 11 GHz Band

Table 31 MINI-LINK 6363 11

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
01L		10695.00	10877.00	182.00	11185.00	11385.00	200.00	ETSI/ANSI
01H		11185.00	11385.00	200.00	10695.00	10877.00	182.00	ETSI/ANSI
02L		10835.00	11055.00	220.00	11339.00	11575.00	236.00	ETSI/ANSI
02H		11339.00	11575.00	236.00	10835.00	11055.00	220.00	ETSI/ANSI
03L		11015.00	11200.00	185.00	11507.00	11705.00	198.00	ETSI/ANSI
03H		11507.00	11705.00	198.00	11015.00	11200.00	185.00	ETSI/ANSI

Sub-band 0xL/H (Duplex 490 and 530 MHz) is valid for CS 7, 14, 28, 40, and 56 MHz.

Sub-band 0xL/H (Duplex 490 and 500 MHz) is valid for CS 10, 20, 30, 40, and 50 MHz.

3.2.4.7 MINI-LINK 6363 13 GHz Band

Table 32 MINI-LINK 6363 13; MINI-LINK 6363/2 13

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
01L		12751.00	12900.00	149.00	13017.00	13157.00	140.00	ETSI/ANSI
01H		13017.00	13157.00	140.00	12751.00	12900.00	149.00	ETSI/ANSI
03L		12863.00	12975.00	112.00	13129.00	13241.00	112.00	ETSI/ANSI
03H		13129.00	13241.00	112.00	12863.00	12975.00	112.00	ETSI/ANSI

Note: FCC part 101.147(p)(2) frequency range begins at 12700.00 MHz.

Sub-band 0xL/H (Duplex 266 MHz) is valid for 7, 14, 28, and 56 MHz.

Sub-band 0xL/H (Duplex 225 and 266 MHz) is valid for CS 10, 20, 30, 40, and 50 MHz.

3.2.4.8 MINI-LINK 6363 15 GHz Band

Table 33 MINI-LINK 6363 15

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
01L		14495.75	14774.00	278.25	15055.75	15348.00	292.25	ETSI
01H		15055.75	15348.00	292.25	14495.75	14774.00	278.25	ETSI
02L		14604.25	14739.00	134.75	14919.25	15061.00	141.75	ETSI
02H		14919.25	15061.00	141.75	14604.25	14739.00	134.75	ETSI
03L		14698.75	14828.50	129.75	15006.75	15145.00	138.25	ETSI
03H		15006.75	15145.00	138.25	14698.75	14828.50	129.75	ETSI
04L		14795.00	14933.50	138.50	15117.00	15248.50	131.50	ETSI
04H		15117.00	15248.50	131.50	14795.00	14933.50	138.50	ETSI
11L		14397.75	14660.00	262.25	14887.75	15130.00	242.25	ETSI/ANSI
11H		14887.75	15130.00	242.25	14397.75	14660.00	262.25	ETSI/ANSI
12L		14501.00	14732.00	231.00	14921.00	15195.00	274.00	ETSI/ANSI
12H		14921.00	15195.00	274.00	14501.00	14732.00	231.00	ETSI/ANSI
13L		14700.00	14928.00	228.00	15139.75	15350.00	210.25	ETSI/ANSI
13H		15139.75	15350.00	210.25	14700.00	14928.00	228.00	ETSI/ANSI

Sub-band 0xL/H (Duplex 308, 315, 322, 490, 644, 728, and 735 MHz) is valid for CS 7, 14, 28, and 56 MHz.

Sub-band 1xL/H (Duplex 420, 470, and 490 MHz) is valid for CS 7, 14, 28, and 56 MHz.

Sub-band 1xL/H (Duplex 475 MHz) is valid for CS 10, 20, 30, 40, and 50 MHz.

Table 34 MINI-LINK 6363/2 15

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
01L		14495.75	14774.00	278.25	15055.75	15348.00	292.25	ETSI
01H		15055.75	15348.00	292.25	14495.75	14774.00	278.25	ETSI
02L		14604.25	14739.00	134.75	14919.25	15061.00	141.75	ETSI
02H		14919.25	15061.00	141.75	14604.25	14739.00	134.75	ETSI
03L		14698.75	14828.50	129.75	15006.75	15145.00	138.25	ETSI
03H		15006.75	15145.00	138.25	14698.75	14828.50	129.75	ETSI
04L		14795.00	14933.50	138.50	15117.00	15248.50	131.50	ETSI
04H		15117.00	15248.50	131.50	14795.00	14933.50	138.50	ETSI
11L		14397.75	14660.00	262.25	14887.75	15130.00	242.25	ETSI/ANSI
11H		14887.75	15130.00	242.25	14397.75	14660.00	262.25	ETSI/ANSI
12L		14600.00	14732.00	132.00	15027.75	15195.00	167.25	ETSI/ANSI
12H		15027.75	15195.00	167.25	14600.00	14732.00	132.00	ETSI/ANSI
13L		14700.00	14928.00	228.00	15139.75	15350.00	210.25	ETSI/ANSI
13H		15139.75	15350.00	210.25	14700.00	14928.00	228.00	ETSI/ANSI

Sub-band 0xL/H (Duplex 308, 315, 322, 490, 644, 728, and 735 MHz) is valid for CS 7, 14, 28, and 56 MHz.

Sub-band 1xL/H (Duplex 420, 470, and 490 MHz) is valid for CS 7, 14, 28, and 56 MHz.

Sub-band 1xL/H (Duplex 475 MHz) is valid for CS 10, 20, 30, 40, and 50 MHz.

3.2.4.9 MINI-LINK 6363 18 GHz Band

Table 35 MINI-LINK 6363 18; MINI-LINK 6363/2 18

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
11L		17706.50	18236.50	530.00	18600.00	19246.50	646.50	ETSI/ANSI
11H		18600.00	19246.50	646.50	17706.50	18236.50	530.00	ETSI/ANSI
13L		18002.25	18676.50	674.25	19094.75	19686.50	591.75	ETSI/ANSI
13H		19094.75	19686.50	591.75	18002.25	18676.50	674.25	ETSI/ANSI

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
21L		18580.00	18670.00	90.00	18920.00	19010.00	90.00	ETSI/ANSI
21H		18920.00	19010.00	90.00	18580.00	18670.00	90.00	ETSI/ANSI
22L		18655.00	18745.00	90.00	18995.00	19085.00	90.00	ETSI/ANSI
22H		18995.00	19085.00	90.00	18655.00	18745.00	90.00	ETSI/ANSI
23L		18730.00	18830.00	100.00	19070.00	19170.00	100.00	ETSI/ANSI
23H		19070.00	19170.00	100.00	18730.00	18830.00	100.00	ETSI/ANSI
24L		18820.00	18920.00	100.00	19160.00	19260.00	100.00	ETSI/ANSI
24H		19160.00	19260.00	100.00	18820.00	18920.00	100.00	ETSI/ANSI
31L		17700.00	18140.00	440.00	19260.00	19700.00	440.00	ETSI/ANSI
31H		19260.00	19700.00	440.00	17700.00	18140.00	440.00	ETSI/ANSI

Sub-band 1xL/H (Duplex 1008 and 1010 MHz), 2xL/H (Duplex 340 MHz), and 3xL/H (Duplex 1560 MHz) are valid for CS 7, 13.75/14, 27.5/28, 55/56, and 110/112 MHz.

Sub-band 1xL/H (Duplex 1160 MHz), 2xL/H (Duplex 340 MHz), and 3xL/H (Duplex 1560 MHz) are valid for CS 10, 20, 30, 40, 50, 60, and 80 MHz.

3.2.4.10 MINI-LINK 6363 23 GHz Band

Table 36 MINI-LINK 6363 23; MINI-LINK 6363/2 23

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
01L		21200.00	21824.75	624.75	22400.00	23044.25	644.25	ETSI/ANSI
01H		22400.00	23044.25	644.25	21200.00	21824.75	624.75	ETSI/ANSI
02L		21784.00	22600.00	816.00	22996.25	23600.00	603.75	ETSI/ANSI
02H		22996.25	23600.00	603.75	21784.00	22600.00	816.00	ETSI/ANSI

Sub-band 0xL/H (Duplex 1008, 1050, 1200, and 1232 MHz) is valid for CS 7, 14, 28, 56, and 112 MHz.

Sub-band 0xL/H (Duplex 1200 and 1232 MHz) is valid for CS 10, 20, 30, 40, 50, 60, and 80 MHz.

3.2.4.11 MINI-LINK 6363 24 GHz Band

Table 37 MINI-LINK 6363 24

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
41L		24250.00	24450.00	200.00	25050.00	25250.00	200.00	ANSI
41H		25050.00	25250.00	200.00	24250.00	24450.00	200.00	ANSI

Sub-band 4xL/H (Duplex 800 MHz) is valid for CS 10, 20, 30, 40, and 50 MHz.

3.2.4.12 MINI-LINK 6363 26 GHz Band

Table 38 MINI-LINK 6363 26

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
01L		24549.00	25165.00	616.00	25557.00	26173.00	616.00	ETSI
01H		25557.00	26173.00	616.00	24549.00	25165.00	616.00	ETSI
02L		24883.25	25473.00	589.75	25891.25	26481.00	589.75	ETSI
02H		25891.25	26481.00	589.75	24883.25	25473.00	589.75	ETSI

Sub-band 0xL/H (Duplex 1008 MHz) is valid for CS 7, 14, 28, 56, and 112 MHz.

3.2.4.13 MINI-LINK 6363 28 GHz Band

Table 39 MINI-LINK 6363 28

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
01L		27548.50	27996.50	448.00	28556.50	29004.50	448.00	ETSI
01H		28556.50	29004.50	448.00	27548.50	27996.50	448.00	ETSI
02L		27996.50	28444.50	448.00	29004.50	29452.50	448.00	ETSI
02H		29004.50	29452.50	448.00	27996.50	28444.50	448.00	ETSI
11L		27500.00	27701.00	201.00	27925.00	28150.00	225.00	ANSI
11H		27925.00	28150.00	225.00	27500.00	27701.00	201.00	ANSI
12L		27700.00	27925.00	225.00	28121.00	28350.00	229.00	ANSI
12H		28121.00	28350.00	229.00	27700.00	27925.00	225.00	ANSI

Sub-band 0xL/H (Duplex 1008 MHz) is valid for CS 7, 14, 28, 56, and 112 MHz.

Sub-band 1xL/H (Duplex 420 and 450 MHz) is valid for CS 10, 20, 30, 40, and 50 MHz.

3.2.4.14 MINI-LINK 6363 32 GHz Band

Table 40 MINI-LINK 6363 32

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
11L		31815.00	32207.00	392.00	32627.00	33019.00	392.00	ETSI/ANSI
11H		32627.00	33019.00	392.00	31815.00	32207.00	392.00	ETSI/ANSI
13L		32207.00	32599.00	392.00	33019.00	33411.00	392.00	ETSI/ANSI
13H		33019.00	33411.00	392.00	32207.00	32599.00	392.00	ETSI/ANSI

Sub-band 1xL/H (Duplex 812 MHz) is valid for CS 7, 14, 28, 56, and 112 MHz.

3.2.4.15 MINI-LINK 6363 38 GHz Band

Table 41 MINI-LINK 6363 38; MINI-LINK 6363/2 38

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
11L		37058.00	37619.75	561.75	38318.00	38879.75	561.75	ETSI
11H		38318.00	38879.75	561.75	37058.00	37619.75	561.75	ETSI
12L		37618.00	38179.75	561.75	38878.00	39439.75	561.75	ETSI
12H		38878.00	39439.75	561.75	37618.00	38179.75	561.75	ETSI
31L		38600.00	38800.00	200.00	39300.00	39500.00	200.00	ANSI
31H		39300.00	39500.00	200.00	38600.00	38800.00	200.00	ANSI
32L		38770.00	38970.00	200.00	39470.00	39670.00	200.00	ANSI
32H		39470.00	39670.00	200.00	38770.00	38970.00	200.00	ANSI
33L		38930.00	39130.00	200.00	39630.00	39830.00	200.00	ANSI
33H		39630.00	39830.00	200.00	38930.00	39130.00	200.00	ANSI
34L		39100.00	39300.00	200.00	39800.00	40000.00	200.00	ANSI
34H		39800.00	40000.00	200.00	39100.00	39300.00	200.00	ANSI

Sub-band 1xL/H (Duplex 1260 MHz) is valid for CS 7, 14, 28, 56, and 112 MHz.

Sub-band 3xL/H (Duplex 700 MHz) is valid for CS 10, 20, 30, 40, and 50 MHz.

3.2.4.16 MINI-LINK 6363 42 GHz Band

Table 42 MINI-LINK 6363 42

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
01L		40522.00	41054.00	532.00	42022.00	42554.00	532.00	ETSI
05H		42022.00	42554.00	532.00	40522.00	41054.00	532.00	ETSI
02L		40998.00	41502.00	504.00	42498.00	43002.00	504.00	ETSI
02H		42498.00	43002.00	504.00	40998.00	41502.00	504.00	ETSI
03L		41446.00	41964.00	518.00	42946.00	43464.00	518.00	ETSI
03H		42946.00	43464.00	518.00	41446.00	41964.00	518.00	ETSI

Sub-band 0xL/H (Duplex 1500 MHz) is valid for CS 7, 14, 28, 56, and 112 MHz.

3.2.4.17 MINI-LINK 6363 80 GHz Band

Table 43 MINI-LINK 6363 80

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
01L		71125.00	72250.00	1125.00	81125.00	82250.00	1125.00	ETSI/ANSI
01H		81125.00	82250.00	1125.00	71125.00	72250.00	1125.00	ETSI/ANSI
02L		72250.00	73500.00	1250.00	82250.00	83500.00	1250.00	ETSI/ANSI
02H		82250.00	83500.00	1250.00	72250.00	73500.00	1250.00	ETSI/ANSI
03L		73500.00	74750.00	1250.00	83500.00	84750.00	1250.00	ETSI/ANSI
03H		83500.00	84750.00	1250.00	73500.00	74750.00	1250.00	ETSI/ANSI
04L		74750.00	75875.00	1125.00	84750.00	85875.00	1125.00	ETSI/ANSI
04H		84750.00	85875.00	1125.00	74750.00	75875.00	1125.00	ETSI/ANSI

Sub-band 0xL/H is valid for CS 62.5 and 125 MHz (with CS 56, 60, 80, and 112 MHz physical modes).

3.2.5 MINI-LINK 6364

3.2.5.1 MINI-LINK 6364 13 GHz Band

Table 44 MINI-LINK 6364 13

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
W01L		12751.00	12975.00	224.00	13017.00	13241.00	224.00	ETSI

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
W01H		13017.00	13241.00	224.00	12751.00	12975.00	224.00	ETSI

Sub-band W01L/H (Duplex 266 MHz) is valid for 7, 14, 28, 56, and 112 MHz.

3.2.5.2 MINI-LINK 6364 15 GHz Band

Table 45 MINI-LINK 6364 15

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
W01L		14397.75	14933.50	535.75	14865.00	15375.00	510.00	ETSI
W01H		14865.00	15375.00	510.00	14397.75	14933.50	535.75	ETSI

Sub-band W01L/H (Duplex 420, 470, 490, and 735 MHz) is valid for CS 7, 14, 28, 56, and 112 MHz.

3.2.5.3 MINI-LINK 6364 18 GHz Band

Table 46 MINI-LINK 6364 18

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
W01L		17700.00	18690.00	990.00	18590.00	19700.00	1110.00	ETSI
W01H		18590.00	19700.00	1110.00	17700.00	18690.00	990.00	ETSI

Sub-band W01L/H (Duplex 1010 and 1560 MHz) are valid for CS 7, 13.75/14, 27.5/28, 55/56, 110/112, and 220/224 MHz.

3.2.6 MINI-LINK 6365

3.2.6.1 MINI-LINK 6365 6 GHz Band

Table 47 MINI-LINK 6365 6

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
A41L		5925.000	6020.250	95.250	6175.000	6277.000	102.000	ETSI/ANSI
A41H		6175.000	6277.000	102.000	5925.000	6020.250	95.250	ETSI/ANSI
A42L		6005.000	6110.250	105.250	6255.000	6362.300	107.300	ETSI/ANSI

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
A42H		6255.000	6362.300	107.300	6005.000	6110.250	105.250	ETSI/ANSI
A43L		6078.500	6175.000	96.500	6330.550	6425.300	94.750	ETSI/ANSI
A43H		6330.550	6425.300	94.750	6078.500	6175.000	96.500	ETSI/ANSI
A44L		5983.000	6055.000	72.000	6241.350	6305.000	63.650	ETSI/ANSI
A44H		6241.350	6305.000	63.650	5983.000	6055.000	72.000	ETSI/ANSI
B21L		6430.000	6565.000	135.000	6770.000	6905.000	135.000	ETSI/ANSI
B21H		6770.000	6905.000	135.000	6430.000	6565.000	135.000	ETSI/ANSI
B22L		6540.000	6700.000	160.000	6880.000	7040.000	160.000	ETSI/ANSI
B22H		6880.000	7040.000	160.000	6540.000	6700.000	160.000	ETSI/ANSI
B23L		6620.000	6780.000	160.000	6960.000	7120.000	160.000	ETSI/ANSI
B23H		6960.000	7120.000	160.000	6620.000	6780.000	160.000	ETSI/ANSI
B24L		6500.000	6620.000	120.000	6840.000	6960.000	120.000	ETSI/ANSI
B24H		6840.000	6960.000	120.000	6500.000	6620.000	120.000	ETSI/ANSI
B31L		6540.000	6610.000	70.000	6700.000	6770.000	70.000	ANSI
B31H		6700.000	6770.000	70.000	6540.000	6610.000	70.000	ANSI
B32L		6597.500	6670.000	72.500	6740.000	6830.000	90.000	ANSI
B32H		6740.000	6830.000	90.000	6597.500	6670.000	72.500	ANSI
B33L		6640.000	6710.000	70.000	6800.000	6870.000	70.000	ANSI
B33H		6800.000	6870.000	70.000	6640.000	6710.000	70.000	ANSI

Sub-band A4xL/H (Duplex 240, 252.04, 260, and 266 MHz) is valid for CS 7, 14, 28/29.65, and 56/59.3 MHz.

Sub-band A4xL/H (Duplex 252.04 MHz) are valid for CS 9.88/10, 20, 29.65/30, 40, 50, and 59.3/60 MHz.

Sub-band B2xL/H (Duplex 340 MHz) is valid for CS 7, 14, 28/30, 40, 56/60 and 80 MHz.

Sub-band B2xL/H (Duplex 340 MHz) is valid for CS 10, 20, 30, 40, 50 and 60 MHz.

Sub-band B3xL/H (Duplex 160 and 170 MHz) are valid for CS 10, 20, 30, 40, 50 and 60 MHz.

3.2.6.2 MINI-LINK 6365 7/8 GHz Band

Table 48 MINI-LINK 6365 7/8

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
A01L		7107.000	7219.000	112.000	7303.000	7415.000	112.000	ETSI
A01H		7303.000	7415.000	112.000	7107.000	7219.000	112.000	ETSI

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
A03L		7163.000	7247.000	84.000	7359.000	7443.000	84.000	ETSI
A03H		7359.000	7443.000	84.000	7163.000	7247.000	84.000	ETSI
A11L		7414.000	7515.000	101.00	7575.000	7673.000	98.00	ETSI/ANSI
A11H		7575.000	7673.000	98.00	7414.000	7515.000	101.00	ETSI/ANSI
A13L		7470.000	7568.000	98.00	7635.000	7729.000	94.00	ETSI/ANSI
A13H		7635.000	7729.000	94.00	7470.000	7568.000	98.00	ETSI/ANSI
A21L		7426.500	7569.750	143.250	7671.500	7814.750	143.250	ETSI
A21H		7671.500	7814.750	143.250	7426.500	7569.750	143.250	ETSI
A23L		7510.250	7653.750	143.500	7755.250	7898.750	143.500	ETSI
A23H		7755.250	7898.750	143.500	7510.250	7653.750	143.500	ETSI
A31L		7107.000	7212.000	105.00	7275.000	7373.000	98.00	ETSI/ANSI
A31H		7275.000	7373.000	98.00	7107.000	7212.000	105.00	ETSI/ANSI
A33L		7163.000	7268.000	105.00	7331.000	7429.000	98.00	ETSI/ANSI
A33H		7331.000	7429.000	98.00	7163.000	7268.000	105.00	ETSI/ANSI
A81L		7249.50	7337.00	87.50	7410.50	7498.00	87.50	ETSI
A81H		7410.50	7498.00	87.50	7249.50	7337.00	87.50	ETSI
A83L		7305.50	7393.00	87.50	7466.50	7554.00	87.50	ETSI
A83H		7466.50	7554.00	87.50	7305.50	7393.00	87.50	ETSI
A94L		7527.000	7583.000	56.00	7695.000	7751.000	56.00	ETSI/ANSI
A94H		7695.000	7751.000	56.00	7527.000	7583.000	56.00	ETSI/ANSI
B01L		7744.750	7793.750	49.000	7893.000	7942.250	49.250	ETSI
B01H		7893.000	7942.250	49.250	7744.750	7793.750	49.000	ETSI
B02L		7779.750	7828.750	49.000	7928.000	7977.250	49.250	ETSI
B02H		7928.000	7977.250	49.250	7779.750	7828.750	49.000	ETSI
B11L		7718.050	7851.500	133.450	8016.500	8162.800	146.300	ETSI/ANSI
B11H		8016.500	8162.800	146.300	7718.050	7851.500	133.450	ETSI/ANSI
B12L		7777.000	7911.000	134.000	8073.000	8222.250	149.250	ETSI/ANSI
B12H		8073.000	8222.250	149.250	7777.000	7911.000	134.000	ETSI/ANSI
B14L		7835.000	7985.000	150.000	8128.500	8281.500	153.000	ETSI/ANSI
B14H		8128.500	8281.500	153.000	7835.000	7985.000	150.000	ETSI/ANSI
B21L		8279.000	8328.000	49.000	8398.000	8450.500	52.500	ETSI
B21H		8398.000	8450.500	52.500	8279.000	8328.000	49.000	ETSI
B23L		8324.500	8377.000	52.500	8447.000	8496.000	49.000	ETSI
B23H		8447.000	8496.000	49.000	8324.500	8377.000	52.500	ETSI
B42L		8307.000	8349.000	42.000	8426.000	8475.000	49.000	ETSI
B42H		8426.000	8475.000	49.000	8307.000	8349.000	42.000	ETSI
B61L		7905.000	8024.000	119.000	8171.000	8327.000	156.000	ETSI
B61H		8171.000	8327.000	156.000	7905.000	8024.000	119.000	ETSI
B62L		7961.000	8073.000	112.000	8234.000	8383.000	149.000	ETSI
B62H		8234.000	8383.000	149.000	7961.000	8073.000	112.000	ETSI
B63L		7989.000	8136.000	147.000	8290.000	8439.000	149.000	ETSI
B63H		8290.000	8439.000	149.000	7989.000	8136.000	147.000	ETSI
B64L		8073.000	8185.000	112.000	8383.000	8495.000	112.000	ETSI

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
B64H		8383.000	8495.000	112.000	8073.000	8185.000	112.000	ETSI
B91L		8050.000	8134.000	84.000	8258.000	8342.000	84.000	ETSI
B91H		8258.000	8342.000	84.000	8050.000	8134.000	84.000	ETSI
B92L		8106.000	8190.000	84.000	8314.000	8398.000	84.000	ETSI
B92H		8314.000	8398.000	84.000	8106.000	8190.000	84.000	ETSI
B93L		8162.000	8246.000	84.000	8370.000	8454.000	84.000	ETSI
B93H		8370.000	8454.000	84.000	8162.000	8246.000	84.000	ETSI

Sub-band A0xL/H (Duplex 196 MHz) and A2xL/H (Duplex 245 MHz) are valid for CS 7, 14, 28, 56, and 112 MHz.

Sub-band A1xL/H (Duplex 154 and 161 MHz) and A3xL/H and A8xL/H (Duplex 161 MHz) are valid for CS 7, 14, 28, and 56 MHz.

Sub-band A1xL/H (Duplex 150 MHz), A3xL/H (Duplex 175 MHz), and A9xL/H (Duplex 150 MHz) are valid for CS 10, 20, 30, 40, and 50 MHz.

Sub-band B2xL/H and B4xL/H (Duplex 119 and 126 MHz) are valid for CS 7, 14, and 28/29.65 MHz.

Sub-band B1xL/H (Duplex 283.5, 310, and 311.32 MHz) and B6xL/H (Duplex 266 and 310 MHz) are valid for CS 7, 14, 28/29.65, 56/59.3, and 112 MHz.

Sub-band B9xL/H (Duplex 208 MHz) is valid for CS 7, 14, 28/29.65, and 56/59.3 MHz.

Sub-band B1xL/H (Duplex 300 MHz) is valid for CS 10, 20, 30, 40, and 50 MHz.

Sub-band B1xL/H (Duplex 310 MHz) is valid for CS 10, 20, and 40 MHz.

3.2.6.3 MINI-LINK 6365 10/11 GHz Band

Table 49 MINI-LINK 6365 10/11

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
A21L		10500.50	10528.50	28.00	10591.50	10619.50	28.00	ETSI
A21H		10591.50	10619.50	28.00	10500.50	10528.50	28.00	ETSI
A22L		10528.50	10556.50	28.00	10619.50	10647.50	28.00	ETSI
A22H		10619.50	10647.50	28.00	10528.50	10556.50	28.00	ETSI
A23L		10556.50	10584.50	28.00	10647.50	10675.50	28.00	ETSI
A23H		10647.50	10675.50	28.00	10556.50	10584.50	28.00	ETSI
A41L		10308.00	10420.00	112.00	10476.00	10588.00	112.00	ETSI
A41H		10476.00	10588.00	112.00	10308.00	10420.00	112.00	ETSI
A71L		10000.00	10189.00	189.00	10350.00	10539.00	189.00	ETSI

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
A71H		10350.00	10539.00	189.00	10000.00	10189.00	189.00	ETSI
A72L		10125.00	10330.00	205.00	10475.00	10680.00	205.00	ETSI
A72H		10475.00	10680.00	205.00	10125.00	10330.00	205.00	ETSI
B01L		10695.00	10905.00	210.00	11185.00	11425.00	240.00	ETSI/ANSI
B01H		11185.00	11425.00	240.00	10695.00	10905.00	210.00	ETSI/ANSI
B02L		10793.00	11075.00	282.00	11311.00	11605.00	294.00	ETSI/ANSI
B02H		11311.00	11605.00	294.00	10793.00	11075.00	282.00	ETSI/ANSI
B03L		10989.00	11200.00	211.00	11479.00	11705.00	226.00	ETSI/ANSI
B03H		11479.00	11705.00	226.00	10989.00	11200.00	211.00	ETSI/ANSI

Sub-band A2xL/H (Duplex 91 MHz) is valid for CS 7, 14, and 28 MHz.

Sub-band A4xL/H (Duplex 168 MHz) and 7xL/H (Duplex 350 MHz) are valid for CS 7, 14, 28, 56, and 112 MHz.

Sub-band B0xL/H (Duplex 490 and 530 MHz) is valid for CS 7, 14, 28, 40, 56, 80, and 112 MHz.

Sub-band B0xL/H (Duplex 520 MHz) is valid for CS 60 MHz.

Sub-band B0xL/H (Duplex 490 and 500 MHz) is valid for CS 10, 20, 30, 40, 60, and 80 MHz.

3.2.6.4 MINI-LINK 6365 13 GHz Band

Table 50 MINI-LINK 6365 13

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
A01L		12751.00	12919.00	168.00	13017.00	13185.00	168.00	ETSI/ANSI
A01H		13017.00	13185.00	168.00	12751.00	12919.00	168.00	ETSI/ANSI
A03L		12863.00	12975.00	112.00	13125.00	13241.00	116.00	ETSI/ANSI
A03H		13125.00	13241.00	116.00	12863.00	12975.00	112.00	ETSI/ANSI

Note: FCC part 101.147(p)(2) frequency range begins at 12700.00 MHz.

Sub-band A0xL/H (Duplex 266 MHz) is valid for 7, 14, 28, 56, and 112 MHz.

Sub-band A0xL/H (Duplex 225 and 266 MHz) is valid for CS 10, 20, 30, 40, and 50 MHz.

3.2.6.5 MINI-LINK 6365 15 GHz Band

Table 51 MINI-LINK 6365 15

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
A01L		14495.75	14781.00	285.25	15055.75	15348.00	292.25	ETSI
A01H		15055.75	15348.00	292.25	14495.75	14781.00	285.25	ETSI
A11L		14397.75	14669.00	271.25	14865.00	15135.00	270.00	ETSI/ANSI
A11H		14865.00	15135.00	270.00	14397.75	14669.00	271.25	ETSI/ANSI
A12L		14501.00	14739.00	238.00	14919.25	15229.00	309.75	ETSI/ANSI
A12H		14919.25	15229.00	309.75	14501.00	14739.00	238.00	ETSI/ANSI
A13L		14700.00	14933.50	233.50	15117.00	15350.00	233.00	ETSI/ANSI
A13H		15117.00	15350.00	233.00	14700.00	14933.50	233.50	ETSI/ANSI
A21L		14698.75	14828.50	129.75	15006.75	15145.00	138.25	ETSI
A21H		15006.75	15145.00	138.25	14698.75	14828.50	129.75	ETSI

Sub-band A0xL/H and A1xL/H (Duplex 420, 490, and 728 MHz) is valid for CS 7, 14, 28, 56, and 112 MHz.

Sub-band A1xL/H (Duplex 475 MHz) is valid for CS 10, 20, 30, 40, 50, 60, and 80 MHz.

3.2.6.6 MINI-LINK 6365 18 GHz Band

Table 52 MINI-LINK 6365 18

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
A11L		17700.00	18236.50	536.50	18590.00	19260.00	670.00	ETSI/ANSI
A11H		18590.00	19260.00	670.00	17700.00	18236.50	536.50	ETSI/ANSI
A13L		18002.25	18690.00	687.75	19081.25	19700.00	618.75	ETSI/ANSI
A13H		19081.25	19700.00	618.75	18002.25	18690.00	687.75	ETSI/ANSI
A21L		18580.00	18745.00	165.00	18920.00	19085.00	165.00	ETSI/ANSI
A21H		18920.00	19085.00	165.00	18580.00	18745.00	165.00	ETSI/ANSI
A23L		18730.00	18920.00	190.00	19070.00	19260.00	190.00	ETSI/ANSI
A23H		19070.00	19260.00	190.00	18730.00	18920.00	190.00	ETSI/ANSI
A31L		17700.00	18140.00	440.00	19260.00	19700.00	440.00	ETSI/ANSI
A31H		19260.00	19700.00	440.00	17700.00	18140.00	440.00	ETSI/ANSI

Sub-band A1xL/H (Duplex 1010 MHz) and A3xL/H (Duplex 1560 MHz) are valid for CS 7, 13.75/14, 27.5/28, 55/56, 110/112, and 220/224 MHz.

Sub-band A1xL/H (Duplex 1160 MHz) and A3xL/H (Duplex 1560MHz) are valid for CS 10, 20, 30, 40, 50, 60, and 80 MHz.

3.2.6.7 MINI-LINK 6365 23 GHz Band

Table 53 MINI-LINK 6365 23

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
A01L		21200.00	21896.00	696.00	22400.00	23128.00	728.00	ETSI/ANSI
A01H		22400.00	23128.00	728.00	21200.00	21896.00	696.00	ETSI/ANSI
A02L		21784.00	22600.00	816.00	22996.00	23600.00	604.00	ETSI/ANSI
A02H		22996.00	23600.00	604.00	21784.00	22600.00	816.00	ETSI/ANSI

Sub-band A0xL/H (Duplex 1008, 1050, 1200, and 1232 MHz) is valid for CS 7, 14, 28, 56, 112, and 224 MHz.

Sub-band A0xL/H (Duplex 1200 and 1232 MHz) is valid for CS 10, 20, 30, 40, 50, 60, and 80 MHz.

3.2.6.8 MINI-LINK 6365 32 GHz Band

Table 54 MINI-LINK 6365 32

Sub-band / Duplex (MHz)		Transmitter frequency information			Receiver frequency information			Telecom Standard
		Tx Lower edge	Tx Upper edge	Tx Bw (MHz)	Rx Lower edge	Rx Upper edge	Rx Bw (MHz)	
A11L		31815.00	32319.00	504.00	32627.00	33131.00	504.00	ETSI/ANSI
A11H		32627.00	33131.00	504.00	31815.00	32319.00	504.00	ETSI/ANSI
A13L		32095.00	32599.00	504.00	32907.00	33411.00	504.00	ETSI/ANSI
A13H		32907.00	33411.00	504.00	32095.00	32599.00	504.00	ETSI/ANSI

Sub-band A1xL/H (Duplex 812 MHz) is valid for CS 7, 14, 28, 56, 112, and 224 MHz

3.3 Carrier Aggregation

Carrier Aggregation (CA) is supported by the following MMUs and radio units:

- MMU 1002
- MMU 1004
- MINI-LINK 6364
- MINI-LINK 6365

Detailed information about physical modes supported with CA can be found in Supported Physical Modes on page 138.

3.3.1 Maximum frequency separation

The figures below shows the maximum allowed frequency separation, in terms of empty channels, for the supported channels in Carrier Aggregation. Both channels must be within the radio sub-band.

ETSI	2x 28 MHz	≤2 empty gaps	
	2x 56 MHz	Adjacent	

Figure 1 Maximum frequency separation for MINI-LINK 6364 13, 15

ETSI	2x 28 MHz	≤4 empty gaps	
	2x 56 MHz	≤1 empty gaps	
	2x 112 MHz	Adjacent	

Figure 2 Maximum frequency separation for MINI-LINK 6364 18

ETSI	2x 28 MHz	≤4 empty gaps	
	2x 40 MHz	≤2 empty gaps	
	2x 56 MHz	≤1 empty gaps	
	2x 80 MHz	Adjacent	
	2x 112 MHz	Adjacent	
ANSI	2x 30 MHz	≤4 empty gaps	
	2x 40 MHz	≤2 empty gaps	
	2x 50 MHz	≤2 empty gaps	
	2x 60 MHz	≤1 empty gaps	
	2x 80 MHz	Adjacent	

Figure 3 Maximum frequency separation for MINI-LINK 6365

3.3.2 Configuration limitations

— The channel separation (CS) must be the same on the two channels

— The duplex configuration must be the same on the two channels

— Both sides of the link (near end and far end) must be configured with Carrier Aggregation

3.4 Transmitter Performance

See Supported Physical Modes on page 138 for supported physical modes and traffic capacity.

3.4.1 Frequency Tolerance

The transmitter carrier frequency does not deviate more than ±10 ppm from nominal frequency. During the first year of operation the deviation is less than ±3 ppm.

3.4.2 Output Power Tolerance

Table 55 Output Power Tolerance

Radio Type	Output Power Tolerance (dB)	Output Power Tolerance at Pmax (dB)
RAU2 X	±2	-1/+2
MINI-LINK 6363 6-42	±2	-1/+2
MINI-LINK 6363 80	±2.5	±2
MINI-LINK 6363/2	±2	±2
MINI-LINK 6364	±2	-1/+2
MINI-LINK 6365	±2	-1/+2
MINI-LINK 6364 CA mode	±2	±2
MINI-LINK 6365 CA mode	±2	±2

3.4.3 Output Power for QAM, Static Modulation

MINI-LINK 6363, MINI-LINK 6364, and MINI-LINK 6365 Output power including high power license (+4 dB).

Note that 8192QAM is not supported as static modulation.

The output power is set in 1 dB steps in ranges:

Table 56 RAU2 X Output Power for QAM

Radio Type	Pmax (dBm) versus Modulation (QAM)										P_{min} (dBm)
	4	16	32	64	128	256	512	1024	2048	4096	
RAU2 X 5 HP	30	30	30	30	30	29	29	28	27[1]	26[1]	-10
RAU2 X 6L	29	27	27	26	26	25	25	24	23[1]	22[1]	-10
RAU2 X 6L HP	30	30	30	30	30	29	29	28	27[1]	26[1]	-10
RAU2 X 6U	29	27	27	26	26	25	25	24	23[1]	22[1]	-10
RAU2 X 6U HP	30	30	30	30	30	29	29	28	27[1]	26[1]	-10
RAU2 X 7	29	27	27	26	26	25	25	24	23[1]	22[1]	-10
RAU2 X 7 HP	30	30	30	30	30	29	29	28	27[1]	26[1]	-10
RAU2 X 8	29	27	27	26	26	25	25	24	23[1]	22[1]	-10
RAU2 X 8 HP	30	30	30	30	30	29	29	28	27[1]	26[1]	-10
RAU2 X 10[2]	28	26	26	25	25	24	24	23	22[1]	21[1]	-10
RAU2 X 10 HP[2]	30	30	30	29	29	28	28	27	26[1]	25[1]	-10
RAU2 X 11	28	26	26	25	25	24	24	23	22[1]	21[1]	-10
RAU2 X 11 HP	30	30	30	29	29	28	28	27	26[1]	25[1]	-10
RAU2 X 13	24	22	22	21	21	20	20	19	18[1]	17[1]	-10
RAU2 X 13 HP	28	26	26	25	25	24	24	23	22[1]	21[1]	-10
RAU2 X 15	24	22	22	21	21	20	20	19	18[1]	17[1]	-10
RAU2 X 15 HP	28	26	26	25	25	24	24	23	22[1]	21[1]	-10
RAU2 X 18	21	19	19	18	18	17	17	16	15[1]	14[1]	-10
RAU2 X 18 HP	26	24	24	23	23	22	22	21	20[1]	19[1]	-10
RAU2 X 23	21	19	19	18	18	17	17	16	15[1]	14[1]	-10
RAU2 X 23 HP	25	23	23	22	22	21	21	20	19[1]	18[1]	-10
RAU2 X 24	23	21	21	20	20	19	19	18	17[1]	16[1]	-10
RAU2 X 26	23	21	21	20	20	19	19	18	17[1]	16[1]	-10
RAU2 X 28	22	20	20	19	19	18	18	17	16[1]	15[1]	-10
RAU2 X 32	20	18	18	17	17	16	16	15	14[1]	13[1]	-10
RAU2 X 38	20	18	18	17	17	16	16	15	14[1]	13[1]	-10
RAU2 X 42	18	16	16	15	15	14	14	13	12[1]	11[1]	-10

(1) With RAU2 X R-state ≥ R6A
(2) With duplex ≤ 168 MHz; Pmax 1 dB lower

Table 57 MINI-LINK 6363 and MINI-LINK 6363/2 Output Power for QAM

Radio Type	Pmax (dBm) versus Modulation (QAM)										P_{min} (dBm)
	4	16	32	64	128	256	512	1024	2048	4096	
MINI-LINK 6363 6L	30	30	30	30	30	29	29	28	28	27	-10

Radio Type	Pmax (dBm) versus Modulation (QAM)										P_{min} (dBm)
	4	16	32	64	128	256	512	1024	2048	4096	
MINI-LINK 6363 6U	30	30	30	30	30	29	29	28	28	27	-10
MINI-LINK 6363 7	30	30	30	30	30	29	29	28	28	27	-10
MINI-LINK 6363 8	30	30	30	29	29	28	28	27	27	27	-10
MINI-LINK 6363 10	30	30	30	29	29	28	28	27	27	26	-10
MINI-LINK 6363 11	30	30	30	29	29	28	28	27	27	26	-10
MINI-LINK 6363 13	27	26	26	25	25	24	24	23	23	22	-10
MINI-LINK 6363 15	27	26	26	25	25	24	24	23	23	22	-10
MINI-LINK 6363 18	25	24	24	23	23	22	22	21	21	20	-10
MINI-LINK 6363 23	24	23	23	22	22	21	21	20	20	19	-10
MINI-LINK 6363 24	25	24	24	23	23	22	22	21	21	20	-10
MINI-LINK 6363 26	25	24	24	23	23	22	22	21	21	20	-10
MINI-LINK 6363 28	23	22	22	21	21	20	20	19	19	18	-10
MINI-LINK 6363 32	22	21	21	20	20	19	19	18	18	17	-10
MINI-LINK 6363 38	22	21	21	20	20	19	19	18	18	17	-10
MINI-LINK 6363 42	18	17	17	16	16	15	15	14	14	13	-10
MINI-LINK 6363 80	17	16	16	15	15	14	14	13	13(1)	12(1)	-10
MINI-LINK 6363/2 13	19	18	18	17	17	16	16	15	15	14	-10
MINI-LINK 6363/2 15	19	18	18	17	17	16	16	15	15	14	-10
MINI-LINK 6363/2 18	17	16	16	15	15	14	14	13	13	12	-10
MINI-LINK 6363/2 23	16	15	15	14	14	13	13	12	12	11	-10
MINI-LINK 6363/2 38	14	13	13	12	12	11	11	10	10	9	-10

(1) Modulations ≥2048QAM is not supported. Specified values shall be used as Pmax reference in Admod.

Table 58 MINI-LINK 6364 Output Power for QAM

Radio Type	Pmax (dBm) versus Modulation (QAM)										P_{min} (dBm)
	4	16	32	64	128	256	512	1024	2048	4096	
MINI-LINK 6364 13	27	26	26	25	25	24	24	23	23	22	-10
MINI-LINK 6364 15	27	26	26	25	25	24	24	23	23	22	-10
MINI-LINK 6364 18(1)	26	25	25	24	24	23	23	22	22	21	-10
MINI-LINK 6364 13 CA mode	21	20	20	19	19	18	18	17	17	16	+3
MINI-LINK 6364 15 CA mode	21	20	20	19	19	18	18	17	17	16	+3
MINI-LINK 6364 18 CA mode	19	18	18	18	18	17	17	16	16	15	0

(1) For CS 220 MHz, maximum output power is 3 dB lower and P_{min} is 3 dBm.

Table 59 MINI-LINK 6365 Output Power for QAM

Radio Type	Pmax (dBm) versus Modulation (QAM)										P_{min} (dBm)
	4	16	32	64	128	256	512	1024	2048	4096	
MINI-LINK 6365 6	30	30	30	30	30	29	29	28	28	27	-10
MINI-LINK 6365 7/8	30	30	30	30	30	29	29	28	28	27	-10

Radio Type	Pmax (dBm) versus Modulation (QAM)										P_{min} (dBm)
	4	16	32	64	128	256	512	1024	2048	4096	
MINI-LINK 6365 10/11	30	30	30	29	29	28	28	27	27	26	-10
MINI-LINK 6365 13	27	26	26	25	25	24	24	23	23	22	-10
MINI-LINK 6365 15	27	26	26	25	25	24	24	23	23	22	-10
MINI-LINK 6365 18(1)	26	25	25	24	24	23	23	22	22	21	-10
MINI-LINK 6365 23(2)	25	24	24	23	23	22	22	21	21	20	-10
MINI-LINK 6365 32(2)	22	21	21	20	20	19	19	18	18	17	-10
MINI-LINK 6365 6 CA mode	21	21	21	21	21	21	21	21	21	21	+3
MINI-LINK 6365 7/8 CA mode	21	21	21	21	21	21	21	21	21	21	+3
MINI-LINK 6365 10/11 CA mode	21	21	21	21	21	21	21	21	21	20	+3
MINI-LINK 6365 13 CA mode	21	20	20	19	19	18	18	17	17	16	+3
MINI-LINK 6365 15 CA mode	21	20	20	19	19	18	18	17	17	16	+3
MINI-LINK 6365 18 CA mode	19	19	19	18	18	17	17	16	16	15	0
MINI-LINK 6365 23 CA mode	19	18	18	17	17	16	16	15	15	14	-5
MINI-LINK 6365 32 CA mode	16	15	15	14	14	13	13	12	12	11	-5

(1) For CS 220 MHz, maximum output power is 3 dB lower and P_{min} is 3 dBm.

(2) For CS 224 MHz, maximum output power is 3 dB lower and P_{min} is -2 dBm.

3.4.4 Output Power for QAM, Adaptive Modulation

3.4.4.1 ETSI

Maximum output power values (Pmax) are according to Output Power for QAM, Static Modulation on page 116 with the following limitations:

MINI-LINK 6363, MINI-LINK 6364, MINI-LINK 6365, MINI-LINK 6363/2, and RAU2 X Max output power is relative to 4096QAM (dB).

Table 60 Output Power for QAM, Adaptive Modulation - ETSI

RSEC Modulation	Pmax (dBm) relative 4096QAM			P_{min} (dBm)
	2	4L 4H	5LB/5HB 6LB/6HB 7B	
4QAM	5	4	3	-10
16QAM	4	4	3	-10
32QAM	4	4	3	-10
64QAM	3	3	3	-10
128QAM	3	3	3	-10
256QAM	2	2	2	-10

RSEC Modulation	Pmax (dBm) relative 4096QAM			P_{min} (dBm)
	2	4L 4H	5LB/5HB 6LB/6HB 7B	
512QAM	1	1	1	-10
1024QAM	1	1	1	-10
2048QAM	0	0	0	-10
4096QAM	0/-1(1)	0/-1(1)	0/-1(1)	-10
8192QAM	-1	-1	-1	0

(1) Offset is -1 dB for MINI-LINK 6363 R-state ≥ R4A, MINI-LINK 6364, and MINI-LINK 6365 for frame ID 358 and 359. That is frame IDs with support for 8192QAM.

3.4.4.2 ANSI

Maximum output power values (Pmax) are according to Output Power for QAM, Static Modulation on page 116 with the following limitations:

MINI-LINK 6363, MINI-LINK 6365, MINI-LINK 6363/2 and RAU2 X/Xu Max output power is relative to 4096QAM (dB).

Table 61 Output Power for QAM, Adaptive Modulation - ANSI

Modulation	Pmax (dBm) relative 4096QAM	Pmin (dBm)
4QAM	5	-10
16QAM	4	-10
32QAM	4	-10
64QAM	3	-10
128QAM	3	-10
256QAM	2	-10
512QAM	1	-10
1024QAM	1	-10
2048QAM	0	-10
4096QAM	0/-1(1)	-10
8192QAM	-1	0

(1) Offset is -1 dB for MINI-LINK 6363 R-state ≥ R4A, MINI-LINK 6364, and MINI-LINK 6365 for frame ID 364 and 365. That is frame IDs with support for 8192QAM.

3.5 Emission Designator

3.5.1 Adaptive Modulation

Table 62 Adaptive Modulation - ETSI

Channel separation (MHz)	Emission Designator
7	6M30D7W
14/13.75	12M8D7W
28/27.5	25M6D7W
40	36M0D7W
56/55/62.5	51M5D7W
80	74M0D7W
112/110/125	103MD7W
224/220	212MD7W

Table 63 Adaptive Modulation - ANSI

Channel separation (MHz)	Emission Designator
10	8M75D7W
20	18M1D7W
28	25M6D7W
30	27M4D7W
40	36M8D7W
50	46M1D7W
56	51M5D7W
60	55M4D7W
80	74MD7W
112	103MD7W

3.5.2 Transmitter off

RF output power in Tx off mode: -50 dBm.

3.5.3 Transmitter Spurious Levels for QAM

Transmitter spurious levels are below:

— -50 dBm in the band 30 MHz-21.2 GHz
    - -50 dBm in any 100 kHz band from 30 MHz to 1 GHz
    - -50 dBm in any 1 MHz band from 1 GHz to 21.2 GHz
— -30 dBm in the band 21.2 – 110 GHz
    - -30 dBm in any 100 kHz band for channel separation ≤7 MHz, and in the range from ± 2.5 times of channel separation to ± 56 MHz
    - -30 dBm in any 1 MHz band in all other cases

The above excludes a frequency band ± 2.5 times the channel separation from the nominal transmitter frequency.

3.6 Receiver Performance

See Supported Physical Modes on page 138 for supported physical modes, traffic capacity, and XPIC or MIMO support.

3.6.1 Threshold Definition

Guarantee Guaranteed value for all temperatures.

Planning Ericsson recommendation for path planning.

Planning threshold = 1 dB below guarantee threshold.

Planning threshold is used by path planning programs.

Typical Average value in room temperature.

3.6.2 Detection Performance for QAM, Adaptive Modulation

3.6.2.1 Detection Performance, ETSI

The receiver complies with detection performance listed below.

Data for standard Frame ID's (256, 257, 258, 259, 260, 261, 303, 1256, 1257, 1258, 1259, 1260, 1261, and 1303) can be found in revision BT of this document.

Table 64 Detection Performance, ETSI

The detection performance is applicable to the following radio types:

— RAU2 X 5, 6L, 6U, 7, 8, 10 (Dupl. > 168MHz), 11, 13, 15

- MINI-LINK 6363 6L, 6U, 7, 8, 10 (Dupl. > 168MHz), 11, 13, 15
- MINI-LINK 6363/2 13, 15
- MINI-LINK 6364 13, 15
- MINI-LINK 6365 6, 7/8, 10/11, 13, 15

CS (Frame ID)	Modulation	BER 10^{-6} threshold (dBm)
		Typ.
7 (356 1356)	4QAM S	-95.5
	4QAM	-94
	16QAM S	-89
	16QAM	-87.5
	32QAM	-84
	64QAM	-81.5
	128QAM	-78.5
	256QAM	-75.5
	512QAM	-71
	1024QAM	-68
13.75 14 (357 1357)	4QAM S	-92.5
	4QAM	-91
	16QAM S	-86
	16 QAM	-84.5
	32QAM	-81
	64QAM	-78.5
	128QAM	-75.5
	256QAM	-72.5
	512QAM	-68
	1024QAM	-65
	2048QAM	-63
	2048QAM L	-61.5
27.5 28 (358 1358)	4QAM S	-89.5
	4QAM	-88
	16QAM S	-83
	16 QAM	-81.5
	32QAM	-78
	64QAM	-75.5
	128QAM	-72.5
	256QAM	-69.5
	512QAM	-65
	1024QAM	-62
	2048QAM	-60
	2048QAM L	-58.5
	4096QAM	-56.5
	4096QAM L	-55
	8192QAM	-52

CS (Frame ID)	Modulation	BER 10^{-6} threshold (dBm)
		Typ.
27.5 28 (2358)	4QAM S	-89
	4QAM	-87.5
	16QAM S	-82.5
	16 QAM	-81
	32QAM	-77.5
	64QAM	-75
	128QAM	-72
	256QAM	-69
	512QAM	-66
	512QAM L	-64.5
40 (359 1359)	4QAM S	-88
	4QAM	-86.5
	16QAM S	-81.5
	16 QAM	-80
	32QAM	-76.5
	64QAM	-74
	128QAM	-71
	256QAM	-68
	512QAM	-63.5
	1024QAM	-60.5
	2048QAM	-58.5
	2048QAM L	-57
	4096QAM	-55
	4096QAM L	-53.5
	8192 QAM	-50.5
55 56 62.5 (360 1360)	4QAM S	-86.5
	4QAM	-85
	16QAM S	-80
	16 QAM	-78.5
	32QAM	-75
	64QAM	-72.5
	128QAM	-69.5
	256QAM	-66.5
	512QAM	-62
	1024QAM	-59
	2048 QAM	-57
	2048 QAM L	-55.5
	4096QAM	-53.5
	4096QAM L	-52

CS (Frame ID)	Modulation	BER 10^{-6} threshold (dBm)
		Typ.
55 56 (2360)	4QAM S	-86
	4QAM	-84.5
	16QAM S	-79.5
	16 QAM	-78
	32QAM	-74.5
	64QAM	-72
	128QAM	-69
	256QAM	-66
	512QAM	-63
	512QAM L	-61.5
	1024QAM	-60
	1024QAM L	-58.5
80 (403 1403)	4QAM S	-85
	4QAM	-83.5
	16QAM S	-78.5
	16 QAM	-77
	32QAM	-73.5
	64QAM	-71
	128QAM	-68
	256QAM	-65
	512QAM	-60.5
	1024QAM	-57.5
	2048QAM	-55.5
	2048QAM L	-54
	4096QAM	-52
	4096QAM L	-49.5
110 112 125 (361 1361)	4QAM S	-83.5
	4QAM	-82
	16QAM S	-77
	16 QAM	-75.5
	32QAM	-72
	64QAM	-69.5
	128QAM	-66.5
	256QAM	-63.5
	512QAM	-59
	1024QAM	-56
	2048QAM	-54
	2048QAM L	-52.5
	4096QAM	-50.5

CS (Frame ID)	Modulation	BER 10^{-6} threshold (dBm)
		Typ.
220[1] 224[2] (404)	4QAM S	-80.5
	4QAM	-79
	16QAM S	-74
	16 QAM	-72.5
	32QAM	-69
	64QAM	-66.5
	128QAM	-63.5
	256QAM	-60.5
	512QAM	-56
	1024QAM	-53

(1) Carrier Aggregation with 2x110 (Frame ID 404) is used in CS 220 but thresholds are related to total input power.

(2) Carrier Aggregation with 2x112 (Frame ID 404) is used in CS 224 but thresholds are related to total input power.

Table 65 Detection Performance, ETSI

The detection performance is applicable to the following radio types:

- RAU2 X 10[1] (Dupl. ≤ 168 MHz), 18, 23, 26
- MINI-LINK 6363 10[1] (Dupl. ≤ 168 MHz), 18, 23, 26
- MINI-LINK 6363/2 18, 23
- MINI-LINK 6364 18
- MINI-LINK 6365 18, 23

CS (Frame ID)	Modulation	BER 10^{-6} threshold (dBm)
		Typ.
All	All	Add 1 dB to figures in Table 64 above.

(1) Max CS = 28 MHz

Table 66 DetectionPerformance, ETSI

The detection performance is applicable to the following radio types:

- RAU2 X 28, 32, 38
- MINI-LINK 6363 28, 32, 38
- MINI-LINK 6363/2 38

- MINI-LINK 6365 32

CS (Frame ID)	Modulation	BER 10^{-6} threshold (dBm)
		Typ.
All	All	Add 2 dB to figures in Table 64 above.

Table 67 Detection Performance, ETSI

The detection performance is applicable to the following radio types:

- RAU2 X 42
- MINI-LINK 6363 42

CS (Frame ID)	Modulation	BER 10^{-6} threshold (dBm)
		Typ.
All	All	Add 3 dB to figures in Table 64 above.

Table 68 Detection Performance, ETSI

The detection performance is applicable to the following radio type:

- MINI-LINK 6363 80

CS (Frame ID)	Modulation	BER 10^{-6} threshold (dBm)
		Typ.
55 56 62.5 (360 1360)	All	Add 7 dB to figures in Table 64 above
110 112 125 (361 1361)	All	Add 7 dB to figures in Table 64 above

3.6.2.2 Detection Performance, ANSI

The receiver complies with detection performance listed below.

Data for standard Frame ID's (262, 263, 264, 265, 266, 267, 268, 1262, 1263, 1264, 1265, 1266, 1267, and 1268) can be found in revision BT of this document.

Table 69 Detection Performance, ANSI

The detection performance is applicable to the following radio types:

- RAU2 X 5, 6L, 6U, 7, 8, 10 (Dupl. > 168MHz), 11, 13, 15

- MINI-LINK 6363 6L, 6U, 7, 8, 10 (Dupl. > 168MHz), 11, 13, 15
- MINI-LINK 6363/2 13, 15
- MINI-LINK 6365 6, 7/8, 10/11, 13, 15

CS (Frame ID)	Modulation	BER 10^{-6} threshold (dBm)
		Typ.
10 (362 1362)	4QAM S	-94
	4QAM	-92.5
	16QAM S	-87.5
	16QAM	-86
	32QAM	-82.5
	64QAM	-80
	128QAM	-77
	256QAM	-74
	512QAM	-69.5
	1024QAM	-66.5
20 (363 1363)	4QAM S	-91
	4QAM	-89.5
	16QAM S	-84.5
	16 QAM	-83
	32QAM	-79.5
	64QAM	-77
	128QAM	-74
	256QAM	-71
	512QAM	-66.5
	1024QAM	-63.5
	2048QAM	-61.5
	2048QAM L	-60
28 (371 1371)	4QAM S	-89.5
	4QAM	-88
	16QAM S	-83
	16 QAM	-81.5
	32QAM	-78
	64QAM	-75.5
	128QAM	-72.5
	256QAM	-69.5
	512QAM	-65
	1024QAM	-62
	2048QAM	-60
	2048QAM L	-58.5
	4096QAM	-56.5
	4096QAM L	-55

CS (Frame ID)	Modulation	BER 10^{-6} threshold (dBm)
		Typ.
30 (364 1364)	4QAM S	-89.5
	4QAM	-88
	16QAM S	-83
	16 QAM	-81.5
	32QAM	-78
	64QAM	-75.5
	128QAM	-72.5
	256QAM	-69.5
	512QAM	-65
	1024QAM	-62
	2048QAM	-60
	2048QAM L	-58.5
	4096QAM	-56.5
	4096QAM L	-55
	8192QAM	-52
30 (2364)	4QAM S	-89
	4QAM	-87.5
	16QAM S	-82.5
	16 QAM	-81
	32QAM	-77.5
	64QAM	-75
	128QAM	-72
	256QAM	-69
	512QAM	-66
	512QAM L	-64.5
40 (365 1365)	4QAM S	-88
	4QAM	-86.5
	16QAM S	-81.5
	16 QAM	-80
	32QAM	-76.5
	64QAM	-74
	128QAM	-71
	256QAM	-68
	512QAM	-63.5
	1024QAM	-60.5
	2048QAM	-58.5
	2048QAM L	-57
	4096QAM	-55
	4096QAM L	-53.5
	8192QAM	-50.5

CS (Frame ID)	Modulation	BER 10^{-6} threshold (dBm)
		Typ.
40 (2365)	4QAM S	-87.5
	4QAM	-86
	16QAM S	-81
	16 QAM	-79.5
	32QAM	-76
	64QAM	-73.5
	128QAM	-70.5
	256QAM	-67.5
	512QAM	-64.5
	512QAM L	-63
50 (366 1366)	4QAM S	-87
	4QAM	-85.5
	16QAM S	-80.5
	16 QAM	-79
	32QAM	-75.5
	64QAM	-73
	128QAM	-70
	256QAM	-67
	512QAM	-62.5
	1024QAM	-59.5
	2048QAM	-57.5
	2048QAM L	-56
	4096QAM	-54
	4096QAM L	-52.5
56 (373 1373)	4QAM S	-86.5
	4QAM	-85
	16QAM S	-80
	16 QAM	-78.5
	32QAM	-75
	64QAM	-72.5
	128QAM	-69.5
	256QAM	-66.5
	512QAM	-62
	1024QAM	-59
	2048 QAM	-57
	2048 QAM L	-55.5
	4096QAM	-53.5
	4096QAM L	-52

CS (Frame ID)	Modulation	BER 10^{-6} threshold (dBm)
		Typ.
60 (367 1367)	4QAM S	-86
	4QAM	-84.5
	16QAM S	-79.5
	16 QAM	-78
	32QAM	-74.5
	64QAM	-72
	128QAM	-69
	256QAM	-66
	512QAM	-61.5
	1024QAM	-58.5
	2048QAM	-56.5
	2048QAM L	-55
	4096QAM	-53
	4096QAM L	-51.5
80 (368 1368)	4QAM S	-85
	4QAM	-83.5
	16QAM S	-78.5
	16 QAM	-77
	32QAM	-73.5
	64QAM	-71
	128QAM	-68
	256QAM	-65
	512QAM	-60.5
	1024QAM	-57.5
	2048QAM	-55.5
	2048QAM L	-54
	4096QAM	-52
	4096QAM L	-49.5
112 (374 1374)	4QAM S	-83.5
	4QAM	-82
	16QAM S	-77
	16 QAM	-75.5
	32QAM	-72
	64QAM	-69.5
	128QAM	-66.5
	256QAM	-63.5
	512QAM	-59
	1024QAM	-56
	2048QAM	-54
	2048QAM L	-52.5
	4096QAM	-50.5

Table 70 Detection Performance, ANSI

The detection performance is applicable to the following radio types:

- RAU2 X 10[(1)] (Dupl. ≤ 168 MHz), 18, 23, 24
- MINI-LINK 10[(1)](Dupl. ≤ 168 MHz), 18, 23, 26
- MINI-LINK 6363/2 18, 23
- MINI-LINK 6365 18, 23

CS (Frame ID)	Modulation	BER 10^{-6} threshold (dBm)
		Typ.
All	All	Add 1 dB to figures in Table 69 above

(1) Max CS=20 MHz

Table 71 Detection Performance, ANSI

The detection performance is applicable to the following radio types:

- RAU2 X 28, 32, 38
- MINI-LINK 6363 28, 32, 38
- MINI-LINK 6363/2 38
- MINI-LINK 6365 32

CS (Frame ID)	Modulation	BER 10^{-6} threshold (dBm)
		Typ.
All	All	Add 2 dB to figures in Table 69 above

Table 72 Detection Performance, ANSI

The detection performance is applicable to the following radio types:

- RAU2 X 42
- MINI-LINK 6363 42

CS (Frame ID)	Modulation	BER 10^{-6} threshold (dBm)
		Typ.
All	All	Add 3 dB to figures in Table 69 above

Table 73 Detection Performance, ANSI

The detection performance is applicable to the following radio type:

— MINI-LINK 6363 80

CS (Frame ID)	Modulation	BER 10^{-6} threshold (dBm)
		Typ.
60 (367)	All	Add 7 dB to figures in Table 69 above
80 (368)		

3.6.3 Switching Level, Adaptive Modulation

Typical switching levels between different physical modes are at Residual BER thresholds and are based on a measurement of the SNIR in the received signal.

For path planning usage this RBER level for down switching can be approximated to 4 dB above the typical 10^{-6} BER threshold for the currently used modulation scheme and CS.

For Frame ID 2358, 2360, 2364 and 2365 the RBER level for down switching can be approximated to 6 dB above the typical 10^{-6} BER threshold for the currently used modulation scheme and CS.

3.6.4 Co-channel Interference for QAM

The limits of co-channel interference are as given in table below, giving C/I values for 1 dB and 3 dB increase of the 10^{-6} BER thresholds, specified in chapter Detection Performance for QAM, Adaptive Modulation on page 122.

Table 74 Limits of Co-channel Interference

Co-channel	C/I values for 1 dB & 3 dB	
Modulation	1dB	3dB
4QAM S	13	9
4QAM	14	10
16QAM S	19	15
16QAM	21	17
32QAM	24	20
64QAM	27	23
128QAM	30	26
256QAM	34	30
512QAM	36.5	32.5
1024QAM	40	36
2048QAM	42	38

Co-channel	C/I values for 1 dB & 3 dB	
Modulation	1dB	3dB
2048QAM L	43	39
4096QAM	45	41
4096QAM L	48	44
8192QAM	51	47

3.6.5 Adjacent Channel Interference for QAM

3.6.5.1 ETSI

The limits of first adjacent-channel interference are as given in table below, giving C/I values for 1 dB and 3 dB increase of the 10^{-6} BER thresholds, specified in Detection Performance, ETSI on page 122.

Table 75 RAU2 X and MINI-LINK 6363

Modulation	RSEC	C/I values for 1 dB and 3 dB	
		1 dB	3dB
4QAM	2	-16	-20
	4L/4H	-20	-24
	5B/6B	-23	-27
16QAM	2/4L/4H	-20	-24
	5B/6B	-23	-27
32QAM	2/4L/4H	-20	-24
	5B/6B	-23	-27
64QAM	2/4L/4H	-20	-24
	5B/6B	-22	-26
128QAM	All	-19	-23
256QAM	All	-16	-20
512QAM	All	-14	-14
1024QAM	All	-10(1)	-10
2048QAM	All	-7	-7
4096QAM	All	1	1
8192 QAM	All	1	1

(1) Add 4 dB for MINI-LINK 6363 80GHz.

Table 76 MINI-LINK 6364 and MINI-LINK 6365

Modulation	RSEC	C/I values for 1 dB and 3 dB	
		1 dB	3dB
4QAM	2	-16	-20
	4L/4H	-20	-24
	5B/6B	-23	-27
16QAM	2/4L/4H	-20	-24
	5B/6B	-23	-27
32QAM	2/4L/4H	-20	-24
	5B/6B	-23	-27
64QAM	2/4L/4H	-20	-24
	5B/6B	-22	-26
128QAM	All	-19	-23
256QAM	All	-16	-20
512QAM	All	-12	-16
1024QAM	All	-8	-12
2048QAM	All	-6	-10
4096QAM	All	-3	-7
8192QAM	All	0	-4

3.6.5.2 ANSI

The limits of first adjacent-channel interference are as given in table below, giving C/I values for 1 dB and 3 dB increase of the 10^{-6} BER thresholds, specified in Detection Performance, ANSI on page 127.

Table 77 RAU2 X and MINI-LINK 6363

Modulation	C/I values for 1 dB and 3 dB	
	1 dB	3dB
4QAM	-23	-27
16QAM	-23	-27
32QAM	-23	-27
64QAM	-23	-27
128QAM	-19	-23
256QAM	-16	-20
512QAM	-14	-14

Modulation	C/I values for 1 dB and 3 dB	
	1 dB	3dB
1024QAM	-10	-10
2048QAM	-7	-7
4096QAM	1	1
8192QAM	1	1

Table 78 MINI-LINK 6365

Modulation	C/I values for 1 dB and 3 dB	
	1 dB	3dB
4QAM	-23	-27
16QAM	-23	-27
32QAM	-23	-27
64QAM	-23	-27
128QAM	-19	-23
256QAM	-16	-20
512QAM	-12	-16
1024QAM	-8	-12
2048QAM	-6	-10
4096QAM	-3	-7
8192QAM	0	-4

3.6.6 CW Interference

For a receiver operating at the specified 10^{-6} threshold, the introduction of a CW interferer with C/I of -30 dB at any frequency up to 80 GHz, excluding a frequency 2.5 times the channel separation on either side of the wanted frequency, does not result in a BER greater than 10^{-5}.

3.6.7 Signature for QAM

Reference delay: 6.3 ns.

Minimum phase and non-minimum phase.

The table below states the Notch depth (dB) at BER 10^{-6}, as specified in Detection Performance for QAM, Adaptive Modulation on page 122.

The Notch depth of BER 10^{-3} is 1 dB higher than the BER 10^{-6} value.

Table 79 ETSI/ANSI

BER 10-6 Notch depth (dB)													
Modulation	Signature width (MHz)												
	7.5	11	15	22	31	33	44	55	61	66	88	123	246
	Channel Separation (MHz)												
	7	10	14	20	28	30	40	50	56	60	80	112	224
4QAM	40	40	40	40	40	40	40	40	40	40	40	40	40
16QAM	40	40	40	40	40	40	38	36	35	34	32	29	29
32QAM	40	40	40	38	36	34	32	30	29	28	26	23	23
64QAM	40	40	39	36	34	32	30	28	27	26	24	20	20
128QAM	40	40	37	34	31	30	28	26	25	24	22	18	18
256QAM	40	38	35	32	30	28	26	24	23	22	20	17	17
512QAM	40	37	34	31	29	27	25	23	22	21	19	16	16
1024QAM	39	36	33	30	27	26	24	22	21	20	18	15	15
2048QAM			32	29	26	25	23	21	20	19	17	14	14
4096QAM					25	23	21	19	18	17	15	13	13
8192QAM					21	20	18						

When the notch frequency is swept across the defined bandwidth with a rate up to 100 MHz/s, the notch depth for BER=10^{-6} will not degrade by more than 1 dB with respect to the values listed in the table above.

3.6.8 Receiver Overload

Maximum input level where normal operation is guaranteed: -20 dBm

3.6.9 Receiver Resistibility

Maximum tolerable input power without permanent degradation is 0 dBm.

3.6.10 Received Signal Indication

3.6.10.1 For Path Acceptance

When measured in steady state condition, an RF-input level measure is given with an accuracy of:

— for RF-input levels -30 dBm to -60 dBm: ± 2 dB

— for RF-input levels -60 dBm to -80 dBm: ± 3 dB

3.6.10.2 For Antenna Alignment

This detector presents on an external standard voltmeter a voltage corresponding to RF-input level.

The RF input level referred to the antenna port in dBm can be calculated from the measured voltage using the following formula: Rfin(dBm) = 40*measured_voltage(V) – 120

When measured at the Antenna Alignment Port, the accuracy of the measured voltage converted to RF-input level using the formula above shall be:

— for RF-input levels -30 dBm to -60 dBm: ± 2.5 dB

— for RF-input levels -60 dBm to -80 dBm: ± 3 dB

3.7 Supported Physical Modes

A physical mode is supported when both the radio unit and the MMU supports it. For readability purpose, the radio unit never show a higher physical mode than what is supported by the most capable MMU.

3.7.1 Radio Units

3.7.1.1 MINI-LINK RAU2 X HW

MINI-LINK RAU2 X HW supports physical modes according to the tables below. The physical modes supported are denoted by an X. See Radio Frequencies on page 74 for supported frequencies and channel separation for a specific RAU2 X.

Table 80 Supported Physical Modes ETSI

Telecom Standard: ETSI					
Products: RAU2 X 5-42 ≥ R6A					
CS / Mod.	7 MHz	14/13.75 MHz	28/27.5 MHz	40 MHz	56/55 MHz
4QAM S	X(1)	X(1)	X(1)	X(1)	X(1)
4QAM	X(1)	X(1)	X(1)	X(1)	X(1)
16QAM S	X(1)	X(1)	X(1)	X(1)	X(1)
16QAM	X(1)	X(1)	X(1)	X(1)	X(1)
32QAM	X(1)	X(1)	X(1)	X(1)	X(1)
64QAM	X(1)	X(1)	X(1)	X(1)	X(1)
128QAM	X(1)	X(1)	X(1)	X(1)	X(1)
256QAM	X(1)	X(1)	X(1)	X(1)	X(1)

Telecom Standard: ETSI					
Products: RAU2 X 5-42 ≥ R6A					
CS Mod.	7 MHz	14/13.75 MHz	28/27.5 MHz	40 MHz	56/55 MHz
512QAM	X(1)	X(1)	X(1)	X(1)	X(1)
1024QAM	X	X(1)	X(1)	X(1)	X(1)
2048QAM		X(2)	X(1)(2)	X(1)(2)	X(1)(2)
2048QAM L		X(2)	X(1)(2)	X(1)(2)	X(1)(2)
4096QAM			X(1)(2)	X(1)(2)	X(1)(2)
4096QAM L			X(1)(2)	X(1)(2)	X(1)(2)

(1) Supports XPIC
(2) Requires RAU SW CXP 901 2878 R5A or later

Table 81 Supported Physical Modes ETSI

Telecom Standard: ETSI					
Products: RAU2 X 5–11 < R6A, RAU2 X 13&15 ≥ R3A & < R6A, RAU2 X 18&23 ≥ R5A & < R6A					
CS Mod.	7 MHz	14/13.75 MHz	28/27.5 MHz	40 MHz	56/55 MHz
4QAM S	X(1)	X(1)	X(1)	X(1)	X(1)
4QAM	X(1)	X(1)	X(1)	X(1)	X(1)
16QAM S	X(1)	X(1)	X(1)	X(1)	X(1)
16QAM	X(1)	X(1)	X(1)	X(1)	X(1)
32QAM	X(1)	X(1)	X(1)	X(1)	X(1)
64QAM	X(1)	X(1)	X(1)	X(1)	X(1)
128QAM	X(1)	X(1)	X(1)	X(1)	X(1)
256QAM	X(1)	X(1)	X(1)	X(1)	X(1)
512QAM	X	X(1)	X(1)	X(1)	X(1)
1024QAM		X(2)	X(1)(2)	X(1)(2)	X(1)(2)

(1) Supports XPIC
(2) Requires RAU SW CXP 901 2878 R-state R4D or later (RAU2 X/Xu 10/11/18/23 R-state R1A use RAU SW CXC 113 500 and hence cannot support 1024 QAM.)

Table 82 Supported Physical Modes ETSI

Telecom Standard: ETSI					
Products: RAU2 X 13&15 < R3A, RAU2 X 18&23 < R5A, RAU2 X 26–42 < R6A					
CS Mod.	7 MHz	14/13.75 MHz	28/27.5 MHz	40 MHz	56/55 MHz
4QAM S	X(1)	X(1)	X(1)	X(1)	X(1)
4QAM	X(1)	X(1)	X(1)	X(1)	X(1)

Telecom Standard: ETSI					
Products: RAU2 X 13&15 < R3A, RAU2 X 18&23 < R5A, RAU2 X 26–42 < R6A					
CS / Mod.	7 MHz	14/13.75 MHz	28/27.5 MHz	40 MHz	56/55 MHz
16QAM S	X(1)	X(1)	X(1)	X(1)	X(1)
16QAM	X(1)	X(1)	X(1)	X(1)	X(1)
32QAM	X(1)	X(1)	X(1)	X(1)	X(1)
64QAM	X	X(1)	X(1)	X(1)	X(1)
128QAM	X	X	X(1)	X(1)	X(1)
256QAM	X	X	X(1)	X(1)	X(1)
512QAM	X	X	X	X	X(1)
1024QAM		X(2)	X(2)	X(2)	X(2)

(1) Supports XPIC
(2) Requires RAU SW CXP 901 2878 R-state R4D or later (RAU2 X/Xu 10/11/18/23 R-state R1A use RAU SW CXC 113 500 and hence cannot support 1024 QAM.)

Table 83 Supported Physical Modes ANSI

Telecom Standard: ANSI							
Products: RAU2 X 5-42 ≥ R6A							
CS / Mod.	10 MHz	20 MHz	28 MHz	30 MHz	40 MHz	50 MHz	56 MHz
4QAM S	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
4QAM	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
16QAM S	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
16QAM	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
32QAM	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
64QAM	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
128QAM	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
256QAM	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
512QAM	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
1024QAM	X	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
2048QAM		X(2)	X(1)(2)	X(1)(2)	X(1)(2)	X(1)(2)	X(1)(2)
2048QAM L		X(2)	X(1)(2)	X(1)(2)	X(1)(2)	X(1)(2)	X(1)(2)
4096QAM			X(1)(2)	X(1)(2)	X(1)(2)	X(1)(2)	X(1)(2)
4096QAM L			X(1)(2)	X(1)(2)	X(1)(2)	X(1)(2)	X(1)(2)

(1) Supports XPIC
(2) Requires RAU SW CXP 901 2878 R5A or later

Table 84 Supported Physical Modes ANSI

Telecom Standard: ANSI							
Products: RAU2 X 6L–11 < R6A, RAU2 X 13&15 ≥ R3A & < R6A, RAU2 X 18&23 ≥ R5A & < R6A							
CS / Mod.	10 MHz	20 MHz	28 MHz	30 MHz	40 MHz	50 MHz	56 MHz
4QAM S	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
4QAM	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
16QAM S	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
16QAM	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
32QAM	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
64QAM	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
128QAM	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
256QAM	X	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
512QAM	X	X	X(1)	X(1)	X(1)	X(1)	X(1)
1024QAM		X(2)	X(1)(2)	X(1)(2)	X(1)(2)	X(1)(2)	X(1)(2)

(1) Supports XPIC

(2) Requires RAU SW CXP 901 2878 R-state R4D or later (RAU2 X/Xu 10/11/18/23 R-state R1A use RAU SW CXC 113 500 and hence cannot support 1024 QAM.)

Table 85 Supported Physical Modes ANSI

Telecom Standard: ANSI							
Products: RAU2 X 13 & 15 < R3A, RAU2 X 18 & 23 < R5A, RAU2 X 24 – 38 < R6A							
CS / Mod.	10 MHz	20 MHz	28 MHz	30 MHz	40 MHz	50 MHz	56 MHz
4QAM S	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
4QAM	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
16QAM S	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
16QAM	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
32QAM	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
64QAM	X	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
128QAM	X	X	X(1)	X(1)	X(1)	X(1)	X(1)
256QAM	X	X	X(1)	X(1)	X(1)	X(1)	X(1)
512QAM	X	X	X	X	X	X(1)	X (1)
1024QAM		X(2)	X(2)	X(2)	X(2)	X(2)	X(2)

(1) Supports XPIC

(2) Requires RAU SW CXP 901 2878 R-state R4D or later (RAU2 X/Xu 10/11/18/23 R-state R1A use RAU SW CXC 113 500 and hence cannot support 1024 QAM.)

3.7.1.2 MINI-LINK 6363, MINI-LINK 6363/2 HW

MINI-LINK 6363 and MINI-LINK 6363/2 HW supports physical modes according to the tables below. The physical modes supported are denoted by an X, and M in those cases where only MIMO is supported. See Radio Frequencies on page 74 for supported frequencies and channel separations for a specific frequency band.

Table 86 Supported Physical Modes ETSI

Telecom Standard: ETSI							
Products: MINI-LINK 6363 6L- 42 < R4A, MINI-LINK 6363/2 13 – 38 ≥ R1A							
CS / Mod.	7 MHz	14/13.75 MHz	28/27.5 MHz	40 MHz	56/ 55/62.5 MHz	80 MHz	112/ 110/125 MHz
4QAM S	X(1)	X(1)	X(1)(2)	X(1)	X(1)(2)	X(1)	X(1)
4QAM	X(1)	X(1)	X(1)(2)	X(1)	X(1)(2)	X(1)	X(1)
16QAM S	X(1)	X(1)	X(1)(2)	X(1)	X(1)(2)	X(1)	X(1)
16QAM	X(1)	X(1)	X(1)(2)	X(1)	X(1)(2)	X(1)	X(1)
32QAM	X(1)	X(1)	X(1)(2)	X(1)	X(1)(2)	X(1)	X(1)
64QAM	X(1)	X(1)	X(1)(2)	X(1)	X(1)(2)	X(1)	X(1)
128QAM	X(1)	X(1)	X(1)(2)	X(1)	X(1)(2)	X(1)	X(1)
256QAM	X(1)	X(1)	X(1)(2)	X(1)	X(1)(2)	X(1)	X(1)
512QAM	X(1)	X(1)	X(1)(2)	X(1)	X(1)(2)	X(1)	X(1)
512QAM L			M(2)		M(2)		
1024QAM	X	X(1)	X(1)	X(1)	X(1)(2)	X(1)	X(1)
1024QAM L					M(2)		
2048QAM		X	X(1)	X(1)	X(1)	X(1)	X(1)
2048QAM L		X	X(1)	X(1)	X(1)	X(1)	X(1)
4096QAM			X(1)	X(1)	X(1)	X	X
4096QAM L			X(1)	X(1)	X(1)	X	
8192QAM							

(1) Supports XPIC

(2) Supports MIMO

Table 87 Supported Physical Modes ETSI

Telecom Standard: ETSI							
Products: MINI-LINK 6363 10 – 26 ≥ R4A, MINI-LINK 6363 38 ≥ R4A							
CS / Mod.	7 MHz	14/13.75 MHz	28/27.5 MHz	40 MHz	56/ 55/62.5 MHz	80 MHz	112/ 110/125 MHz
4QAM S	X(1)	X(1)	X(1)(2)	X(1)	X(1)(2)	X(1)	X(1)

Telecom Standard: ETSI							
Products: MINI-LINK 6363 10 – 26 ≥ R4A, MINI-LINK 6363 38 ≥ R4A							
CS / Mod.	7 MHz	14/13.75 MHz	28/27.5 MHz	40 MHz	56/ 55/62.5 MHz	80 MHz	112/ 110/125 MHz
4QAM	X(1)	X(1)	X(1)(2)	X(1)	X(1)(2)	X(1)	X(1)
16QAM S	X(1)	X(1)	X(1)(2)	X(1)	X(1)(2)	X(1)	X(1)
16QAM	X(1)	X(1)	X(1)(2)	X(1)	X(1)(2)	X(1)	X(1)
32QAM	X(1)	X(1)	X(1)(2)	X(1)	X(1)(2)	X(1)	X(1)
64QAM	X(1)	X(1)	X(1)(2)	X(1)	X(1)(2)	X(1)	X(1)
128QAM	X(1)	X(1)	X(1)(2)	X(1)	X(1)(2)	X(1)	X(1)
256QAM	X(1)	X(1)	X(1)(2)	X(1)	X(1)(2)	X(1)	X(1)
512QAM	X(1)	X(1)	X(1)(2)	X(1)	X(1)(2)	X(1)	X(1)
512QAM L			M(2)		M(2)		
1024QAM	X	X(1)	X(1)	X(1)	X(1)(2)	X(1)	X(1)
1024QAM L					M(2)		
2048QAM		X	X(1)	X(1)	X(1)	X(1)	X(1)
2048QAM L		X	X(1)	X(1)	X(1)	X(1)	X(1)
4096QAM			X(1)	X(1)	X(1)	X(1)	X(1)
4096QAM L			X(1)	X(1)	X(1)	X(1)	
8192QAM			X(3)	X(3)			

(1) Supports XPIC
(2) Supports MIMO
(3) Note that static modulation is not supported for 8192QAM

Table 88 Supported Physical Modes ETSI

Telecom Standard: ETSI							
Products: MINI-LINK 6363 80 ≥ R1A							
CS / Mod.	7 MHz	14/13.75 MHz	28/27.5 MHz	40 MHz	56/ 55/62.5 MHz	80 MHz	112/ 110/125 MHz
4QAM S					X(1)		X(1)
4QAM					X(1)		X(1)
16QAM S					X(1)		X(1)
16QAM					X(1)		X(1)
32QAM					X(1)		X(1)
64QAM					X(1)		X(1)
128QAM					X(1)		X(1)
256QAM					X(1)		X(1)
512QAM					X(1)		X(1)
1024QAM					X		X

Telecom Standard: ETSI							
Products: MINI-LINK 6363 80 ≥ R1A							
CS Mod.	7 MHz	14/13.75 MHz	28/27.5 MHz	40 MHz	56/ 55/62.5 MHz	80 MHz	112/ 110/125 MHz
2048QAM							
2048QAM L							
4096QAM							
4096QAM L							
8192QAM							

(1) Supports XPIC

Table 89 Supported Physical Modes ANSI

Telecom Standard: ANSI										
Products: MINI-LINK 6363 6L – 42 < R4A, MINI-LINK 6363/2 13 – 38 ≥ R1A										
CS Mod.	10 MHz	20 MHz	28 MHz	30 MHz	40 MHz	50 MHz	56 MHz	60 MHz	80 MHz	112 MHz
4QAM S	X(1)	X(1)	X(1)	X(1)(2)	X(1)(2)	X(1)	X(1)	X(1)	X(1)	X(1)
4QAM	X(1)	X(1)	X(1)	X(1)(2)	X(1)(2)	X(1)	X(1)	X(1)	X(1)	X(1)
16QAM S	X(1)	X(1)	X(1)	X(1)(2)	X(1)(2)	X(1)	X(1)	X(1)	X(1)	X(1)
16QAM	X(1)	X(1)	X(1)	X(1)(2)	X(1)(2)	X(1)	X(1)	X(1)	X(1)	X(1)
32QAM	X(1)	X(1)	X(1)	X(1)(2)	X(1)(2)	X(1)	X(1)	X(1)	X(1)	X(1)
64QAM	X(1)	X(1)	X(1)	X(1)(2)	X(1)(2)	X(1)	X(1)	X(1)	X(1)	X(1)
128QAM	X(1)	X(1)	X(1)	X(1)(2)	X(1)(2)	X(1)	X(1)	X(1)	X(1)	X(1)
256QAM	X(1)	X(1)	X(1)	X(1)(2)	X(1)(2)	X(1)	X(1)	X(1)	X(1)	X(1)
512QAM	X(1)	X(1)	X(1)	X(1)(2)	X(1)(2)	X(1)	X(1)	X(1)	X(1)	X(1)
512QAM L				M(2)	M(2)					
1024QAM	X	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
2048QAM		X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
2048QAM L		X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
4096QAM			X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X	X
4096QAM L			X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X	
8192QAM										

(1) Supports XPIC

(2) Supports MIMO

Table 90 Supported Physical Modes ANSI

Telecom Standard: ANSI										
Products: MINI-LINK 6363 10 – 26 ≥ R4A, MINI-LINK 6363 38 ≥ R4A										
CS Mod.	10 MHz	20 MHz	28 MHz	30 MHz	40 MHz	50 MHz	56 MHz	60 MHz	80 MHz	112 MHz
4QAM S	X[1]	X[1]	X[1]	X[1][2]	X[1][2]	X[1]	X[1]	X[1]	X[1]	X[1]
4QAM	X[1]	X[1]	X[1]	X[1][2]	X[1][2]	X[1]	X[1]	X[1]	X[1]	X[1]
16QAM S	X[1]	X[1]	X[1]	X[1][2]	X[1][2]	X[1]	X[1]	X[1]	X[1]	X[1]
16QAM	X[1]	X[1]	X[1]	X[1][2]	X[1][2]	X[1]	X[1]	X[1]	X[1]	X[1]
32QAM	X[1]	X[1]	X[1]	X[1][2]	X[1][2]	X[1]	X[1]	X[1]	X[1]	X[1]
64QAM	X[1]	X[1]	X[1]	X[1][2]	X[1][2]	X[1]	X[1]	X[1]	X[1]	X[1]
128QAM	X[1]	X[1]	X[1]	X[1][2]	X[1][2]	X[1]	X[1]	X[1]	X[1]	X[1]
256QAM	X[1]	X[1]	X[1]	X[1][2]	X[1][2]	X[1]	X[1]	X[1]	X[1]	X[1]
512QAM	X[1]	X[1]	X[1]	X[1][2]	X[1][2]	X[1]	X[1]	X[1]	X[1]	X[1]
512QAM L				M[2]	M[2]					
1024QAM	X	X[1]	X[1]	X[1]	X[1]	X[1]	X[1]	X[1]	X[1]	X[1]
2048QAM		X[1]	X[1]	X[1]	X[1]	X[1]	X[1]	X[1]	X[1]	X[1]
2048QAM L		X[1]	X[1]	X[1]	X[1]	X[1]	X[1]	X[1]	X[1]	X[1]
4096QAM			X[1]	X[1]	X[1]	X[1]	X[1]	X[1]	X[1]	X[1]
4096QAM L			X[1]	X[1]	X[1]	X[1]	X[1]	X[1]	X[1]	
8192QAM				X[3]	X[3]					

(1) Supports XPIC
(2) Supports MIMO
(3) Note that static modulation is not supported for 8192QAM

Table 91 Supported Physical Modes ANSI

Telecom Standard: ANSI										
Products MINI-LINK 6363 80 ≥ R1A										
CS Mod.	10 MHz	20 MHz	28 MHz	30 MHz	40 MHz	50 MHz	56 MHz	60 MHz	80 MHz	112 MHz
4QAM S							X[1]	X[1]	X[1]	X[1]
4QAM							X[1]	X[1]	X[1]	X[1]
16QAM S							X[1]	X[1]	X[1]	X[1]
16QAM							X[1]	X[1]	X[1]	X[1]
32QAM							X[1]	X[1]	X[1]	X[1]
64QAM							X[1]	X[1]	X[1]	X[1]
128QAM							X[1]	X[1]	X[1]	X[1]
256QAM							X[1]	X[1]	X[1]	X[1]

Telecom Standard: ANSI										
Products MINI-LINK 6363 80 ≥ R1A										
CS Mod.	10 MHz	20 MHz	28 MHz	30 MHz	40 MHz	50 MHz	56 MHz	60 MHz	80 MHz	112 MHz
512QAM							X[1]	X[1]	X[1]	X[1]
1024QAM							X	X	X	X
2048QAM										
2048QAM L										
4096QAM										
4096QAM L										
8192QAM										

(1) Supports XPIC

3.7.1.3 MINI-LINK 6364 HW

MINI-LINK 6364 HW supports physical modes according to the tables below. The physical modes supported are denoted by an X, and M in those cases where only MIMO is supported. See Radio Frequencies on page 74 for supported frequencies and channel separations for a specific frequency band.

Table 92 Supported Physical Modes ETSI

Telecom Standard: ETSI							
Products: MINI-LINK 6364 13, 15 ≥ R1A[1]							
CS Mod.	7 MHz	14/13.75 MHz	28/27.5 MHz	40 MHz	56/ 55 MHz	80 MHz	112/ 110 MHz
4QAM S	X[2]	X[2]	X[2][3]	X[2]	X[2][3]	X[2]	X[2]
4QAM	X[2]	X[2]	X[2][3]	X[2]	X[2][3]	X[2]	X[2]
16QAM S	X[2]	X[2]	X[2][3]	X[2]	X[2][3]	X[2]	X[2]
16QAM	X[2]	X[2]	X[2][3]	X[2]	X[2][3]	X[2]	X[2]
32QAM	X[2]	X[2]	X[2][3]	X[2]	X[2][3]	X[2]	X[2]
64QAM	X[2]	X[2]	X[2][3]	X[2]	X[2][3]	X[2]	X[2]
128QAM	X[2]	X[2]	X[2][3]	X[2]	X[2][3]	X[2]	X[2]
256QAM	X[2]	X[2]	X[2] [3]	X[2]	X[2][3]	X[2]	X[2]
512QAM	X[2]	X[2]	X[2] [3]	X[2]	X[2][3]	X[2]	X[2]
512QAM L			M[3]		M[3]		
1024QAM	X	X[2]	X[2]	X[2]	X[2][3]	X[2]	X[2]
1024QAM L					M[3]		
2048QAM		X	X[2]	X[2]	X[2]	X[2]	X[2]
2048QAM L		X	X[2]	X[2]	X[2]	X[2]	X[2]
4096QAM			X[2]	X[2]	X[2]	X[2]	X[2]
4096QAM L			X[2]	X[2]	X[2]	X[2]	

Telecom Standard: ETSI							
Products: MINI-LINK 6364 13, 15 ≥ R1A[1]							
CS / Mod.	7 MHz	14/13.75 MHz	28/27.5 MHz	40 MHz	56/ 55 MHz	80 MHz	112/ 110 MHz
8192QAM			X[4]	X[4]			

(1) The minimum modulation shall be set to 512 QAM or lower, for both static and adaptive modulation, when using MINI-LINK 6364 radio units. This is applicable for countries complying to ETSI EN 302 217.

(2) Supports XPIC

(3) Supports MIMO

(4) Note that static modulation is not supported for 8192QAM. See also (1).

Table 93 Supported Physical Modes ETSI

Telecom Standard: ETSI								
Products: MINI-LINK 6364 18 ≥ R1A[1]								
CS / Mod.	7 MHz	14/13.75 MHz	28/27.5 MHz	40 MHz	56/ 55 MHz	80 MHz	112/ 110 MHz	220[2] MHz
4QAM S	X [3]	X[3]	X[3][4]	X[3]	X[3][4]	X[3]	X[3]	X
4QAM	X[3]	X[3]	X[3][4]	X[3]	X[3][4]	X[3]	X[3]	X
16QAM S	X[3]	X[3]	X[3][4]	X[3]	X[3][4]	X[3]	X[3]	X
16QAM	X[3]	X[3]	X[3][4]	X[3]	X[3][4]	X[3]	X[3]	X
32QAM	X[3]	X[3]	X[3][4]	X[3]	X[3][4]	X[3]	X[3]	X
64QAM	X[3]	X[3]	X[3][4]	X[3]	X[3][4]	X[3]	X[3]	X
128QAM	X[3]	X[3]	X[3][4]	X[3]	X[3][4]	X[3]	X[3]	X
256QAM	X[3]	X[3]	X[3] [4]	X[3]	X[3][4]	X[3]	X[3]	X
512QAM	X[3]	X[3]	X[3] [4]	X[3]	X[3][4]	X[3]	X[3]	X
512QAM L			M[4]		M[4]			
1024QAM	X	X[3]	X[3]	X[3]	X[3][4]	X[3]	X[3]	X
1024QAM L					M[4]			
2048QAM		X	X[3]	X[3]	X[3]	X[3]	X[3]	
2048QAM L		X	X[3]	X[3]	X[3]	X[3]	X[3]	
4096QAM			X[3]	X[3]	X[3]	X[3]	X[3]	
4096QAM L			X[3]	X[3]	X[3]	X[3]		
8192QAM			X[5]	X[5]				

(1) The minimum modulation shall be set to 512 QAM or lower, for both static and adaptive modulation, when using MINI-LINK 6364 radio units. This is applicable for countries complying to ETSI EN 302 217.

(2) For CS 220 MHz, Carrier Aggregation with 2x110 MHz is configured (Frame ID 404).

(3) Supports XPIC

(4) Supports MIMO

(5) Note that static modulation is not supported for 8192QAM. See also (1).

Table 94 Supported Physical Modes ETSI with Carrier Aggregation

Telecom Standard: ETSI with Carrier Aggregation					
Products: MINI-LINK 6364 13, 15 ≥ R1A(1)					
CS / Mod.	28/27.5 MHz	40 MHz	56/ 55 MHz	80 MHz	112/ 110 MHz
4QAM S	X		X		
4QAM	X		X		
16QAM S	X		X		
16QAM	X		X		
32QAM	X		X		
64QAM	X		X		
128QAM	X		X		
256QAM	X		X		
512QAM	X		X		
1024QAM	X		X		
2048QAM	X		X		
2048QAM L	X				
4096QAM	X				
4096QAM L					
8192QAM					

(1) The minimum modulation shall be set to 512 QAM or lower, for both static and adaptive modulation, when using MINI-LINK 6364 radio units. This is applicable for countries complying to ETSI EN 302 217.

Table 95 Supported Physical Modes ETSI with Carrier Aggregation

Telecom Standard: ETSI with Carrier Aggregation					
Products: MINI-LINK 6364 18 ≥ R1A(1)					
CS / Mod.	28/27.5 MHz	40 MHz	56/ 55 MHz	80 MHz	112/ 110 MHz
4QAM S	X		X		X
4QAM	X		X		X
16QAM S	X		X		X
16QAM	X		X		X
32QAM	X		X		X
64QAM	X		X		X
128QAM	X		X		X
256QAM	X		X		X
512QAM	X		X		X
1024QAM	X		X		X
2048QAM	X		X		
2048QAM L	X				
4096QAM	X				
4096QAM L					

Telecom Standard: ETSI with Carrier Aggregation					
Products: MINI-LINK 6364 18 ≥ R1A[1]					
CS / Mod.	28/27.5 MHz	40 MHz	56/ 55 MHz	80 MHz	112/ 110 MHz
8192QAM					

(1) The minimum modulation shall be set to 512 QAM or lower, for both static and adaptive modulation, when using MINI-LINK 6364 radio units. This is applicable for countries complying to ETSI EN 302 217.

3.7.1.4 MINI-LINK 6365 HW

MINI-LINK 6365 HW supports physical modes according to the tables below. The physical modes supported are denoted by an X, and M in those cases where only MIMO is supported. See Radio Frequencies on page 74 for supported frequencies and channel separations for a specific frequency band.

Table 96 Supported Physical Modes ETSI

Telecom Standard: ETSI							
Products: MINI-LINK 6365 6 - 15 ≥ R1A[1]							
CS / Mod.	7 MHz	14/13.75 MHz	28/27.5 MHz	40 MHz	56/ 55 MHz	80 MHz	112/ 110 MHz
4QAM S	X[2]	X[2]	X[2][3]	X[2]	X[2][3]	X[2]	X[2]
4QAM	X[2]	X[2]	X[2][3]	X[2]	X[2][3]	X[2]	X[2]
16QAM S	X[2]	X[2]	X[2][3]	X[2]	X[2][3]	X[2]	X[2]
16QAM	X[2]	X[2]	X[2][3]	X[2]	X[2][3]	X[2]	X[2]
32QAM	X[2]	X[2]	X[2][3]	X[2]	X[2][3]	X[2]	X[2]
64QAM	X[2]	X[2]	X[2][3]	X[2]	X[2][3]	X[2]	X[2]
128QAM	X[2]	X[2]	X[2][3]	X[2]	X[2][3]	X[2]	X[2]
256QAM	X[2]	X[2]	X[2] [3]	X[2]	X[2][3]	X[2]	X[2]
512QAM	X[2]	X[2]	X[2] [3]	X[2]	X[2][3]	X[2]	X[2]
512QAM L			M[3]		M[3]		
1024QAM	X	X[2]	X[2]	X[2]	X[2][3]	X[2]	X[2]
1024QAM L					M[3]		
2048QAM		X	X[2]	X[2]	X[2]	X[2]	X[2]
2048QAM L		X	X[2]	X[2]	X[2]	X[2]	X[2]
4096QAM			X[2]	X[2]	X[2]	X[2]	X[2]
4096QAM L			X[2]	X[2]	X[2]	X[2]	
8192QAM			X[4]	X[4]			

(1) The minimum modulation shall be set to 512 QAM or lower, for both static and adaptive modulation, when using MINI-LINK 6365 radio units. This is applicable for countries complying to ETSI EN 302 217.

(2) Supports XPIC

(3) Supports MIMO

(4) Note that static modulation is not supported for 8192QAM. See also (1).

Table 97 Supported Physical Modes ETSI

Telecom Standard: ETSI								
Products: MINI-LINK 6365 18, 23, 32 ≥ R1A(1)								
CS Mod.	7 MHz	14/13.75 MHz	28/27.5 MHz	40 MHz	56/ 55 MHz	80 MHz	112/ 110 MHz	224/ 220(2) MHz
4QAM S	X(3)	X(3)	X(3)(4)	X(3)	X(3)(4)	X(3)	X(3)	X
4QAM	X(3)	X(3)	X(3)(4)	X(3)	X(3)(4)	X(3)	X(3)	X
16QAM S	X(3)	X(3)	X(3)(4)	X(3)	X(3)(4)	X(3)	X(3)	X
16QAM	X(3)	X(3)	X(3)(4)	X(3)	X(3)(4)	X(3)	X(3)	X
32QAM	X(3)	X(3)	X(3)(4)	X(3)	X(3)(4)	X(3)	X(3)	X
64QAM	X(3)	X(3)	X(3)(4)	X(3)	X(3)(4)	X(3)	X(3)	X
128QAM	X(3)	X(3)	X(3)(4)	X(3)	X(3)(4)	X(3)	X(3)	X
256QAM	X(3)	X(3)	X(3) (4)	X(3)	X(3)(4)	X(3)	X(3)	X
512QAM	X(3)	X(3)	X(3) (4)	X(3)	X(3)(4)	X(3)	X(3)	X
512QAM L			M(4)		M(4)			
1024QAM	X	X(3)	X(3)	X(3)	X(3)(4)	X(3)	X(3)	X
1024QAM L					M(4)			
2048QAM		X	X(3)	X(3)	X(3)	X(3)	X(3)	
2048QAM L		X	X(3)	X(3)	X(3)	X(3)	X(3)	
4096QAM			X(3)	X(3)	X(3)	X(3)	X(3)	
4096QAM L			X(3)	X(3)	X(3)	X(3)		
8192QAM			X(5)(6)	X(5)(6)				

(1) The minimum modulation shall be set to 512 QAM or lower, for both static and adaptive modulation, when using MINI-LINK 6365 radio units. This is applicable for countries complying to ETSI EN 302 217.

(2) For MINI-LINK 6365 23 and 32 at CS 224 MHz, Carrier Aggregation with 2x112 MHz is configured (Frame ID 404).

For MINI-LINK 6365 18 and CS 220 MHz, Carrier Aggregation with 2x110 MHz is configured (Frame ID 404).

(3) Supports XPIC

(4) Supports MIMO

(5) Note that static modulation is not supported for 8192QAM. See also (1).

(6) Note that 8192QAM is currently not supported on MINI-LINK 6365 32. The HW is prepared.

Table 98 Supported Physical Modes ETSI with Carrier Aggregation

Telecom Standard: ETSI with Carrier Aggregation					
Products: MINI-LINK 6365 6, 7/8, 10/11, 13, 15, 18, 23, 32 ≥ R1A(1)					
CS Mod.	28/27.5 MHz	40 MHz	56/ 55 MHz	80 MHz	112/ 110 MHz
4QAM S	X	X	X	X	X

Telecom Standard: ETSI with Carrier Aggregation					
Products: MINI-LINK 6365 6, 7/8, 10/11, 13, 15, 18, 23, 32 ≥ R1A(1)					
CS Mod.	28/27.5 MHz	40 MHz	56/ 55 MHz	80 MHz	112/ 110 MHz
4QAM	X	X	X	X	X
16QAM S	X	X	X	X	X
16QAM	X	X	X	X	X
32QAM	X	X	X	X	X
64QAM	X	X	X	X	X
128QAM	X	X	X	X	X
256QAM	X	X	X	X	X
512QAM	X	X	X	X	X
1024QAM	X	X	X	X	X
2048QAM	X	X	X		
2048QAM L	X	X			
4096QAM	X				
4096QAM L					
8192QAM					

(1) The minimum modulation shall be set to 512 QAM or lower, for both static and adaptive modulation, when using MINI-LINK 6365 radio units. This is applicable for countries complying to ETSI EN 302 217.

Table 99 Supported Physical Modes ANSI

Telecom Standard: ANSI										
Products MINI-LINK 6365 6 - 32 ≥ R1A										
CS Mod.	10 MHz	20 MHz	28 MHz	30 MHz	40 MHz	50 MHz	56 MHz	60 MHz	80 MHz	112 MHz
4QAM S	X(1)	X(1)	X(1)	X(1)(2)	X(1)(2)	X(1)	X(1)	X(1)	X(1)	X(1)
4QAM	X(1)	X(1)	X(1)	X(1)(2)	X(1)(2)	X(1)	X(1)	X(1)	X(1)	X(1)
16QAM S	X(1)	X(1)	X(1)	X(1)(2)	X(1)(2)	X(1)	X(1)	X(1)	X(1)	X(1)
16QAM	X(1)	X(1)	X(1)	X(1)(2)	X(1)(2)	X(1)	X(1)	X(1)	X(1)	X(1)
32QAM	X(1)	X(1)	X(1)	X(1)(2)	X(1)(2)	X(1)	X(1)	X(1)	X(1)	X(1)
64QAM	X(1)	X(1)	X(1)	X(1)(2)	X(1)(2)	X(1)	X(1)	X(1)	X(1)	X(1)
128QAM	X(1)	X(1)	X(1)	X(1)(2)	X(1)(2)	X(1)	X(1)	X(1)	X(1)	X(1)
256QAM	X(1)	X(1)	X(1)	X(1)(2)	X(1)(2)	X(1)	X(1)	X(1)	X(1)	X(1)
512QAM	X(1)	X(1)	X(1)	X(1)(2)	X(1)(2)	X(1)	X(1)	X(1)	X(1)	X(1)
512QAM L				M(2)	M(2)					
1024QAM	X	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
2048QAM		X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
2048QAM L		X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
4096QAM			X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)
4096QAM L			X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	X(1)	

Telecom Standard: ANSI										
Products MINI-LINK 6365 6 - 32 ≥ R1A										
CS Mod.	10 MHz	20 MHz	28 MHz	30 MHz	40 MHz	50 MHz	56 MHz	60 MHz	80 MHz	112 MHz
8192QAM				X(3) (4)	X(3)(4)					

(1) Supports XPIC

(2) Supports MIMO

(3) Note that static modulation is not supported for 8192QAM

(4) Note that 8192QAM is currently not supported on MINI-LINK 6365 32. The HW is prepared.

Table 100 Supported Physical Modes ANSI with Carrier Aggregation

Telecom Standard: ANSI with Carrier Aggregation								
Products MINI-LINK 6365 6, 7/8, 10/11, 13, 15, 18, 23, 32 ≥ R1A								
CS Mod.	28 MHz	30 MHz	40 MHz	50 MHz	56 MHz	60 MHz	80 MHz	112 MHz
4QAM S		X	X	X		X	X	
4QAM		X	X	X		X	X	
16QAM S		X	X	X		X	X	
16QAM		X	X	X		X	X	
32QAM		X	X	X		X	X	
64QAM		X	X	X		X	X	
128QAM		X	X	X		X	X	
256QAM		X	X	X		X	X	
512QAM		X	X	X		X	X	
1024QAM		X	X	X		X	X	
2048QAM		X	X	X		X		
2048QAM L		X	X					
4096QAM		X						
4096QAM L								
8192QAM								

3.7.2 MMU

This chapter describes the traffic capacities of each MMU per carrier, depending on channel separation and modulation. Note that the support may require a certain SW.

Data for standard Frame ID's (256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, and 303) can be found in revision BT of this document.

— Static physical modes are supported up to 4096QAM Light, by setting Adaptive Coding and Modulation (ACM) Max Capacity—Modulation equal to Min Capacity—Modulation.

— S= Strong coding and L= Light coding

— The figures in the tables related to maximum E1/DS1 are valid when TDM is used in a single direction. When TDM in 2 directions is enabled, the maximum number of E1/DS1 is limited to 40 per direction.

Note: TDM is not supported by MINI-LINK 6366 and MINI-LINK 6371, therefore the maximum number of E1/DS1 in the following tables are not applicable to these network elements.

ETSI

Table 101 MMU 1001, PNM 1001, MINI-LINK 6651/1, MINI-LINK 6651/3 and MINI-LINK 6366

Modulation	CS 7 Frame ID 356	CS 13.75, 14 Frame ID 357	CS 27.7, 28 Frame ID 358	CS 40 Frame ID 359	CS 55, 56, 62.5 Frame ID 360	CS 80 Frame ID 403	CS 110, 112, 125 Frame ID 361
4QAM S	8 Mbps 2XE1(1)	19 Mbps 6xE1(1)	37 Mbps 15xE1(1)	53 Mbps 23xE1(1)	75 Mbps 34xE1(1)	108 Mbps 49xE1(1)	151 Mbps 70xE1(1)
4QAM	10 Mbps 3XE1(1)	22 Mbps 8xE1(1)	44 Mbps 18xE1(1)	62 Mbps 28xE1(1)	88 Mbps 40xE1(1)	126 Mbps 58xE1(1)	176 Mbps 80xE1(1)
16QAM S	18 Mbps 6xE1(1)	37 Mbps 15xE1(1)	75 Mbps 34xE1(1)	107 Mbps 49xE1(1)	151 Mbps 70xE1(1)	217 Mbps 80xE1(1)	302 Mbps 80xE1(1)
16QAM	21 Mbps 7xE1(1)	43 Mbps 18xE1(1)	87 Mbps 33xE1(1)	124 Mbps 57xE1(1)	176 Mbps 71xE1(1)	253 Mbps 80xE1(1)	352 Mbps 80xE1(1)
32QAM	26 Mbps 10xE1(1)	54 Mbps 24xE1(1)	109 Mbps 50xE1(1)	156 Mbps 73xE1(1)	221 Mbps 80xE1(1)	317 Mbps 80xE1(1)	441 Mbps 80xE1(1)
64QAM	33 Mbps 13xE1(1)	68 Mbps 30xE1(1)	137 Mbps 63xE1(1)	196 Mbps 80xE1(1)	277 Mbps 80xE1(1)	397 Mbps 80xE1(1)	553 Mbps 80xE1(1)
128QAM	39 Mbps 16xE1(1)	81 Mbps 36xE1(1)	162 Mbps 75xE1(1)	231 Mbps 80xE1(1)	327 Mbps 80xE1(1)	470 Mbps 80xE1(1)	654 Mbps 80xE1(1)
256QAM	45 Mbps 19xE1(1)	93 Mbps 42xE1(1)	186 Mbps 80xE1(1)	267 Mbps 80xE1(1)	377 Mbps 80xE1(1)	542 Mbps 80xE1(1)	754 Mbps 80xE1(1)
512QAM	51 Mbps 22xE1(1)	105 Mbps 48xE1(1)	211 Mbps 80xE1(1)	302 Mbps 80xE1(1)	427 Mbps 80xE1(1)	614 Mbps 80xE1(1)	855 Mbps 80xE1(1)
1024QAM	56 Mbps 25xE1	117 Mbps 54xE1(1)	234 Mbps 80xE1(1)	335 Mbps 80xE1(1)	473 Mbps 80xE1(1)	679 Mbps 80xE1(1)	946 Mbps 80xE1(1)
2048QAM	-	121 Mbps 56xE1	243 Mbps 80xE1(1)	348 Mbps 80xE1(1)	492 Mbps 80xE1(1)	706 Mbps 80xE1(1)	983 Mbps 80xE1(1)
2048QAM L	-	127 Mbps 59xE1	256 Mbps 80xE1(1)	366 Mbps 80xE1(1)	517 Mbps 80xE1(1)	742 Mbps 80xE1(1)	1033 Mbps 80xE1(1)
4096QAM	-	-	264 Mbps 80xE1(1)	378 Mbps 80xE1(1)	534 Mbps 80xE1(1)	767 Mbps 80xE1	1068 Mbps 80xE1
4096QAM L	-	-	276 Mbps 80xE1(1)	395 Mbps 80xE1(1)	559 Mbps 80xE1(1)	-	-
8192QAM	-	-	-	-	-	-	-

(1) Supports XPIC

Table 102 MMU 1004, MMU 1002, PNM 1002, MINI-LINK 6651/4, MINI-LINK 6651/2, and MINI-LINK 6371

Modulation	CS 7 Frame ID 356	CS 13.75, 14 Frame ID 357	CS 27.5, 28 Frame ID 358	CS 40 Frame ID 359	CS 55, 56, 62.5 Frame ID 360	CS 80 Frame ID 403	CS 110, 112, 125 Frame ID 361	CS 220, 224(1) (2) Frame ID 404
4QAM S	8 Mbps 2XE1(3)	19 Mbps 6xE1(3)	37 Mbps 15xE1(3)	53 Mbps 23xE1(3)	75 Mbps 34xE1(3)	108 Mbps 49xE1(3)	151 Mbps 70xE1(3)	302 Mbps 70xE1
4QAM	10 Mbps 3XE1(3)	22 Mbps 8xE1(3)	44 Mbps 18xE1(3)	62 Mbps 28xE1(3)	88 Mbps 40xE1(3)	126 Mbps 58xE1(3)	176 Mbps 80xE1(3)	352 Mbps 80xE1
16QAM S	18 Mbps 6xE1(3)	37 Mbps 15xE1(3)	75 Mbps 34xE1(3)	107 Mbps 49xE1(3)	151 Mbps 70xE1(3)	217 Mbps 80xE1(3)	302 Mbps 80xE1(3)	604 Mbps 80xE1
16QAM	21 Mbps 7xE1(3)	43 Mbps 18xE1(3)	87 Mbps 33xE1(3)	124 Mbps 57xE1(3)	176 Mbps 71xE1(3)	253 Mbps 80xE1(3)	352 Mbps 80xE1(3)	704 Mbps 80xE1
32QAM	26 Mbps 10xE1(3)	54 Mbps 24xE1(3)	109 Mbps 50xE1(3)	156 Mbps 73xE1(3)	221 Mbps 80xE1(3)	317 Mbps 80xE1(3)	441 Mbps 80xE1(3)	882 Mbps 80xE1
64QAM	33 Mbps 13xE1(3)	68 Mbps 30xE1(3)	137 Mbps 63xE1(3)	196 Mbps 80xE1(3)	277 Mbps 80xE1(3)	397 Mbps 80xE1(3)	553 Mbps 80xE1(3)	1106 Mbps 80xE1
128QAM	39 Mbps 16xE1(3)	81 Mbps 36xE1(3)	162 Mbps 75xE1(3)	231 Mbps 80xE1(3)	327 Mbps 80xE1(3)	470 Mbps 80xE1(3)	654 Mbps 80xE1(3)	1308 Mbps 80xE1
256QAM	45 Mbps 19xE1(3)	93 Mbps 42xE1(3)	186 Mbps 80xE1(3)	267 Mbps 80xE1(3)	377 Mbps 80xE1(3)	542 Mbps 80xE1(3)	754 Mbps 80xE1(3)	1508 Mbps 80xE1
512QAM	51 Mbps 22xE1(3)	105 Mbps 48xE1(3)	211 Mbps 80xE1(3)	302 Mbps 80xE1(3)	427 Mbps 80xE1(3)	614 Mbps 80xE1(3)	855 Mbps 80xE1(3)	1710 Mbps 80xE1
1024QAM	56 Mbps 25xE1	117 Mbps 54xE1(3)	234 Mbps 80xE1(3)	335 Mbps 80xE1(3)	473 Mbps 80xE1(3)	679 Mbps 80xE1(3)	946 Mbps 80xE1(3)	1892 Mbps 80xE1
2048QAM	-	121 Mbps 56xE1	243 Mbps 80xE1(3)	348 Mbps 80xE1(3)	492 Mbps 80xE1(3)	706 Mbps 80xE1(3)	983 Mbps 80xE1(3)	
2048QAM L	-	127 Mbps 59xE1	256 Mbps 80xE1(3)	366 Mbps 80xE1(3)	517 Mbps 80xE1(3)	742 Mbps 80xE1(3)	1033 Mbps 80xE1(3)	
4096QAM	-	-	264 Mbps 80xE1(3)	378 Mbps 80xE1(3)	534 Mbps 80xE1(3)	767 Mbps 80xE1(3)	1068 Mbps 80xE1(3)	
4096QAM L	-	-	276 Mbps 80xE1(3)	395 Mbps 80xE1(3)	559 Mbps 80xE1(3)	803 Mbps 80xE1(3)	-	
8192QAM	-	-	284 Mbps 80xE1	406 Mbps 80xE1	-	-	-	

(1) Only applicable for MMU 1004

(2) For CS 220 MHz and 224 MHz, Carrier Aggregation with 2x110 MHz or 2x112 MHz is configured.

(3) Supports XPIC

Table 103 MMU 1004, MMU 1002 MIMO

Modulation	CS 27.5, 28 Frame ID 2358	CS 55, 56 Frame ID 2360
4QAM S	36 Mbps 15xE1	73 Mbps 33xE1

Modulation	CS 27.5, 28 Frame ID 2358	CS 55, 56 Frame ID 2360
4QAM	42 Mbps 18xE1	86 Mbps 39xE1
16QAM S	72 Mbps 33xE1	146 Mbps 68xE1
16QAM	85 Mbps 38xE1	171 Mbps 80xE1
32QAM	109 Mbps 50xE1	219 Mbps 80xE1
64QAM	133 Mbps 62xE1	268 Mbps 80xE1
128QAM	157 Mbps 74xE1	317 Mbps 80xE1
256QAM	182 Mbps 80xE1	366 Mbps 80xE1
512QAM	194 Mbps 80xE1	390 Mbps 80xE1
512QAM L	206 Mbps 80xE1	415 Mbps 80xE1
1024QAM	-	435 Mbps 80xE1
1024QAM L	-	459 Mbps 80xE1

Table 104 MMU 1004, MMU 1002 Carrier Aggregation

Modulation	CS 27.5, 28 Frame ID 358	CS 40 Frame ID 359	CS 55, 56 Frame ID 360	CS 80 Frame ID 403	CS 110, 112(1) Frame ID 361
4QAM S	37 Mbps 15xE1	53 Mbps 23xE1	75 Mbps 34xE1	108 Mbps 49xE1	151 Mbps 70xE1
4QAM	44 Mbps 18xE1	62 Mbps 28xE1	88 Mbps 40xE1	126 Mbps 58xE1	176 Mbps 80xE1
16QAM S	75 Mbps 34xE1	107 Mbps 49xE1	151 Mbps 70xE1	217 Mbps 80xE1	302 Mbps 80xE1
16QAM	87 Mbps 33xE1	124 Mbps 57xE1	176 Mbps 71xE1	253 Mbps 80xE1	352 Mbps 80xE1
32QAM	109 Mbps 50xE1	156 Mbps 73xE1	221 Mbps 80xE1	317 Mbps 80xE1	441 Mbps 80xE1
64QAM	137 Mbps 63xE1	196 Mbps 80xE1	277 Mbps 80xE1	397 Mbps 80xE1	553 Mbps 80xE1
128QAM	162 Mbps 75xE1	231 Mbps 80xE1	327 Mbps 80xE1	470 Mbps 80xE1	654 Mbps 80xE1
256QAM	186 Mbps 80xE1	267 Mbps 80xE1	377 Mbps 80xE1	542 Mbps 80xE1	754 Mbps 80xE1
512QAM	211 Mbps 80xE1	302 Mbps 80xE1	427 Mbps 80xE1	614 Mbps 80xE1	855 Mbps 80xE1
1024QAM	234 Mbps 80xE1	335 Mbps 80xE1	473 Mbps 80xE1	679 Mbps 80xE1	946 Mbps 80xE1
2048QAM	243 Mbps 80xE1	348 Mbps 80xE1	492 Mbps 80xE1	-	-

Modulation	CS 27.5, 28 Frame ID 358	CS 40 Frame ID 359	CS 55, 56 Frame ID 360	CS 80 Frame ID 403	CS 110, 112(1) Frame ID 361
2048QAM L	256 Mbps 80xE1	366 Mbps 80xE1	-	-	-
4096QAM	264 Mbps 80xE1	-	-	-	-
4096QAM L	-	-	-	-	-
8192QAM	-	-	-	-	-

(1) Only applicable for MMU 1004

ANSI

Table 105 MMU 1001, PNM 1001, MINI-LINK 6651/1, MINI-LINK 6651/3 and MINI-LINK 6366

Modulation	CS 10 Frame ID 362	CS 20 Frame ID 363	CS 28 Frame ID 371	CS 30 Frame ID 364	CS 40 Frame ID 365	CS 50 Frame ID 366	CS 56 Frame ID 373	CS 60 Frame ID 367	CS 80 Frame ID 368	CS 112 Frame ID 374
4QAM S	13 Mbps 5xDS1 (1)	26 Mbps 14xDS1 (1)	37 Mbps 21xDS1 (1)	40 Mbps 23xDS1 (1)	54 Mbps 32xDS1 (1)	68 Mbps 40xDS1 (1)	75 Mbps 45xDS1 (1)	81 Mbps 49xDS1 (1)	108 Mbps 66xDS1 (1)	151 Mbps 80xDS1 (1)
4QAM	15 Mbps 7xDS1 (1)	31 Mbps 17xDS1 (1)	44 Mbps 25xDS1 (1)	47 Mbps 27xDS1 (1)	63 Mbps 37xDS1 (1)	79 Mbps 47xDS1 (1)	88 Mbps 54xDS1 (1)	95 Mbps 58xDS1 (1)	126 Mbps 78xDS1 (1)	177 Mbps 80xDS1 (1)
16QAM S	25 Mbps 13xDS1 (1)	53 Mbps 31xDS1 (1)	75 Mbps 45xDS1 (1)	80 Mbps 48xDS1 (1)	108 Mbps 66xDS1 (1)	135 Mbps 80xDS1 (1)	151 Mbps 80xDS1 (1)	162 Mbps 80xDS1 (1)	217 Mbps 80xDS1 (1)	302 Mbps 80xDS1 (1)
16QAM	29 Mbps 16xDS1 (1)	61 Mbps 36xDS1 (1)	87 Mbps 53xDS1 (1)	93 Mbps 57xDS1 (1)	126 Mbps 77xDS1 (1)	158 Mbps 80xDS1 (1)	176 Mbps 80xDS1 (1)	189 Mbps 80xDS1 (1)	253 Mbps 80xDS1 (1)	352 Mbps 80xDS1 (1)
32QAM	37 Mbps 21xDS1 (1)	77 Mbps 46xDS1 (1)	109 Mbps 67xDS1 (1)	117 Mbps 72xDS1 (1)	157 Mbps 80xDS1 (1)	198 Mbps 80xDS1 (1)	221 Mbps 80xDS1 (1)	237 Mbps 80xDS1 (1)	317 Mbps 80xDS1 (1)	441 Mbps 80xDS1 (1)
64QAM	46 Mbps 27xDS1 (1)	97 Mbps 59xDS1 (1)	137 Mbps 80xDS1 (1)	147 Mbps 80xDS1 (1)	197 Mbps 80xDS1 (1)	248 Mbps 80xDS1 (1)	277 Mbps 80xDS1 (1)	297 Mbps 80xDS1 (1)	397 Mbps 80xDS1 (1)	553 Mbps 80xDS1 (1)
128QAM	55 Mbps 32xDS1 (1)	114 Mbps 70xDS1 (1)	162 Mbps 80xDS1 (1)	173 Mbps 80xDS1 (1)	233 Mbps 80xDS1 (1)	293 Mbps 80xDS1 (1)	327 Mbps 80xDS1 (1)	352 Mbps 80xDS1 (1)	470 Mbps 80xDS1 (1)	654 Mbps 80xDS1 (1)
256QAM	63 Mbps 37xDS1 (1)	132 Mbps 80xDS1 (1)	186 Mbps 80xDS1 (1)	200 Mbps 80xDS1 (1)	269 Mbps 80xDS1 (1)	338 Mbps 80xDS1 (1)	377 Mbps 80xDS1 (1)	406 Mbps 80xDS1 (1)	542 Mbps 80xDS1 (1)	754 Mbps 80xDS1 (1)
512QAM	71 Mbps 43xDS1 (1)	149 Mbps 80xDS1 (1)	211 Mbps 80xDS1 (1)	226 Mbps 80xDS1 (1)	305 Mbps 80xDS1 (1)	383 Mbps 80xDS1 (1)	427 Mbps 80xDS1 (1)	460 Mbps 80xDS1 (1)	614 Mbps 80xDS1 (1)	855 Mbps 80xDS1 (1)

Modulation	CS 10 Frame ID 362	CS 20 Frame ID 363	CS 28 Frame ID 371	CS 30 Frame ID 364	CS 40 Frame ID 365	CS 50 Frame ID 366	CS 56 Frame ID 373	CS 60 Frame ID 367	CS 80 Frame ID 368	CS 112 Frame ID 374
1024QAM	79 Mbps 48xDS1	165 Mbps 80xDS1 (1)	234 Mbps 80xDS1 (1)	251 Mbps 80xDS1 (1)	337 Mbps 80xDS1 (1)	423 Mbps 80xDS1 (1)	473 Mbps 80xDS1 (1)	509 Mbps 80xDS1 (1)	679 Mbps 80xDS1 (1)	946 Mbps 80xDS1 (1)
2048QAM	-	172 Mbps 80xDS1 (1)	243 Mbps 80xDS1 (1)	260 Mbps 80xDS1 (1)	351 Mbps 80xDS1 (1)	440 Mbps 80xDS1 (1)	492 Mbps 80xDS1 (1)	529 Mbps 80xDS1 (1)	706 Mbps 80xDS1 (1)	983 Mbps 80xDS1 (1)
2048QAM L	-	180 Mbps 80xDS1 (1)	256 Mbps 80xDS1 (1)	274 Mbps 80xDS1 (1)	369 Mbps 80xDS1 (1)	463 Mbps 80xDS1 (1)	517 Mbps 80xDS1 (1)	556 Mbps 80xDS1 (1)	742 Mbps 80xDS1 (1)	1033 Mbps 80xDS1 (1)
4096QAM	-	-	264 Mbps 80xDS1	283 Mbps 80xDS1 (1)	381 Mbps 80xDS1 (1)	478 Mbps 80xDS1 (1)	534 Mbps 80xDS1 (1)	574 Mbps 80xDS1 (1)	767 Mbps 80xDS1	1068 Mbps 80xDS1
4096QAM L	-	-	276 Mbps 80xDS1	296 Mbps 80xDS1 (1)	399 Mbps 80xDS1 (1)	500 Mbps 80xDS1 (1)	559 Mbps 80xDS1 (1)	601 Mbps 80xDS1 (1)	-	-
8192QAM	-	-	-	-	-	-	-	-	-	-

(1) Supports XPIC

Table 106 MMU 1004, MMU 1002, PNM 1002, MINI-LINK 6651/4, MINI-LINK 6651/2, and MINI-LINK 6371

Modulation	CS 10 Frame ID 362	CS 20 Frame ID 363	CS 28 Frame ID 371	CS 30 Frame ID 364	CS 40 Frame ID 365	CS 50 Frame ID 366	CS 56 Frame ID 373	CS 60 Frame ID 367	CS 80 Frame ID 368	CS 112 Frame ID 374
4QAM S	13 Mbps 5xDS1 (1)	26 Mbps 14xDS1 (1)	37 Mbps 21xDS1 (1)	40 Mbps 23xDS1 (1)	54 Mbps 32xDS1 (1)	68 Mbps 40xDS1 (1)	75 Mbps 45xDS1 (1)	81 Mbps 49xDS1 (1)	108 Mbps 66xDS1 (1)	151 Mbps 80xDS1 (1)
4QAM	15 Mbps 7xDS1 (1)	31 Mbps 17xDS1 (1)	44 Mbps 25xDS1 (1)	47 Mbps 27xDS1 (1)	63 Mbps 37xDS1 (1)	79 Mbps 47xDS1 (1)	88 Mbps 54xDS1 (1)	95 Mbps 58xDS1 (1)	126 Mbps 78xDS1 (1)	177 Mbps 80xDS1 (1)
16QAM S	25 Mbps 13xDS1 (1)	53 Mbps 31xDS1 (1)	75 Mbps 45xDS1 (1)	80 Mbps 48xDS1 (1)	108 Mbps 66xDS1 (1)	135 Mbps 80xDS1 (1)	151 Mbps 80xDS1 (1)	162 Mbps 80xDS1 (1)	217 Mbps 80xDS1 (1)	302 Mbps 80xDS1 (1)
16QAM	29 Mbps 16xDS1 (1)	61 Mbps 36xDS1 (1)	87 Mbps 53xDS1 (1)	93 Mbps 57xDS1 (1)	126 Mbps 77xDS1 (1)	158 Mbps 80xDS1 (1)	176 Mbps 80xDS1 (1)	189 Mbps 80xDS1 (1)	253 Mbps 80xDS1 (1)	352 Mbps 80xDS1 (1)
32QAM	37 Mbps 21xDS1 (1)	77 Mbps 46xDS1 (1)	109 Mbps 67xDS1 (1)	117 Mbps 72xDS1 (1)	157 Mbps 80xDS1 (1)	198 Mbps 80xDS1 (1)	221 Mbps 80xDS1 (1)	237 Mbps 80xDS1 (1)	317 Mbps 80xDS1 (1)	441 Mbps 80xDS1 (1)
64QAM	46 Mbps 27xDS1 (1)	97 Mbps 59xDS1 (1)	137 Mbps 80xDS1 (1)	147 Mbps 80xDS1 (1)	197 Mbps 80xDS1 (1)	248 Mbps 80xDS1 (1)	277 Mbps 80xDS1 (1)	297 Mbps 80xDS1 (1)	397 Mbps 80xDS1 (1)	553 Mbps 80xDS1 (1)

Modulation	CS 10 Frame ID 362	CS 20 Frame ID 363	CS 28 Frame ID 371	CS 30 Frame ID 364	CS 40 Frame ID 365	CS 50 Frame ID 366	CS 56 Frame ID 373	CS 60 Frame ID 367	CS 80 Frame ID 368	CS 112 Frame ID 374
128QAM	55 Mbps 32xDS1 (1)	114 Mbps 70xDS1 (1)	162 Mbps 80xDS1 (1)	173 Mbps 80xDS1 (1)	233 Mbps 80xDS1 (1)	293 Mbps 80xDS1 (1)	327 Mbps 80xDS1 (1)	352 Mbps 80xDS1 (1)	470 Mbps 80xDS1 (1)	654 Mbps 80xDS1 (1)
256QAM	63 Mbps 37xDS1 (1)	132 Mbps 80xDS1 (1)	186 Mbps 80xDS1 (1)	200 Mbps 80xDS1 (1)	269 Mbps 80xDS1 (1)	338 Mbps 80xDS1 (1)	377 Mbps 80xDS1 (1)	406 Mbps 80xDS1 (1)	542 Mbps 80xDS1 (1)	754 Mbps 80xDS1 (1)
512QAM	71 Mbps 43xDS1 (1)	149 Mbps 80xDS1 (1)	211 Mbps 80xDS1 (1)	226 Mbps 80xDS1 (1)	305 Mbps 80xDS1 (1)	383 Mbps 80xDS1 (1)	427 Mbps 80xDS1 (1)	460 Mbps 80xDS1 (1)	614 Mbps 80xDS1 (1)	855 Mbps 80xDS1 (1)
1024QAM	79 Mbps 48xDS1	165 Mbps 80xDS1 (1)	234 Mbps 80xDS1 (1)	251 Mbps 80xDS1 (1)	337 Mbps 80xDS1 (1)	423 Mbps 80xDS1 (1)	473 Mbps 80xDS1 (1)	509 Mbps 80xDS1 (1)	679 Mbps 80xDS1 (1)	946 Mbps 80xDS1 (1)
2048QAM	-	172 Mbps 80xDS1 (1)	243 Mbps 80xDS1 (1)	260 Mbps 80xDS1 (1)	351 Mbps 80xDS1 (1)	440 Mbps 80xDS1 (1)	492 Mbps 80xDS1 (1)	529 Mbps 80xDS1 (1)	706 Mbps 80xDS1 (1)	983 Mbps 80xDS1 (1)
2048QAM L	-	180 Mbps 80xDS1 (1)	256 Mbps 80xDS1 (1)	274 Mbps 80xDS1 (1)	369 Mbps 80xDS1 (1)	463 Mbps 80xDS1 (1)	517 Mbps 80xDS1 (1)	556 Mbps 80xDS1 (1)	742 Mbps 80xDS1 (1)	1033 Mbps 80xDS1 (1)
4096QAM	-	-	264 Mbps 80xDS1	283 Mbps 80xDS1 (1)	381 Mbps 80xDS1 (1)	478 Mbps 80xDS1 (1)	534 Mbps 80xDS1 (1)	574 Mbps 80xDS1 (1)	767 Mbps 80xDS1 (1)	1068 Mbps 80xDS1 (1)
4096QAM L	-	-	276 Mbps 80xDS1	296 Mbps 80xDS1 (1)	399 Mbps 80xDS1 (1)	500 Mbps 80xDS1 (1)	559 Mbps 80xDS1 (1)	601 Mbps 80xDS1 (1)	803 Mbps 80xDS1 (1)	-
8192QAM	-	-	-	304 Mbps 80xDS1	409 Mbps 80xDS1	-	-	-	-	-

(1) Supports XPIC

Table 107 MMU 1004, MMU 1002 MIMO

Modulation	CS 30 Frame ID 2364	CS 40 Frame ID 2365
4QAM S	39 Mbps 22xDS1	52 Mbps 31xDS1
4QAM	46 Mbps 26xDS1	61 Mbps 36xDS1
16QAM S	78 Mbps 47xDS1	105 Mbps 64xDS1
16QAM	91 Mbps 55xDS1	122 Mbps 75xDS1
32QAM	117 Mbps 72xDS1	157 Mbps 80xDS1

Modulation	CS 30 Frame ID 2364	CS 40 Frame ID 2365
64QAM	143 Mbps 80xDS1	192 Mbps 80xDS1
128QAM	169 Mbps 80xDS1	227 Mbps 80xDS1
256QAM	195 Mbps 80xDS1	262 Mbps 80xDS1
512QAM	208 Mbps 80xDS1	279 Mbps 80xDS1
512QAM L	221 Mbps 80xDS1	297 Mbps 80xDS1

Table 108 MMU 1004, MMU 1002, Carrier Aggregation

Modulation	CS 30 Frame ID 364	CS 40 Frame ID 365	CS 50 Frame ID 366	CS 60(1) Frame ID 367	CS 80(1) Frame ID 368
4QAM S	40 Mbps 23xDS1	54 Mbps 32xDS1	68 Mbps 40xDS1	81 Mbps 49xDS1	108Mbps 66xDS1
4QAM	47 Mbps 27xDS1	63 Mbps 37xDS1	79 Mbps 47xDS1	95 Mbps 58xDS1	126Mbps 78xDS1
16QAM S	80 Mbps 48xDS1	108 Mbps 66xDS1	135 Mbps 80xDS1	162Mbps 80xDS1	217Mbps 80xDS1
16QAM	93 Mbps 57xDS1	126 Mbps 77xDS1	158 Mbps 80xDS1	189Mbps 80xDS1	253Mbps 80xDS1
32QAM	117 Mbps 72xDS1	157 Mbps 80xDS1	198 Mbps 80xDS1	237Mbps 80xDS1	317Mbps 80xDS1
64QAM	147 Mbps 80xDS1	197 Mbps 80xDS1	248 Mbps 80xDS1	297Mbps 80xDS1	397Mbps 80xDS1
128QAM	173 Mbps 80xDS1	233 Mbps 80xDS1	293 Mbps 80xDS1	352Mbps 80xDS1	470Mbps 80xDS1
256QAM	200 Mbps 80xDS1	269 Mbps 80xDS1	338 Mbps 80xDS1	406Mbps 80xDS1	542Mbps 80xDS1
512QAM	226 Mbps 80xDS1	305 Mbps 80xDS1	383 Mbps 80xDS1	460Mbps 80xDS1	614Mbps 80xDS1
1024QAM	251 Mbps 80xDS1	337 Mbps 80xDS1	423 Mbps 80xDS1	509Mbps 80xDS1	679Mbps 80xDS1
2048QAM	260 Mbps 80xDS1	351 Mbps 80xDS1	440 Mbps 80xDS1	529Mbps 80xDS1	-
2048QAM L	274 Mbps 80xDS1	369 Mbps 80xDS1	-	-	-
4096QAM	283 Mbps 80xDS1	-	-	-	-
4096QAM L	-	-	-	-	-
8192QAM	-	-	-	-	-

(1) Only applicable for MMU 1004

4 Physical Interfaces

4.1 Ethernet Traffic Interfaces

4.1.1 Interface Types

10BASE-T	IEEE802.3i ncl.. In 802.3-2005
100BASE-TX	IEEE802.3u ncl.. In 802.3-2005
1000BASE-T	IEEE802.3ab incl. In 802.3-2005
1000BASE-SX	IEEE 802.3z incl. In 802.3-2005
1000BASE-LX	IEEE 802.3z incl. In 802.3-2005
1000BASE-ZX	IEEE 802.3z incl. In 802.3-2005
1000BASE-BX10	IEEE 802.3(58) incl. In 802.3-2005
1000BASE-X	CWDM (1470-1610 nm)
10GBASE-LR	IEEE 802.3ae (49)
10GBASE-ER	IEEE 802.3ae (49)
10GBASE-ZR	Single Mode 1550 nm

4.1.2 Interfaces per Application

Table 109 Interfaces per Application

Application	Connector type	Rate (Mbit/s)	# of ports
NPU 1002	Shielded RJ45 jack	10/100/1000	2
	SFP/SFP+	See Ethernet SFP on page 162.	3 (max 2 SFP+)
NPU 1003	Shielded RJ45 jack	10/100/1000	2
	SFP/SFP+	See Ethernet SFP on page 162.	3 (max 2 SFP+)
NPU 1005	Shielded RJ45 jack	10/100/1000	2
	SFP/SFP+	See Ethernet SFP on page 162.	3 (max 2 SFP+)
ETU 1001	Shielded RJ45 jack	10/100/1000	Up to 4(1)

Application	Connector type	Rate (Mbit/s)	# of ports
ETU 1002	SFP	1000	Up to 4(2)
	SFP+	10G	1(3)
PNM 1001	Shielded RJ45 jack	10/100/1000	2
	SFP/SFP+ (≤ 2.5G)	See Ethernet SFP on page 162.	4 (max 2 SFP+)
PNM 1002	Shielded RJ45 jack	10/100/1000	2
	SFP/SFP+ (≤ 2.5G)	See Ethernet SFP on page 162.	4 (max 2 SFP+)
MINI-LINK 6651/1	Shielded RJ45 jack	10/100/1000	2
	SFP/SFP+ (≤ 2.5G)	See Ethernet SFP on page 162.	4
MINI-LINK 6651/2	Shielded RJ45 jack	10/100/1000	2
	SFP/SFP+ (≤ 2.5G)	See Ethernet SFP on page 162.	3
MINI-LINK 6651/3	Shielded RJ45 jack	10/100/1000	2
	SFP/SFP+ (≤ 2.5G)	See Ethernet SFP on page 162.	4
MINI-LINK 6651/4	Shielded RJ45 jack	10/100/1000	2
	SFP/SFP+	See Ethernet SFP on page 162.	4 (max 4 SFP+)
MINI-LINK 6366	Shielded RJ45 jack	10/100/1000	2
	SFP/SFP+ (≤ 2.5G)	See Ethernet SFP on page 162.	2
MINI-LINK 6371	Shielded RJ45 jack	10/100/1000	1
	SFP/SFP+	See Ethernet SFP on page 162.	3 (max 3 SFP+)

(1) Number of usable ports depends on the slot used, and the NPU type. .
(2) The ports can be configured for up to 4×1G or 1×10G Base-X, but not at the same time.
(3) 10G only available when the ETU 1002 is installed in specific slots. .

All interfaces support Auto negotiation and set-up.

4.1.3 Ethernet SFP

The “SFP” (Small Form-factor Pluggable) enables the customer to choose between optical and electrical interfaces. The SFPs are not locked to a certain brand.

Note: Non-Ericsson SFPs will be activated by the node if it is possible, but Ericsson can then not guarantee interoperability between the node and the SFP.

Table 110 Ethernet SFP Interface Capability

Interface	Capability
Electrical, shielded RJ45 jack	10/100/1000BASE-T
Optical, LC connector	1000BASE-SX Multi mode 850 nm
Optical, LC connector	1000BASE-LX Single mode 1310 nm
Optical, LC connector	1000BASE-LX Single/Multi mode 1310 nm
Optical, LC connector	1000BASE-ZX Single mode 1550 nm
Optical, LC connector	1000BASE-BX10-U Single mode Tx 1310 Rx 1490 nm
Optical, LC connector	1000BASE-BX10-D Single mode Tx 1490 Rx 1310 nm
Optical, LC connector	1000BASE-BX40-U Single mode Tx 1310 Rx 1490 nm
Optical, LC connector	1000BASE-BX40-D Single mode Tx 1490 Rx 1310 nm
Optical, LC connector	10GBASE-LR Single mode 1310nm
Optical, LC connector	1000BASE-X CWDM Single mode 1470-1610 nm
Optical, LC connector	10GBASE-ER Single Mode 1550 nm
Optical, LC connector	10GBASE-ZR Single Mode 1550 nm
Optical, LC connector	10GBASE-X DWDM Single mode 1528-1566 nm
Optical, LC connector	10GBASE-BX20-U Single mode Tx 1270 Rx 1330 nm

Interface	Capability
Optical, LC connector	10GBASE-BX20-D Single mode Tx 1330 Rx 1270 nm
Optical, LC connector	10GBASE-BX30-U Single mode Tx 1270 Rx 1330 nm
Optical, LC connector	10GBASE-BX30-D Single mode Tx 1330 Rx 1270 nm

4.1.3.1 Ethernet DAC Cable

The DAC (Direct Attach Copper) cable enables the customer to connect two collocated nodes at 10Gbps rate. DAC is a cost-effective alternative for Ethernet SFP+ modules and cables. The DACs are not locked to a certain brand.

Note: Non-Ericsson DACs will be activated by the node if it is possible but Ericsson can then not guarantee interoperability between the nodes.

Table 111 Connector Type Capacity

Connector type	Rate
SFP+	10Gbps

4.2 PDH Interfaces

4.2.1 ETSI

E1 electrical interface is according to G.703 for 75 Ω and 120 Ω. (See ETSI on page 164.)

Output pulse mask in resistive load is according to ITU-T Rec. G.703.

4.2.2 ANSI

DS1 electrical interface is according to T1.403-1999 with line build out for 0-655 ft.

Output mask complies with T1.403-1999 Figure 2.

Line code is AMI/B8Z5.

4.3 SDH Interfaces

4.3.1 SDH SFP

The SFP (Small Form-factor Pluggable) enables the customer to choose between optical and electrical interfaces. The SFPs are not locked to a certain brand. Non-Ericsson SFPs will be activated by the node if it is possible, but Ericsson can then not guarantee interoperability between the node and the SFP.

The SDH SFP will be used as STM-1.

Table 112 SDH SFP Interface Capability

Interface	Capability
Electrical, DIN 1.0/2.3 75 Ohm, female	S-1.E
Optical, LC connector	S-1.1 1310nm
Optical, LC connector	L-1.1 1310nm
Optical, LC connector	L-1.2 1550nm
Optical, LC connector	BiDi 1310/1550nm
Optical, LC connector	BiDi 1550/1310nm
Optical, LC connector	L-1/4/16.2C CWDM 1470-1610nm

4.4 PDH Traffic Connectors

4.4.1 ETSI

For NPU 1003, PNM 1001, PNM 1002, LTU 1001 and LTU 1002, the E1 connector is a male SOFIX 24 pin connector with 4xE1 120 Ω balanced and 75 Ω unbalanced short haul (6 dB) terminations. The impedance is selectable between 75 Ω and 120 Ω.

For MINI-LINK 6651, the E1 connector on is an RJ45 connector. Only 120 Ω impedance is supported.

4.4.2 ANSI

For NPU 1003, PNM 1001, PNM 1002, LTU 1001 and LTU 1002, the DS1 connector is a male SOFIX 24-pin connector, with 4xDS1 terminations.

4.5 Local O&M

4.5.1 Site LAN Port

One of the fixed Ethernet ports on NPU 1002, NPU 1003, NPU 1005, PNM 1001, PNM 1002, MINI-LINK 6651, MINI-LINK 6366, and MINI-LINK 6371 can be configured as a site LAN port.

— The Ethernet connection is a shielded 8 pin RJ45 modular jack (DTE).

— The interface supports 10/100/1000 Mbit/s full duplex Ethernet with auto-negotiate

— The green LED on NPUs shows “Link up“ connectivity.

4.5.2 USB Interface

There is a mini USB device port on NPU 1002, NPU 1003, NPU 1005, PNM 1001, PNM 1002, MINI-LINK 6651, MINI-LINK 6366, and MINI-LINK 6371.

— The interface is a 5 pin USB2 connector. (Mini-B USB connector)

— The bit rate is up to 480 Mbit

4.5.3 User I/O Interface

The User I/O interface includes a number of output and input signals.

— The output signals can be used to export alarms from the MINI-LINK 6600 to other equipment’s supervision systems.

— The input signals can be used to transfer alarm and status information from on-site equipment to central management systems.

Table 113 Plug-in Units with User I/O Interface

Board Type	# of input signals	# of output signals	Connector Type
NPU 1002	6	3	Male 24 pin SOFIX connector
NPU 1003	2	1	Male 24 pin SOFIX connector
NPU 1005	6	3	Male 24 pin SOFIX connector
PNM 1001	2	1	Male 24 pin SOFIX connector

Board Type	# of input signals	# of output signals	Connector Type
PNM 1002	2	1	Male 24 pin SOFIX connector

4.5.3.1 Input Signals

The input signals are opto-coupled and have a reference that is floating with respect to each other and station ground. All signals are positive to the reference and shall read as follows:

— logical "0" when the Voltage < 1.0 V DC

— logical "1" when the Voltage > 2.4 V DC

These signals can be connected directly to a "Normaly Open" (NO) or Normally Closed (NC) equipment like a relay or a mechanical switch, since they have week internal drivers (2.5 Volt driver with ~4 Kohm serial resistors).

An input Voltage less than 15 V DC will not damage the equipment.

4.5.3.2 Output Signals

The output signals are performed with relay settings.

The output signals consist of three pins:

— NCL (Normally Closed)

— RTN (ReTurN)

— NOP (Normally Open)

At start-up the default position is the following:

— NCL-RTN is "normally closed" (impedance < 1Ω)

— NOP-RTN is "normally open" (impedance > 1 MΩ)

The relays used to switch the settings have the contact rating:

— 100 V DC, 1 A

— 125 V AC, 1 A

The outputs are reset to default temporarily upon cold restart but are not affected by a warm restart of the board.

4.5.3.3 LED Indications

For Information about functionality and behavior please see CPI document, 35/1551-HRA 901 20/11 LED Descriptions.

4.6 Antenna Interface

Table 114 Antenna Interface

Frequency band(s)	Waveguide interface, flange types
5 GHz	154 IEC-UDR 48
6 GHz Lower and Upper	154 IEC-UDR 70
7, 8, 7/8 GHz	154 IEC-UBR 84
10, 11, 10/11, 13 GHz	154 IEC-UBR 120
15 GHz	154 IEC-UBR 140
18, 23 GHz	154 IEC-UBR 220
24, 26, 28 GHz	154 IEC-UBR 260
32, 38 GHz	154 IEC-UBR 320
42 GHz	Ericsson proprietary flange (waveguide R500)
80 GHz	Integrated installation only (waveguide R740)

4.7 Indoor-Outdoor Interconnection

RAU connector type: N

MMU connector type: TNC

ETSI

Maximum cable length for performance as specified above:

Table 115 ETSI Maximum Cable Length

	RAU2 X	MINI-LINK 6363		MINI-LINK 6364 MINI-LINK 6365		
Radio cable diameter	CS 7-56 MHz	CS 7-56 MHz	CS 80-112 MHz	Single Carrier CS 7-112 MHz	Carrier Aggregation CS 2x 28-56 MHz	Carrier Aggregation CS 2x 80-112 MHz
TZC 500 97 (7.6 mm)	100 m	100 m	85 m	100 m	100 m	85 m
TZC 500 32 (10 mm)	200 m	200 m	160 m	200 m	200 m	160 m
TZC 501 26 (16 mm)	400 m	400 m	300 m	400 m	400 m	350 m

ANSI

Maximum cable length for performance as specified above:

Table 116 ANSI Maximum Cable Length

	RAU2 X	MINI-LINK 6363		MINI-LINK 6365		
Radio cable diameter	CS 10-56 MHz	CS 10-60 MHz	CS 80-112 MHz	Single Carrier CS 10-112 MHz	Carrier Aggregation CS 2x 28-56 MHz	Carrier Aggregation CS 2x 60-112 MHz
TZC 500 95 (3/8 in)	656 ft (200 m)	656 ft (200 m)	524 ft (160 m)	656 ft (200 m)	656 ft (200 m)	524 ft (160 m)
TZC 500 80 (1/2 in)	1312 ft (400 m)	1312 ft (400 m)	984 ft (300 m)	1312 ft (400 m)	1312 ft (400 m)	1148 ft (350 m)

5 Power

5.1 Power Supply

MINI-LINK 6691 has two DC inputs located on the PFU 1101.

MINI-LINK 6692 has one DC input located on each PFU 1201.

MINI-LINK 6693 has two DC inputs located on the PFU 1301.

MINI-LINK 6694 has one DC input located on each PFU 1601.

MINI-LINK 6654 has two DC inputs located on PNM 1001/1002.

MINI-LINK 6655 has two DC inputs located on PNM 1002.

MINI-LINK 6651 has two DC inputs.

MINI-LINK 6366 has one DC input.

MINI-LINK 6371 has one DC input.

5.1.1 DC Supply Interface

— The power is floating, i.e. not connected to station ground.

— The PFU provides surge protection.

5.1.2 DC Supply Voltage

Service Voltage Ranges

Table 117 Service Voltage Ranges

Nominal Voltage	-48 VDC			
Product	6691, 6692, 6693 and 6694	6654 and 6655	6651	6366 and 6371
Normal service voltage range	-58.8 V to -40 V	58.8 V to -40 V	-58.8 V to -40 V	-58.8 V to -38 V
Abnormal service voltage range	-60 V to -58.8 V	-60 V to -58.8 V	-60 V to -58.8 V	-60 V to -58.8 V
	-40 V to 0 V	-40 V to 0 V	-40 V to 0 V	-38 V to 0 V
Typical startup voltage	-39 V to -43 V	-41 V to -43 V	-44 V to -46 V	-44 V to -46 V
Typical shutdown voltage	−33.5 V to -37.5 V	−33.5 V to -37.5 V	−37.5 V to -39.5 V	−35.5 V to -37.5 V

Normal Service Voltage Range

The system is able to run at full operation in this range.

Abnormal Service Voltage Range

No function is guaranteed, but it will not result in any permanent damage, when operated in this range.

The system will restore to full operation when returning to normal service voltage range.

5.1.2.1 Clarification of Input Voltage Behavior for MINI-LINK 6691, 6692, 6693 and 6694

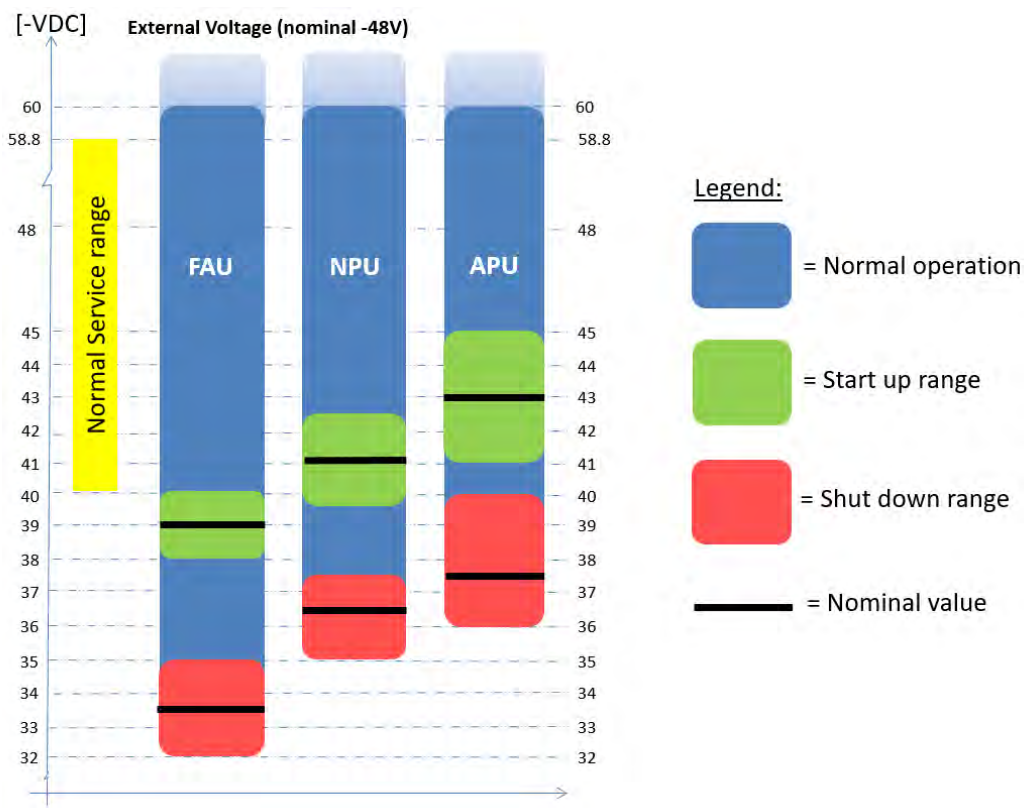


Figure 4 Input Voltage Behavior for MINI-LINK 6691, 6692, 6693 and 6694

Figure 4 shows the Input voltage behavior for MINI-LINK 6691, 6692, 6693 and 6694. The different units within MINI-LINK 6691, 6692, 6693 and 6694 will be turned on and off at different voltages.

There is a hysteresis for all units to prevent power flapping (turning on/off repeatedly around a threshold).

5.1.2.2 Clarification of Input Voltage Behavior for MINI-LINK 6654 and 6655

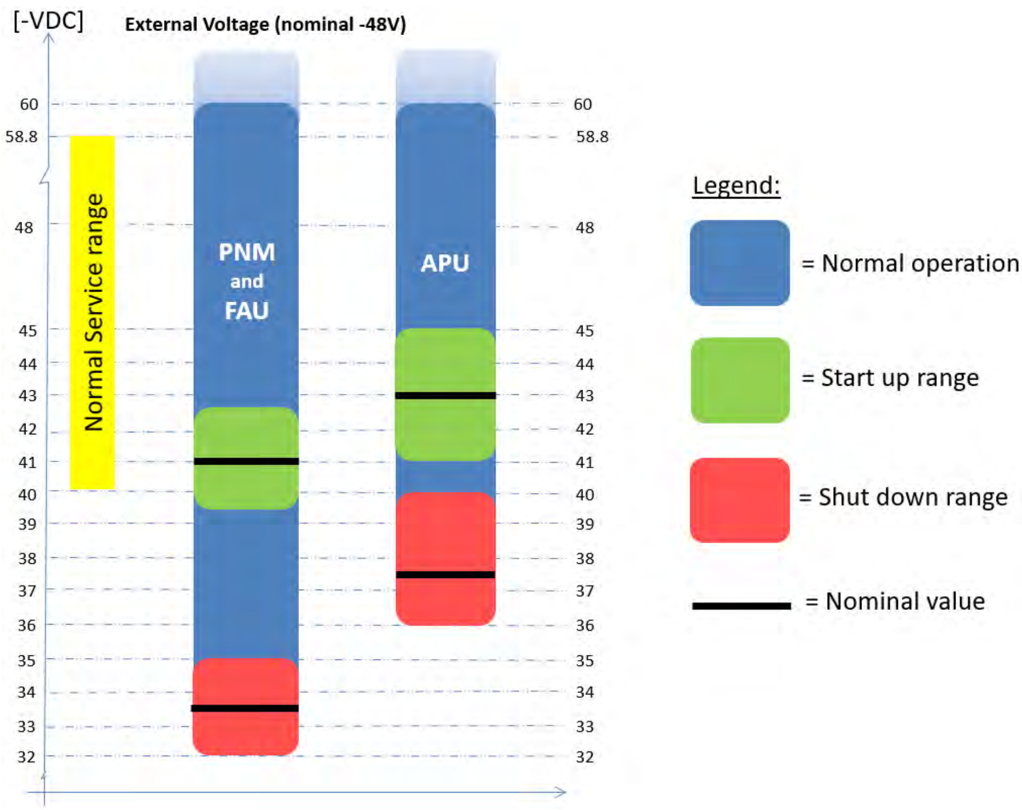


Figure 5 Input Voltage Behavior for MINI-LINK 6654 and MINI-LINK 6655

Figure 5 shows the Input voltage behavior for MINI-LINK 6654 and 6655. PNM and APU's will be turned on and off at different voltages.

There is a hysteresis for all units to prevent power flapping (turning on/off repeatedly around a threshold).

5.1.3 Power Supply Protection

PFU 1101, PFU 1301, PNM 1001, PNM 1002, and MINI-LINK 6651 have an external redundant power supply.

The same is applicable for PFU 1201 and PFU 1601 but these PFUs also support a redundant PFU solution.

If the input voltages to the PFU are lost, an alarm is sent.

MINI-LINK 6366 and MINI-LINK 6371 does not support redundant power supply.

5.1.4 Soft Start (all Plug-in Units)

The soft start function limits inrush current at start up or in case of a short circuit accordingly to EN 300 132-2.

5.1.5 Power Connector

Table 118 Power Connector

PFU 1101	Male 2-pin bus bar
PFU 1201	Male 3-pin bus bar
PFU 1301	Male 2-pin bus bar
PFU 1601	Male 2-pin bus bar
PNM 1001	Male 2-pin bus bar
PNM 1002	Male 2-pin bus bar
MINI-LINK 6651	Male 2-pin bus bar
MINI-LINK 6366/1	2-pole power terminal with connection for shield
MINI-LINK 6366/4	Male 2-pin with shield, Octis type
MINI-LINK 6371	Male 2-pin with shield, Octis type

5.2 Power Line Disturbance

MINI-LINK 6691, 6692, 6693, 6694, PNM 1001, and PNM 1002 support Power Line Disturbance according to ATIS-0600315.2007 §5.5 (10 ms Fuse Blowing Transient) without restart.

APU, Application Plug-in Units are dimensioned to handle up to 0.1 ms transients.

5.3 Power Consumption

Power consumptions to be used for dimensioning of site power supply are 33% higher than the typical values. For OPEX calculation regarding power consumption the typical values give the best estimate.

5.3.1 Maximum Power Level for Fuse and Power Dimensioning

The supply voltage is specified in DC Supply Voltage on page 169.

The figures below are to be used for fuse and power dimensioning only.

For MINI-LINK 6200 installations other fuse values might be applicable. See 1/1301-HRA 901 20/14 MINI-LINK 6200 Product Specification.

Fuse Type Requirements

DC voltage of minimum 80 V, a breaking capacity of 5000 A or more, and one of the following types:

— Thermo-electromagnetic over-current release certified according to IEC 60947-2, according to curve C (IEC 60898).

— Hydraulic-magnetic over-current release according to Eaton/Heinemann curve 3 or equivalent.

Circuit Breaker and Cable Dimensioning

Table 119 Circuit Breaker (CB) and Cable Dimensioning

	CB and Cable Dimensioning	
Product	**Max CB value**	**Cable**
MINI-LINK 6691	10 A	RPM 517 560 or NTM 20372 up to 20m
MINI-LINK 6692	40 A	RPM 777 551 up to 10m
MINI-LINK 6693	16 A	RPM 517 560 or NTM 20372 up to 10m
MINI-LINK 6694	20 A	RPM 517 560 or NTM 20372 up to 10m
MINI-LINK 6654	16 A	RPM 517 560 or NTM 20372 up to 10m
MINI-LINK 6655	20 A	RPM 517 560 or NTM 20372 up to 10m
MINI-LINK 6651	10 A	RPM 517 560 or NTM 20372 up to 20m
MINI-LINK 6366	See Fuse and Power Dimensioning for Outdoor Products on page 173.	
MINI-LINK 6371	See Fuse and Power Dimensioning for Outdoor Products on page 173.	

5.3.1.1 Fuse and Power Dimensioning for Outdoor Products

Cable to be used:

— TFL 252 504/2 (2x4 mm^2)

— NTM 203 72 (2x2.5 mm²)

Table 120 Recommended Hydraulic Magnetic Circuit Breaker Values

The following circuit breaker values are applicable to TFL 252 504/2 (2x4 mm²).

Power Rating of Product	Length							
	10 m	20 m	50 m	70 m	100 m	120 m	150 m	180 m
50 W	4 A	4 A	4 A	4 A	4 A	4 A	4 A	X
75 W	4 A	4 A	4 A	4 A	4 A	4 A	4 A (1)	X
100 W	4 A	4 A	4 A	4 A	4 A(1)	4 A(1)	4 A(1)	X
125 W	6 A	6 A	6 A	6 A	6 A(1)	X	X	X
150 W	6 A	6 A	6 A	6 A(1)	6 A(1)	X	X	X
200 W	10 A	10 A	10 A(1)	X	X	X	X	X

(1) Acceptable from safety point of view but will lead to a higher voltage drop.

Table 121 Recommended Hydraulic Magnetic Circuit Breaker Values

The following circuit breaker values are applicable to NTM 203 72 (2x2.5 mm²).

Power Rating of Product	Length					
	10 m	20 m	50 m	70 m	100 m	120 m
50 W	4 A	4 A	4 A	4 A(1)	4 A(1)	X
75 W	4A	4 A	4 A	4 A(1)	4 A(1)	X
100 W	4 A	4 A	4 A	4 A(1)	4 A(1)	X
125 W	6 A	6 A	6 A(1)	X	X	X
150 W	6 A	6 A	6 A(1)	X	X	X
200 W	10 A	10 A	X	X	X	X

(1) Acceptable from safety point of view but will lead to a higher voltage drop.

Table 122 Recommended Thermoelectric Magnetic Circuit Breaker

The following circuit breaker values are applicable to NTM 203 72 (2x2.5 mm^2).

Power rating of product	Length					
	10 m	20 m	50 m	70 m	100 m	120 m
50 W	4 A	4 A	4 A	4 A(1)	4 A(1)	X
75 W	4 A	4 A	4 A	4 A(1)	4 A(1)	X
100 W	6 A	6 A	6 A	X	X	X
125 W	6 A	6 A	6A(1)	X	X	X
150 W	10 A	10 A	X	X	X	X
200 W	10 A	10 A	X	X	X	X

(1) Acceptable from safety point of view but will lead to a higher voltage drop.

5.3.2 Power Consumption and Heat Dissipation

Preconditions: 25 °C ambient temperature, -48V DC supply

Table 123 Typical Power Consumption and Heat Dissipation

Unit	Typical Power Consumption and Heat Dissipation
NPU 1002(1) (2)	30 W
NPU 1003(1) (2)	23 W
NPU 1005(1) (2)	41 W
PNM 1001(1) (2) (3)	44 W
PNM 1002(2) (3)	48 W
PFU 1101(3) (4)	2 W (4 W)
PFU 1201(3) (5)	2 W (8 W)
PFU 1301(3) (6)	2 W (5 W)
PFU 1601(3) (6)	2 W (5 W)
FAU 1101(7)	6 W (20 W)
FAU 1201(7)	8 W (15 W)
FAU 1301(7)	2.5 W (10.5 W)
FAU 1401(7)	1.7 W (12 W)
FAU 1501(7)	2.5 W (10.5 W)

Unit	Typical Power Consumption and Heat Dissipation
FAU 1601[7]	2.5 W (10.5 W)
LTU 1001	5 W
LTU 1002[1]	20 W
ETU 1001	7 W
ETU 1002[1]	18 W
MINI-LINK 6651/1[1] [2] [7]	40 W (57 W)
MINI-LINK 6651/2[1] [2] [7]	40 W (57 W)
MINI-LINK 6651/3[1] [2]	27 W
MINI-LINK 6651/4[1] [2] [7]	63 W (80 W)
MINI-LINK 6366[1] [2]	37 W
MINI-LINK 6371[1] [2]	63 W

(1) Each SFP adds 1 W and each SFP+ adds 1.5 W to the consumption value.
(2) Additional power consumption per connected radio unit. See Typical MMU Power Consumption and Indoor Heat Dissipation on page 176. The specified value is applicable when no radio units are connected.
(3) FAU DC loss included.
(4) Enclosure equipped with 1 MMU 1002 or MMU 1004 and 2 radio units consuming 42 W each. Number within brackets represents PFU power consumption for enclosure equipped with 2 MMU 1002 or MMU 1004 and 4 radio units consuming 42 W each. Value within brackets includes fan-unit (FAU) running at full speed.
(5) Enclosure equipped with 2 MMU 1002 or MMU 1004 and 4 radio units consuming 42W each. Number within brackets represents PFU power consumption for enclosure equipped with 8 MMU 1002 or MMU 1004 and 16 radio units consuming 42 W each. Value within brackets includes fan-unit (FAU) running at full speed.
(6) Enclosure equipped with 2 MMU 1002 or MMU 1004 and 4 radio units consuming 42W each. Number within brackets represents PFU power consumption for enclosure equipped with 4 MMU 1002 or MMU 1004 and 8 radio units consuming 42 W each. Value within brackets includes fan-unit (FAU) running at full speed.
(7) Nominal value at room temperature. Value within brackets is when the fan-unit (FAU) is running at full speed (high temperature).

5.3.3 Radio Terminal Power Consumption

5.3.3.1 Typical MMU Power Consumption and Indoor Heat Dissipation

Preconditions: 25 °C ambient temperature, -48V DC supply

Table 124 Typical MMU Power Consumption and Indoor Heat Dissipation

Unit	Typical Power Consumption and Heat Dissipation
MMU 1001[1]	21 W
MMU 1002[1]	25 W
MMU 1004[1]	25 W
Additional power consumption in MMU 1001, MMU 1002, MMU 1004, PNM 1001, PNM 1002, MINI-LINK 6651, MINI-LINK 6366 or MINI-LINK 6371 per connected radio unit	10% of the radio unit's power consumption

(1) Applicable when no radio units are connected.

5.3.3.2 RAU2 X Power Consumption and Outdoor Heat Dissipation

Typical power consumption and heat dissipation (W) at different RAU output power levels.

Table 125 Typical Power Consumption and Outdoor Heat Dissipation of RAU2 X

RAU Type	Nominal cons.	Eco Mode		
		P_{max} [1]	$P_{max-10dB}$	P_{min}
RAU2 X 5 HP	42	37	23	15
RAU2 X 6L	30	27	24	17
RAU2 X 6L HP	42	37	28	15
RAU2 X 6U	28	25	22	15
RAU2 X 6U HP	42	37	28	15
RAU2 X 7	29	26	23	16
RAU2 X 7 HP	42	37	28	15
RAU2 X 8	30	27	24	16
RAU2 X 8 HP	42	42	26	16
RAU2 X 10	32	32	24	17
RAU2 X 10 HP	38	38	28	18
RAU2 X 11	27	27	20	16
RAU2 X 11 HP	39	39	28	17

RAU Type	Nominal cons.	Eco Mode		
		P_{max} (1)	$P_{max-10dB}$	P_{min}
RAU2 X 13	23	20	19	15
RAU2 X 13 HP	26	22	20	15
RAU2 X 15	24	19	19	15
RAU2 X 15 HP	26	21	20	15
RAU2 X 18	22	20	19	16
RAU2 X 18 HP	27	24	24	16
RAU2 X 23	22	20	19	16
RAU2 X 23 HP	28	25	24	16
RAU2 X 24	25	22	18	16
RAU2 X 26	25	22	18	16
RAU2 X 28	26	23	19	17
RAU2 X 32	24	22	22	15
RAU2 X 38	27	24	24	20
RAU2 X 42	25	23	21	19

(1) Requires RAU2 X HW ≥ R6A.

5.3.3.3 MINI-LINK 6363 Power Consumption and Outdoor Heat Dissipation

Typical power consumption and heat dissipation (W) at P_{max} (Including HP License), $P_{max-10dB}$ and P_{min}.

Table 126 Typical Power Consumption and Outdoor Heat Dissipation of MINI-LINK 6363

Radio Type	P_{max}	$P_{max-10dB}$	P_{min}
MINI-LINK 6363 6L	33	27	17
MINI-LINK 6363 6U	33	27	17
MINI-LINK 6363 7	32	26	16
MINI-LINK 6363 8	32	26	16
MINI-LINK 6363 10	31	22	19
MINI-LINK 6363 11	31	24	19

Radio Type	P_{max}	$P_{max-10dB}$	P_{min}
MINI-LINK 6363 13	23	18	15
MINI-LINK 6363 15	25	20	16
MINI-LINK 6363 18	23	21	19
MINI-LINK 6363 23	23	21	19
MINI-LINK 6363 24	24	21	19
MINI-LINK 6363 26	24	21	19
MINI-LINK 6363 28	23	20	19
MINI-LINK 6363 32	23	20	19
MINI-LINK 6363 38	23	22	20
MINI-LINK 6363 42	23	22	20
MINI-LINK 6363 80	24	23	19

Typical power consumption and heat dissipation (W) at P_{max}, $P_{max-10dB}$ and P_{min}.

Table 127 Typical Power Consumption and Outdoor Heat Dissipation of MINI-LINK 6363/2

Radio Type	P_{max}	$P_{max-10dB}$	P_{min}
MINI-LINK 6363/2 13	16	15	14
MINI-LINK 6363/2 15	16	15	14
MINI-LINK 6363/2 18	14	13	12
MINI-LINK 6363/2 23	14	13	12
MINI-LINK 6363/2 38	20	20	19

5.3.3.4 MINI-LINK 6364 Power Consumption and Outdoor Heat Dissipation

Typical power consumption and heat dissipation (W) at P_{max} (Including HP License), $P_{max-10dB}$ and P_{min}.

Table 128 Typical Power Consumption and Outdoor Heat Dissipation of MINI-LINK 6364

Radio Type	P_{max}	$P_{max-10dB}$	P_{min}
MINI-LINK 6364 13	26	22	18
MINI-LINK 6364 15	26	22	18

Radio Type	P_{max}	$P_{max-10dB}$	P_{min}
MINI-LINK 6364 18	25	22	20
MINI-LINK 6364 13 CA mode	26	22	21
MINI-LINK 6364 15 CA mode	26	22	21
MINI-LINK 6364 18 CA mode	27	23	22

5.3.3.5 MINI-LINK 6365 Power Consumption and Outdoor Heat Dissipation

Typical power consumption and heat dissipation (W) at P_{max} (Including HP License), $P_{max-10dB}$ and P_{min}.

Table 129 Typical Power Consumption and Outdoor Heat Dissipation of MINI-LINK 6365

Radio Type	P_{max}	$P_{max-10dB}$	P_{min}
MINI-LINK 6365 6	35	29	19
MINI-LINK 6365 7/8	35	29	19
MINI-LINK 6365 10/11	35	29	19
MINI-LINK 6365 13	26	22	18
MINI-LINK 6365 15	26	22	18
MINI-LINK 6365 18	25	22	20
MINI-LINK 6365 23	25	22	20
MINI-LINK 6365 32	23	20	19
MINI-LINK 6365 6 CA mode	37	31	22
MINI-LINK 6365 7/8 CA mode	35	29	24
MINI-LINK 6365 10/11 CA mode	36	30	21
MINI-LINK 6365 13 CA mode	26	22	21
MINI-LINK 6365 15 CA mode	26	22	21
MINI-LINK 6365 18 CA mode	27	23	22
MINI-LINK 6365 23 CA mode	26	23	22
MINI-LINK 6365 32 CA mode	24	21	21

6 Environment

6.1 Environmental Conditions

Continuous Conditions (Normal Operation)
Environmental conditions in which all units are able to function as specified.

Exceptional Conditions (Safe Function)
Environmental stress outside the limits for normal operation in which all units continue to function, but performance or capacity may be reduced, e.g. slightly increased bit error rates.

6.1.1 Indoor Equipment

Ambient Temperature Range:

Continuous Conditions (Normal Operation)
-5 to +60° C (+23 to +131° F)

Exceptional Conditions (Safe Function — except for MINI-LINK 6651/3)
-25 to +65° C (-13 to +140° F)

Exceptional Conditions (Safe Function — for MINI-LINK 6651/3)
-25 to +60° C (-13 to +131° F)

Relative Humidity Range:

Relative Humidity Range
5-95%

6.1.2 Outdoor Equipment

Ambient Temperature Range:

Continuous Conditions (Normal Operation)
-33 to +55° C (-27 to +131° F)

Note: Outdoor temperature is measured in an open unshielded area preferably close to the radio. Sensor has to be protected from the sun. Minimum distance to other objects is 50 cm.

Exceptional Conditions (Safe Function)
-45 to +60° C (-49 to +140° F)

Note: Outdoor temperature is measured in an open unshielded area preferably close to the radio. Sensor has to be protected from the sun. Minimum distance to other objects is 50 cm.

Relative Humidity Range:

Relative Humidity Range
8-100 %

7 Mechanical Data

7.1 Outdoor Units

7.1.1 Weight (antennas not included)

Table 130 RAU2 X

Frequency	Typical		Max(1)	
	(kg)	(lb)	(kg)	(lb)
5–8 GHz	4.8	10.6	5.5	12.1
10–23 GHz	4.0	8.8	4.5	9.9
24–42 GHz	3.7	8.2	4.0	8.8

(1) Maximum weight varies due to different sub-bands' diplexers.

Table 131 MINI-LINK 6363, MINI-LINK 6363/2, MINI-LINK 6364, and MINI-LINK 6365

Frequency	Typical		Max(1)	
	(kg)	(lb)	(kg)	(lb)
6 – 15 GHz	2.7	6.0	3.2	7.1
18 – 80 GHz	2.3	5.1	2.7	6.0

(1) Maximum weight varies due to different sub-bands' diplexers.

Table 132 MINI-LINK 6366/1 and MINI-LINK 6366/4

	(kg)	(lb)
Without mounting bracket	4.0	8.8
With mounting bracket for integrated mount	5.2	11.5
With two brackets for split-mount	4.2	9.3

Table 133 MINI-LINK 6371

	(kg)	(lb)
Without mounting bracket	5.6	12.2
With mounting bracket for integrated mount	6.7	14.8
With two brackets for split-mount	5.8	12.7
With mounting bracket for rail-mount	6.4	14.1

7.1.2 Nominal Dimensions

Table 134 Outdoor Unit Dimensions

Product	DxWxH	
	(mm)	(inch)
RAU2 X	97 x 260 x 321	3 3/4 x 10 1/4 x 12 1/2
MINI-LINK 6363, MINI-LINK 6363/2, MINI-LINK 6364, and MINI-LINK 6365	79 x 197 x 179	3 7/64 x 7 3/4 x 7 3/64
MINI-LINK 6366/1 without mounting bracket	43 x 462 x 303	1 11/16 x 20 17/64 x 11 59/64
MINI-LINK 6366/1 with mounting bracket for integrated mount	158 x 462 x 303	6 7/32 x 20 17/64 x 11 59/64
MINI-LINK 6366/4 without mounting bracket	70 x 310 x 291	2 3/4 x 12 1/5 x 11 5/11
MINI-LINK 6366/4 with mounting bracket for integrated mount	188 x 335 x 291	7 2/5 x 13 1/5 x 11 5/11
MINI-LINK 6371 without mounting bracket	86 x 310 x 294	3 25/64 x 12 1/5 x 11 37/64
MINI-LINK 6371 with mounting bracket for integrated mount	204 x 335 x 294	8 1/32 x 13 1/5 x 11 37/64

7.2 Indoor Units

7.2.1 Weight

Table 135 Weight of units

	(kg)	(lb)
Enclosure 1101	2.9	6.4
Enclosure 1201	6.2	13.7
Enclosure 1301	3.6	7.9
Enclosure 1401	2.9	6.4
Enclosure 1501	3.5	7.7

	(kg)	(lb)
Enclosure 1601	4.8	10.6
PFU 1101	0.2	0.4
PFU 1201	0.2	0.4
PFU 1301	0.2	0.4
PFU 1401	0.2	0.4
FAU 1101	0.3	0.7
FAU 1201	0.6	1.3
FAU 1301	0.3	0.7
FAU 1401	0.2	0.4
FAU 1501	0.3	0.7
FAU 1601	0.4	0.9
FAU 1101	0.3	0.7
FAU 1201	0.6	1.3
FAU 1301	0.3	0.7
FAU 1401	0.2	0.4
FAU 1501	0.3	0.7
FAU 1601	0.4	0.9
NPU 1002	0.9	2.0
NPU 1003	0.7	1.5
NPU 1005	0.9	2.0
PNM 1001	1.0	2.2
PNM 1001	1.2	2.6
LTU 1001	0.4	0.9
LTU 1002	0.4	0.9
ETU 1001	0.4	0.9
ETU 1002	0.4	0.9
MMU 1001	0.6	1.4
MMU 1002	0.7	1.5
MMU 1004	0.7	1.5
APU Dummy unit	0.3	0.6
NPU Dummy unit	0.5	1.1
PFU Dummy unit	0.05	0.11
MINI-LINK 6651/1, /2 and /4 (incl. fan)	4.2	9.3

	(kg)	(lb)
MINI-LINK 6651/3	3.0	6.6

7.2.1.1 Full Configurations

Table 136 Weight of full configurations

	(kg)	(lb)
MINI-LINK 6691 (Incl. NPU 1002, PFU 1101, FAU 1101, 2 x MMU 1002)	5.6	12.3
MINI-LINK 6692 (Incl. NPU 1002, PFU 1201, FAU 1201, 8 x MMU 1002)	13.5	29.8
MINI-LINK 6693 (Incl. NPU 1003, PFU 1301, FAU 1301, 4 x MMU 1002)	7.3	16.1
MINI-LINK 6694 (Incl. NPU 1002, PFU 1601, FAU 1601, 4 x MMU 1002)	9.5	20.9
MINI-LINK 6654 (Incl. PNM 1001, FAU 1401, 2 x MMU 1002)	5.5	12.1
MINI-LINK 6655 (Incl. PNM 1002, FAU 1501, 4 x MMU 1002)	7.7	17.0

7.2.2 Nominal Dimensions

The sub-racks fit into standard IEC 297-3 19" cabinets or into cabinets following metric standard IEC 917-2-2.

Table 137 MINI-LINK 6691 and MINI-LINK 6654

	(mm)	(inch)
Depth (total; with connectors):	259	10 13/64
Depth (behind mounting brackets):	240	9 29/64
Width (total):	483	19 1/64
Width (without mounting brackets):	446	17 9/16
Height:	44	1 3/4

Table 138 MINI-LINK 6692

	(mm)	(inch)
Depth (total; with connectors):	259	10 13/64
Depth (behind mounting brackets):	240	9 29/64
Width (total):	483	19 1/64
Width (without mounting brackets):	446	17 9/16
Height:	132.7	5 7/32

Table 139 MINI-LINK 6693 and MINI-LINK 6655

	(mm)	(inch)
Depth (total; with connectors):	259	10 13/64
Depth (behind mounting brackets):	240	9 29/64
Width (total):	483	19 1/64
Width (without mounting brackets):	446	17 9/16
Height:	66	2 19/32

Table 140 MINI-LINK 6694

	(mm)	(inch)
Depth (total; with connectors):	259	10 13/64
Depth (behind mounting brackets):	240	9 29/64
Width (total):	483	19 1/64
Width (without mounting brackets):	446	17 9/16
Height:	89	3 1/2

Table 141 MINI-LINK 6651/1, /2 and /4

	(mm)	(inch)
Depth (total; with connectors):	261	10 9/32
Depth (behind mounting brackets):	240	9 29/64
Width (total):	483	19 1/64
Width (without mounting brackets):	444	17 31/64
Height:	44	1 3/4

Table 142 MINI-LINK 6651/3

	(mm)	(inch)
Depth (total; with connectors):	194	7 41/64
Depth (behind mounting brackets):	171	6 47/64
Width (total):	483	19 1/64
Width (without mounting brackets):	444	17 31/64
Height:	44	1 3/4

8 Standards

Compliance with relevant parts of the listed standards.

8.1 Radio Equipment Directive (RED)

Essential requirements of Directive 2014/53/EU (Radio Equipment Directive, RED)

8.2 ATEX Directive

Applicable for MINI-LINK 6363, MINI-LINK 6364, and MINI-LINK 6365.

Essential requirements of Directive 2014/34/EU (Equipment for potentially explosive atmospheres)

8.3 RoHS Directive

Directive 2011/65/EU CE	Of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment

8.4 Council Recommendation

Council Recommendation 1999/519/EC (10 W/m2 – Public)	Of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz)

8.5 RoHS

EN 50581	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances

8.6 Normative References

Code of Federal Regulations Title 21 Volume 8	Food and Drugs Chapter 1 — Food and Drugs Administration Department of Health and Human Services Subchapter J — Radiological Health
Code of Federal Regulations Title 47 Volume 1 & 5	Telecommunication Chapter I — Federal Communications Commission Chapter I
Interference-Causing Equipment Standards (ICES)	Spectrum Management and Telecommunication Official Publications, Standards, Interference-Causing Equipment Standards (ICES)
Radio Standards Specification (RSS)	Spectrum Management and Telecommunication Official Publications, Standards, Radio Equipment Standards, Radio Standards Specifications (RSS)
Spectrum Utilization Policy (SP)	Spectrum Management and Telecommunication Official Publications, Policies, Spectrum Utilization Policies (SP)
Standard Radio System Plan (SRSP)	Spectrum Management and Telecommunication Official Publications, Standards, Standard Radio System Plan (SRSP)
Telecommunications Regulation Circulars (TRC)	Spectrum Management and Telecommunication Official Publications, Information, Telecommunications Regulation Circulars (TRC)

8.7 Mechanics

IEC 60297-3-100	Mechanical structures for electronic equipment — Dimensions of mechanical structures of the 482.6 mm (19 in) series Part 3-100: Basic dimensions of front panels, sub racks, chassis, racks and cabinets
IEC 60297-3-101	Mechanical structures for electronic equipment — Dimensions of mechanical structures of the 482.6 mm (19 in) series Part 3-101: Sub-racks and associated plug-in units
IEC 60297-3-105	Mechanical structures for electronic equipment — Dimensions of mechanical structures of the 482.6 mm (19 in) series Part 3-105: Dimensions and design aspects for 1U high chassis
ETSI EN 300 119-3	Environmental Engineering: European telecommunication standard for equipment practice; Part 3: Engineering requirements for miscellaneous racks and cabinets

ETSI EN 300 119-4	Environmental Engineering: European telecommunication standard for equipment practice; Part 4: Engineering requirements for sub racks in miscellaneous racks and cabinets
IEC 60917-2-2	Modular order for the development of mechanical structures for electronic equipment practices — Part 2: Sectional specification — Interface co-ordination dimensions for the 25 mm equipment practice — Section 2: Detail specification — Dimensions for sub racks, chassis, back planes, front panels and plug-in units

8.8 Power

EN 300 132-2	Environment Engineering (EE); Power supply interface at the input to telecommunications equipment and atacom (ICT); Part 2: Operated by -48 V direct current (dc)
ATIS-0600315	Voltage Levels for DC-powered Equipment Used in the Telecommunications Environment

8.9 EMC

ETSI EN 301 489-4 (CE DC — Table 6)	Electromagnetic compatibility and Radio spectrum Matters (ERM); Electro-Magnetic Compatibility (EMC) standard for radio equipment and services; Part 4: Specific conditions for fixed radio links and ancillary equipment
ETSI EN 301 489-1 (Emission — Class B Immunity — Level 2)	Electromagnetic compatibility and Radio spectrum Matters (ERM); Electro-Magnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements
FCC 47 CFR part 15	Code of Federal Regulations Title 47: Telecommunication Part 15 — Radio frequency devices
ICES-003	Information Technology Equipment (ITE) — Limits and methods of measurement
GR-1089-CORE	Telcordia Technologies Generic Requirements Electromagnetic Compatibility (EMC) and Electrical Safety — Generic Criteria for Network Telecommunications Equipment

8.10 Safety/Health

IEC/EN 60215	Safety requirements for radio transmitting equipment

(100 W/m2)	
IEC/EN 60 950-1 (Class III Equipment)	Information technology equipment – Safety, Part1: General requirements
IEC/EN 60 950-22	Information technology equipment – Safety – Part 22: Equipment installed outdoors
IEC/EN 60 825-1 (Class 1 Laser)	Safety of laser products – Part 1: Equipment classification, requirements and user's guide
IEC/EN 60529 — IP 66 – Outdoor MINI-LINK 6363 — IP 55 – Outdoor RAU2 with Ingress Protection Cover — IP 20 – Indoor	Degrees of protection provided by enclosures (IP Code)
IEC/EN 62311 (10 W/m2 – Public)	Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz-300 GHz)
EN 50385 (10 W/m2 – Public)	Product standard to demonstrate the compliance of radio base stations and fixed terminal stations for wireless telecommunication systems with the basic restrictions or the reference levels related to human exposure to radio frequency electromagnetic fields (110 MHz – 40 GHz) – General public
ETSI TR 102 457 — 10 W/m2 – Public — 50 W/m2 – Workers	Transmission and Multiplexing I; Study on the electromagnetic radiated field in fixed radio systems for environmental issues
ICNIRP Health Physics (Table 7) — 10 W/m2 – Public — 50 W/m2 – Workers	Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (Up to 300 GHz)
ANSI/UL 60950-1 (Listed/Recognized)	Information Technology Equipment – Safety – Part 1: General Requirements
CSA-C22.2 No. 60950-1 (Listed/Recognized)	Information Technology Equipment – Safety – Part 1: General Requirements (Bi-National standard, with UL 60950-1)

ANSI/UL 60950-22 (RAU2)	Information Technology Equipment — Safety — Part 22: Equipment to be Installed Outdoors
CSA-C22.2 No. 60950-22 (RAU2)	Information Technology Equipment — Safety — Part 22: Equipment to be Installed Outdoors (Bi-National standard, with UL 60950-22)
UL 50E (Type 3R Enclosure)	Enclosures for Electrical Equipment, Environmental Considerations
CSA-C22.2 No.94 (Type 3R Enclosure)	Enclosures for Electrical Equipment, Environmental Considerations (Tri-National Standard, with NMX-J-235/2-ANCE-2007 and UL 50E)
FCC 21 CFR part 1040, § Sec. 1040.10 (Class 1 Laser)	Code of Federal Regulations Title 21 Volume 8 — Food and Drugs Chapter 1 — Food and Drugs Administration Department of Health and Human Services Subchapter J — Radiological Health — Performance Standards for Light-Emitting Products — Laser Products
REDR C1370	Radiation Emitting Devices Regulations
FCC OET Bulletin 65 — 10 W/m2 — Public — 100 W/m2 — Workers	Evaluating Compliance with FCC Guidelines Human Exposure to Radiofrequency Electromagnetic Fields
IEEE Std C95.1 — 10 W/m2 — Public — 100 W/m2 — Workers	IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz
Safety Code 6 — 10 W/m2 — Public — 50 W/m2 — Workers	Limits of Human Exposure to radio frequency Electromagnetic Fields in the Frequency Range from 3 kHz to 300 GHz

8.11 Environmental and Climatic

ETSI EN 300 132-2	Environment Engineering (EE); Power supply interface at the input to telecommunications equipment and atacom (ICT); Part 2: Operated by -48 V direct current (dc)
ETSI EN 300 019-1-1 (Class 1.2)	Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-1: Classification of environmental conditions; Storage
ETSI EN 300 019-1-2 (Class 2.3)	Equipment Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-2: Classification of environmental conditions; Transportation
ETSI EN 300 019-1-3 (Class 3.1E — Normal Operation, Class 3.3 — Safe Function)	Equipment Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-3: Classification of environmental conditions; Stationary use at weather protected locations
ETSI EN 300 019-1-4 (Class 4.1 & 4.2H — Normal Operation, Class 4.1E & 4.2H — Safe Function)	Equipment Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-4: Classification of environmental conditions; Stationary use at non-weather protected locations
ETSI EN 300 019-2-1	Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 2-1: Specification of environmental tests; Storage
ETSI EN 300 019-2-2	Equipment Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 2-2: Specification of environmental tests; Transportation

ETSI EN 300 019-2-3	Equipment Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 2-3: Specification of environmental tests; Stationary use at weather protected locations
ETSI EN 300 019-2-4	Equipment Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 2-4: Specification of environmental tests; Stationary use at non-weather protected locations
GR-63-CORE	Telcordia Technologies Generic Requirements NEBSTM Requirements: Physical Protection
FCC 47 CFR part 2	Code of Federal Regulations Title 47: Telecommunication Part 2 — Frequency allocations and radio treaty matters; general rules and regulations.
CENELEC EN 60079-0:2012 (MINI-LINK 6363, MINI-LINK 6364, and MINI-LINK 6365)	Explosive atmospheres — Part 0: Equipment — General requirements
CENELEC EN 60079-7:2015 (MINI-LINK 6364 and MINI-LINK 6365)	Explosive atmospheres — Part 7: Equipment protection by increased safety "e"
CENELEC EN 60079-15:2012 (MINI-LINK 6363)	Explosive atmospheres — Part 15: Equipment protection by type of protection “n”

8.12 PDH

ITU-T O.151 10/92	Error performance measuring equipment operating at the primary rate and above
ITU-T G.703 10/98	Physical/electrical characteristics of hierarchical digital interfaces
ITU-T G.823 03/00	The control of jitter and wander within digital networks which are based on

	the 2048 Kbit/s hierarchy; Jitter and wander
ITU-T G.826 12/02	Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate. (Definition of parameters)
ITU-T G.921	Digital sections based on the 2048 kbit/s hierarchy
ITU-T G.775 10/98	Loss of Signal (LOS), Alarm Indication Signal (AIS) and Remote Defect Indication (RDI) defect detection and clearance criteria for PDH signals
G.742-88	Second order digital multiplex operating at 8.448 Mbit/s.
G.751-88	Third order digital multiplex operating at 34.368 Mbit/s.
ANSI T1.403-1999	Network to customer installation interface-DS1 electrical interface.
ANSI T1.102-1993	Digital Hierarchy, electrical interfaces
ANSI T1.231-1997	Digital Hierarchy-Layer 1 in-Service Digital Transmission Performance Monitoring.
ANSI T1.404-1994	DS3 and Metallic Interface Specification
Bellcore GR-499 –CORE	Transport Systems Generic Requirements (TSGR).

8.13 SDH

ITU-T G.703 10/98	Physical/electrical characteristics of hierarchical digital interfaces
ITU-T G.707 12/03	Network Element interface for the synchronous digital hierarchy (SDH)
ITU-T G.783 02/04	Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks
ITU-T G.826 12/02	Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate.

ITU-T G.828 02/00	Error performance parameters and objectives for international, constant bit rate synchronous digital paths
ITU-T G.841 10/98	Types and characteristics of SDH network protection architecture
ITU-T G.957 07/99	Optical interfaces for equipments and systems relating to the synchronous digital hierarchy
ITU-T M.2120 02/00	PDH path, section and transmission system and SDH path and multiplex section fault detection and localization procedures
ITU-T G.664	Optical safety procedures and requirements for optical transport systems
SFF-8472	Diagnostic Monitoring Interface for Optical Xcvrs
ETSI 301 167	Transmission and Multiplex II; Management of Synchronous Digital Hierarchy (SDH) transmission equipment; Fault management and performance monitoring; Functional description

8.14 Ethernet

IEEE 802.3/802.3u/ 802.3ab (Ethernet Interface)	CSMA/CD Access Method and Physical Layer Specifications
IEEE 802.3ac	Frame Extensions for Virtual Bridged Local Area Network (VLAN) Tagging on IEEE 802.3 Networks
IEEE 802.1ad	IEEE Standard for Local and metropolitan area networks Virtual Bridged Local Area Networks Amendment 4: Provider Bridges
IEEE 802.3ah	Media Access Control Parameters, Physical layers, and Management Parameters for Subscriber Access Networks
IEEE 802.3as-2006 (Frame size)	Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications

IEEE 802.1	Working group for 802 LAN/MAN architecture, internetworking among 802 LANs, MANs and other wide area networks, 802 Security, 802 overall network management, and protocol layers above the MAC & LLC layers.
IEEE 802.1p (Priority)	Traffic Class Expediting and Dynamic Multicast Filtering (published in 802.1D-1998)
IEEE 802.1D	IEEE Standard for Local and metropolitan area networks: Media Access Control (MAC) Bridges
IEEE 802.1Q	IEEE Standard for Local and Metropolitan Area Networks---Virtual Bridged Local Area Networks
IEEE 802.3x (Flow control)	IEEE Standards for Local and Metropolitan Area Networks: Specification for 802.3 Full Duplex Operation
IEEE 802.1AX	IEEE Standard for Local and metropolitan area networks— Link Aggregation
IETF RFC 1242	Benchmarking Terminology for Network Interconnection Devices: Performance measurements
RFC 2309	Recommendations on Queue Management and Congestion Avoidance in the Internet
IETF RFC 2544	Benchmarking Methodology for Network Interconnect Devices: Measurement of latency for SDH
RFC 4188	Definitions of Managed Objects for Bridges
MEF 2	Requirements and Framework for Ethernet Service Protection in Metro Ethernet Networks
MEF 9	Abstract Test Suite for Ethernet Services at the UNI
MEF 10	Ethernet Services Attributes Phase I
MEF 14	Abstract Test Suite for Ethernet Services at the UNI
IEEE 802.1ag/ITU-T Y.1731	Ethernet Service OAM CFM
ITU-T Y.1731	Ethernet Service OAM PM

8.15 Synchronization

ITU-T G.781 07/99	Synchronization layer functions
ITU-T G.813 03/03	Timing characteristics of SDH equipment slave clocks (SEC)
ITU-T G.823 03/00	The control of jitter and wander within digital networks which are based on the 2048 Kbit/s hierarchy; Jitter and wander
ITU-T G.8261/Y.1361	Timing and synchronization aspects in packet network
ITU-T G.8262/Y.1362	Timing characteristics of a synchronous Ethernet equipment slave clock
ITU-T G.8264/Y.1364	Distribution of timing information through packet networks
G.8265.1	Precision time protocol telecom profile for frequency synchronization
ITU-T G.8273.2	Timing characteristics of telecom boundary clocks and telecom time slave clocks
ITU-T G.8271.1	Network limits for time synchronization in packet networks
ITU-T G.8275.1	Precision time protocol telecom profile for phase/time synchronization with full timing support from the network
IEEE 1588-2008	Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems

8.16 Digital Radio Transmission

ETSI EN 302 217-2-2 (Radio equipment Class II)	Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 2-2: Digital systems operating in frequency bands where frequency co-ordination is applied; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive
ETSI EN 302 217-2-1	Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 2-1: System-dependent requirements for digital systems operating in frequency bands where frequency coordination is applied
ETSI EN 302 217-1	Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 1: Overview and system independent common characteristics
ETSI EN 301 126-1	Fixed Radio Systems; Conformance testing; Part 1: Point-to-Point equipment — Definitions, general requirements and test procedures
ETSI EN 301 390	Fixed Radio Systems; Point-to-point and Multipoint Systems; Unwanted emissions in the spurious domain and receiver immunity limits at equipment/antenna port of Digital Fixed Radio Systems
CEPT ERC/DEC/(00) 07	Shared use of the band 17.7-19.7 GHz by the fixed service and Earth stations of the fixed-satellite service.
CEPT/ERC/REC 74-01E	Unwanted Emissions in the Spurious Domain

Rec. ITU-R F.1099	Radio-frequency channel arrangements for high- and medium-capacity digital fixed wireless systems in the upper 4 GHz (4 400-5 000 MHz) band
Rec. ITU-R F.383	Radio-frequency channel arrangements for high-capacity fixed wireless systems operating in the lower 6 GHz (5 925 to 6 425 MHz) band
Rec. ITU-R F.384	Radio-frequency channel arrangements for medium- and high-capacity digital fixed wireless systems operating in the 6 425-7 125 MHz band
Rec. ITU-R F.385	Radio-frequency channel arrangements for fixed wireless systems operating in the 7 110-7 900 MHz band
Rec. ITU-R F.386	Radio-frequency channel arrangements for fixed wireless systems operating in the 8 GHz (7 725 to 8 500 MHz) band
Rec. ITU-R F.747	Radio-frequency channel arrangements for fixed wireless systems operating in the 10.0-10.68 GHz band
Rec. ITU-R F.1568	Radio-frequency block arrangements for fixed wireless access systems in the range 10.15-10.3/10.5-10.65 GHz
Rec. ITU-R F.387	Radio-frequency channel arrangements for fixed wireless systems operating in the 10.7-11.7 GHz band
Rec. ITU-R F.497	Radio-frequency channel arrangements for fixed wireless systems operating in the 13 GHz (12.75-13.25 GHz) frequency band
Rec. ITU-R F.636	Radio-frequency channel arrangements for fixed wireless systems operating in the 14.4-15.35 GHz band
Rec. ITU-R F.595	Radio-frequency channel arrangements for fixed wireless systems operating in the 17.7-19.7 GHz frequency band

Rec. ITU-R F.637	Radio-frequency channel arrangements for fixed wireless systems operating in the 21.2-23.6 GHz band
Rec. ITU-R F.748	Radio-frequency arrangements for systems of the fixed service operating in the 25, 26 and 28 GHz bands
Rec. ITU-R F.1520	Radio-frequency arrangements for systems in the fixed service operating in the band 31.8-33.4 GHz
Rec. ITU-R F.749	Radio-frequency arrangements for systems of the fixed service operating in the 36-40.5 GHz band
Rec. ITU-R F.2005	Radio-frequency channel and block arrangements for fixed wireless systems operating in the 42 GHz (40.5 to 43.5 GHz) band
CEPT/ERC/REC 14-01 E	Radio-frequency channel arrangements for high capacity analogue and digital radio-relay systems operating in the band 5925 MHz — 6425 MHz
CEPT/ERC/REC 14-02 E	Radio-frequency channel arrangements for medium and high capacity analogue or high capacity digital radio-relay systems operating in the band 6425 MHz-7125 MHz
ECC/REC/(02)06	Preferred channel arrangements for digital Fixed Service Systems operating in the frequency range 7125-8500 MHz
CEPT/ERC/REC 12-05 E	Harmonized radio frequency channel arrangements for digital terrestrial fixed systems operating in the band 10.0 — 10.68 GHz
CEPT/ERC/REC 12-06 E	Preferred channel arrangements for fixed service systems operating in the frequency band 10.7 — 11.7 GHz
CEPT/ERC/REC 12-02 E	Harmonized radio frequency channel arrangements for analogue and digital terrestrial fixed systems operating in the bands 12.75 GHz to 13.25 GHz

CEPT/ERC/REC 12-07 E	Harmonized radio frequency channel arrangements for analogue and digital terrestrial fixed systems operating in the bands 14.5 – 14.62 GHz paired with 15.23 -15.35 GHz
CEPT/ERC/REC 12-03 E	Harmonized radio frequency channel arrangements for analogue and digital terrestrial fixed systems operating in the bands 17.7 GHz to 19.7 GHz
T/R 13-02	Preferred channel arrangements for fixed services in the range 22.0-29.5 GHz
ERC/REC/(01)02	Preferred channel arrangements for digital fixed service systems operating in the frequency band 31.8 – 33.4 GHz
T/R 12-01 E	Harmonized radio frequency channel arrangements for analogue and digital terrestrial fixed systems operating in the bands 37-39.5 GHz
ECC/REC/(01)04	Recommended guidelines for the accommodation and assignment of multimedia wireless systems (MWS) and point-to-point (P-P) fixed wireless systems in the frequency band 40.5 – 43.5 GHz
FCC 47 CFR part 2 (§ 2.902 Verification)	Code of Federal Regulations Title 47: Telecommunication Part 2 – Frequency allocations and radio treaty matters; general rules and regulations.
FCC 47 CFR part 101	Code of Federal Regulations Title 47: Telecommunication Part 101 – Fixed microwave services
RSS-191	Local Multipoint Communication Systems in the Band 25.35-28.35 GHz; Point-to-Point and Point-to-Multipoint Broadband Communication Systems in the Bands 24.25-24.45 GHz and 25.05-25.25 GHz; and Point-to-Multipoint Broadband Communications in the Band 38.6-40.0 GHz
SP Gen	General Information Related to Spectrum Utilization and Radio Systems Policies
SP 1-20 GHz	Revisions to Microwave Spectrum Utilization Policies in the Range of 1-20 GHz

SP 3-30 GHz	Revisions to Spectrum Utilization Policies in the 3-30 GHz Frequency Range and Further Consultation
SRSP-305.9	Technical Requirements for Fixed Line-of-Sight Radio Systems Operating in the Band 5925 – 6425 MHz
SRSP-306.4	Technical Requirements for Fixed Line-of-Sight Radio Systems Operating in the Band 6425 – 6930 MHz
SRSP-306.5	Technical Requirements for Radio Systems Operating in the Fixed Service and Providing Television Auxiliary Services in the Bands 6590 – 6770 MHz and 6930 – 7125 MHz
SRSP-307.1	Technical Requirements for Fixed Line-of-Sight Radio Systems Operating in the Band 7125 – 7725 MHz
SRSP-307.7	Technical Requirements for Fixed Line-of-Sight Radio Systems Operating in the Band 7725 – 8275 MHz
SRSP-310.5	Technical Requirements for Fixed Line-of-Sight Radio Systems Operating in the Band 10.55-10.68 GHz
SRSP-310.7	Technical Requirements for Fixed Line-of-Sight Radio Systems Operating in the Band 10.7 – 11.7 GHz
SRSP-314.5	Technical Requirements for Fixed Line-of-Sight Radio Systems Operating in the Band 14.5 – 15.35 GHz
SRSP-317.8	Technical Requirements for Fixed Line-of-Sight Radio Systems Operating in the Bands, 17.8-18.3 GHz and 19.3-19.7 GHz
SRSP-321.8	Technical Requirements for the Fixed Line-of-Sight Radio Systems Operating in the Bands 21.8 – 22.4 GHz and 23.0 – 23.6 GHz

SRSP-324.25	Technical requirements for Fixed Radio Systems Operating in the Bands 24.25 – 24.45 GHz and 25.05 – 25.25 GHz
SRSP-325.25	Technical Requirements for Fixed Radio Systems Operating in the Bands 25.25-26.5 GHz and 27.5-28.35 GHz
SRSP-338.6	Technical Requirements for Fixed Radio Systems Operating in the Band 38.6 – 40.0 GHz
TRC-43	Designation of Emissions (Including Necessary Bandwidth and Classification), Class of Station and Nature of Service

8.17 Operation & Maintenance Interfaces

8.17.1 DCN

IEEE 802.3	10 BASE-T Ethernet
IEEE 802.2	Local and metropolitan area networks-Specific requirements; Part 2: Logical Link Control
IETF RFC 768	User Datagram Protocol
IETF RFC 791	Internet protocol DARPA internet program protocol specification
IETF RFC 792	Internet control message protocol DARPA internet program protocol specification
IETF RFC 793	Transmission control protocol DARPA internet program protocol specification
IETF RFC 826	Address Resolution Protocol for SiteLAN and local access port
IETF RFC 854	Telnet protocol specification
IETF RFC 894	Transmission of IP datagrams over Ethernet Networks on SiteLAN Access and the local access port.
IETF RFC 951	Bootstrap protocol (bootp)
IETF RFC 959	File transfer protocol (ftp)
IETF RFC 1035	Domain names – implementation and specification
IETF RFC 1042	Transmission of IP Datagrams over IEEE 802 Networks on SiteLAN Access and the local access port.

IETF RFC 1144	PPP TCP/IP header compression
IETF RFC 1305	Network Time Protocol (Version 3) Specification, Implementation and Analysis
IETF RFC 1519	Classless Inter-Domain Routing (CIDR): an Address Assignment and Aggregation Strategy
IETF RFC 1542	Clarifications and Extensions for the Bootstrap Protocol
IETF RFC 1631	The IP Network Address Translator (NAT) for the local access port.
IETF RFC 1700	Assigned Numbers (Telnet)
IETF RFC 1812	Requirements for IP Version 4 Routers
IETF RFC 2096	IP Forwarding Table MIB
IETF RFC 2131	Dynamic Host Configuration Protocol for the Local Access Port.
IETF RFC 2328	OSPF Version 2
IETF RFC 2474	Definition of the Differentiated Services Field (DS Field) in the Ipv4 and Ipv6 Headers
IETF RFC 2508	Compressing IP/UDP/RTP Headers for Low-Speed Serial Links
IETF RFC 2509	IP Header Compression over PPP
IETF RFC 2780	IANA Allocation Guidelines for values in the Internet Protocol and Related Headers
IETF RFC 4251	The Secure Shell (SSH) Protocol Architecture
IETF RFC 5426	Transmission of Syslog Messages over UDP

8.17.2 SNMP

The list below shows all IETF RFCs, which the MINI-LINK 6600, MINI-LINK 6366, and MINI-LINK 6371 complies with in applicable parts. None of the IETF specified notification types are supported.

IETF RFC 1157	A Simple Network Management Protocol (SNMP)
IETF RFC 1212	Concise MIB Definitions
IETF RFC 1213	Management Information Base for Network Management of TCP/IP-based internets: MIB-II
IETF RFC 1850	OSPF Version 2 Management Information Base
IETF RFC 1901	Introduction to Community-Based SNMPv2
IETF RFC 2011	SNMPv2 Management Information Base for the Internet Protocol using SMIv2

IETF RFC 2012	SNMPv2 Management Information Base for the Transmission Control Protocol using SMIv2
IETF RFC 2013	SNMPv2 Management Information Base for the User Datagram Protocol using SMIv2
IETF RFC 2558	Definitions of Managed Objects for the SONET/SDH Interface Type
IETF RFC 2571	An Architecture for Describing SNMP Management Frameworks
IETF RFC 2578/STD58	Structure of Management Information Version 2 (SMIv2)
IETF RFC 2579/STD58	Textual Conventions for SMIv2
IETF RFC 2580/STD58	Conformance Statements for SMIv2
IETF RFC 2737	Entity MIB
IETF RFC 2863	The Interfaces Group MIB for SiteLAN
IETF RFC 2864	The Inverted Stack Table Extension to the Interfaces Group MIB
IETF RFC 3410	Introduction and Applicability Statements for Internet-standard Network Management Framework
IETF RFC 3411/STD62	An architecture for Describing SNMP Management Frameworks
IETF RFC 3412/STD62	Message Processing and Dispatching for the SNMP
IETF RFC 3413/STD62	SNMP Applications
IETF RFC 3414/STD62	User-based Security Model (USM) for SNMPv3
IETF RFC 3415/STD62	View-based Access Control Model (VACM) for SNMP
IETF RFC 3416/STD62	Version 2 of the Protocol Operations for SNMP
IETF RFC 3417/STD62	Transport Mappings for SNMP
IETF RFC 3418/STD62	Management Information Base for SNMP
IETF RFC 3584	Co-existence Between Version 1, Version 2,and Version 3 of the Internet-Standard Network Management Framework
IETF RFC 3593	Textual Conventions for MIB Modules Using Performance History Based on 15 Minute Intervals
IETF RFC 4133	Entity MIB (Version 3)
IETF RFC 4188	Definition of Managed Objects for Bridges
IETF RFC 4001	Textual conventions for Internet network addresses
IETF RFC 4805	Definitions of Managed Objects for the DS1, J1, E1, DS2, and E2 Interface Types

8.18 Security

ITU-T X.800	Security Architecture for open system interconnection for CCIT applications
ITU-T X.805	Security Architecture for systems providing end-to-end communications
IETF RFC 2865	RADIUS
IETF draft-grant-tacacs-02.txt	TACACS+ v 1.78
IETF RFC 4251, RFC 4252, RFC 4253	SSH
IETF RFC 3414/STD62	User-based Security Model (USM) for SNMPv3
IETF RFC 3826	The Advanced Encryption Standard (AES) Cipher Algorithm in the SNMP User-based Security Model
IETF RFC 7630	HMAC-SHA-2 Authentication Protocols in the User-based Security Model (USM) for SNMPv3

9 Definitions/Abbreviations

ACAP	Adjacent Channel Alternate Polarization
ACCP	Adjacent Channel Co-Polarization
AIS	Alarm Indicating Signal
APU	Application Plug-in Unit
ATPC	Automatic Transmit Power Control
AU-n	Administrative Unit-n
BER	Bit Error Rate
BERT	Bit error Ratio Test
CBS	Committed Burst Size
CCDP	Co-Channel Dual-Polarization
CESoPSN	Structure-aware TDM Circuit Emulation Service over Packet Switched Network
CIR	Committed Information Rate
CW	Continuous Wave
DCN	Data Communication Network
DTE	Data Terminal Equipment
EBS	Excess Burst Size
ECID	Emulated Circuit Identifier
EIR	Excess Information Rate
EM	Electro Magnetic
EMC	Electro Magnetic Compatibility
ETU	Ethernet Termination Unit

FAU	Fan Unit
FTP	File Transfer Protocol
IEC	International Electro technical Commission
IETF	Internet Engineering Task Force
IME	Inverse Multiplexing
LAG	Link Aggregation Group
LAN	Local Area Network
LED	Light Emitting Diode
LTU	Line Termination Unit
MEF	Metro Ethernet Forum
MIB	Management Information Base
MMU	Modem Unit
MSP	Multiplexer Section Protection
NNI	Network-Network Interface
NPU	Node Processor Unit
OSPF	Open Shortest Path First
PEP	Provider Edge Port
PFU	Power Filtering Unit
PL	Packet Link
PPP	Point to Point Protocol
PRT	Product Ready for Tender
PSU	Power Supply Unit
PTP	Precision Timing Protocol

PW	Pseudowire
QAM	Quadrature Amplitude Modulation
QL	Quality Level
RADIUS	Remote Authentication Dial In User Service
RAU	Radio Unit
RBER	Residual Bit Error Rate
RFC	Request For Comments
RLB	Radio Link Bonding
RLP	Radio Link Protection
RSEC	Reference Spectral Efficiency Class
RTPC	Remote Transmit Power Control
SAToP	Structure-Agnostic TDM over Packet
SFP	Small Form-factor Pluggable
SFPe	SFP electrical
SFPo	SFP optical
SI	Single Interface
SMI	Structure of Management Information
SNCP	Sub-Network Connection Protection
SNMP	Simple Network Management Protocol
SPQ	Strict Priority Queuing
SSM	Synchronization Status Message
STM-n	Synchronous Transport Module-n
TACACS+	Terminal Access Control, Access Control Server

TBD	To Be Determined
TC	Traffic Class
TCP/IP	Transmission Control Protocol/Internet Protocol
TDM	Time Division Multiplexing
TOS	Type Of Service
TUG	Tributary Unit Group
U	Measure used in mechanical constructions (1U = 44.45 mm)
UDP	User Datagram Protocol
UNI	User-Network Interface
USM	User-based Security Model
VACM	View-based Access Model
VCAT	Virtual Concatenation
VC-n	Virtual Container
VCC	Virtual Channel Connection
VID	VLAN ID
VPC	Virtual Path Connection
WAN	Wide Area Network
WDPR	Weighted Deficit Round Robin
WFQ	Weighted Fair Queuing
WRED	Weighted Random Early Detection
XPIC	Cross-Polarization Interference Canceller

ERICSSON

Technical Description

MINI-LINK 6600 R1

DESCRIPTION

47/221 02-HRA 901 20/11 Uen BA

Disclaimer

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Contents

1 Introduction

MINI-LINK 6600 consists of small flexible nodes for high capacity, with advanced Ethernet functionality and designed for an efficient migration path for customers going to an all-IP network.

The MINI-LINK 6600 product family:

— MINI-LINK 6651 (Compact Node)

— MINI-LINK 6654 with PNM 1001 or PNM 1002

— MINI-LINK 6655 with PNM 1002

— MINI-LINK 6691 with NPU 1002, NPU 1003, or NPU 1005

— MINI-LINK 6692 with NPU 1002 or NPU 1005

— MINI-LINK 6693 with NPU 1002, NPU 1003, or NPU 1005

— MINI-LINK 6694 with NPU 1002, NPU 1003, or NPU 1005

MINI-LINK 6600 provides a switch capacity of up to 88 Gbps and can connect up to 16 split mounted radio links with a maximum of 15 radio directions due to being equipped with dual carrier modems. 1 Gbps, 2.5 Gbps, and 10 Gbps interfaces, fiber rings and E-band links can also be connected to the node. The node supports radio links with high modulation of 8192 QAM.

MINI-LINK 6600 offers both compact nodes and nodes using plug-in units, which make it easy to customize configurations and make future upgrades. The full range of MINI-LINK outdoor units can easily be combined in many different ways: traditional frequencies (6–42 GHz), V-band 60 GHz, E-band 70/80 GHz, single and dual carrier, Coax and Ethernet interface.

Different packet migration strategies are supported by MINI-LINK 6600. For cost efficient migration MINI-LINK 6600 are hop compatible with MINI-LINK TN R6 equipped with MMU4 A. Upgrading a site to MINI-LINK 6600, the radio unit, antenna and outdoor cabling can be reused.

2 System Overview

From a functional and configuration perspective, a Network Element (NE) based on MINI-LINK 6600 can be divided into the following parts:

Basic Node The Basic Node holds the system platform providing traffic and system control.

Specific plug-in units provide Ethernet and TDM traffic interfaces for connection to other network equipment, for example radio base stations.

It also includes indoor mechanical housing, power distribution, and cooling.

Radio Terminals A Radio Terminal provides microwave transmission and consists of an outdoor radio connected to an indoor modem carrier, that is, a split mount solution.

MINI-LINK 6600 provides single or dual carrier modem, and can be connected to two outdoor radios to create two separate Radio Terminals.

For more information, see Section 3 on page 9.

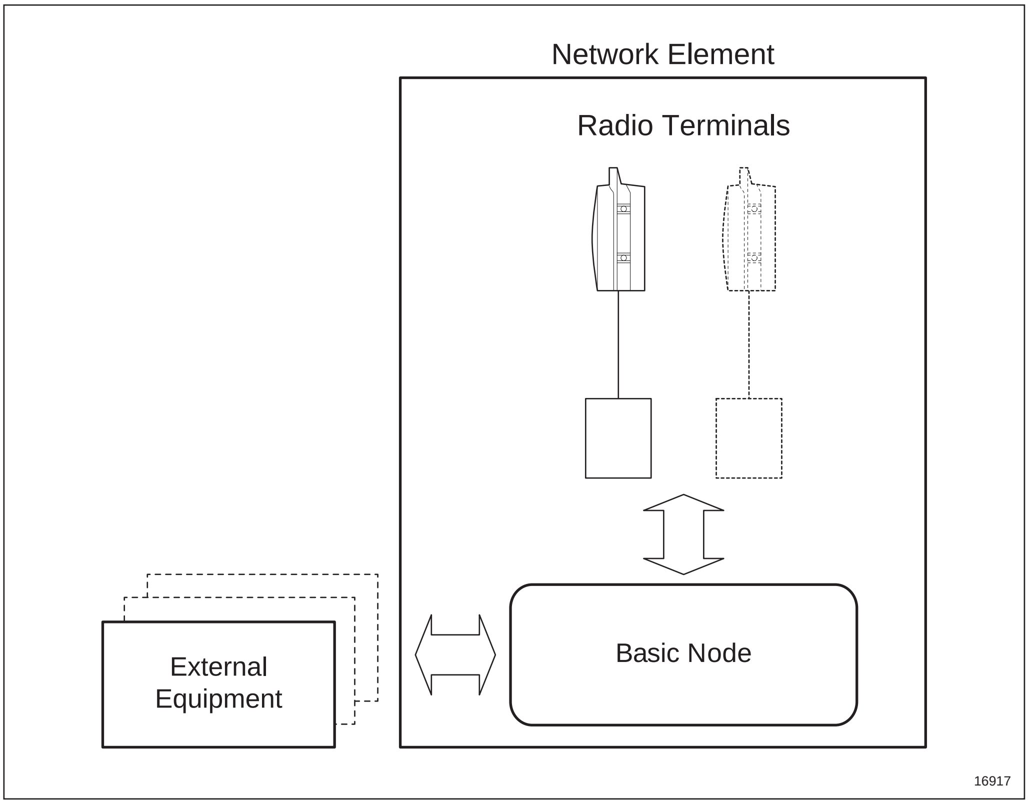

Figure 1 Basic Node and Radio Terminals

2.1 Indoor Part

All MINI-LINK 6600 products fit into standard 19" or metric racks.

Table 1 MINI-LINK 6600 Comparison

	MINI-LINK 6651/1 Compact Node	**MINI-LINK 6651/2 Compact Node**	**MINI-LINK 6651/3 Compact Node**	**MINI-LINK 6651/4 Compact Node**	**MINI-LINK 6654**	**MINI-LINK 6655**	**MINI-LINK 6691**	**MINI-LINK 6692**	**MINI-LINK 6693**	**MINI-LINK 6694**
Height	1U	1U	1U	1U	1U	1.5U	1U	3U	1.5U	2U
Traffic interfaces	2×FE/1G RJ45 4×1G/2.5G SFP+ 8×E1	2×FE/1G RJ45 3×1G/2.5G SFP+ 8×E1	2×FE/1G RJ45 4×1G/2.5G SFP+ 8×E1	2×1G RJ45 4×1G/10G SFP+ 8×E1	2xFE/1G RJ45 2x1G SFP 2x1G/10G SFP+ 4xE1/DS1	2xFE/1G RJ45 2x1G SFP 2x1G/10G SFP+ 4xE1/DS1	2×FE/1G RJ45 1×FE/1G SFP 2×1G/10G SFP+	2×FE/1G RJ45 1×FE/1G SFP 2×1G/10G SFP+	2×FE/1G RJ45 1×FE/1G SFP 2×1G/10G SFP+	2×FE/1G RJ45 1×FE/1G SFP 2×1G/10G SFP+
Switch capacity	14.5 Gbps	14.5 Gbps	14.5 Gbps	47 Gbps	36.5 Gbps (PNM 1001) 44 Gbps (PNM 1002)	44 Gbps	38 Gbps (NPU 1002 or NPU 1003) 43 Gbps (NPU 1005)	88 Gbps[1] (NPU 1002) 65.5 Gbps (NPU 1005)	46.5 Gbps (NPU 1002) 45.5 Gbps (NPU 1003) 55.5 Gbps (NPU 1005)	59.5 Gbps (NPU 1002) 45.5 Gbps (NPU 1003) 55.5 Gbps (NPU 1005)
Combo solution (PFU, NPU, and MMU)	–	–	–	–	PNM 1001 or PNM 1002	PNM 1002	–	–	–	–
Node Processor Unit (NPU)	–	–	–	–	–	–	NPU 1002, NPU 1003 or NPU 1005	NPU 1002 or NPU 1005[2]	NPU 1002, NPU 1003 or NPU 1005	NPU 1002, NPU 1003 or NPU 1005[2]
Dual Carrier Modem Unit (MMU)	–	–	–	–	MMU 1002 or MMU 1004	MMU 1002 or MMU 1004	MMU 1002 or MMU 1004	MMU 1002 or MMU 1004	MMU 1002 or MMU 1004	MMU 1002 or MMU 1004
Single Carrier Modem Unit (MMU)	–	–	–	–	MMU 1001	MMU 1001	MMU 1001	MMU 1001	MMU 1001	MMU 1001
Line Termination Unit (LTU) for E1/DS1	–	–	–	–	LTU 1001	LTU 1001	LTU 1001	LTU 1001	LTU 1001	LTU 1001
Line Termination Unit (LTU) for E1/DS1 and STM-1	–	–	–	–	LTU 1002	LTU 1002	LTU 1002	LTU 1002	LTU 1002	LTU 1002

Table 1 MINI-LINK 6600 Comparison

	MINI-LINK 6651/1 Compact Node	MINI-LINK 6651/2 Compact Node	MINI-LINK 6651/3 Compact Node	MINI-LINK 6651/4 Compact Node	MINI-LINK 6654	MINI-LINK 6655	MINI-LINK 6691	MINI-LINK 6692	MINI-LINK 6693	MINI-LINK 6694
Ethernet Termination Unit (ETU)	–	–	–	–	ETU 1001	ETU 1001	ETU 1001	ETU 1001	ETU 1001	ETU 1001
Ethernet Termination Unit (ETU)	–	–	–	–	ETU 1002	ETU 1002	ETU 1002	ETU 1002	ETU 1002	ETU 1002

(1) 7.5 Gbps is reserved for future use.

(2) NPU protection can be used with two NPU 1002 or two NPU 1005.

The indoor part also includes cables and installation accessories.

The interconnection between the outdoor part (radios and antennas) and the indoor part is one coaxial cable per carrier interface. This cable carries full duplex traffic, DC supply voltage, and management data.

2.1.1 MINI-LINK 6651 Indoor Parts

MINI-LINK 6651 is a compact node suitable for tail sites.

It has a replaceable Fan Unit that provides cooling for the indoor part.

There are four variants, MINI-LINK 6651/1 (Figure 2), MINI-LINK 6651/2 (Figure 3), MINI-LINK 6651/3 (Figure 4), and MINI-LINK 6651/4 (Figure 5).

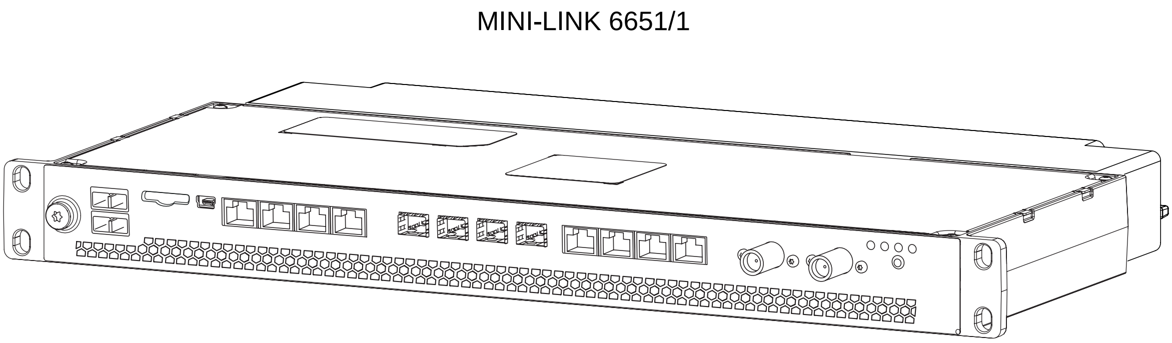

Figure 2 MINI-LINK 6651/1

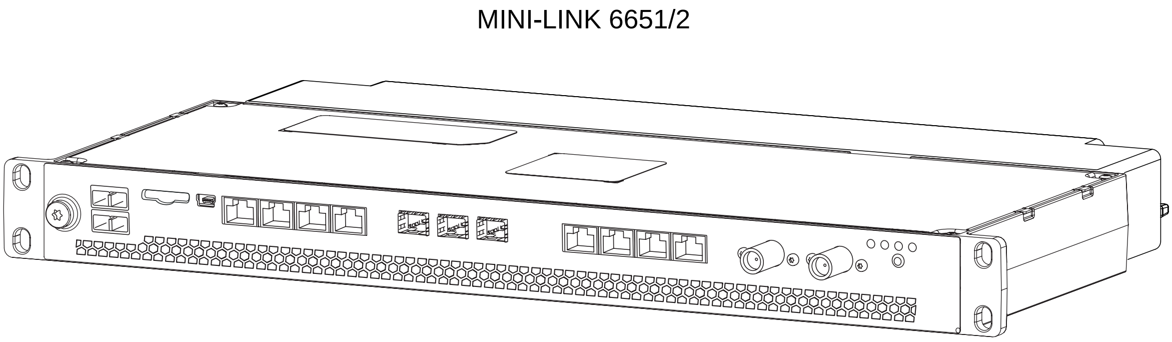

Figure 3 MINI-LINK 6651/2

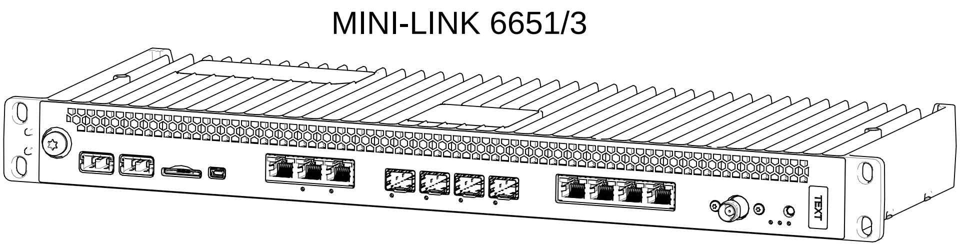

Figure 4 MINI-LINK 6651/3

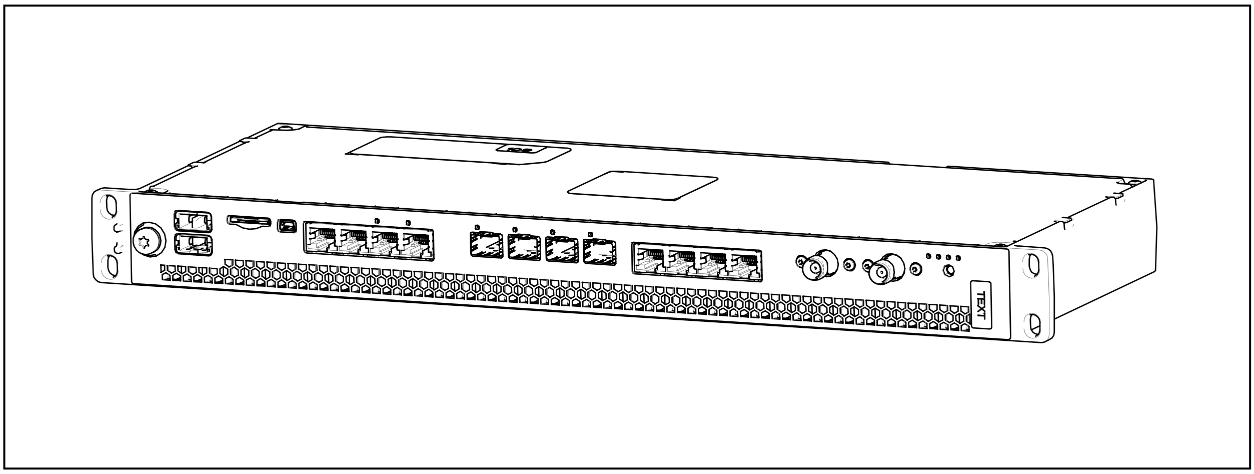

Figure 5 MINI-LINK 6651/4

2.1.2 MINI-LINK 6654 and MINI-LINK 6655 Indoor Parts

The indoor part consists of an Enclosure with plug-in units interconnected through a backplane. One plug-in unit occupies one slot in the Enclosure.

Enclosure The Enclosure houses the plug-in units and provides backplane interconnection of traffic, power, and control signals. It fits into standard 19" or metric racks.

PFU, NPU, and MMU (PNM) Unit

The PNM handles the control functions of the system. It also provides traffic and management interfaces.

Modem Unit (MMU)

The MMU constitutes the indoor part of a Radio Terminal. It determines the traffic capacity and modulation scheme.

Fan Unit (FAU)

The FAU provides cooling for the indoor part.

Line Termination Unit (LTU)

The LTU provides E1/DS1 interfaces. LTU 1002 also provides an STM-1 interface.

Ethernet Termination Unit (ETU)

The ETU provides Ethernet interfaces.

2.1.3 MINI-LINK 6691, MINI-LINK 6692, MINI-LINK 6693, and MINI-LINK 6694 Indoor Parts

The indoor part consists of an Enclosure with plug-in units interconnected through a backplane. One plug-in unit occupies one slot in the Enclosure.

Enclosure	The Enclosure houses the plug-in units and provides backplane interconnection of traffic, power, and control signals. It fits into standard 19" or metric racks.
Node Processor Unit (NPU)	The NPU handles the control functions of the system. It also provides traffic and management interfaces.
Modem Unit (MMU)	The MMU constitutes the indoor part of a Radio Terminal. It determines the traffic capacity and modulation scheme.
Power Filter Unit (PFU)	The PFU filters the external power and distributes the internal power to the plug-in units through the backplane.
Fan Unit (FAU)	The FAU provides cooling for the indoor part.
Line Termination Unit (LTU)	The LTU provides E1/DS1 interfaces. LTU 1002 also provides an STM-1 interface.
Ethernet Termination Unit (ETU)	The ETU provides Ethernet interfaces.

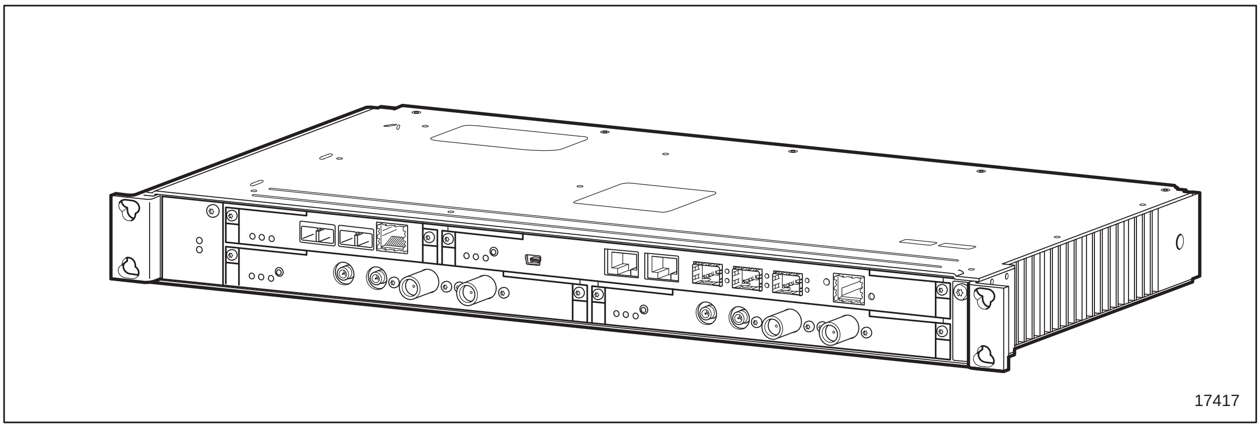

Figure 6 MINI-LINK 6691

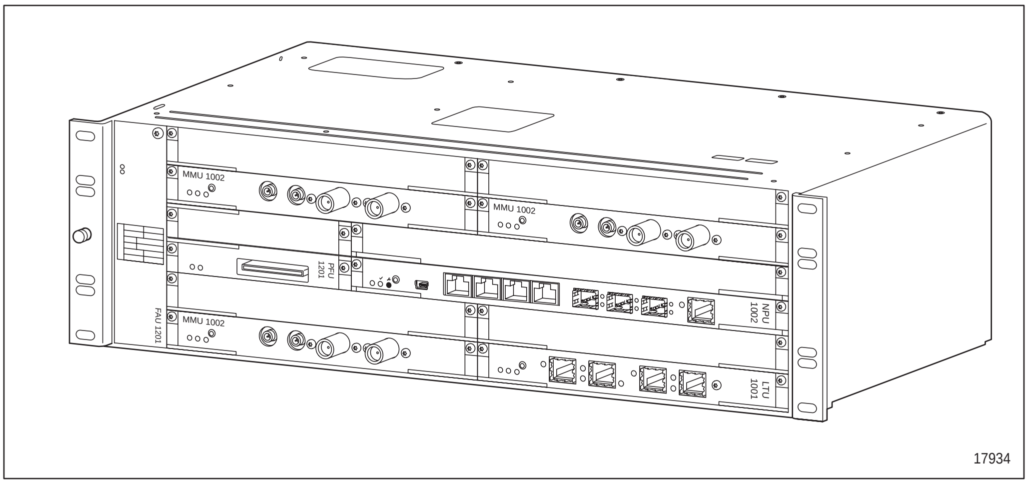

Figure 7 MINI-LINK 6692

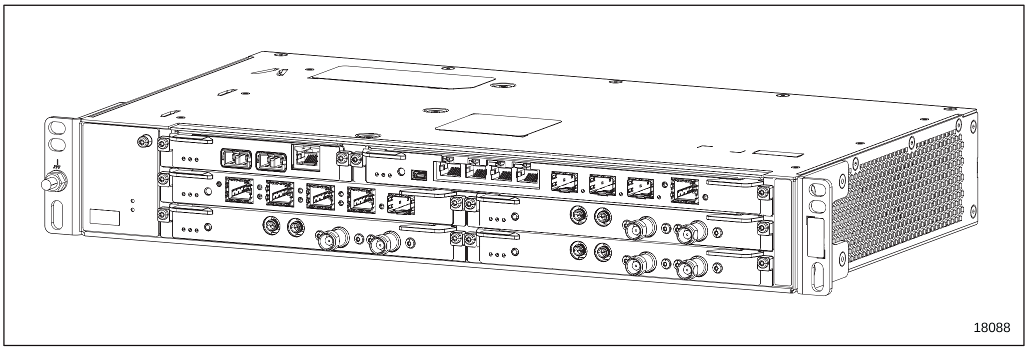

Figure 8 MINI-LINK 6693

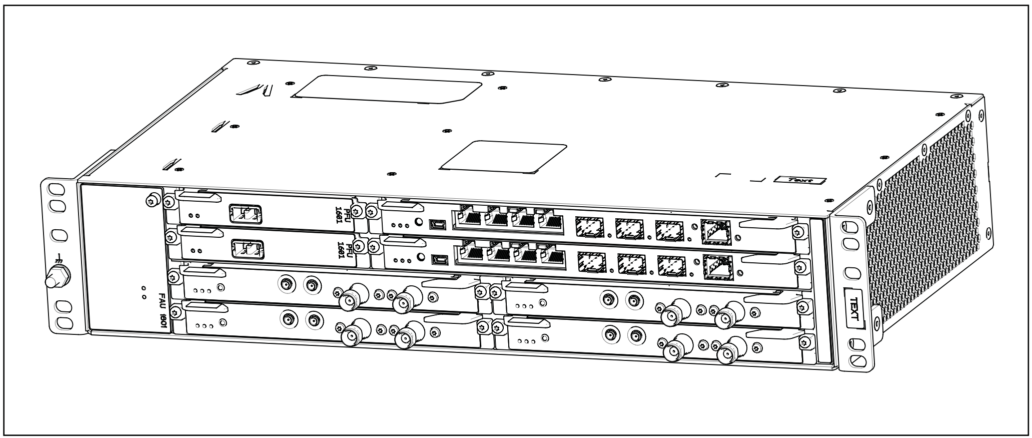

Figure 9 MINI-LINK 6694

2.2 Outdoor Part

The outdoor part is supplied for various frequency bands, including the E-band (80 GHz). It consists of an antenna, a radio, and associated installation hardware. The MINI-LINK 6363, MINI-LINK 6363/2, MINI-LINK 6364, MINI-LINK 6365, and RAU2 X radios can be connected to a MINI-LINK 6600 modem.

The radio and the antenna are easily installed on a wide range of support structures. The radio is fitted directly to the antenna as standard, integrated installation. The radio and the antenna can also be fitted separately and connected by a flexible waveguide. In all cases, the antenna is easily aligned and the radio can be disconnected and replaced without affecting the antenna alignment.

The MINI-LINK 6363, MINI-LINK 6363/2, MINI-LINK 6364, MINI-LINK 6365, and RAU2 X radios are described in more detail in Section 15.18 on page 214.

The antennas are described in more detail in Section 15.19 on page 225.

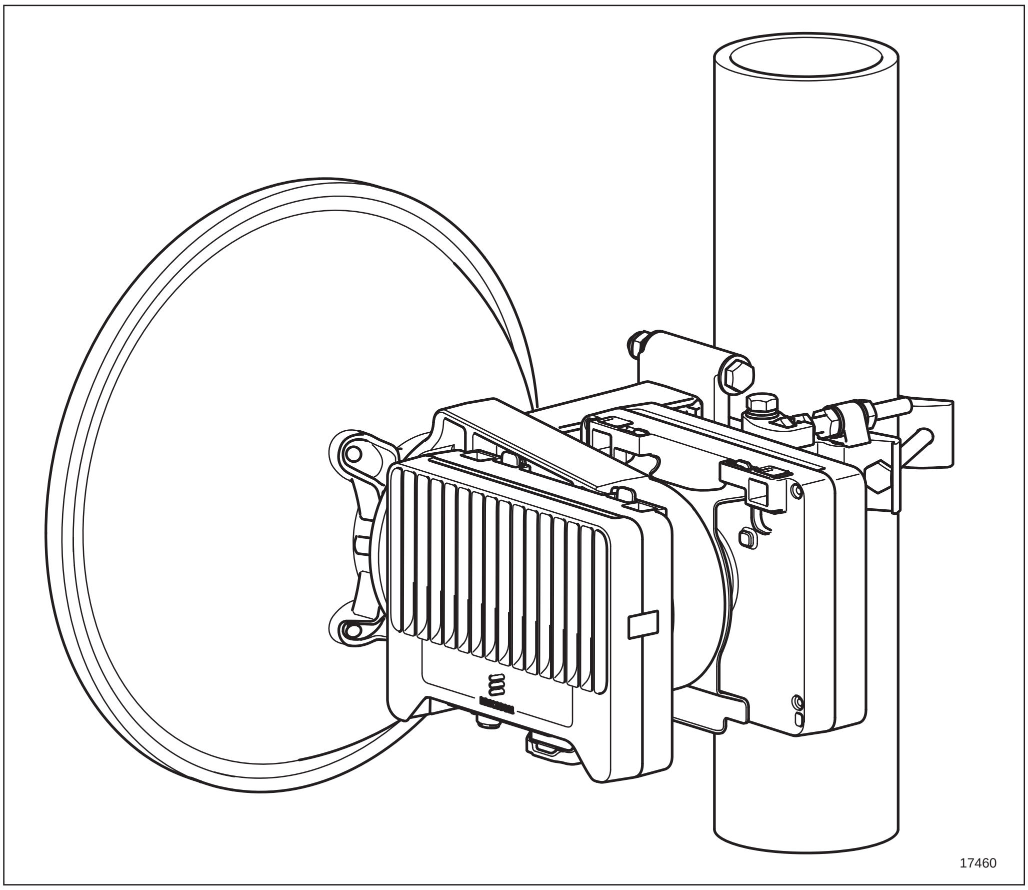

Figure 10 MINI-LINK 6363, MINI-LINK 6364, or MINI-LINK 6365 and Antenna

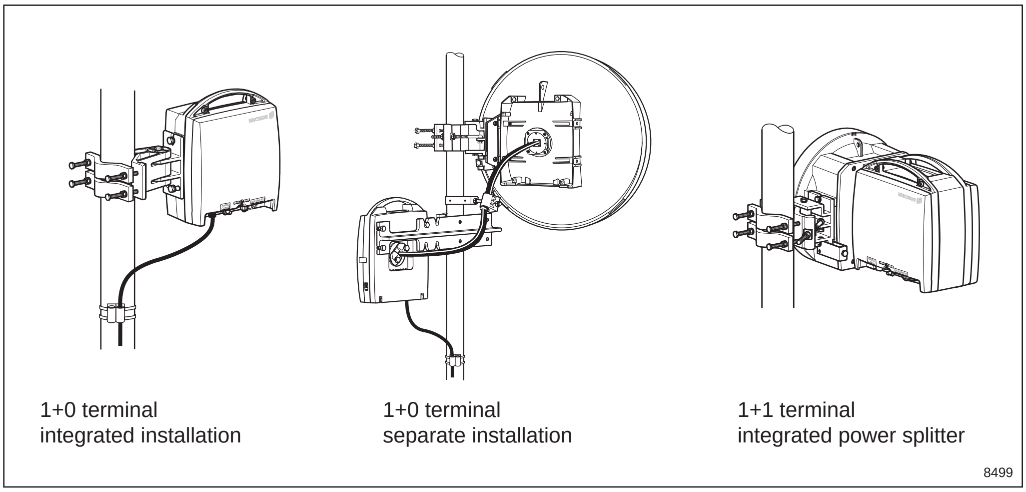

Figure 11 RAU2 X and Antennas in Different Installation Alternatives

3 Radio Link

MINI-LINK 6600 provides radio links for microwave transmission up to 1067 Mbps, operating within the 5 to 80 GHz frequency bands, using 4–8192 QAM modulation schemes.

MINI-LINK 6600 supports Ethernet (packet link), PDH, and a mix thereof in a Hybrid Radio Link sending Ethernet and PDH traffic simultaneously.

MINI-LINK 6600 can be configured as unprotected (1+0), 1+1 Radio Link Protection, or 2+0 Radio Link Bonding, and supports Cross Polarization Interference Canceller (XPIC), Adaptive Coding and Modulation (ACM). MINI-LINK 6600, except from MINI-LINK 6651, also supports Multiple Input Multiple Output (MIMO). Dual 1+0 is available in MINI-LINK 6600, except with MINI-LINK 6651/1 or MINI-LINK 6651/3.

3.1 Hybrid Radio Link

A Hybrid Radio Link is a Radio Link optimized for maximum throughput of Ethernet and PDH traffic.

Note: MINI-LINK 6651 can only send PDH traffic with E1s, that is, only for ETSI.

Ethernet and PDH traffic are sent simultaneously over the Hybrid Radio Link, see Figure 12.

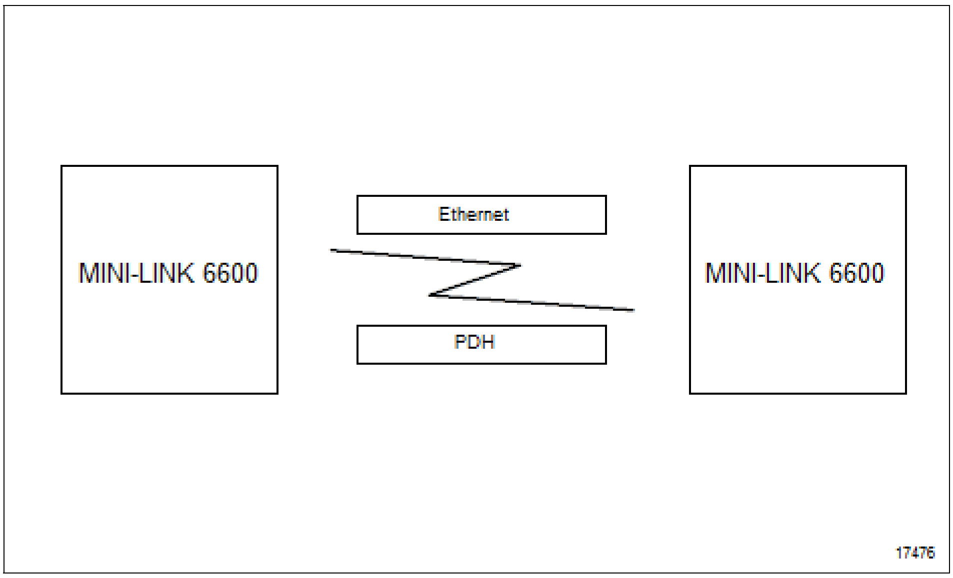

Figure 12 Traffic over a Hybrid Radio Link

The Ethernet traffic is sent over a dedicated physical link. When Ethernet is sent over a Hybrid Radio Link, the capacity range is from 0 Mbps to total link capacity depending on the amount of configured PDH Traffic.

A Hybrid Radio Link supports flat multiplexing of PDH traffic, which enables control of the number of E1s/DS1s to be transported. PDH traffic is normally transported in sets of 4×E1/DS1 and 16×E1/DS1. With flat multiplexing it is possible to set an exact number of E1s/DS1s to be transported, for example, 7×E1/DS1 or 23×E1/DS1. This allows optimized usage of bandwidth since all E1s/DS1s fitting in the bandwidth also can be transported. Due to the use of one mux layer for all E1s/DS1s, instead of one mux layer for each set of 4×E1/DS1 and 16×E1/DS1, the PDH overhead is decreased. A minimum of the total link capacity is used for overhead and PDH traffic and all remaining capacity can be used for Ethernet.

The ratio between Ethernet and PDH traffic is configurable and is set with E1/DS1 granularity, see Figure 13.

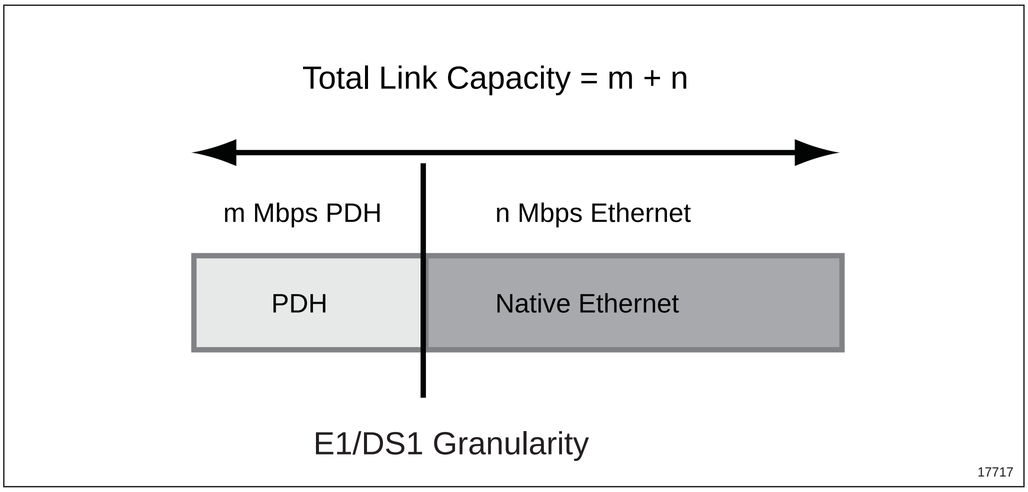

Figure 13 Packet Sent over a Hybrid Radio Link

Example (ETSI)

— Total link capacity: 154 Mbps

— PDH traffic capacity: 22×E1 (45 Mbps)

— Ethernet capacity: 154 Mbps – 45 Mbps = 109 Mbps

Example (ANSI)

— Total link capacity: 158 Mbps

— PDH traffic capacity: 22×DS1 (34 Mbps)

— Ethernet capacity: 158 Mbps – 34 Mbps = 124 Mbps

In Hybrid Radio Links, Ethernet capacity range from 0 to maximum link capacity, while PDH capacity range from 0 to 80×E1/DS1. The PDH capacity is limited by the backplane capacity of the modem.

MMU 1002/1004 and MINI-LINK 6651 are hop compatible with MMU4 A in MINI-LINK TN R6. See MINI-LINK 6600 R1 Compatibility, Reference [1], for details regarding hop compatibility.

3.2 Hitless Adaptive Coding and Modulation

Hitless Adaptive Coding and Modulation (ACM) enables automatic switching between different physical modes, depending on radio channel conditions. Hitless ACM makes it possible to increase the available capacity over the same frequency channel during periods of normal propagation conditions.

Code rate and modulation, and thereby capacity, are high during normal radio channel conditions and lower during less favorable channel conditions, for example, when affected by rain or snow. Physical mode switches are hitless, that is, error free. In situations where traffic interruption normally would occur, it is possible to maintain parts of the traffic by switching to a lower physical mode, using Hitless ACM.

Figure 14 shows how the capacity changes when the received input signal crosses the receiver threshold for each physical mode order.

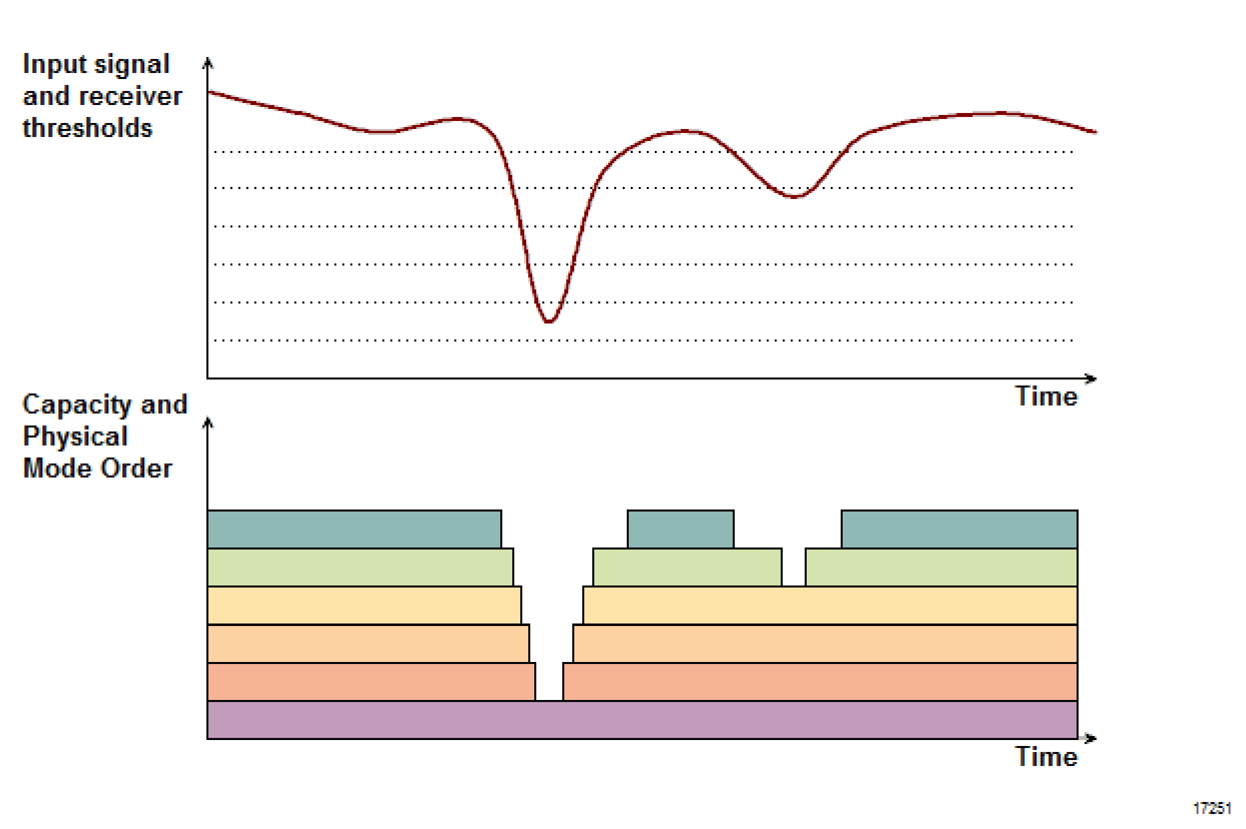

Figure 14 Principles of Hitless ACM

When using only Adaptive Modulation, the steps in Figure 14 only differ in terms of modulation. When using ACM, the steps can differ in both coding and modulation, which increases the number of possible steps.

In order to handle channel variations, the channel conditions are continuously monitored on the Rx side by measurement of Signal to Noise and Interference Ratio (SNIR). When the receiver, based on this data, detects that channel conditions imply a change to the next higher or lower physical mode, a message is sent to the transmitter on the other side requesting a higher or lower physical mode. Upon receipt of such request the transmitter starts transmitting with the new physical mode. Each direction is independent. At demodulation the receiver follows the physical mode as a slave.

The physical mode can also be configured with the maximum physical mode equal to the minimum physical mode, and thereby achieving a mode comparable to static mode, where the physical mode remains unchanged.

Hitless ACM is compatible with Automatic Transmit Power Control (ATPC), which works in a closed loop in any configured physical mode. If the modulation goes down, for example, due to interference, then the output power does not go to the maximum level.

Buffering

ACM can influence the design of the buffer dimensioning. In case packet aging is not used, the maximum delay variation time will increase due to that the buffer is configured in bytes and that data will travel at a slower speed during lower physical mode steps. When packet aging is enabled, the maximum delay variation time will be kept regardless of physical mode level. This will also ensure that there is no old data in lower priority queues when physical mode is increased after a fading situation.

ACM can influence the position of the narrowest congestion point in the network, with too small buffers this can have a strong negative impact on utilization and end user TCP performance. To ensure high link utilization and high TCP performance, buffers for TCP traffic should be dimensioned in the area above average Round Trip Time (RTT), which is typically in the area of 100–200 ms.

RSEC (ETSI only)

Reference Spectrum Efficiency Class (RSEC) defines the spectral mask, that is, which SEC that is used as a reference. The maximum output power is dependent on the RSEC used. The configurable RSEC depends on the configured minimum physical mode, which is illustrated in Table 2.

Table 2 RSEC (ETSI)

Configured Minimum Physical Mode	Configurable RSEC
4 QAM	2, 4L, 4H, 5LB, 5HB, 6LB, 6HB, 7
16 QAM	4L, 4H, 5LB, 5HB, 6LB, 6HB, 7
32 QAM	4H, 5LB, 5HB, 6LB, 6HB, 7
64 QAM	5LB, 5HB, 6LB, 6HB, 7
128 QAM	5HB, 6LB, 6HB, 7
256 QAM	6LB, 6HB, 7
512 QAM	6HB, 7
1024 QAM	7
2048 QAM	7
4096 QAM	7
8192 QAM	7

When installing a new link or when upgrading an existing link to ACM, it is important to consider spectrum license requirements. The link configuration must be set with respect to the RSEC (referred to as Reference Mode in ETSI EN 302 217-1 and ETSI EN 302 217-2-2) and output power as specified in the spectrum license. Consult the relevant authority for information on the national radio transmission specifications and spectrum license conditions.

3.3 Transmit Power Control

The radio transmit power can be controlled in Remote Transmit Power Control (RTPC) mode, selectable from the management system, including setting of associated parameters. In Automatic Transmit Power Control (ATPC) mode, the transmit power can be increased rapidly during fading conditions, which allows the transmitter to operate at less than the maximum power during normal path conditions. The normally low transmit power allows more efficient use of the available spectrum, while the high transmit power can be used as input to path reliability calculations, such as fading margin and carrier-to-interference ratio.

Traditionally, the radio unit consumes the same amount of power independent of the output power used in the air interface. By using MINI-LINK ECO Mode, the radio units adjust the power requirements according to the used output power in the radio interface, which varies according to the actual link conditions and output margin design.

The transmitter can be turned on or off from the management system.

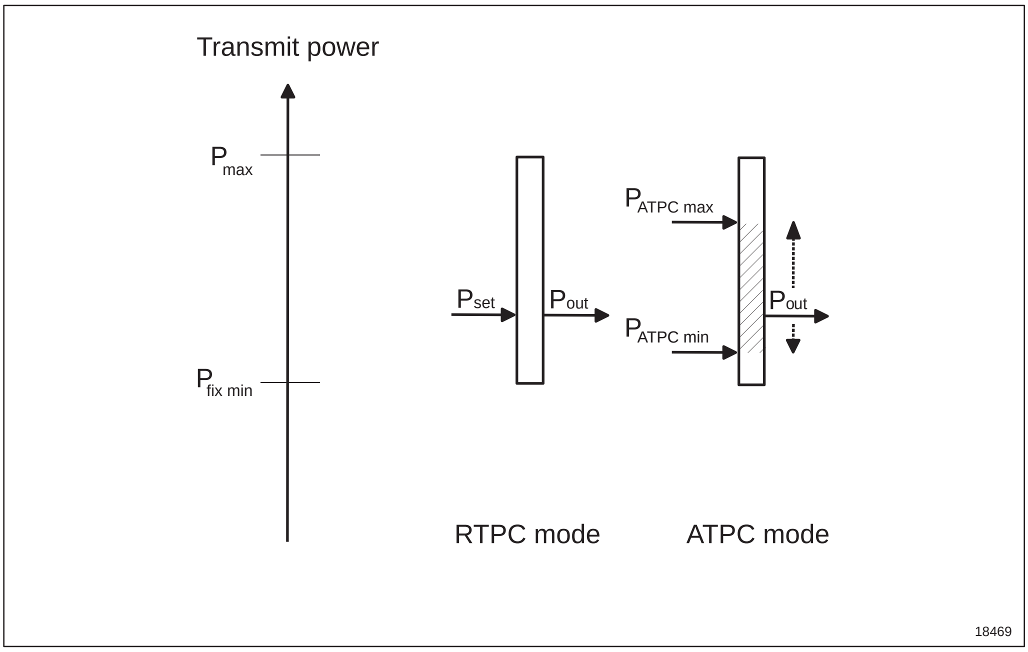

Figure 15 Transmit Power Control

3.3.1 RTPC Mode

In RTPC mode, the transmit power (P_{out}) ranges from a minimum level ($P_{fix\ min}$) to a maximum level (P_{max}). The desired value (P_{set}) can be set in 1 dBm increments.

3.3.2 ATPC Mode

ATPC is used to automatically adjust the transmit power (P_{out}) in order to maintain the received input level at the far-end terminal at a target value. The received input level is compared with the target value, and then a deviation is calculated and sent to the near-end terminal to be used as input for possible adjustment of the transmit power. ATPC varies the transmit power between a selected maximum level ($P_{ATPC\ max}$) and a selected minimum level ($P_{ATPC\ min}$).

The highest possible value for $P_{ATPC\ max}$ is P_{max}. The lowest possible value for $P_{ATPC\ min}$ is $P_{fix\ min}$. Therefore, the maximum adjustment range varies between these two values.

It is possible to enable a fallback mode for the ATPC, so that the transmitted power is decreased to a user settable level ($P_{ATPC\ Fallback}$) if it has been stuck at $P_{ATPC\ max}$ for too long. The ATPC fallback can be enabled using CLI or MINI-LINK Node GUI. When fallback mode is entered, an alarm is raised and is not cleared as long as the system is in ATPC mode.

$P_{ATPC\ Fallback}$ can be set between $P_{ATPC\ max}$ and $P_{ATPC\ min}$.

The fallback timer can be set between 1 and 60 minutes.

It is recommended to set the target to a value 5 dB above the RBER-threshold for the highest configured modulation.

3.3.2.1 Traffic Aware Power Save (TAPS)

TAPS (Traffic Aware Power Save) is a power saving functionality available for all MINI-LINK 6600 products, when used with MINI-LINK 6363, MINI-LINK 6364, or MINI-LINK 6365 radio units. It is aimed at keeping the system power use as low as possible while still handling the actual traffic rate.

When TAPS is enabled, power consumption is automatically adapted based on actual capacity need by minimizing the transmitted power. Every 6 milliseconds, link utilization is measured by comparing the actual traffic rate with the possible traffic rate. If the system is working at the maximum possible rate configured, ATPC is enabled and no output power regulation is done by TAPS. On the other hand, if the system is not working at the maximum possible rate configured, TAPS is enabled and the output power is regulated to minimize the transmit power in relation to the actual traffic rate. If the system is running at the lowest configured rate, the power is slowly increased to avoid link loss. Based on the increases and decreases in near-end transmit power, higher or lower profile is requested by the far-end NE, which results in a higher or lower traffic rate, respectively.

Note: TAPS is a licensed feature.

ATPC has to be configured in order to enable TAPS.

3.4 Dual Carrier Modem

With the modem MMU 1002/1004 in MINI-LINK 6600, and the compact nodes MINI-LINK 6651/1, MINI-LINK 6651/2, and MINI-LINK 6651/4, dual carrier modems are introduced.

A dual carrier modem can be configured in different ways:

— Dual Directions

  When configured as a 1+0 dual directions link, each carrier has its own connection to a switchport and both carriers can optionally be configured as a Hybrid radio link, that is combining TDM and Ethernet traffic on the same radio path. In MINI-LINK 6651/1 dual directions is not available.

— Bonded Single Direction

  When configured as a 2+0 Radio Link Bonding (RLB) single direction link, the capacity of the two carriers are combined and only one switchport is used. In this configuration the combined capacity of the two can optionally be configured as a Hybrid Radio Link.

  When this is configured with one MMU 1002/1004 or one MINI-LINK 6651, RAU and antenna protection is achieved.

  When this is configured with two MMU 1002/1004s, MMU, RAU, and antenna protection is achieved, that is, Equipment Protection (EQP).

— Protected Single Direction

  When configured as a 1+1 Radio Link Protection (RLP) single direction link, both carriers are used for Radio Link path protection, and a single switchport is used.

  When this is configured with one MMU 1002/1004 or one MINI-LINK 6651, RAU and antenna protection is achieved.

  When this is configured with two MMU 1002/1004, MMU, RAU, and antenna protection is achieved, that is, EQP.

Note: EQP is not applicable for MINI-LINK 6651.

MMU 1002/1004 is described in detail in Section 15.12 on page 195.

Note: When having two MMU 1002/1004, 2+2 and 4+0 modes are also available, see Section 3.8.2 on page 24.

3.5 Radio Link Bonding

Radio Link Bonding (RLB) requires a license.

RLB uses multiple radio paths in a single direction to increase capacity. With RLB, a single port on the Ethernet switch is connected to an MMU/modem. The MMU/modem has an internal function to distribute the incoming Ethernet and PDH traffic between the available packet links.

The PDH traffic is prioritized and the remaining capacity is used for the packet links.

Note: MINI-LINK 6651 can only send PDH traffic with E1s, that is, only for ETSI.

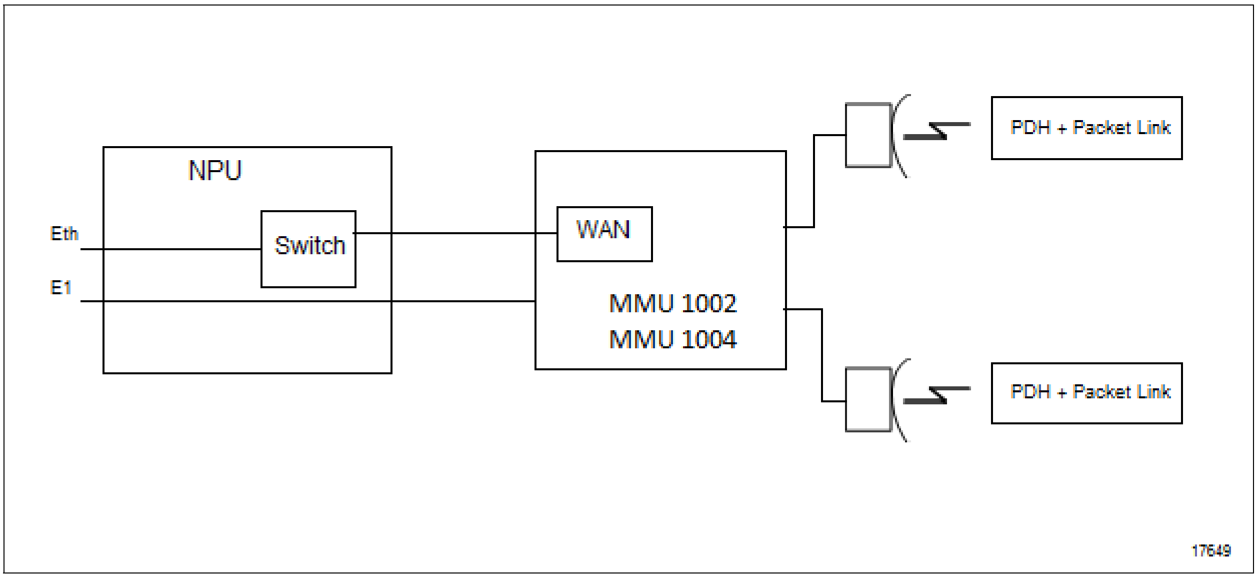

Figure 16 MINI-LINK 6691, 6692, 6693, and 6694, Hybrid Radio Link with RLB, Frequency Diversity

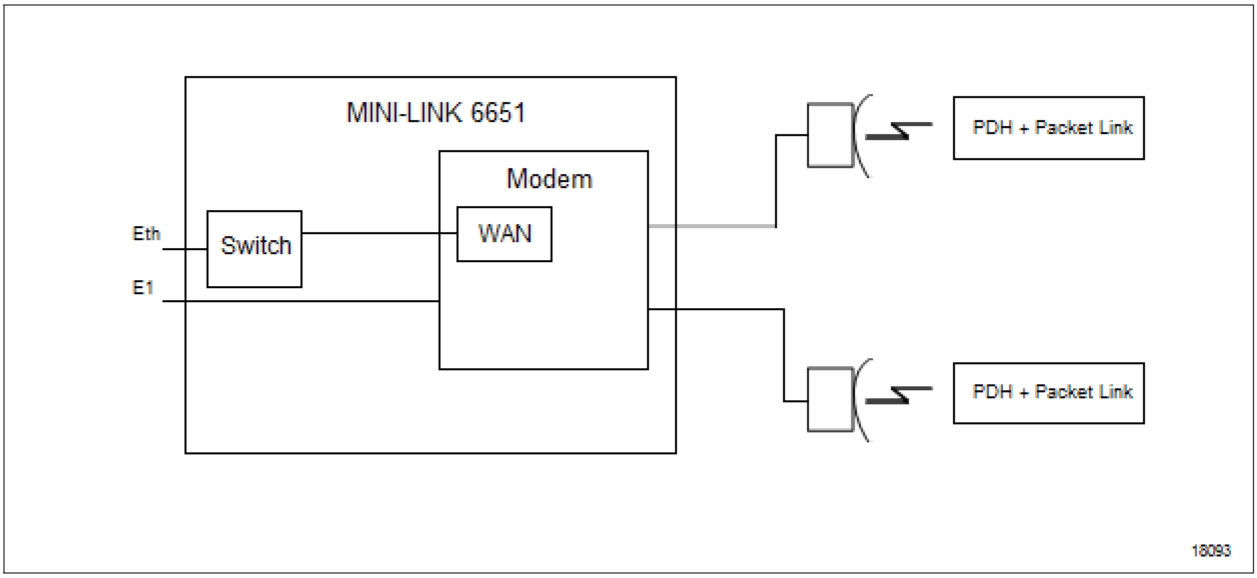

Figure 17 MINI-LINK 6651/1, 6651/2, and 6651/4 Hybrid Radio Link with RLB, Frequency Diversity

3.6 Hierarchical Radio Link Bonding

Hierarchical Radio Link Bonding (RLB) requires a license.

hRLB is a Layer 1 (L1) technology which is used for bonding separately configured Radio Link Terminals (RLTs) into one hRLB interface to achieve a higher radio link capacity. It can also be used for bonding an E-Band radio link with a traditional RLT.

hRLB requires a dedicated resource. In case of NPU1005, RLTs are configured separately on the MMU and the hRLB interface is configured on the NPU. MINI-LINK 6651/4 is a stand-alone product that supports hRLB.

Different configurations are available for the MINI-LINK 6600 family. For details on supported configurations, see MINI-LINK 6600 R1 Compatibility.

Bonding an E-Band radio link with a traditional RLT creates a Multi-Band Booster scenario and requires a MINI-LINK 6352. The MINI-LINK 6352 can connect to the NPU 1005 directly using a LAN interface or through an ETU 1002. For details on Multi-Band Booster supported hRLB configurations, see MINI-LINK 6600 R1 Compatibility.

3.7 Multi-Band Booster

Multi-Band Booster increases the performance of microwave backhaul, and is a tool that can increase network capacity up to tenfold. It supports flexible bonding of different carriers and frequency band combinations. Multi-Band Booster provides more efficient use of diverse backhaul spectrum assets, using higher frequencies over much wider geographical areas.

The main principle for Multi-Band Booster is to use two radio links in different frequency regions, one low frequency region and one high frequency region. Usually, the low frequency region carries also the TDM traffic and the high frequency region carries only Ethernet.

Figure 18 gives examples of multi-band possibilities.

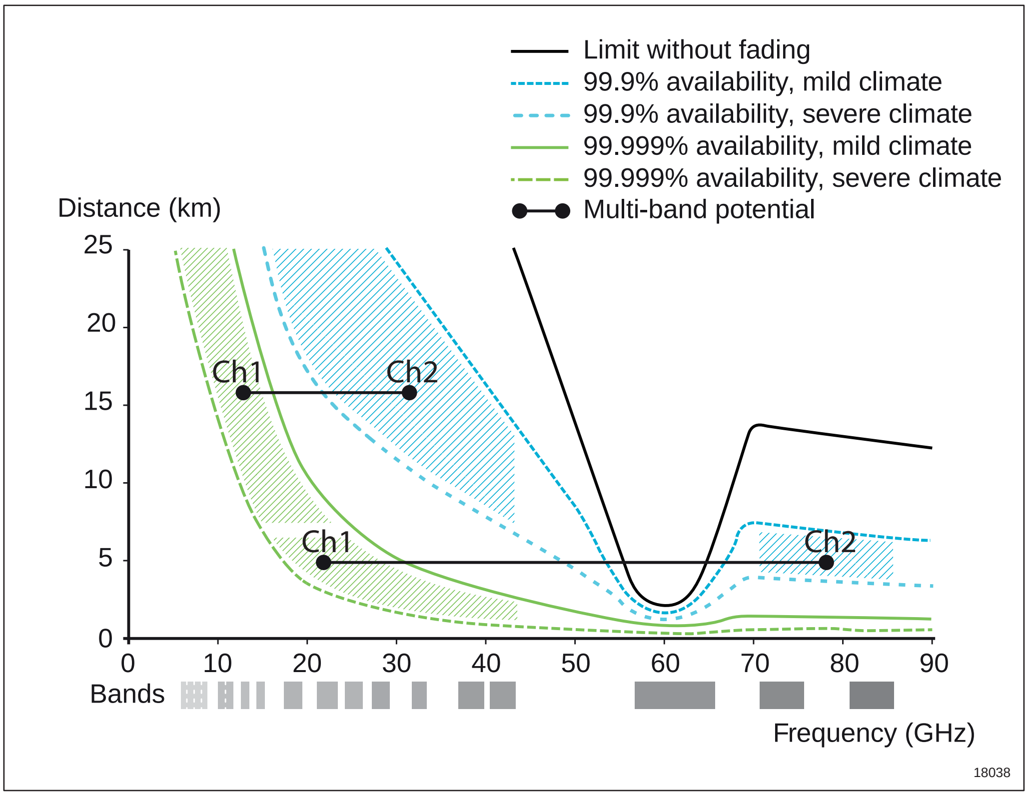

Figure 18 Relevant Distances and Frequency Bands for Multi-Band Booster

The low frequency band is named Ch1, and the high frequency band is named Ch2.

Ch1 – normally the link already in operation – has basic capacity and availability in the range of [99.99 ; 99.999]%. Since Ch1 gives high availability, TDM is transported on Ch1.

Ch2 – the added boosting link – adds high capacity in the range of [99.5 ; 99.95]% availability. This availability target is applicable for the capacity boost needed in non-fading conditions. Since Ch2 gives high capacity, Ethernet is transported on Ch2.

3.7.1 Multi-Band Booster with Policy-Based Forwarding

Policy-Based Forwarding is an enhancement to Multi-Band Booster by L1 packet bonding, which enables scheduling of the traffic with priority fields. This enables the user to select higher-priority traffic to be forwarded on trusted, high-availability links with a lower bandwidth and to forward the remaining traffic on higher-bandwidth links with lower availability. Available priority decisions are VLAN PCP, IP DSCP, and MPLS Traffic Class priority values. Forwarding decision can also be made using VLAN IDs in protected and unprotected mode. Protected mode is when the configured link fails, the VLAN is forwarded on the remaining link. In unprotected mode it is not moved to the remaining link. By default PCP values 5 through 7 are mapped to the master interface and `0` through 4 are mapped to the member interface.

Based on the actual usage of a local WAN interface, VLANs can be dynamically allocated to increase local link utilization.

Dynamic VLAN Mapping

VLANs forwarded using Policy-Based Forwarding can be measured using automatic VLAN allocation in the L1 bonding configuration page. This enables collection of bandwidth utilization data of the VLANs configured and also the current utilization of the master interface. If the utilization of the master interface is below 60%, then whole VLANs are mapped using best fit algorithm to reach 60% utilization. If the link utilization goes above 80%, then some of the dynamically mapped traffic is removed from the master interface to go below the 80% threshold. After a VLAN has been moved back, then the PBF rules are used to make forwarding decisions.

Dynamic PCP Mapping

When using Dynamic Priority Code Point (PCP) Mapping, the bandwidth utilization of the traditional link is measured automatically and traffic is moved to protect high priority traffic and enhance bandwidth utilization. If enabled, bandwidth utilization is measured and PCP mappings are assigned automatically, overriding the manual configuration. Bandwidth measurements are done on the PCP-level and the existing priority values (by default, PCP 5–7 for high-priority traffic and PCP 0–4 for low-priority traffic) are used.

Dynamic allocation can be either PCP-based or VLAN-based. So when Dynamic PCP is used, the dynamic VLAN must be disabled beforehand.

If Dynamic PCP Mapping is enabled, after a 30 seconds measurement period, a mapping action is done based on the gathered utilization data. If the measured utilization of the traditional link is below 60%, traffic with the highest PCP values is moved from the E-Band link to the traditional link until 80% of utilization is achieved. If the measured utilization of the traditional link exceeds 80%, traffic with the lowest PCP values is moved from the traditional link to the E-Band link until the utilization of the traditional link drops to 80%. When the utilization of the traditional link exceeds 80%, or if more than 30 seconds have passed since the last mapping action, the 30 seconds measurement period is not needed.

3.7.2 Multi-Band Booster with Hierarchical Radio Link Bonding

The Multi-Band Booster function can be enhanced by using Hierarchical Radio Link Bonding (hRLB). Multi-Band Booster can bond two radio links that support different frequencies to boost the capacity of the complete link. hRLB can combine E-Band high frequency links with traditional standard bands.

Bonding an E-Band radio link with a traditional RLT creates a Multi-Band Booster scenario and requires a MINI-LINK 6352.

The MINI-LINK 6352 can connect to the NPU 1005 directly using a LAN interface or through an ETU 1002. It is supported in the same direction or in two directions.

Alternatively, the MINI-LINK 6352 can connect to a MINI-LINK 6651/4. The MINI-LINK 6651/4 bonds the traffic of a traditional and an E-Band radio link using MINI-LINK 6352. It is supported in the same direction or in two directions.

The Multi-Band Booster related configurations are described in the Configuring Multi-Band Booster with Hierarchical Radio Link Bonding (hRLB) document in the **Operation and Maintenance** folder.

The supported hRLB configurations are listed in MINI-LINK 6600 R1 Compatibility.

3.8 Radio Link Equipment and Propagation Protection

For Ethernet traffic, Ericsson recommend 2+0 Radio Link Bonding (RLB) with graceful degradation meaning that all available bandwidth is used and if one link experience traffic disturbance the capacity goes down to what the corresponding 1+0 configuration can handle. By using 2+0 RLB configurations, all hardware and spectrum is utilized to its maximum in normal case. It is important to note that it requires some configuration on QoS to decide which traffic gets priority in case of link failure.

For TDM traffic (E1/DS1 or STM-1) that needs high availability (that is, high capacity links or critical links for other parts of the network), 1+1 Radio Link Protection (RLP) configurations are recommended when using a limited spectrum, and 2+0 RLB configurations are recommended when fully utilizing spectrum.

The drawback with 1+1 RLP configurations is that they always have a higher cost than 1+0, by using redundant hardware or diversity installation.

The drawback with 2+0 RLB configurations is that they always consume more bandwidth than 1+0, since the basic idea is to transport traffic over more than one path.

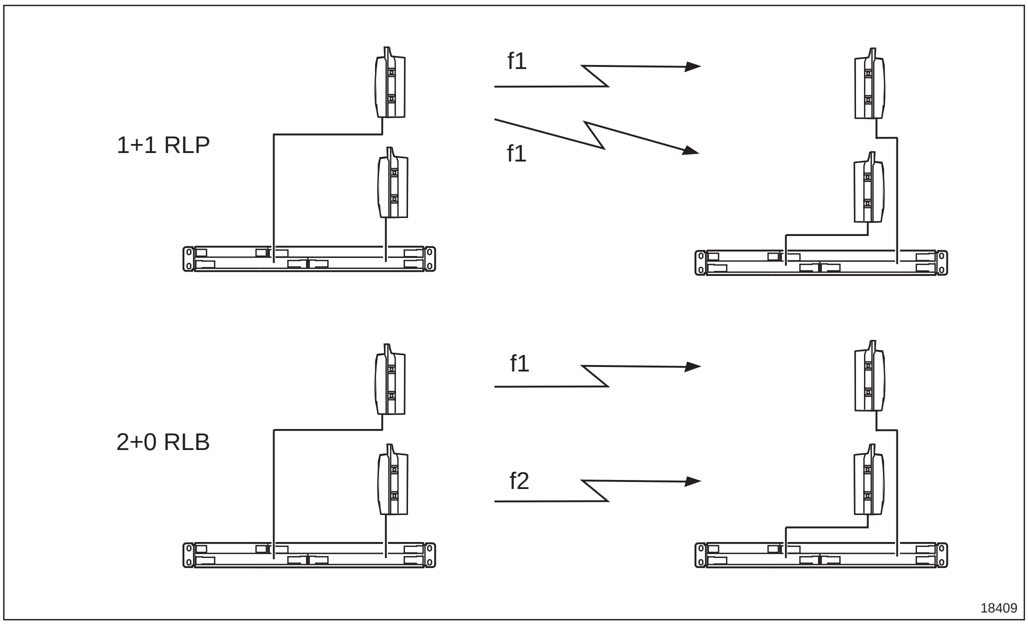

Figure 19 Radio Link Protection Modes

How to choose the optimal configuration is dependent of availability requirements, performance needed by the specific hop situation (hop length, rain zones, fading situation, installation cost, site rent) as well as obtaining a cost-efficient solution.

When planning and configuring this, it is important to consider all means of link utilization and protection, for example RLB (see Section 3.5 on page 17) and Cross Polarization Interference Canceller (XPIC) (see Section 3.9 on page 28).

There are three major protection methods:

— Equipment Protection

  • Tx Equipment Protection

  • Rx Equipment Protection

— Radio Path Protection with Space Diversity

— Radio Path Protection with Frequency Diversity

Equipment Protection may be used on radio links where requirements on availability are high or repair time is assumed to affect the continuation of service.

Radio Path (propagation) Protection may be used on radio links where fading due to meteorological or ground conditions makes it difficult to meet the required transmission quality.

3.8.1 One Dual Carrier Modem Configurations

A Radio Terminal with one dual carrier modem (MINI-LINK 6691/6692/6693/6694/6654/6655 with one MMU 1002/1004, MINI-LINK 6651/1, MINI-LINK 6651/2, or MINI-LINK 6651/4) can be configured for the following:

- 1+1 Radio Link Protection (RLP)
- 2+0 Radio Link Bonding (RLB)

3.8.1.1 1+1 Radio Link Protection

1+1 RLP gives the RAU and the antenna equipment protection.

1+1 RLP can be with or without space diversity. When using two antennas, they can be placed for space diversity with a mutual distance where the impact of selective fading (multipath) is reduced. With one (or two co-located) antenna, space diversity cannot be achieved.

Note: Space diversity is a counter measure against multipath, and is most efficient for frequencies up to 15 GHz.

1+1 RLP uses hot standby. One transmitter is working while the other one, tuned to the same frequency, is in standby. It is not transmitting but ready to transmit if the active transmitter malfunctions. Both RAUs receive signals.

Radio Path Protection

This protection case involves a Diversity selection in each MMU, providing hitless and error free traffic selection in case of radio channel degradation.

The Diversity selection works autonomously and is controlled by the protection logic in the active MMU Rx.

The Diversity selection reacts on quality measures from the two traffic streams. The selection is performed hitless.

3.8.1.2 2+0 Radio Link Bonding

2+0 RLB gives the RAU and the antenna graceful degradation.

2+0 RLB can use one or two frequencies. When using two different frequency channels (ACCP) the impact of selective fading (multipath) is reduced. When using one frequency channel (CCDP) XPIC must be used to achieve full performance.

Note: Frequency diversity is a counter measure against multipath, and is most efficient for frequencies up to 15 GHz.

2+0 RLB is most spectrum efficient when used together with XPIC (see Section 3.5 on page 17).

3.8.2 Two Single or Dual Carrier Modems Configurations

A Radio Terminal with two dual carrier modems (MINI-LINK 6691/6692/6693/6694/6654/6655 with two MMU 1002/1004) can be configured for the following:

- 1+1 Radio Link Protection (RLP) with Equipment Protection (EQP)
- 2+0 Radio Link Bonding (RLB) with EQP
- 4+0 RLB with EQP
- 2+2 RLP with EQP

A Radio Terminal with two single carrier modems (MINI-LINK 6691/6692/6693/6694/6654/6655 with two MMU 1001) can be configured for the following:

- 1+1 Radio Link Protection (RLP) with Equipment Protection (EQP)
- 2+0 Radio Link Bonding (RLB) with EQP

To achieve EQP, the two modems must be positioned in adjacent slots with 2-BPI connection as specified in the installation documents.

MMU Equipment Protection

This protection case involves the Ethernet or TDM traffic switching in the backplane. Tx and Rx traffic is switched from active MMU to standby MMU in case of radio link malfunction.

The NPU monitors the alarms generated in the RAU and MMU, and also controls the switches appropriately.

3.8.2.1 1+1 RLP with EQP

1+1 RLP with EQP gives the MMU, RAU, and antenna equipment protection.

1+1 RLP with EQP can be with or without space diversity. When using two antennas, they can be placed for space diversity with a mutual distance where the impact of selective fading (multipath) is reduced. With one (or two co-located) antenna, space diversity cannot be achieved.

Note: Space diversity is a counter measure against multipath, and is most efficient for frequencies up to 15 GHz.

1+1 RLP with EQP uses hot standby. One transmitter is working while the other one, tuned to the same frequency, is in standby. It is not transmitting but ready to transmit if the active transmitter malfunctions. Both RAUs receive signals.

Radio Path Protection

This protection case involves a Diversity selection in each MMU, providing hitless and error free traffic selection in case of radio channel degradation.

The Diversity selection works autonomously and is controlled by the protection logic in the active MMU Rx.

The Diversity selection reacts on quality measures from the two traffic streams. The selection is performed hitless.

3.8.2.2 2+0 RLB with EQP

2+0 RLB with EQP gives the MMU equipment protection and the RAU and the antenna graceful degradation.

2+0 RLB with EQP can use one or two frequencies. When using two different frequency channels (ACCP) the impact of selective fading (multipath) is reduced. When using one frequency channel (CCDP), XPIC must be used to achieve full performance.

Note: Frequency diversity is a counter measure against multipath, and is most efficient for frequencies up to 15 GHz.

2+0 RLB with EQP is most spectrum efficient when used together with XPIC (see Section 3.5 on page 17).

It is possible to set up a second 2+0 RLB with EQP configuration. Using two dual carrier MMUs, dual Radio Link Bonding can be achieved.

3.8.2.3 4+0 RLB with EQP

4+0 RLB with EQP gives the MMU equipment protection and the RAU and the antenna graceful degradation.

4+0 RLB with EQP with 2×MMU 1002/1004s is an efficient way to achieve high capacity with graceful degradation as well as EQP.

4+0 RLB EQP can use one, two, or four frequencies. When using four different frequency channels (ACCP) the impact of selective fading (multipath) is reduced. When using two frequency channel (CCDP), XPIC must be used to achieve full performance. When using one frequency channel (spatial CCDP), Multiple-Input Multiple-Output (MIMO) must be used to achieve full performance.

Note: Frequency diversity is a counter measure against multipath, and is most efficient for frequencies up to 15 GHz.

4+0 RLB with EQP is more spectrum-efficient when used together with XPIC (see Section 3.5 on page 17).

4+0 RLB with EQP is the most spectrum-efficient when used together with MIMO (see Section 3.10 on page 36).

4+0 RLB EQP with MIMO uses the corresponding XPIC licenses.

3.8.2.4 2+2 RLP with EQP

2+2 RLP with EQP gives the MMU, RAU, and antenna equipment protection.

2+2 RLP with EQP can use one or two frequencies. When using two different frequency channels (ACCP) the impact of selective fading (multipath) is reduced. When using one frequency channel (CCDP), XPIC must be used to achieve full performance.

2+2 RLP with EQP can be with or without space diversity. When using two antennas, they can be placed for space diversity with a mutual distance where the impact of selective fading (multipath) is reduced. With one (or two co-located) antenna, space diversity cannot be achieved.

Note: Space diversity is a counter measure against multipath, and is most efficient for frequencies up to 15 GHz.

2+2 RLP with EQP is most spectrum efficient when used together with XPIC (see Section 3.5 on page 17).

3.8.3 1+1 RLP with Asymmetrical Power Splitters

In a 1+1 protection hop with asymmetrical radio paths, revertive switching assures that a switch is made from a path with higher attenuation back to the path with lower attenuation when the path with lower attenuation has been restored. A switch in a 1+1 protection hop could be triggered by, for example, a system restart.

Revertive switching is applicable for 1+1 RLP with asymmetrical power splitters.

Revertive Switching

When asymmetrical power splitters (−1 dB and −7 dB) are used in master/slave 1+1 RLP configurations, the active radio normally uses the −1 dB path of the splitter. The active radio remains in this path until a fault on the radio occurs or a manual switch of active radio is done.

If system service is performed, it is possible that the active radio is via the −7 dB path after a manual functional test of the system has been performed. In this scenario the system gain is decreased by 12 dB (6 dB on each side of the hop).

The same scenario occurs at a DC power off/on if the −7 dB path is chosen for the radio connected to the MMU in the lowest slot, since this MMU is always active at startup. If this setup is done at both near and far end, the total system gain loss is 12 dB (6 dB on each side of the hop).

Revertive Tx Switching makes it possible to manually set the preferred txRadio (txRadio1 or txRadio 2) and thereby avoid a decrease in system gain.

3.9 Cross Polarization Interference Canceller (XPIC)

Cross Polarization Interference Canceller (XPIC) is used to transmit two radio carriers across the same frequency, increasing the link utilization. XPIC is not a form of protection.

In an XPIC configuration, there is a risk that both receivers lock to the same transmitter. To prevent this, the Carrier-ID is used to uniquely identify each carrier. A far-end receiver can only lock to a near-end transmitter with the same Carrier-ID. Therefore, the Carrier-ID must be set to different values for the horizontal and the vertical polarization, and have identical settings for the same polarization on both sides of the hop according to Figure 20.

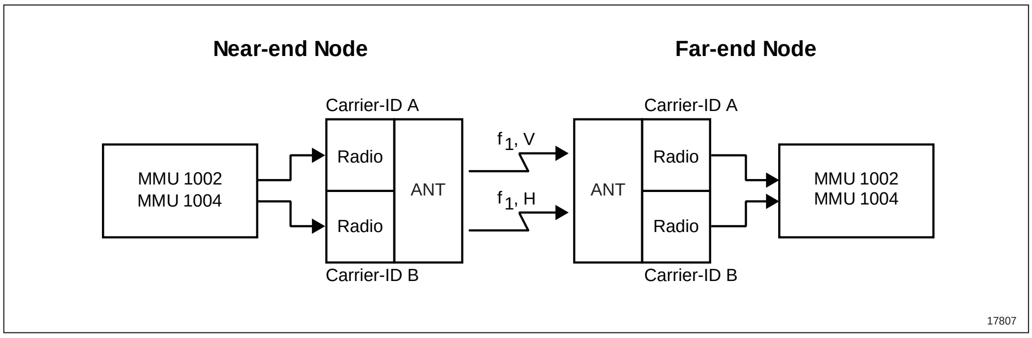

Figure 20 Carrier-ID for XPIC

It is recommended to use one dual-polarized antenna instead of two single-polarized antennas.

3.9.1 XPIC Basics

Cross polarization techniques are used in microwave networks to increase the capacity by transmitting data with two different polarizations over the same frequency band: vertical and horizontal polarization.

On each side of the hop, there are two radios installed per antenna; one radio for each polarization. The two different data streams from these radios are combined and transmitted from one common antenna on the near-end side and received through one common antenna on the far-end side. The received data on the far-end side is then separated again based on the two polarizations, so that one radio receives the vertically polarized signals and the other radio receives the horizontally polarized signals.

Cross Polarization Interference Canceller (XPIC) is an algorithm used to reduce the Cross Polar Interference (XPI) that occurs between the two polarizations when transmitted over the hop. The XPI of a system is represented by the XPI value (measured in dB), which is the sum of all possible factors that can cause XPI.

For example, the following factors can cause cross polar interference:

- The channel conditions for each polarization.
- The alignment and rotation of the installed antennas.
- Variations and differences in the output power for each polarization.
- Cross Polar Discrimination (XPD), which is the ability of each antenna to isolate the two separate polarizations. XPD is relative to the phase angle (ϕ) between the polarizations.

  Note: The XPD value is a characteristic of the antenna and does not change with the antenna alignment or antenna rotation.

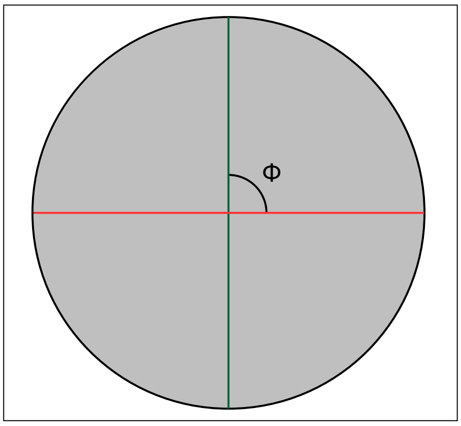

Figure 21 Phase Angle (ϕ) Between the Vertical and Horizontal Polarizations

The XPI value can be adjusted by rotating one of the antennas. This changes the relative phase angle (ψ) between them.

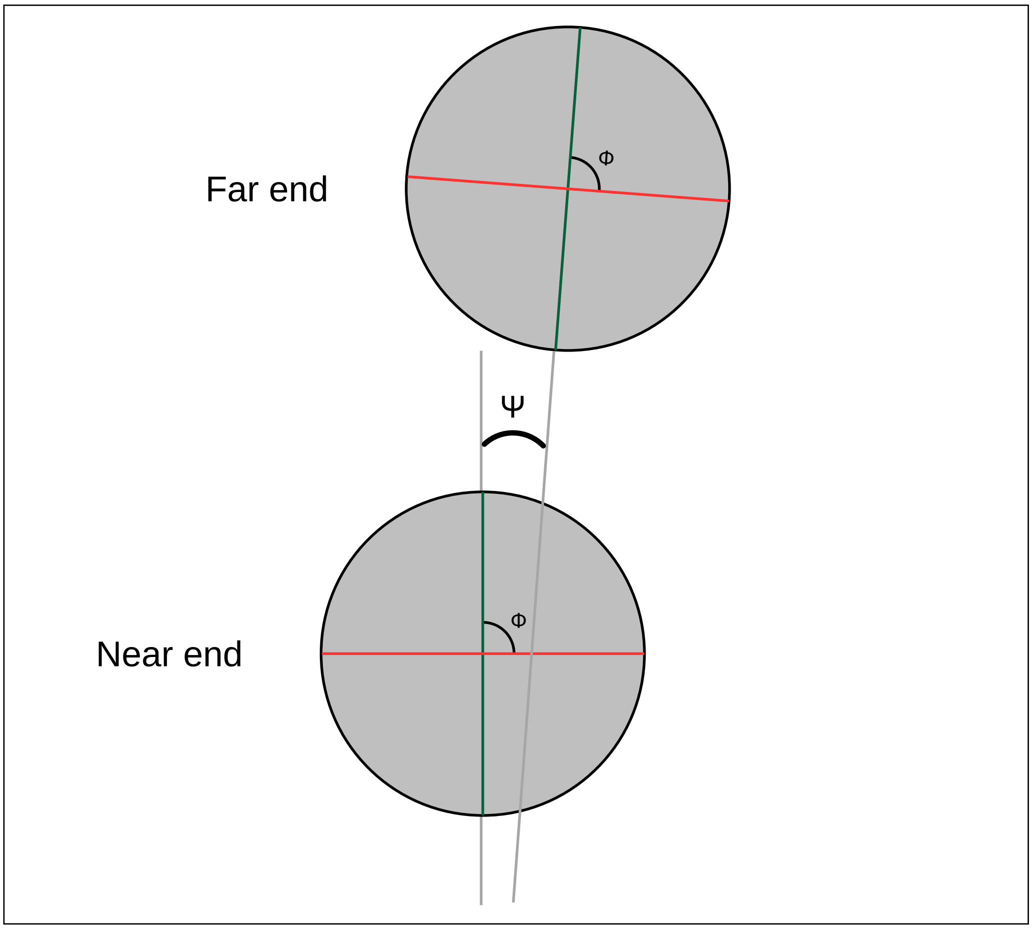

Figure 22 Cross Polar Interference - Mechanical Factors (ϕ) and Antenna Rotation (ψ)

Accepted Levels of Cross Polar Interference In the System

The rage of accepted XPI values for achieving a good radio link performance can be seen in Figure 23. The recommended XPI range for best radio link performance is 24–30 dB. Due to different channel conditions, the XPI value can have natural variations. This is considered in the XPI range recommendation.

Note: For E-band 80 GHz installations using MINI-LINK 6363 radios, the corresponding values are 20–30 dB (AGC 0.5–0.75 V).

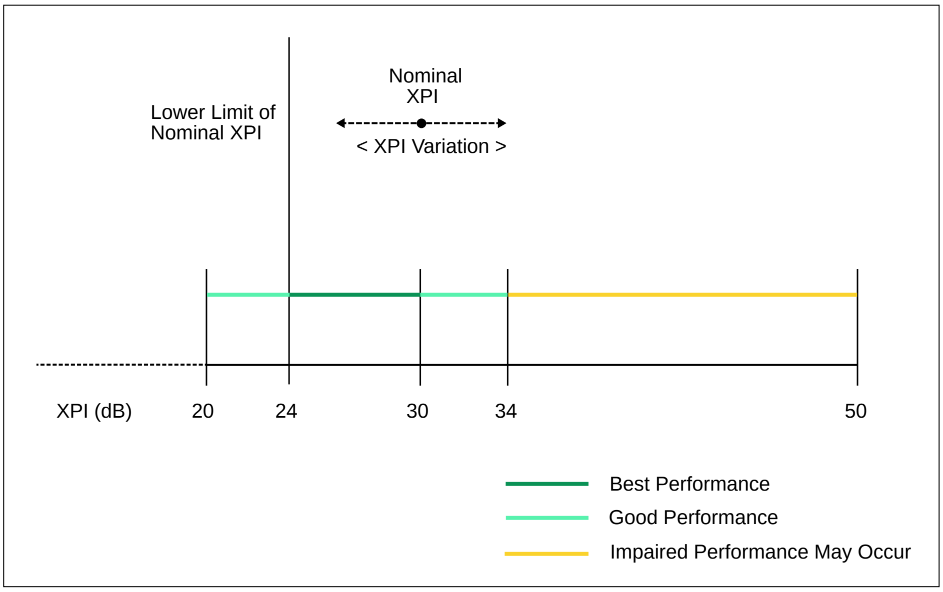

Figure 23 Recommended Range of Cross Polar Interference Levels

Signal to Noise Ratio

XPI means that one polarization leaks onto the other, so that the receiver of the vertically polarized signals also receives levels of the horizontally polarized signals, and the other way around. The undesired signals are referred to as either internal co-channel interference or noise contribution.

Signal to Noise Ratio (SNR) represents the quality of the signal. SNR compares the level of desired signals to the level of undesired signals (the level of total noise).

In an ideal situation where there is no XPI and the isolation is 100% between the polarizations, the SNR is, in theory, the difference between the Received Signal Level (RSL) and the thermal noise floor.

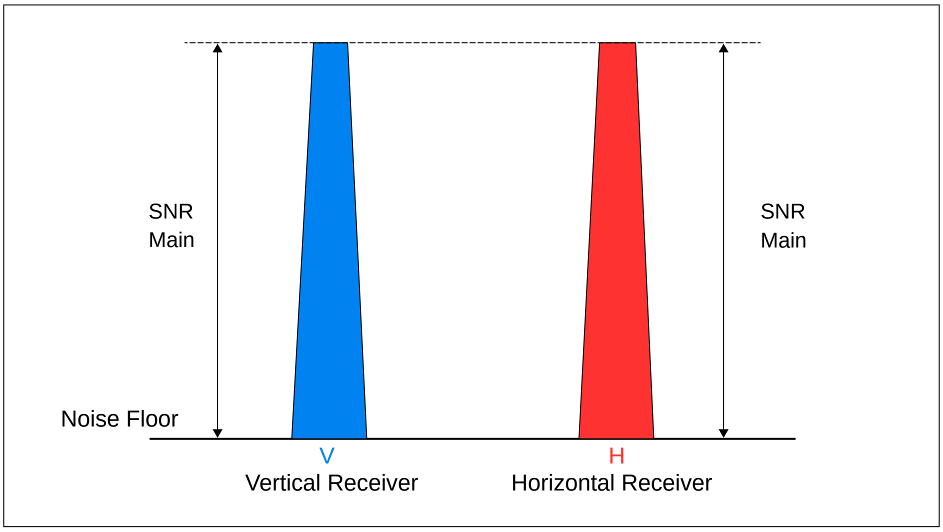

Figure 24 Ideal Situation with 100% Isolation Between the Polarizations

In a system with a high level of XPI, the desired cross polar signals get suppressed, resulting in a low SNR. This leads to the XPIC function receiving a weaker cross polar signal with a higher noise contribution in the interference cancellation process.

If the XPI value is near or equal to the SNR Main value, the strength of the cross polar signal becomes below the noise floor value and the XPIC function can no longer identify the cross polar signals. This can lead to impaired performance.

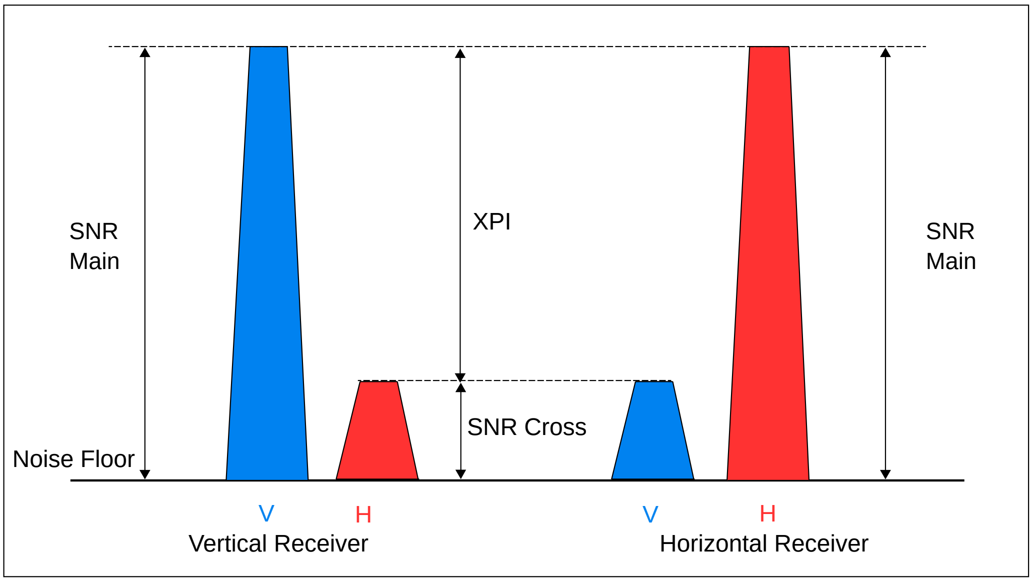

Figure 25 High XPI Values Resulting in Low SNR Values

In a system with a low level of XPI, the desired cross polar signals get less suppressed, resulting in a higher SNR. The XPIC function receives a stronger cross polar signal with less noise contribution in the cancellation process. This condition results in the best performance.

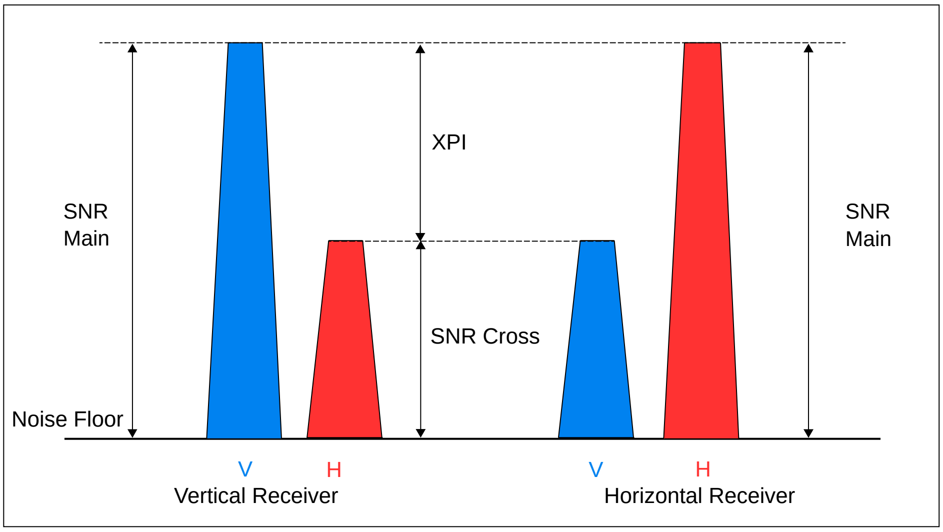

Figure 26 Lower XPI Values Resulting in Higer SNR Values

3.9.2 XPIC Recovery and Restore

When a faulty (horizontal or vertical) receiver of one Carrier Termination (CT) prevents the received signal to be sent from one polarization to the other, then XPIC cannot recover the original signal. This means that both the horizontal and the vertical links are unavailable in the direction toward the faulty receiver, even if only one of the receivers is faulty.

XPIC Recovery

XPIC Recovery is the corrective procedure to recover the data traffic on the faultless channel. XPIC Recovery must be enabled by the user.

XPIC Recovery is triggered either by user actions or by faults, and consists of the following:

— Switching off the two transmitters of the faulty CT.

— Disabling the four XPIC cancellers, both near-end and far-end.

XPIC Restore

XPIC Restore is the procedure to re-configure XPIC on both CTs. XPIC Restore consists of re-enabling all XPIC cancellers and turning all transmitters on. Thanks to this, both cross-polar links (horizontal and vertical) are fully recovered and the traffic is error free.

Considering the example above, once the recovery procedure is triggered, both receivers stop generating XPI. As a result, the traffic over the faultless radio channel is error free. After the fault has been repaired, the restore is triggered, either manually or automatically.

3.9.3 2+0 RLB with XPIC Configuration

The 2+0 RLB with XPIC Radio Link configuration consists of the following equipment on one side of the hop:

— One 1002/1004 (MINI-LINK 6691, MINI-LINK 6692, MINI-LINK 6693, MINI-LINK 6694, MINI-LINK 6654, and MINI-LINK 6655)

  or

  One MINI-LINK 6651/1, one MINI-LINK 6651/2, or MINI-LINK 6651/4

— Two radios

— One integrated dual-polarized antenna

It is possible to use Adaptive Modulation in this configuration.

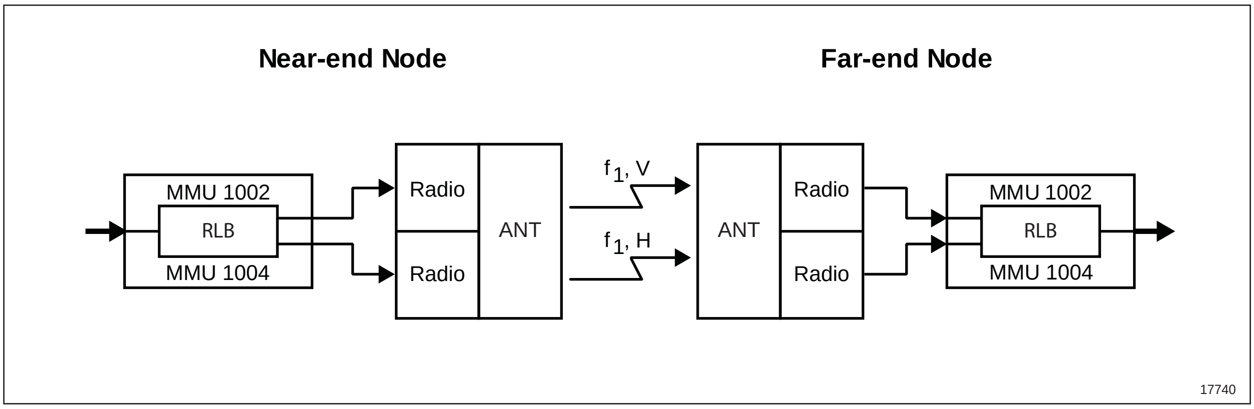

Figure 27

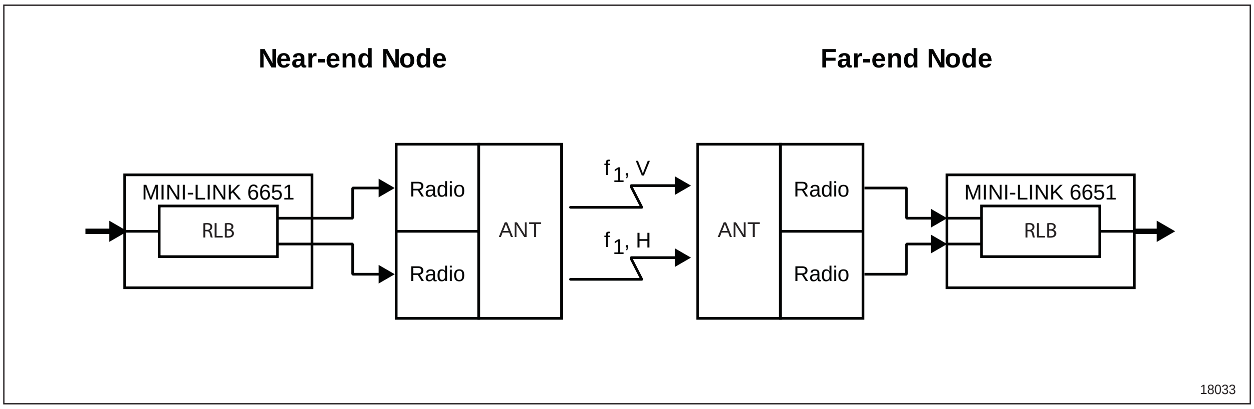

Figure 28 2+0 RLB with XPIC Configuration with MINI-LINK 6651/1, MINI-LINK 6651/2, or MINI-LINK 6651/4

Figure 27 and Figure 28 show only one direction of transmission (from left to right), but the transmission is symmetrical in both directions.

No XPIC cross-cable is needed, since the connection is done internally.

3.9.4 Dual (1+0) with XPIC Configuration

The dual (1+0) with XPIC Radio Link configuration consists of the following equipment on one side of the hop:

— One MMU 1002/1004 (MINI-LINK 6691, MINI-LINK 6692, MINI-LINK 6693, MINI-LINK 6694, MINI-LINK 6654, and MINI-LINK 6655)

  or

  One MINI-LINK 6651/2 or one MINI-LINK 6651/4

— Two radios

— One integrated dual-polarized antenna

It is possible to use Adaptive Modulation in this configuration.

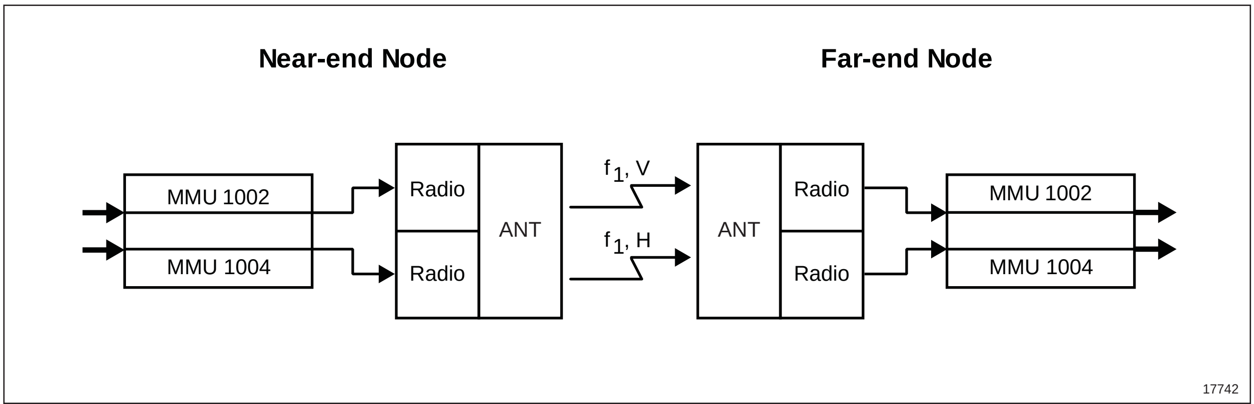

Figure 29 Dual (1+0) with XPIC Configuration with MINI-LINK 6691, MINI-LINK 6692, MINI-LINK 6693, MINI-LINK 6694, MINI-LINK 6654, and MINI-LINK 6655

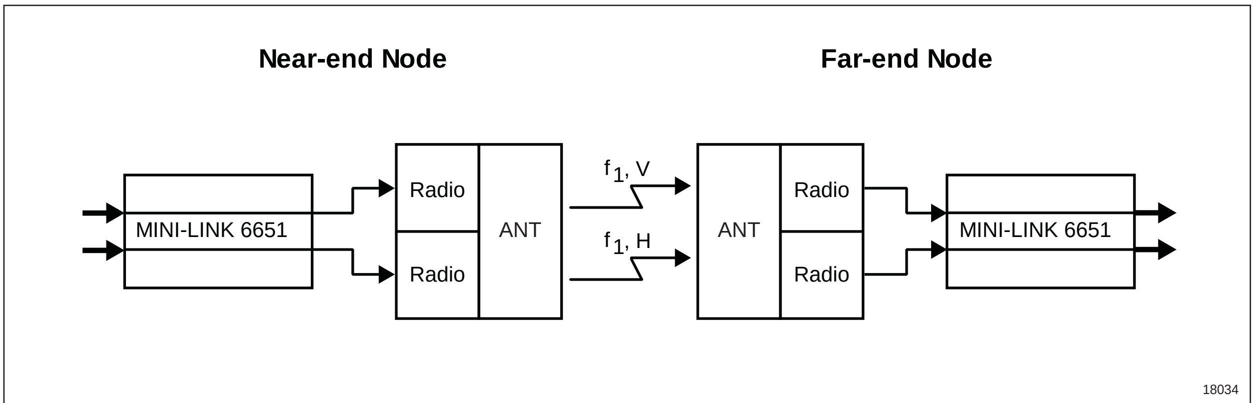

Figure 30 Dual (1+0) with XPIC Configuration with MINI-LINK 6651/2 or MINI-LINK 6651/4

Figure 29 and Figure 30 show only one direction of transmission (from left to right), but the transmission is symmetrical in both directions.

No XPIC cross-cable is needed, since the connection is done internally.

3.9.5 2+0 RLB EQP with XPIC Configuration

The 2+0 RLB EQP with XPIC Radio Link configuration consists of the following equipment on one side of the hop:

- Two MMU 1002/1004s (MINI-LINK 6691, MINI-LINK 6692, MINI-LINK 6693, MINI-LINK 6694, MINI-LINK 6654, and MINI-LINK 6655)

  or

  Two MMU 1001s (MINI-LINK 6691, MINI-LINK 6692, MINI-LINK 6693, MINI-LINK 6694, MINI-LINK 6654, and MINI-LINK 6655)

- Two radios
- One integrated dual-polarized antenna
- XPIC cable

It is possible to use Adaptive Modulation in this configuration.

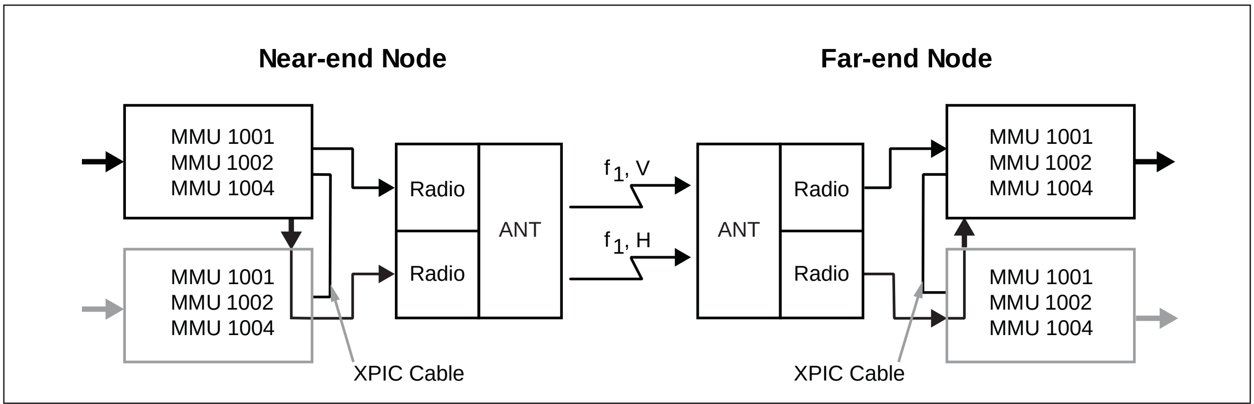

Figure 31 2+0 RLB EQP with XPIC Configuration with MINI-LINK 6691, MINI-LINK 6692, MINI-LINK 6693, MINI-LINK 6694, MINI-LINK 6654, and MINI-LINK 6655

Figure 31 shows only one direction of transmission (from left to right), but the transmission is symmetrical in both directions.

It is possible to set up a second 2+0 RLB EQP with XPIC configuration. Using two MMU 1002/1004s, dual Radio Link Bonding with Equipment Protection and XPIC can be achieved. When configuring two 2+0 RLB EQP links using two adjacent MMU boards, XPIC can be configured on both RLT1 and RLT 2.

3.10 Multiple-Input Multiple-Output (MIMO)

Multiple-Input Multiple-Output (MIMO) is a method for increasing the capacity of a radio link using multiple transmission and receiving antennas, to exploit multiple propagation.

In MINI-LINK 6600 products, the support of MIMO increases the spectral efficiency by utilizing the available spectrum with multiple carriers in the same frequency channel.

4x4 MIMO provides up to four times more capacity and uses the combination of the following modes:

— 2x2 spatial MIMO with antenna separation

— 2x2 polarization MIMO with Cross Polarization Interference Canceller (XPIC)

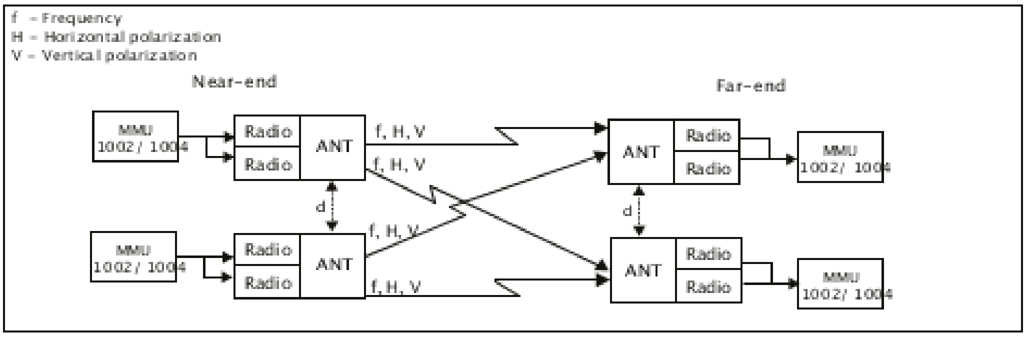

Figure 32 4x4 MIMO

2x2 MIMO provides up to two times more capacity and uses the following mode:

— 2x2 spatial MIMO with antenna separation

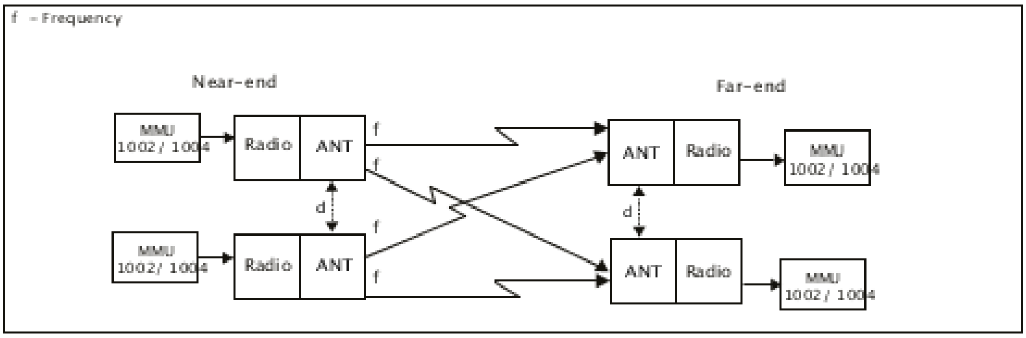

Figure 33 2x2 MIMO

The basis of a fully functional MIMO system is to exchange received baseband information between all involved carriers, for cancellation of the internal co-channel interference. All MMUs must be active in receiving direction, Rx, in order to achieve transmission over the hop. This will limit the EQP function.

When using EQP in a MIMO configuration, switching due to faults in TX direction will lead to graceful degradation and switching due to faults in RX direction may lead to traffic loss.

3.11 Carrier Aggregation (CA)

Carrier Aggregation (CA) aggregates existing channels to wider channels in a cost-effective way. CA has the following advantages:

- Doubled capacity with one radio
- No Integrated Power Splitter (IPS) is required

If a MINI-LINK 6600 product is equipped with MMU 1002 or MMU 1004 dual carrier modems, then it supports CA when connected to a MINI-LINK 6364 or a MINI-LINK 6365 radio.

Both carriers from the modem are placed on the same intermediate frequency (IF) port and cable, using different IF frequencies. The radios filter out each carrier and mix them to a radio frequency (RF) within a radio sub-band.

The CA support is available for a 2+0 RLB scenario only in MINI-LINK 6600 shorthaul products—that is, MINI-LINK 6691, 6692, 6693, 6694, 6654, and 6655.

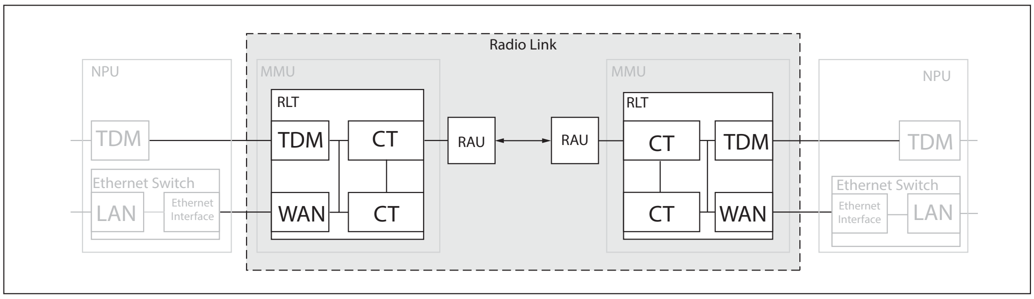

Figure 34 Carrier Aggregation (CA)

Note: On the MMU, port RAU 1 must be used to apply CA. The second port, RAU 2, must be disconnected.

CA is allowed only with symmetrical Channel Separation (CS) on both channels, and symmetrical configuration on both near end and far end.

CA is controlled by license.

3.12 Multi-Layer Header Compression (MLHC)

Multi-Layer Header Compression (MLHC) improves the efficiency of transportation of Ethernet traffic over Radio Links by compressing Ethernet/MPLS (Layer 2), IP (Layer 3), and UDP (Layer 4) headers. MLHC increases the maximum throughput at WAN interface by reducing the size of the Ethernet frames as they are transmitted over the Radio Link. The size is not configurable as it only depends on the type of header of the Ethernet frame. See Figure 35.

Supported headers:

- Ethernet

- Untagged frames
- Customer Bridge
- Provider Bridge

— MPLS

- Up to three labels per frame

— IP

- IPv4
- IPv6

— UDP

MLHC compresses frames with combinations of the above listed headers. Also, compression of L2VPN and L3VPN are supported.

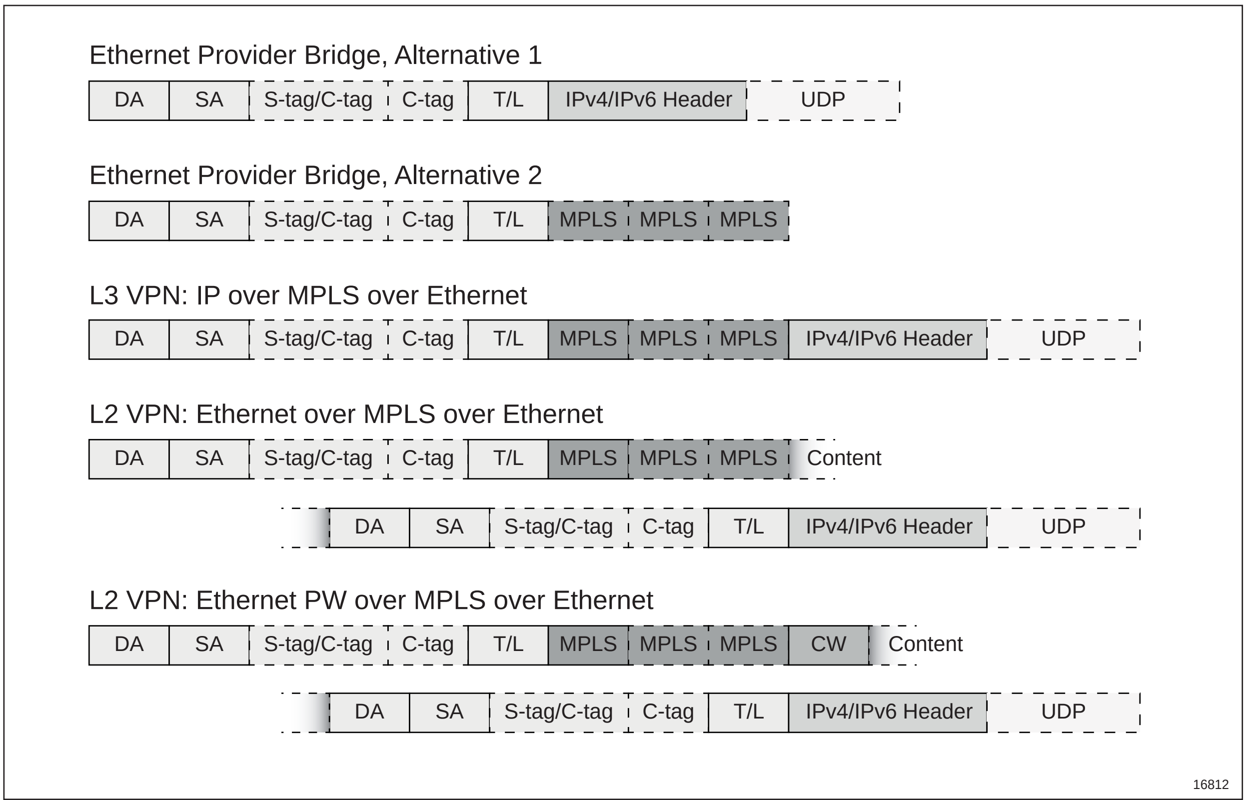

Figure 35 Compression of Headers in Different Layers

Note: 1588 frames are not compressed.

At each side of the Radio Link there is an MLHC compression pair (one compressor and one decompressor), implementing the header compression functionality. The compressor at one side of the Packet Radio Link sends compressed traffic frames to the corresponding decompressor at the other side of the hop. See Figure 36.

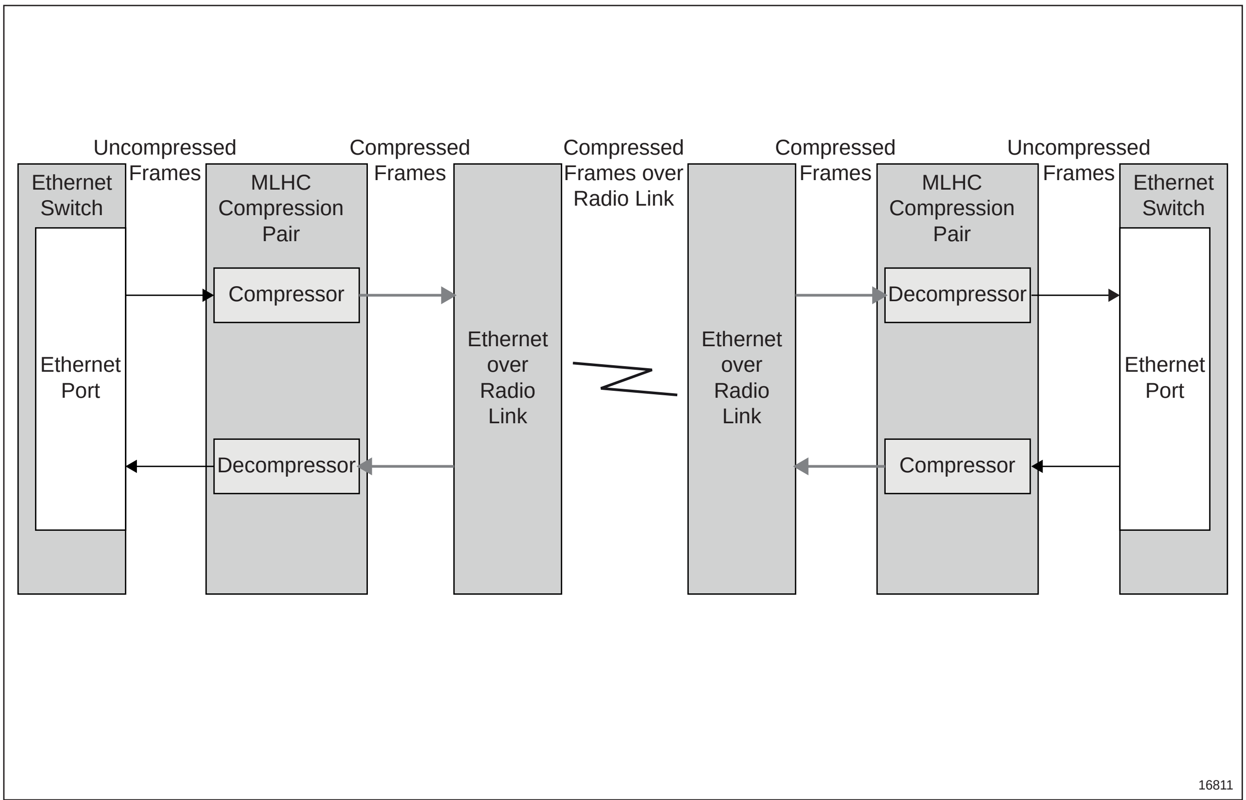

Figure 36 Compression and Decompression Functionality

3.13 AES Encryption Over-the-Hop

AES encryption over-the-hop is a radio link integrity feature. The encryption is to disguise if a radio link is used or not. The encryption is compliant to AES-256-CTR.

Note: Encryption is only possible on MMU 1002/1004 configured as 1+0 or 2+0 (on one modem).

Every carrier termination (CT) has two separate session keys for communication over the radio link:

— one for Near End ⇒ Far End

— one for Far End ⇒ Near End

Every CT can therefore be encrypted independently of each other. The Tx and Rx are also encrypted independently of each other.

AES Encryption over-the-hop is controlled by license. The feature is disabled and hidden until the proper licenses are installed on the node.

4 Ethernet Overview

MINI-LINK 6600 is targeting multiple applications and network environments with the embedded Ethernet capabilities. MINI-LINK 6600 therefore provides flexibility and supports a large number of Ethernet services and features.

For details on the required HW for specific functions, see MINI-LINK 6600 R1 Compatibility, Reference [1].

4.1 Ethernet Services

Ethernet services according to MEF (Metro Ethernet Forum) specifications are supported. The following MEF standards are supported: MEF 2, MEF 9, MEF 10, and MEF 14.

Figure 37 shows a basic model for Ethernet services. The Ethernet service is provided by Metro Ethernet Network (MEN) provider. The Customer Edge (CE) and MEN exchange service frames across the User Network Interface (UNI).

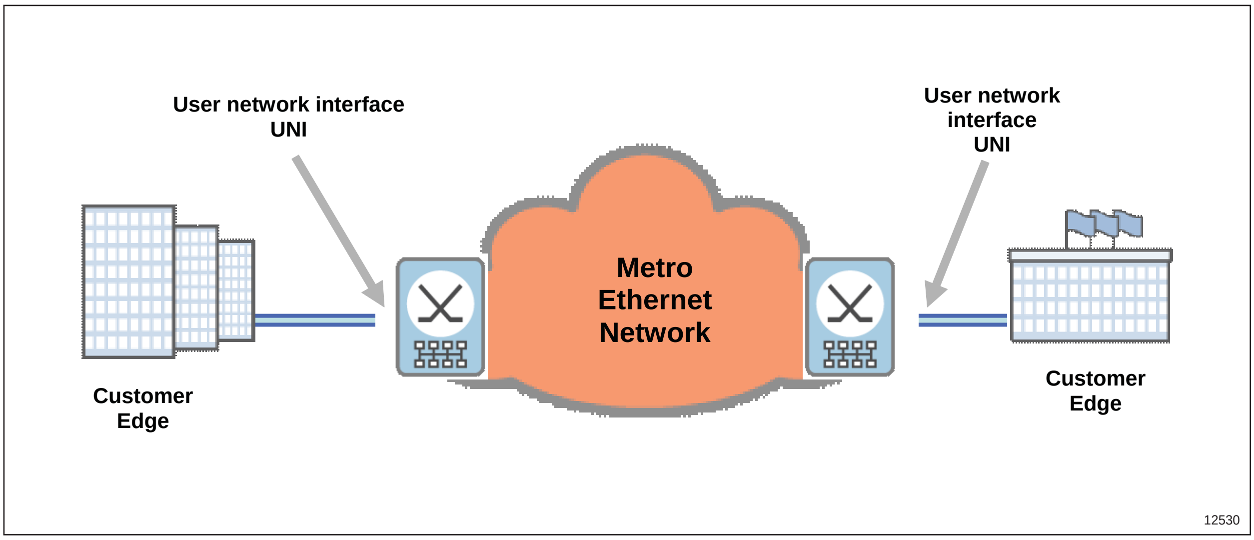

Figure 37 Ethernet Service Model

Based on Ethernet Virtual Connections (EVCs), the following service types are supported:

— Point-to-Point EVC:

- Ethernet Private Line (EPL) service
- Ethernet Virtual Private Line (EVPL) service

— Multipoint-to-Multipoint EVC:

- Ethernet Private LAN (EPLAN) service
- Ethernet Virtual Private LAN (EVPLAN) service

5 Ethernet Bridging/Switching

MINI-LINK 6600 has an embedded Ethernet bridge that can be configured for customer mode (IEEE802.1Q-2005) or provider mode (IEEE802.1ad-2005). MINI-LINK 6600 also supports a MAC bridge/switch according to IEEE802.1D-2004.

The following features are supported:

- Store and forward switching
- VLAN ID (VID) and priority tagging
- Port-based VLAN (up to 1,000 VLANs in the range of 1–4094)
- MAC address table (32,000 entries)
- Self learning with aging of MAC addresses
- Static L2 Unicast routes
- Static L2 Multicast routes
- Head of line blocking prevention (HOLB)
- Rapid Spanning Tree Protocol (RSTP)
- Multiple Spanning Tree Protocol (MSTP)
- Link Aggregation Group (LAG)
- Link Aggregation Control Protocol (LACP)
- SNMP-based management interface, for example, DCN over VLAN
- QinQ
- Many-to-one/All-to-one Mapping for Provider Mode and for QinQ
- Internet Group Management Protocol (IGMP) snooping
- Multicast Listener Discovery (MLD) snooping
- Multiple VLAN configuration

5.1 L2 Connectivity Provisioning for Customers over a Provider Network

The provider network functionality enables transport of customer Ethernet traffic over an L2 network. Upon entrance to a service provider network, a Service VLAN tag (S-tag) is added to the Ethernet frame. The S-tag contains the information required to provide a virtual separation of traffic from different customer domains. Once the frame has been transported through the service provider network, the S-tag is removed from the Ethernet frame at the service provider network egress point. In the service provider network it is treated as an ordinary VLAN Ethernet frame.

MINI-LINK 6600 supports the following two types of L2 connectivity provisioning:

— QinQ

— IEEE 802.1ad

For QinQ, the S-tag is similar to the Customer VLAN tag (C-tag) and includes the following:

— Tag Protocol Identifier (0×8100)

— Priority bits (for priority handling in the provider network)

— Drop Eligible Indicator (DEI) bit (for support of color marking).

— S-VLAN ID

QinQ enhances scalability by removing the 1000 VLANs limitation from Customer Mode (IEEE 802.1Q). In this case, the spanning tree of the customer network is proposed to be split into several spanning tree domains. The interconnection between the customer and provider allowed to be a single L2 link and special care of the loop-free L2 topology has to be taken.

For IEEE 802.1ad, the S-tag is similar to the C-tag and includes the following:

— Tag Protocol Identifier (0×88a8)

— Priority bits (for priority handling in the provider network)

— Drop Eligible Indicator (DEI) bit (for support of color marking).

— S-VLAN ID

Provider Bridge enhances scalability by removing the 1000 VLANs limitation from Customer Mode (IEEE 802.1Q) as well as the size limitation of the spanning tree since the number of hops in the service provider network is not a part of the calculation by the customer spanning tree.

MINI-LINK 6600 implements a Provider Edge Bridge which comprises a single S-VLAN component and one or more C-VLAN components.

- Customer Edge Port (CEP): A C-VLAN component Port on a Provider Edge Bridge that is connected to customer owned equipment and receives and transmits frames for a single customer

  CEP is an external physical interface. It is a UNI interface and is named CE-UNI in MINI-LINK 6600.

- Customer Network Port (CNP): An S-VLAN component within a Provider Edge Bridge that receives and transmits frame for a single customer.

  A CNP can be an external physical interface, or a virtual internal interface when connected to a Provider Edge Port (PEP). The CNP is a UNI interface, named CN-UNI in MINI-LINK 6600.

- Provider Network Port (PNP): An S-VLAN component Port on a Provider Bridge that transmits and receives frames for multiple customers.

  A PNP is an external physical interface. It is an NNI interface, named I-NNI (PN) in MINI-LINK 6600.

- Provider Edge Port (PEP): A C-VLAN component Port within a Provider Edge Bridge that connects to a Customer Network Port and receives and transmits frames for a single customer.

  The PEP is a virtual internal interface and the port parameters are set to fixed values and can be read from the management system.

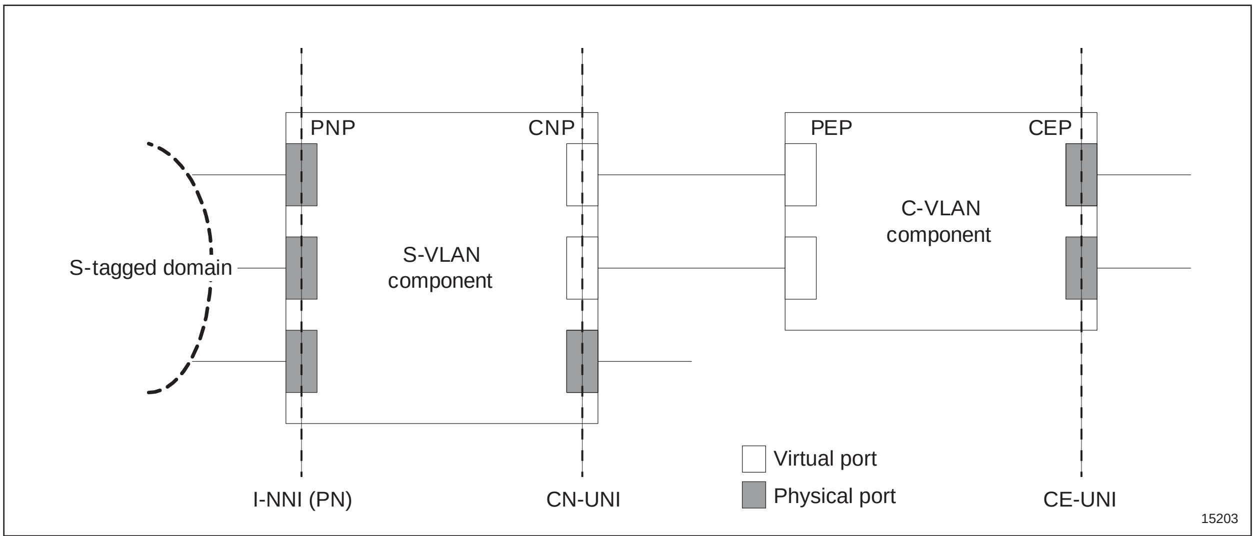

Figure 38 Provider Bridge

5.2 Port Roles

Depending on bridge configuration (customer mode or provider mode) different switch port roles are available in MINI-LINK 6600.

UNI and I-NNI port roles are available in customer mode, while Customer Edge UNI (CE-UNI), Customer Network UNI (CN-UNI) and Provider Network NNI (I-NNI (PN)) are available in provider mode.

The UNI ports in customer mode and the CE-UNI and CN-UNI ports in provider mode are the interface between the customer and operator network.

The I-NNI and I-NNI (PN) ports are interfaces used within a transport network. The I-NNI ports in customer mode accept only C-tagged frames while the I-NNI (PN) ports in provider mode only accept S-tagged frames.

For I-NNI ports the TPID can be changed from the default value to the C-VLAN TPID 0x8100.

5.3 Supported Frame Sizes

Ethernet frames of different sizes are common in real networks and the frame size is often related to the application. A real-time application, for example, voice and video, that requires minimum latency typically uses small Ethernet frames, while a data application with non real-time characteristics uses the maximum frame size. MINI-LINK 6600 handles both small and large Ethernet frames as well as a mix.

All ports support 64 to 9,216 byte frame size.

5.4 Header Decoding

MINI-LINK 6600 supports header decoding for C-VLANs in customer mode and S-VLANs in provider mode. The EtherType value, also referred to as Tag Protocol Identifier (TPID), for C-VLANs is 0×8100. For S-VLANs the EtherType value is 0×88a8.

The EtherType value is unique for the entire network in customer and provider mode, respectively.

5.5 Multiple VLAN Configuration

VLAN operations on a range of VLANs are possible, as batch operations are supported.

6 Ethernet Security and Admission Control

MINI-LINK 6600 supports multiple security and admission control mechanisms to enable the operator to control the traffic flow into the network individually per port.

The security and admission control features are only available on a port configured as an L2 connection.

6.1 Frame Admittance

At the network edge it is possible, with the frame admittance feature, to select which frame types to admit and block. The following frame type options are available:

- Admit Only VLAN Tagged Frames
- Admit Only Untagged and Priority Tagged Frames
- Admit All Frames

The frame admittance settings for bridge ports are specified below.

Customer Mode

- UNI ports: configurable frame types with default value Admit All Frames
- I-NNI ports: non-configurable frame types set to Admit Only VLAN Tagged Frames

Provider Mode

- CE-UNI ports: non-configurable frame types set to Admit All Frames

  Note: Tagged frames with EtherType other than 0×8100 are discarded.

- CN-UNI ports: configurable frame types with default value Admit All Frames
- I-NNI (PN) ports: non-configurable frame types set to Admit Only VLAN Tagged Frames

6.2 L2CP Frames Processing

MINI-LINK 6600 supports the following filtering behavior of Layer 2 control protocols:

- Discard (IEEE 802.1ad/MEF 10.1)

- Peer (MEF 10.1)
- Forward Unchanged
- Tunneling

  L2CP tunneling makes it possible to traverse the incoming Layer 2 protocol frames through the network. Tunneling can only be configured on one interface per network element. When using more tunnels in the same physical Layer 2 segment, different tunnel MAC addresses need to be used per tunnel.

The options above are configurable on UNI, CE-UNI, and CN-UNI ports. On I-NNI and I-NNI (PN) ports, the behavior depends on the protocol running in the node.

For all L2CP listed in the tables below, the default behavior on all port types is discard. This is in accordance with IEEE 802.1ad. The alternative behavior for the protocols supported in MINI-LINK 6600 is presented in the tables below.

Table 3 Filtering Behavior of L2CP Protocols on UNI

MAC Address	Application	Tunnelable	Optional Configurable Behavior
01-80-C2-00-00-00	Customer Bridge Protocol Data Units (BPDUs)	Yes	Peer if enabled
01-80-C2-00-00-01	MAC Pause	No	None
01-80-C2-00-00-02 subtype 0x01	Link Aggregation Control Protocol (LACP)	Yes	Peer if enabled, Forward
01-80-C2-00-00-02 subtype 0x02	Link Aggregation Marker Protocol (LAMP)	Yes	Peer if enabled, Forward
01-80-C2-00-00-02 subtype 0x03	Link OAM	Yes	Peer if enabled, Forward
01-80-C2-00-00-02 subtype 0x04–0x09	Future slow protocols	Yes	None
01-80-C2-00-00-02 subtype 0x0A	Ethernet Synchronization Messaging Channel (ESMC)	No	Peer if enabled(1)
01-80-C2-00-00-03	802.1X authentication	Yes	None
01-80-C2-00-00-0D	Provider GVRP	Yes	None
01-80-C2-00-00-0E	Link Layer Discovery Protocol (LLDP)	Yes	Peer if enabled(2)
01-80-C2-00-00-04	Future standard bridge -04	Yes	None
01-80-C2-00-00-05	Future standard bridge -05	Yes	None
01-80-C2-00-00-06	Future standard bridge -06	Yes	None
01-80-C2-00-00-07	Metro Ethernet Forum ELMI	Yes	None
01-80-C2-00-00-09	Future standard bridge -09	Yes	None

MAC Address	Application	Tunnelable	Optional Configurable Behavior
01-80-C2-00-00-0A	Future standard bridge -0A	Yes	None
01-80-C2-00-00-0B	Future standard bridge -0B	Yes	None
01-80-C2-00-00-0C	Future standard bridge -0C	Yes	None
01-80-C2-00-00-10	All Bridges Protocol	Yes	None
01-80-C2-00-00-20	GARP Multicast Registration Protocol (GMRP)	Yes	None, Forward
01-80-C2-00-00-21	GARP VLAN Registration Protocol (GVRP)	Yes	None, Forward
01-80-C2-00-00-2x (x=2..F)	Generic Attribute Registration Protocol (GARP)	Yes	None, Forward
01-80-C2-00-00-08	Provider Bridge Protocol Data Units (BPDUs)	Yes	None
01-80-C2-00-00-0F	Future standard bridge -0F	Yes	None

(1) Not supported if the interface is an hRLB group interface.

(2) : When LLDP is enabled on a port it is peered regardless of the configured L2CP behavior. The configured L2CP behavior is applied when LLDP is disabled.

Table 4 Filtering Behavior of L2CP Protocols on I-NNI

MAC Address	Application	Alternative Behavior(1)
01-80-C2-00-00-00	Bridge Group Address (BPDUs)	Peer if enabled
01-80-C2-00-00-02 subtype 0x01	Link Aggregation Control Protocol (LACP)	Peer if enabled
01-80-C2-00-00-02 subtype 0x02	Link Aggregation Marker Protocol (LAMP)	Forward unchanged
01-80-C2-00-00-02 subtype 0x03	Link OAM	Peer if enabled
01-80-C2-00-00-02 subtype 0x0A	Ethernet Synchronization Messaging Channel (ESMC)	Peer if enabled
01-80-C2-00-00-0E	Link Layer Discovery Protocol (LLDP)	Peer if enabled
01-80-C2-00-00-0x (x=1,3..F)	All other C-VLAN component reserved group addresses	None

(1) Not configurable

Table 5 Filtering Behavior of L2CP Protocols on CE-UNI

MAC Address	Application	Tunnelable	Optional Configurable Behavior
01-80-C2-00-00-00	Customer Bridge Protocol Data Units (BPDUs)	Yes	Forward
01-80-C2-00-00-01	MAC Pause	No	None

MAC Address	Application	Tunnelable	Optional Configurable Behavior
01-80-C2-00-00-02 subtype 0x01	Link Aggregation Control Protocol (LACP)	Yes	Peer if enabled, Forward
01-80-C2-00-00-02 subtype 0x02	Link Aggregation Marker Protocol (LAMP)	Yes	Peer if enabled, Forward
01-80-C2-00-00-02 subtype 0x03	Link OAM	Yes	Peer if enabled, Forward
01-80-C2-00-00-02 subtype 0x04–0x09	Future slow protocols	Yes	None
01-80-C2-00-00-02 subtype 0x0A	Ethernet Synchronizati on Messaging Channel (ESMC)	No	Peer if enabled(1)
01-80-C2-00-00-03	802.1X authentication	Yes	None
01-80-C2-00-00-0D	Provider GVRP	Yes	None
01-80-C2-00-00-0E	Link Layer Discovery Protocol (LLDP)	Yes	Peer if enabled(2)
01-80-C2-00-00-04	Future standard bridge -04	Yes	None
01-80-C2-00-00-05	Future standard bridge -05	Yes	None
01-80-C2-00-00-06	Future standard bridge -06	Yes	None
01-80-C2-00-00-07	Metro Ethernet Forum ELMI	Yes	None
01-80-C2-00-00-09	Future standard bridge -09	Yes	None
01-80-C2-00-00-0A	Future standard bridge -0A	Yes	None
01-80-C2-00-00-0B	Future standard bridge -0B	Yes	None
01-80-C2-00-00-0C	Future standard bridge -0C	Yes	None
01-80-C2-00-00-10	All Bridges Protocol	Yes	None
01-80-C2-00-00-20	GARP Multicast Registration Protocol (GMRP)	Yes	None, Forward
01-80-C2-00-00-21	GARP VLAN Registration Protocol (GVRP)	Yes	None, Forward
01-80-C2-00-00-2x (x=2..F)	Generic Attribute Registration Protocol (GARP)	Yes	None, Forward
01-80-C2-00-00-08	Provider Bridge Protocol Data Units (BPDUs)	Yes	None
01-80-C2-00-00-0F	Future standard bridge -0F	Yes	None

(1) Not supported if the interface is an hRLB group interface.
(2) : When LLDP is enabled on a port it is peered regardless of the configured L2CP behavior. The configured L2CP behavior is applied when LLDP is disabled.

Table 6 Filtering Behavior of L2CP Protocols on CN-UNI

MAC Address	Application	Tunnelable	Optional Configurable Behavior
01-80-C2-00-00-00	Customer Bridge Protocol Data Units (BPDUs)	Yes	Forward
01-80-C2-00-00-01	MAC Pause	No	None
01-80-C2-00-00-02 subtype 0x01	Link Aggregation Control Protocol (LACP)	Yes	Peer if enabled, Forward
01-80-C2-00-00-02 subtype 0x02	Link Aggregation Marker Protocol (LAMP)	Yes	Peer if enabled, Forward
01-80-C2-00-00-02 subtype 0x03	Link OAM	Yes	Peer if enabled, Forward
01-80-C2-00-00-02 subtype 0x04–0x09	Future slow protocols	Yes	None
01-80-C2-00-00-02 subtype 0x0A	Ethernet Synchronizati on Messaging Channel (ESMC)	No	Peer if enabled(1)
01-80-C2-00-00-03	802.1X authentication	Yes	None
01-80-C2-00-00-0D	Provider GVRP	Yes	None
01-80-C2-00-00-0E	Link Layer Discovery Protocol (LLDP)	Yes	Peer if enabled(2)
01-80-C2-00-00-04	Future standard bridge -04	Yes	None
01-80-C2-00-00-05	Future standard bridge -05	Yes	None
01-80-C2-00-00-06	Future standard bridge -06	Yes	None
01-80-C2-00-00-07	Metro Ethernet Forum ELMI	Yes	Nonev
01-80-C2-00-00-09	Future standard bridge -09	Yes	None
01-80-C2-00-00-0A	Future standard bridge -0A	Yes	None
01-80-C2-00-00-0B	Future standard bridge -0B	Yes	None
01-80-C2-00-00-0C	Future standard bridge -0C	Yes	None
01-80-C2-00-00-10	All Bridges Protocol	Yes	None
01-80-C2-00-00-20	GARP Multicast Registration Protocol (GMRP)	Yes	None, Forward
01-80-C2-00-00-21	GARP VLAN Registration Protocol (GVRP)	Yes	None, Forward
01-80-C2-00-00-2x (x=2..F)	Generic Attribute Registration Protocol (GARP)	Yes	None, Forward

MAC Address	Application	Tunnelable	Optional Configurable Behavior
01-80-C2-00-00-08	Provider Bridge Protocol Data Units (BPDUs)	Yes	Peer if enabled
01-80-C2-00-00-0F	Future standard bridge -0F	Yes	None

(1) Not supported if the interface is an hRLB group interface.
(2) : When LLDP is enabled on a port it is peered regardless of the configured L2CP behavior. The configured L2CP behavior is applied when LLDP is disabled.

Table 7 Filtering Behavior of L2CP Protocols on I-NNI (PN)

MAC Address	Application	Alternative Behavior(1)
01-80-C2-00-00-02 subtype 0x01	Link Aggregation Control Protocol (LACP)	Peer if enabled
01-80-C2-00-00-02 subtype 0x02	Link Aggregation Marker Protocol (LAMP)	Forward unchanged
01-80-C2-00-00-02 subtype 0x03	Link OAM	Peer if enabled
01-80-C2-00-00-02 subtype 0x0A	Ethernet Synchronization Messaging Channel (ESMC)	Peer if enabled
01-80-C2-00-00-08	Provider Bridge Group Address	Peer if enabled
01-80-C2-00-00-0E	Link Layer Discovery Protocol (LLDP)	Peer if enabled
01-80-C2-00-00-0x (1,3..7,9..A)	All other S-VLAN component reserved group addresses	None

(1) Not configurable

6.2.1 L2CP Frames Processing on a Layer 1 Ethernet Service

On an L1 Ethernet Service, MINI-LINK 6600 supports the following filtering behavior of L2 control protocols:

— Discard (IEEE 802.1Q/IEEE 802.3/MEF 6.1)

— Peer (MEF 6.1)

— Forward Unchanged

The default and alternative behavior for the protocols supported in MINI-LINK 6600 are presented in Table 8.

Table 8 Filtering Behavior of Reserved Group MAC Addresses.

MAC Address	Application	Default Behavior	Optional Configurable Behavior
01-80-C2-00-00-00	Bridge Group Address (BPDUs)	Forward unchang ed	None
01-80-C2-00-00-01	MAC Pause	Discard	None
01-80-C2-00-00-02 subtype 0x01	Link Aggregation Control Protocol (LACP)	Discard	Forward unchanged

MAC Address	Application	Default Behavior	Optional Configurable Behavior	
01-80-C2-00-00-02 subtype 0x02	Link Aggregation Marker Protocol (LAMP)	Discard	Forward unchanged	
01-80-C2-00-00-02 subtype 0x03	Link OAM	Discard	Peer if enabled	Forward unchanged
01-80-C2-00-00-02 subtype 0x04–0x09	All other slow Protocols multicast address	Forward unchanged	None	
01-80-C2-00-00-02 subtype 0x0A	Ethernet Synchronization Messaging Channel (ESMC)	Discard	Peer if enabled(1)	
01-80-C2-00-00-0E	Link Layer Discovery Protocol (LLDP)	Forward unchanged	Peer if enabled(2)	Discard
01-80-C2-00-00-0x (x=3...F)	All other reserved group addresses	Forward unchanged	None	

(1) Not supported if the interface is an hRLB group interface.

(2) When LLDP is enabled on a port it is peered regardless of the configured L2CP behavior. The configured L2CP behavior is applied when LLDP is disabled.

6.3 White Lists

Individual white lists can be created per port to specify which source MAC addresses MINI-LINK 6600 can accept on a port. Frames with a source MAC address not on the list will be discarded.

6.4 Ethernet Loop Detection

Ethernet loop detection is used to detect Layer 2 Ethernet loops in the network by configuring Ethernet loop alarms.

There are two use cases for Ethernet loops:

— Ethernet loop

  The NE itself is part of an Ethernet loop.

— Ethernet external loop

  The NE itself is not part of an Ethernet loop, but is connected to a Layer 2 domain where an Ethernet loop occurs.

There are also two use cases regarding provider and customer relations:

— Provider-only loops

  Can be detected when NNI ports are used.

— Provider-customer loops

The customer has redundant interconnection towards the provider network. Can be detected when both NNI and UNI ports are used.

In case a provider has redundant interconnection towards the customer, it is important to detect loops that can occur over the redundant connection. In such a case, configure also the UNI (CE-UNI or CN-UNI) ports for Ethernet loop detection. When Ethernet loop detection is configured on UNI (CE-UNI or CN-UNI) ports, the customer network receives traffic from outside of the customer network. To receive traffic from outside of the customer network, an agreement is needed between the network provider and the customer.

Note: Loop detection can be restricted to search for loops in one or a few VLANs. In this case, only these VLANs will be tested for loops.

It is recommended to use Ethernet loop detection together with storm protection to avoid flooding of the test frames, see Section 6.5 on page 53.

6.5 Storm Protection

Broadcast storm protection is a protection mechanism, which prevents that other parts or areas of the network are affected by traffic flooding from unicast, broadcast, or multicast traffic at a very high data rate.

Filters can be activated per port to prevent flooding of unwanted and hostile traffic. Individual filters are used for broadcast, multicast and destination lookup failure traffic. The filters are specified as frames per second. When the limit is reached, additional frames will be discarded until the frame rate is below the specified threshold.

Storm protection can be configured on all Ethernet bridge ports in provider bridge mode and customer bridge mode.

6.6 Port Blocking

The port blocking feature prevents forwarding of frames from a given ingress port to one or more egress ports.

6.7 MAC Address Learning

If MAC address learning is activated on the node it is possible, from one interface, to flood the learning table. A flooded learning table prevents learning on all other ports. By limiting the MAC addresses per port it is possible to prevent MAC address flooding.

MAC address learning can be disabled on a per port basis or on a per VLAN basis.

7 Quality of Service

Quality of Service (QoS) of a network deals with the ability of the network to provide transport services suitable for the applications using the network itself. The Quality of Service support in MINI-LINK 6600 is ensured by classifying packets and handling their transmission through the network according to the classification results of each packet.

The following three main parameters affect the quality of the transmission:

— Packet loss: packets lost in the network.

— Delay: the time it takes for a packet to traverse through the network from sender to receiver.

— Jitter: variation in the delay within the same traffic flow.

The different service types (video, voice, data) have different QoS requirements.

In order to meet the different QoS requirements, QoS implementation is based on priority assignment. This supports a number of different priorities in accordance with the Ethernet or IP priority scheme. Ethernet priority scheme conforms to the IEEE 802.1Q specification and supports up to 8 priority levels usually served in Strict Priority. IP priority scheme relies on a higher number of priority levels served according to their per-hop-behavior defined for DiffServ.

Both priority schemes have traffic classification where each packet is associated to a traffic class (in a small or large set), instead of an individual flow. There is not a single flow, but a set of indistinct flows with the same characteristics. Each system in the network can be configured to differentiate traffic based on the traffic class. Each traffic class can be managed differently to separate the high priority traffic from the low priority traffic.

Different features contribute to provide QoS and allow the system to resolve bottlenecks and to guarantee higher priority traffic with respect to lower. The features are listed below.

— Policing: the policer manages traffic matching a certain level of service (usually a bandwidth value). The feature is applied to make sure a subscriber is using the allowed amount of resources in a network. A policer usually performs a configurable action on non-compliant traffic, for example, discard or de-prioritize.

— Queue Management: queue management operates at queue level. It drops or marks frames entering the queue before the queue is full. Typically, queue management operates with a probabilistic approach, dropping or marking frames depending on the queue usage (or its evaluation) and a drop-probability.

— Traffic Scheduler: the traffic scheduler typically operates at port level on the queues associated to that port. It manages the forwarding of different packets, based on their service class, using queue management and various scheduling algorithms. The scheduler ensures that frame delivery corresponds to the QoS parameters for each flow.

An overview of the execution order for different QoS functions is illustrated in Figure 39.

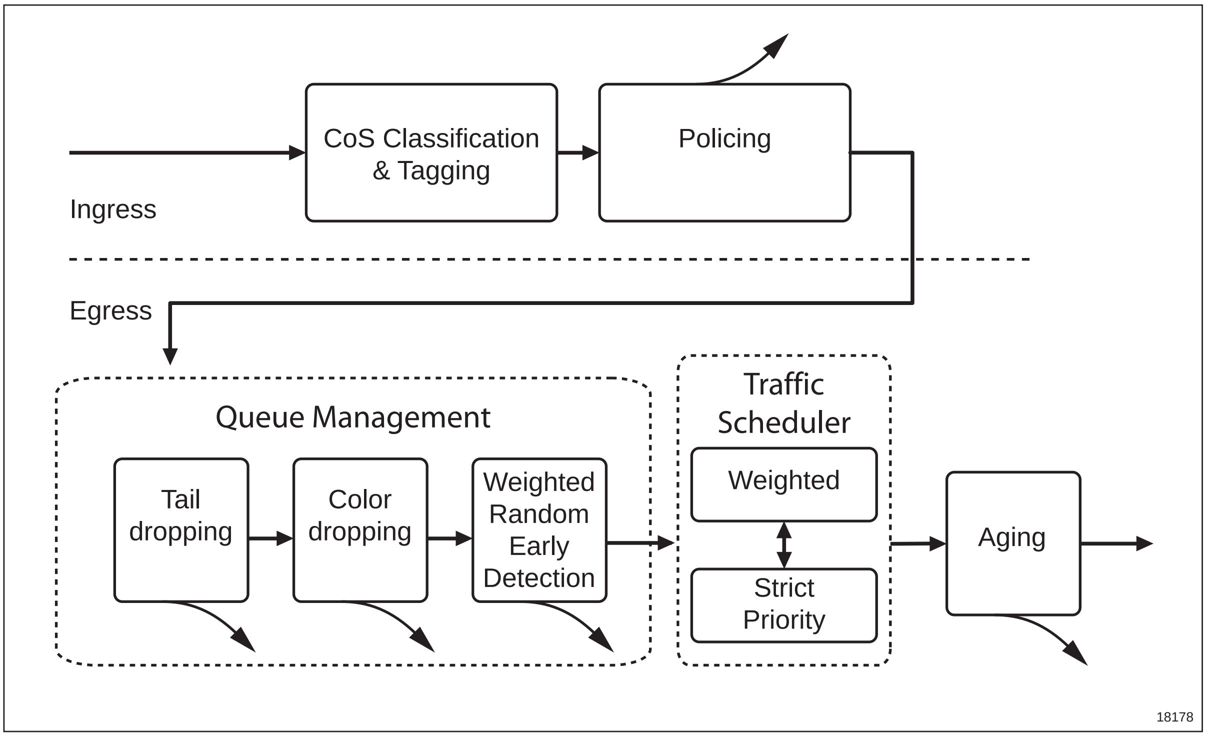

Figure 39 QoS Execution Order

Frames can be dropped at the ingress or egress side by the different QoS functions described in this section.

Note: IEEE 802.3x-based congestion handling mechanism does not take into account the usage of different priority levels. The reception of a PAUSE message triggers a network element to halt all Ethernet frames. This means that IEEE 802.3x-based congestion handling is not suitable for networks configured for different priority levels and transmission of real-time traffic.

7.1 Classification and Tagging

7.1.1 VID Handling

Frames entering UNIs, CN-UNIs, and CE-UNIs are discarded or accepted depending on the information in the frame header and on the parameters set on the port. Before entering the bridge, the frame header can be modified by adding or changing the VLAN tag. The VID is often added to the VLAN tag together with a priority.

VLAN modifications are done if the frame complies with the following conditions:

— The source MAC address of the incoming frame does not belong to the reserved group MAC address

— The format of the incoming frame is supported by the acceptable frame type configured on the port

— The port receiving the frame belongs to the member set of the VLAN carried by the frame (when applicable)

If these conditions are met, the VLAN modifications below are performed.

Customer Mode

A UNI is a C-tag aware interface. Incoming C-tagged frames are accepted. Untagged and priority tagged frames are assigned the Port VID (PVID). The PVID is added as a C-tag.

An I-NNI is C-tag aware interface. C-tagged frames are accepted. Non C-tagged frames are always discarded.

Provider Mode

A CE-UNI is a C-tag aware interface. Incoming C-tagged frames having the C-VID registered in the C-VID registration table are tagged with the corresponding S-VID.

Incoming C-tagged frames not registered in the C-VID registration table are discarded. Untagged and priority tagged frames are assigned the S-VLAN corresponding to the Port VID (PVID) in the C-VID registration table. Untagged frames can also be assigned the PVID as a C-tag. Any tagged frame with EtherType different than `0×8100` is discarded.

Outgoing frames on a CE-UNI port can be filtered on S-VLANs or C-VLAN–S-VLAN pairs registered in the C-VID registration table.

As an external physical interface, a CN-UNI is S-tag aware and C-tag unaware. S-tagged frames are accepted. Incoming C-tagged frames are handled as untagged frames and are assigned the Port VID (PVID). The PVID is added as an S-tag. Untagged and priority tagged frames are assigned the Port VID (PVID).

An I-NNI (PN) is an S-tag aware interface. S-tagged frames are accepted. Non S-tagged frames are always discarded.

7.1.2 C-VID Registration Table

CE-UNI ports have a mapping table for C-VLAN and S-VLAN, which is an explicit C-VID registration table that provides mapping between C-VIDs and S-VIDs. The table has an entry for each of the allowed C-VLANs on the CE-UNI port.

When a frame enters a CE-UNI port and carries one of the allowed C-VLANs for the port, the S-VLAN that corresponds to the frame C-VLAN in the table is added to the frame.

In Provider Mode, it is possible to configure a CE-UNI port with characteristics comparable to a CN-UNI port. By configuring a default mapping rule into the C-VID registration table of a port, all C-VLANs can be mapped to an S-VLAN similar to how a CN-UNI port operates. If needed, it is possible to define exceptions from the all-to-one mapping by adding non-default entries to the C-VID registration table.

When untagged or priority-tagged frames enter the CE-UNI port, the entry corresponding to the port default PVID parameter is used to determine which S-VLAN that is added to the frame. If double tagging on untagged frames is enabled, the PVID is also added to untagged frames as a C-VLAN. If the PVID parameter is set to `0`, incoming untagged and priority tagged frames are dropped (this is the default behavior).

Note: The default mapping rule does not apply to untagged and priority tagged frames.

In order to achieve the ‘‘default’’ tagging behavior for untagged and priority tagged frames, a non-default entry has to be created in the C-VID registration table, between any arbitrary C-VLAN ID and the S-VLAN ID also used for the default mapping rule, and the PVID of the port has to be set to this arbitrary C-VLAN ID.

Example configuration

PVID=999

C-VLAN ID	S-VLAN ID	Effect
1	1	S-VLAN ID 1 is added to incoming frames with C-VLAN 1
2	1	S-VLAN ID 1 is added to incoming frames with C-VLAN 2
3	1	S-VLAN ID 1 is added to incoming frames with C-VLAN 3
0	2	Default mapping rule: S-VLAN ID 2 is added to incoming frames with any C-VLAN ID except 1, 2, 3 and 999
999	2	S-VLAN ID 2 is added to incoming frames with C-VLAN ID 999 S-VLAN ID 2 is added to incoming untagged and priority tagged frames. If double tagging on untagged frames is enabled, C-VLAN ID 999 is also added to the untagged frames.

7.1.3 QinQ

When operating in customer mode, it is possible to encapsulate IEEE 802.1Q VLANs in other IEEE 802.1Q VLANs (both having TPID 0x8100), thus enabling the construction of Provider Ethernet networks without equipment supporting IEEE 802.1ad.

The configuration is possible on UNI ports, using the QinQ Termination Table. This table defines a mapping between Customer Edge VLAN IDs (Ce VLAN ID) and Provider Edge VLAN IDs (Pe VLAN ID).

When a frame enters a UNI port with QinQ Termination configured, and carries a VLAN ID defined as Ce VLAN ID in the QinQ Termination Table of the port, an outer IEEE 802.1Q VLAN tag is added to it with the corresponding Pe VLAN ID (this is called selective, or one-to-one mapping).

It is also possible to define a “default” (many-to-one/all-to-one) mapping in the QinQ Termination Table, by creating a mapping entry with Ce VLAN ID 0. If a many-to-one entry is configured in the QinQ Termination Table of the port, an outer IEEE 802.1Q VLAN tag is attached to ingressing frames which carry a VLAN ID not defined as a Ce VLAN ID in the QinQ Termination Table.

If QinQ Termination is configured on a UNI port, the outer VLAN tag is removed (stripped) from outgoing frames if the carried VLAN ID is registered as Pe VLAN ID in the QinQ Termination Table of the port (either for one-to-one or many-to-one mapping).

Ingressing frames with certain C-VLAN IDs can be admitted “transparently”, without the addition of a second VLAN tag, even if “default” (many-to-one) mapping is configured in the QinQ Termination Table. This is done by configuring the port as member of these VLANs but not using these VLAN IDs either as Ce VLAN IDs or Pe VLAN IDs when configuring QinQ Termination. Egressing frames carrying these VLAN IDs will be transmitted without removing the (outer) VLAN tag.

Note: If a certain VLAN ID is configured as a Pe VLAN ID on a port (either with a one-to-one or many-to-one QinQ Termination mapping), it is not possible to “transparently” admit frames with that VLAN ID. If neither “default” (many-to-one) QinQ Termination mapping, nor a one-to-one QinQ Termination mapping with the certain VLAN ID as Ce VLAN ID is configured, incoming frames with the certain VLAN ID are dropped.

7.1.4 Priority Handling (Ingress)

The main objective of the priority classification/tagging process is to establish a frames relative priority to offer appropriate propagation in the network and internally in MINI-LINK 6600.

Definitions

Trusted Port

In MINI-LINK 6600 there are different criteria that come into play when a frame is priority tagged. First of all the operator must decide whether the connected user domain is trusted or not. For a trusted domain the operator can reuse the priority information in the frame, set by the client. For an untrusted port the default network priority value is used.

User/Customer and Network Domains

The actual priority of a frame in an end to end Ethernet connection can be different based on where in the network it is. A network can be logically split up in a network domain and one or more user/customer domains. All nodes in an area have a similar congestion behavior. In the user/customer domain, the priority settings of an Ethernet frame are based on the individual user/customer definitions and referred to as user/customer priority. In the network domain the network priority settings, defined by the operator, are used.

User/Customer Priority

The priority setting used in the user/customer domain and set by the user/customer. The user/customer priority information can be retrieved from the user domain frames in one of the following ways:

1. From the PCP bits in the C-VLAN Ethernet header (valid for UNI in customer mode; CE-UNI in provider mode; CN-UNI in provider mode, only if the acceptable frame type of the CN-UNI port is set to Admit Only Untagged and Priority Tagged Frames).

2. From the PCP bits in the S-VLAN Ethernet header (valid for CN-UNI in provider mode).

3. From the IPv4 DSCP bits in the IP header.

4. From the IPv6 DSCP bits in the IP header.

5. In Layer 2 mode, the option DSCP IPv4 and IPv6 makes it possible to use trusting on IPv4 and IPv6 DSCP at the same time.

6. From the EXP bits in the MPLS tag.

7. From both the EXP bits in the MPLS tag and the DSCP bits in the IP header. Primarily the classification in this case is based on MPLS EXP, but in case of non-MPLS traffic, the IP DSCP value is used for prioritization.

Network Priority

The network priority is the Ethernet frame’s priority setting used in the operator/network domain. The different network priority values are defined by the operator.

The network priority of an Ethernet frame is typically a representation of the traffic type and the application generating the Ethernet flow, for example, voice call.

The traffic types and associated priority values are standardized in IEEE 802.1Q and IEEE 802.1D. Each traffic type is associated with a priority value to indicate the relative importance of that traffic type. Highest number equals highest priority.

In a network, it is important that only one set of priority definitions is used, for example, IEEE 802.1D. Otherwise, the handling of Ethernet frames and the mapping to egress queues can differ between network elements. The outcome of this scenario is a non predictable behavior for the different traffic types, for example, voice.

Priority Code Point (PCP)

The Priority Code Point is the three bits in the Ethernet header that is used to carry the priority value and coloring information for the Ethernet frame. The priority information is mandatory while coloring information is only applied when the Ethernet flow is policed.

Priority Tagging

When a frame enters the network domain (UNI), the user/customer priority settings are either mapped to the operator network priority definitions (trusted interface) or to the default priority setting (untrusted interface). The main purpose of the priority tagging process is to mark a frame with appropriate priority to be used in the network domain, that is, network priority. Priority tagging is only available on a port configured as a Layer 2 connection.

Figure 40 illustrates how the user/customer priority is mapped to the appropriate network priority at the ingress side of MINI-LINK 6600 as a part of the frame tagging process. The network priority value is stored in the PCP bits in the Ethernet header (the possible user/customer priority alternatives are specified earlier in this chapter). For untagged frames and untrusted interfaces the default network priority is used. The network priority value is used as the frame’s priority in the CoS/congestion handling mechanisms internally in MINI-LINK 6600. On the egress side of MINI-LINK 6600 the PCP value is encoded from the network priority value and stored in the Ethernet frame’s PCP bits. The Ethernet frame is mapped to the appropriate priority/TC buffer.

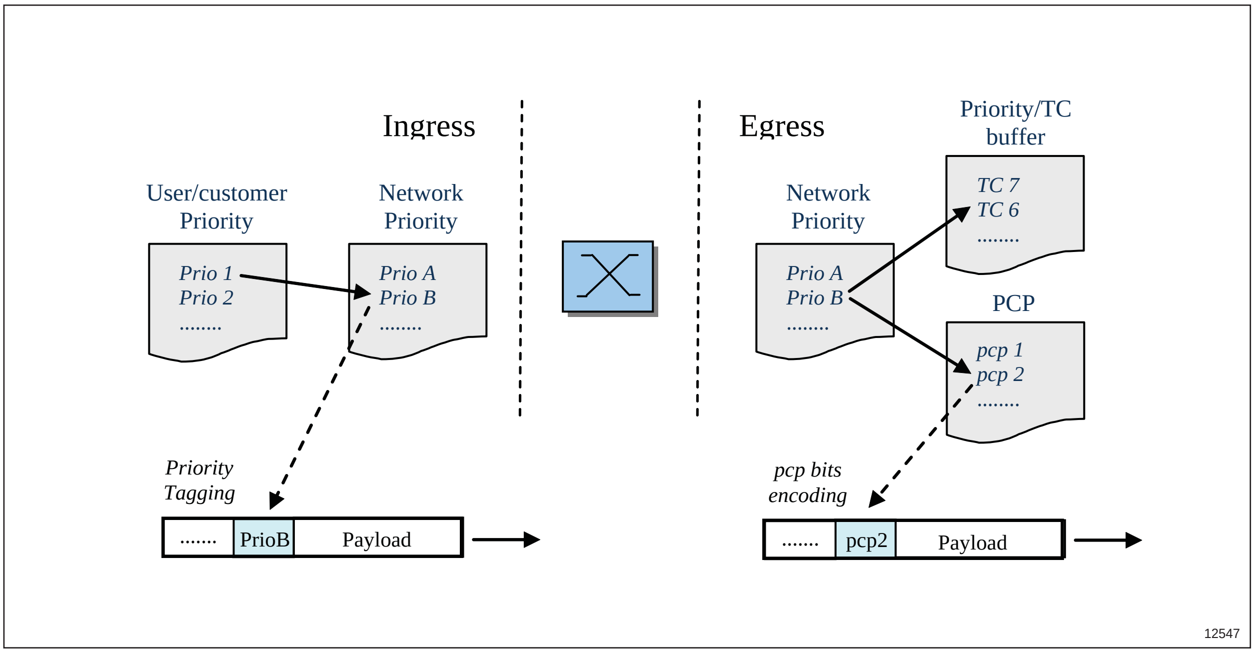

Figure 40 Priority Tagging at Network Edge for Trusted Interface

Note: The network priority and PCP value is a 1:1 mapping unless the PCP bits are used to carry coloring information. See Section 7.2 on page 64, for more information.

The flowchart in Figure 41 is used in the tagging process to establish network priority at the network edge.

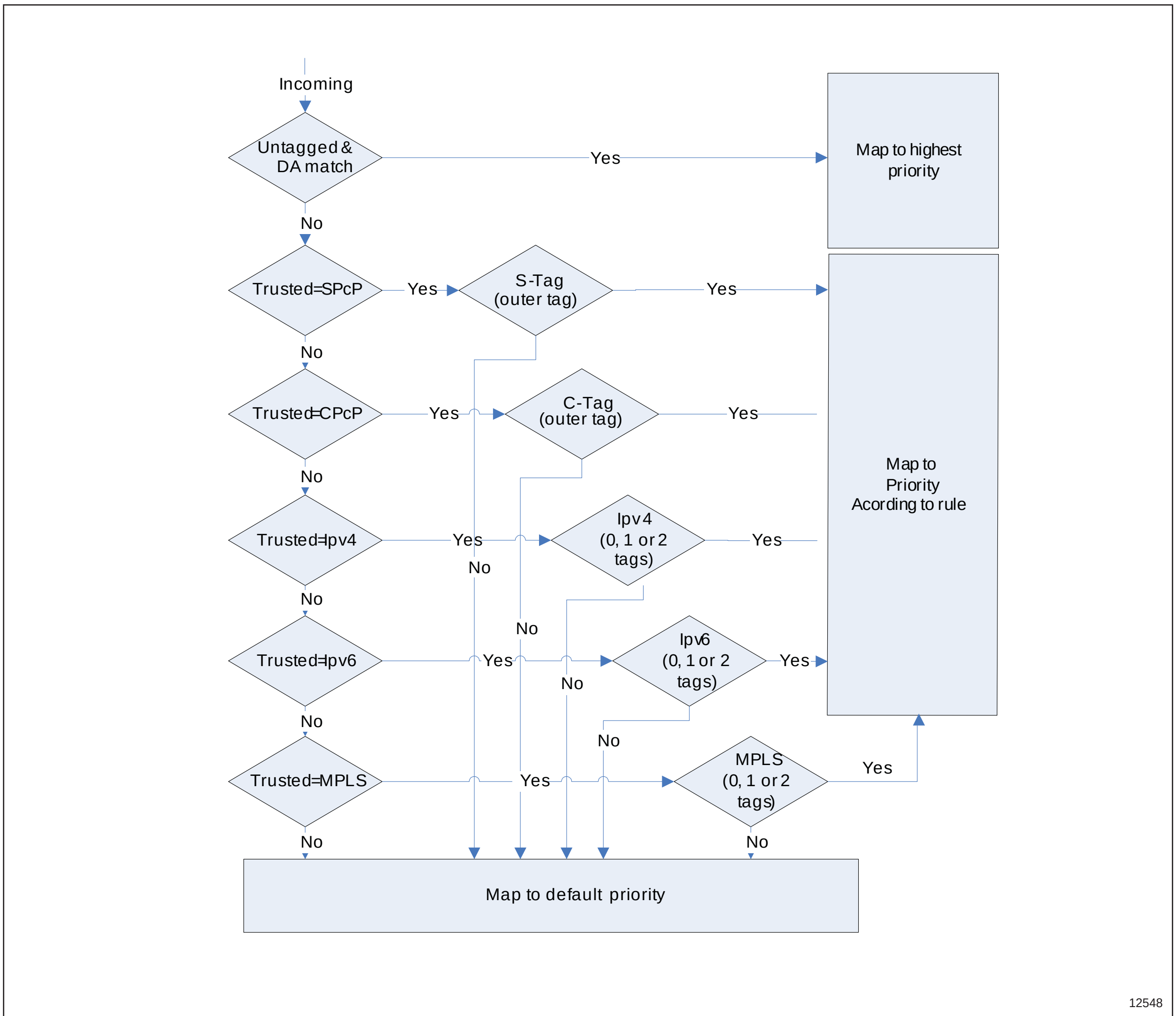

Figure 41 Priority Tagging Flowchart

Untagged & DA match test if the frame is untagged and have a destination MAC address belonging to the reserved group MAC addresses. BPDU, Link OAM, MAC Pause all belong to this category.

On a trusted port, the EXP/DSCP priority information in the MPLS/IP header or PCP bits in the Ethernet header is used to establish the network priority. The translation is done according to a mapping table customized by the operator.

Priority Classification

Priority classification is done internally in the network domain to decode the network priority value from the PCP bits. The network priority value is used as the priority of the frame in the CoS/congestion handling mechanisms internally in MINI-LINK 6600. On the egress side of MINI-LINK 6600 the PCP value is encoded from the network priority value and stored in the PCP bits in the Ethernet frame. The Ethernet frame is put in the appropriate priority/TC buffer, see Figure 42.

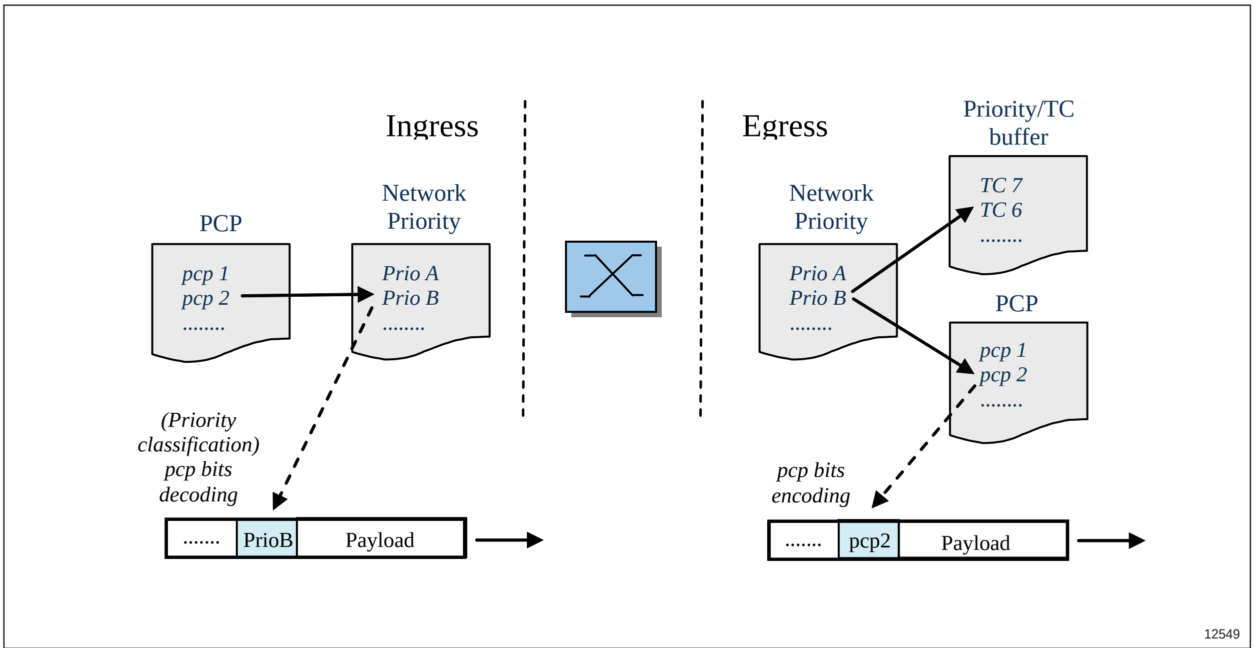

Figure 42 Priority Classification on Internal Network Interfaces

Note: The network priority and PCP value is a 1:1 mapping unless the PCP bits are used to carry coloring information. See Section 7.2 on page 64, for more information.

7.1.5 Priority Handling Layer 1

The contents and concepts described in Section 7.1.4 on page 58 also apply to L1 Ethernet Services.

In the case of a trusted Layer 1 port, the user/customer priority information can be retrieved from the user domain frames in one of the following ways:

1. From the PCP bits in the C-VLAN Ethernet header.
2. From the PCP bits in the S-VLAN Ethernet header.
3. From the IPv4 DSCP bits in the IP header.
4. From the IPv6 DSCP bits in the IP header.
5. With the option DSCP IPv4 and IPv6 it is possible to use trusting on IPv4 and IPv6 DSCP at the same time.
6. From the EXP bits in the MPLS tag.

7. From both the EXP bits in the MPLS tag and the DSCP bits in the IP header. Primarily the classification in this case is based on MPLS EXP, but in case of non-MPLS traffic, the IP DSCP value is used for prioritization.

Header Decoding

L1 Ethernet Service is transparent to all kinds of traffic: untagged traffic; any kind of tagged traffic, including tagged traffic with VLAN ID compliant to IEEE 802.1Q or IEEE 802.1ad.

7.2 Policing/Color Marking (Ingress)

At the network edge the policing rate enforcement feature controls the flow into the network. The policing feature can be used to make sure the traffic from an external customer does not violate the specified input rate and burst size. The policing feature in MINI-LINK 6600 is compliant to the ingress Bandwidth Profile functionality specified in MEF 10.1.

In MINI-LINK 6600, policing can be activated either per port or per port per user/customer priority or per port per VLAN. This means that policing rate enforcement can be activated for the consolidated input flow, independent of the traffic types , or individually for each traffic type in the input flow based on either priority or VLAN. The policing feature is only available on a port configured as a Layer 2 connection.

As described later in this chapter, the user/customer priority can be obtained in different ways, for example, DSCP. To select the appropriate Bandwidth Profile (policer) for a flow, the corresponding user/customer priority value is mapped to a user priority group. The user priority group is pointing to the appropriate Bandwidth Profile, see Figure 43.

In case of VLAN based policing, the Bandwidth Profile assignment can be done in a similar way. VLAN IDs can be mapped to a VLAN group, and the Bandwidth Profile can be assigned to the VLAN group.

For policing per port, the port number is directly associated with the Bandwidth Profile.

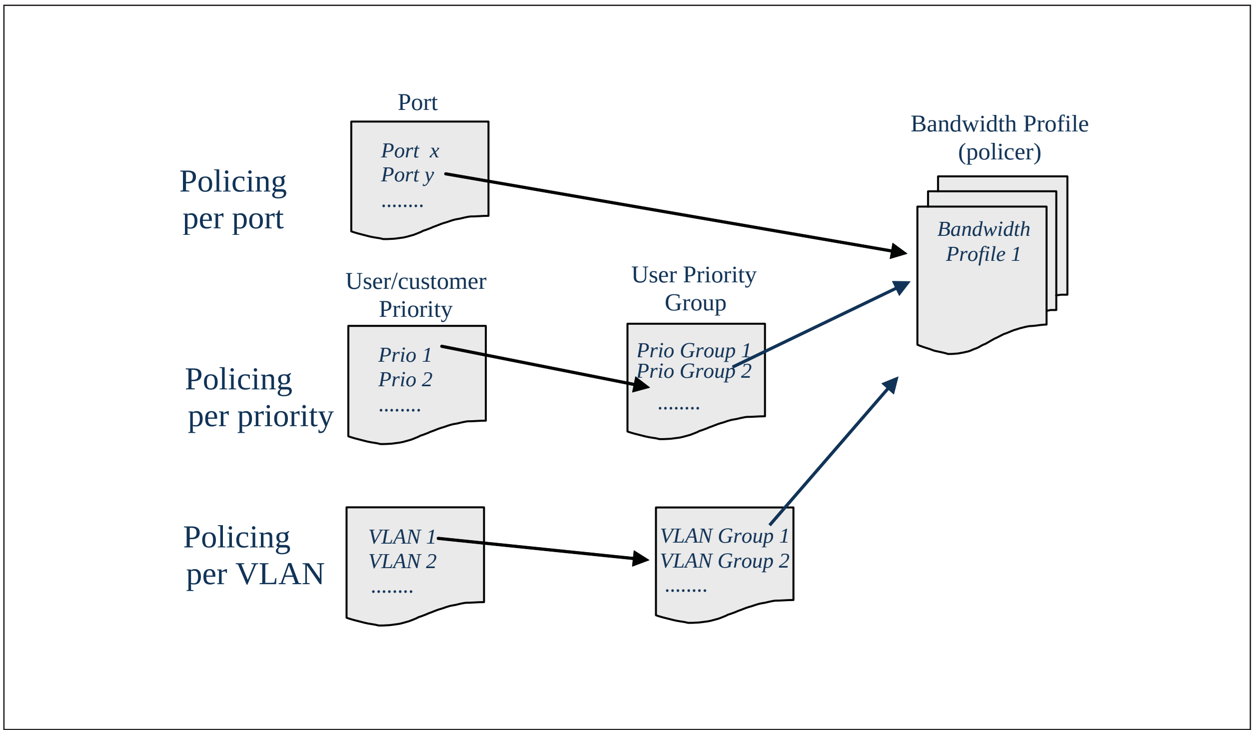

Figure 43 Policing Data Model

The output of the policing function in MINI-LINK 6600 is typically a colored or dropped frame, see Figure 44. The criteria for the deciding whether the frame is colored (green or yellow) or dropped (red) are based on the compliance with the parameters specified below.

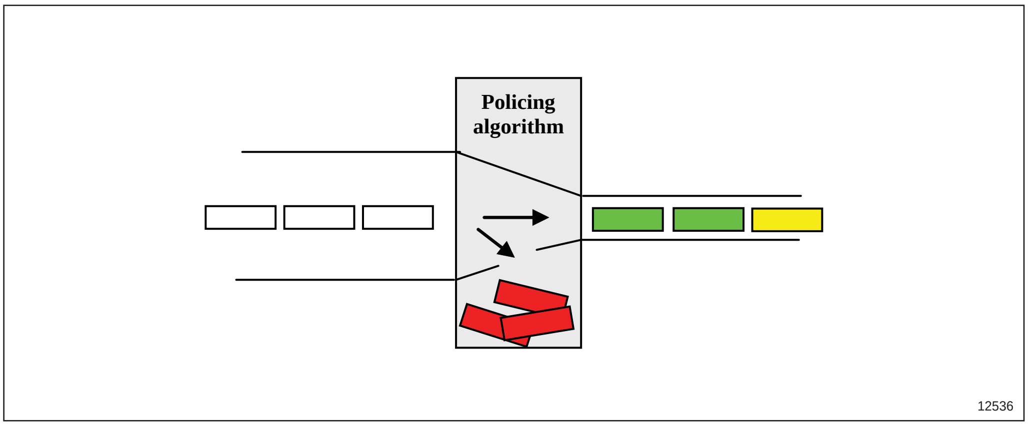

Figure 44 Policing Function in MINI-LINK

By using the policing feature the input flow can be controlled with the following parameters:

— Committed Information Rate (CIR): The CIR value is typically a guaranteed end to end throughput rate, that is, all frames within the CIR value from the external client are propagated transparently with no frame loss. CIR is specified as bps.

— Committed Burst Size (CBS): The CBS value indicates the guaranteed burst length, that is, all frames within the CBS burst length from the external client are propagated transparently with no frame loss. CBS is specified in number of bytes

— Excess Information Rate (EIR): The EIR value is a throughput rate above the CIR committed input rate. Frame rates above the CIR but below EIR are accepted in to the network but with no guarantees. EIR is specified as bps.

— Excess Burst Size (EBS): The EBS value indicates the excess burst length. Burst lengths above the CBS but below the EBS size are accepted in to the network but with no guarantees. EBS is specified in number of bytes.

— Coupling Flag (CF): The CF value controls the volume of the frames that are colored yellow. In MINI-LINK 6600 the CF flag is set to 0, that is, the long term average bit rate of frames declared yellow is bounded by EIR.

— Color mode (CM): The CM value decides whether existing color information in a frame should be used in the policing algorithm or not. In MINI-LINK 6600 the CM is set to Color Blind, that is, existing color information is disregarded in the policing algorithm.

The coloring process uses the above parameters in the following manner to identify the appropriate color for a frame:

— Green frames: Input Rate<CIR and Burst Size<CBS

— Yellow frames: CIR<Input Rate<EIR+CIR and CBS<Burst Size<EBS

— Red frames: Input Rate>EIR or Burst Size>EBS

A graphical presentation of the coloring criteria is illustrated in Figure 45.

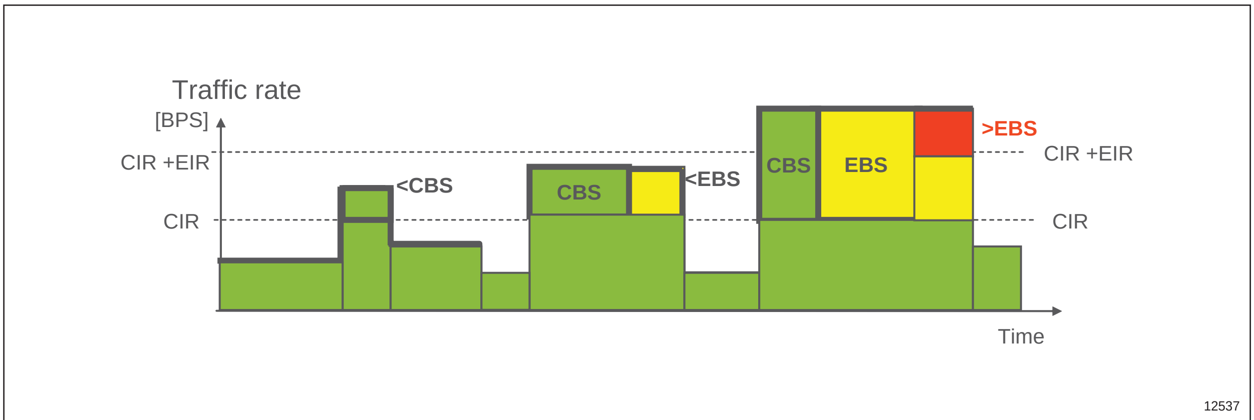

Figure 45 Coloring of Frames in the Policing Function

The color information in a Customer bridge network is transported in the PCP bits in the Q-tag. If policing/coloring is used for a port, the number of priority/TC queues for that port is reduced, that is, some PCP bit values are used for coloring information. For each priority level set up with policing the number of priority/TC queues is reduced by one.

The color information or drop eligibility in a provider network can be either explicitly or implicitly encoded in the S-VLAN tag. Drop eligibility can be encoded with the priority in the PCP field of the S-tag as specified for the C-tag, or it can be encoded explicitly by using the Drop Eligible Indicator (DEI) bit in the S-tag.

The IEEE802.1ad standard defines that PCP allows encoding of five, six, seven, or eight distinct priorities, with a drop eligibility on three, two, one, or zero of those priorities respectively, see Figure 46.

Note: Color dropping is not applicable for the two highest priorities, 6 and 7.

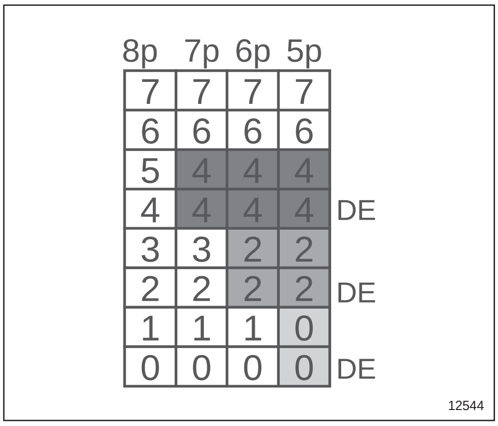

Figure 46 PCP Encoding

8p0d	8 priorities, 0 priorities with color dropping
7p1d	7 priorities, 1 priority with color dropping
6p2d	6 priorities, 2 priorities with color dropping
5p3d	5 priorities, 3 priorities with color dropping
8p8d	Only available in Provider mode. Eight priorities, the DEI bit in the S-VLAN tag is used to retrieve or indicate the drop eligibility of frames.

In Customer mode, coloring is performed at I-NNIs, while the UNIs always operate in 8p0d PCP selection as long as the PCP bits in the C-VLAN tag are trusted.

In Provider mode, coloring is performed at I-NNI (PN)s and CN-UNIs. On I-NNI (PN)s it obeys the selection. CN-UNIs have the following behavior:

— If the PCP value of the incoming frame differs from 8p8d and the PCP bits in the S-VLAN tag are trusted, the PCP value is set to 8p0d.

— If the PCP value of the incoming frame is 8p8d and the PCP bits in the S-VLAN tag are trusted, the PCP value is set to 8p8d.

The CE-UNI always operates in 8p0d PCP selection, if the PCP bits in the C-VLAN tag are trusted.

Coloring can be configured for maximum three priority levels, that is, 5p3d. This means that three out of five priority levels can be color marked. It is possible however to activate policing for the priority levels with no coloring support. These frames will be policed according to CIR/CBS and either dropped or passed through but with no color information applied to the frame.

For a customer interface protected with LAG, policing cannot be activated.

7.3 Queue Management

In a multi service network there is a need to differentiate the processing of the different flows in the congestion points. Typically a voice flow would require low latency/jitter and thus higher priority than a best effort data flow with no latency requirements.

Differentiation of flows is done based on the network priority value in the header part of each Ethernet frame. The network priority value to be used in the network domain is typically set as a part of the tagging process at the network edge.

The priority value of a frame is used to provide different Classes of Service (CoS) and is a representation of the end user application, for example, voice, best effort data, and so on. The priority value of an Ethernet frame indicates what type of behavior it expects from the network and how it shall be prioritized with respect to the other Ethernet frames in an interim network element.

An alternative to the mechanisms described in this chapter is to overprovision the network, that is, the capacity is sufficient to guarantee a congestion free network.

Traffic Class (TC) Mapping

MINI-LINK 6600 supports eight TCs or priority queues for each egress Ethernet port.

The Ethernet frames are mapped to the different TCs based on the network priority value in the PCP bits in the Ethernet header (see Figure 40). The mapping can be done according to IEEE 802.1D, see Figure 47, IEEE 802.1Q, see Figure 48, or it can be customized.

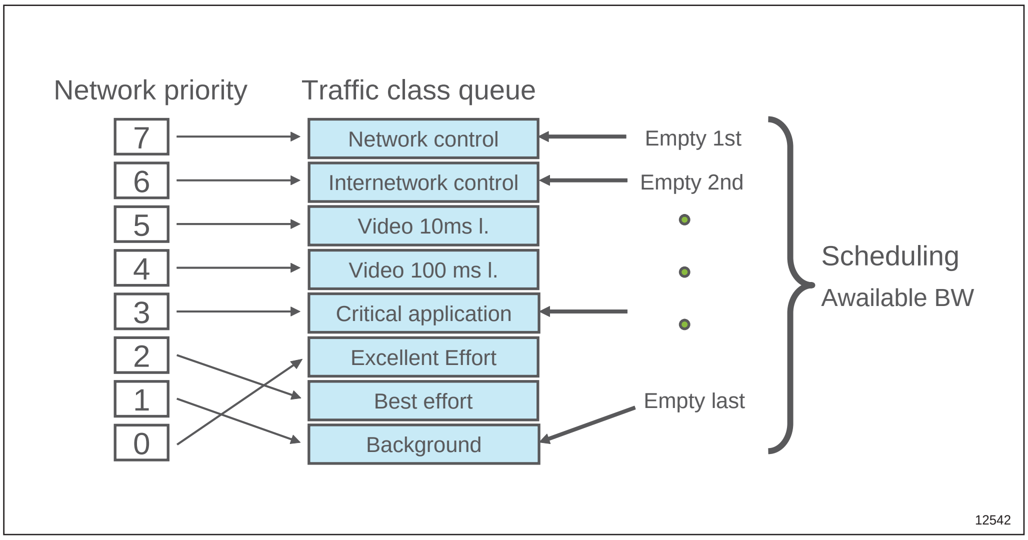

Figure 47 IEEE 802.1D Mapping

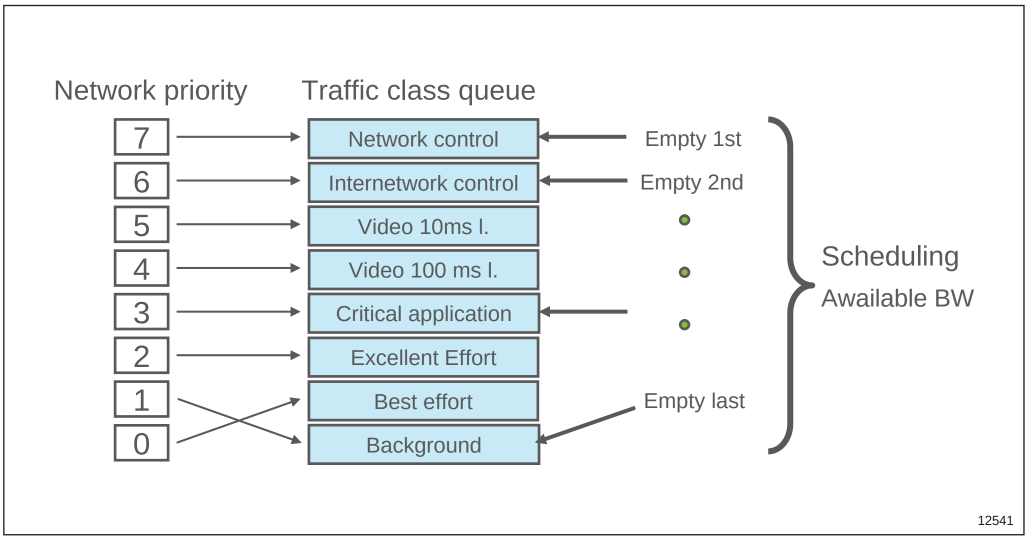

Figure 48 IEEE 802.1Q Mapping

Shared Packet Buffering

Ethernet interfaces share the available memory, so multiple queues compete for the same buffering resource. A buffer management algorithm is used to efficiently manage the existing buffer resources in fair manner.

A discard threshold for the queues is dynamically calculated based on the size of the remaining buffer space. In a non-congested or relatively uncongested state the remaining buffer space is large, so the queue discard thresholds are set to a higher value which allows better burst absorption. On the other hand, if the remaining buffer space is very small, then the switch is facing severe congestion, therefore queue discard threshold is lower.

A frame is enqueued in the corresponding queue, if the queue length is smaller than the calculated discard threshold. Otherwise the frame is dropped. In congested state the frames attempting to enter the longer queues are more likely to be dropped than frames entering shorter queues since the queue length of the longer queues would be higher than the threshold. Consequently this fair buffer management algorithm aggressively drops frames belonging to longer queues, thereby freeing up resources for queues that are relatively uncongested, see Figure 49.

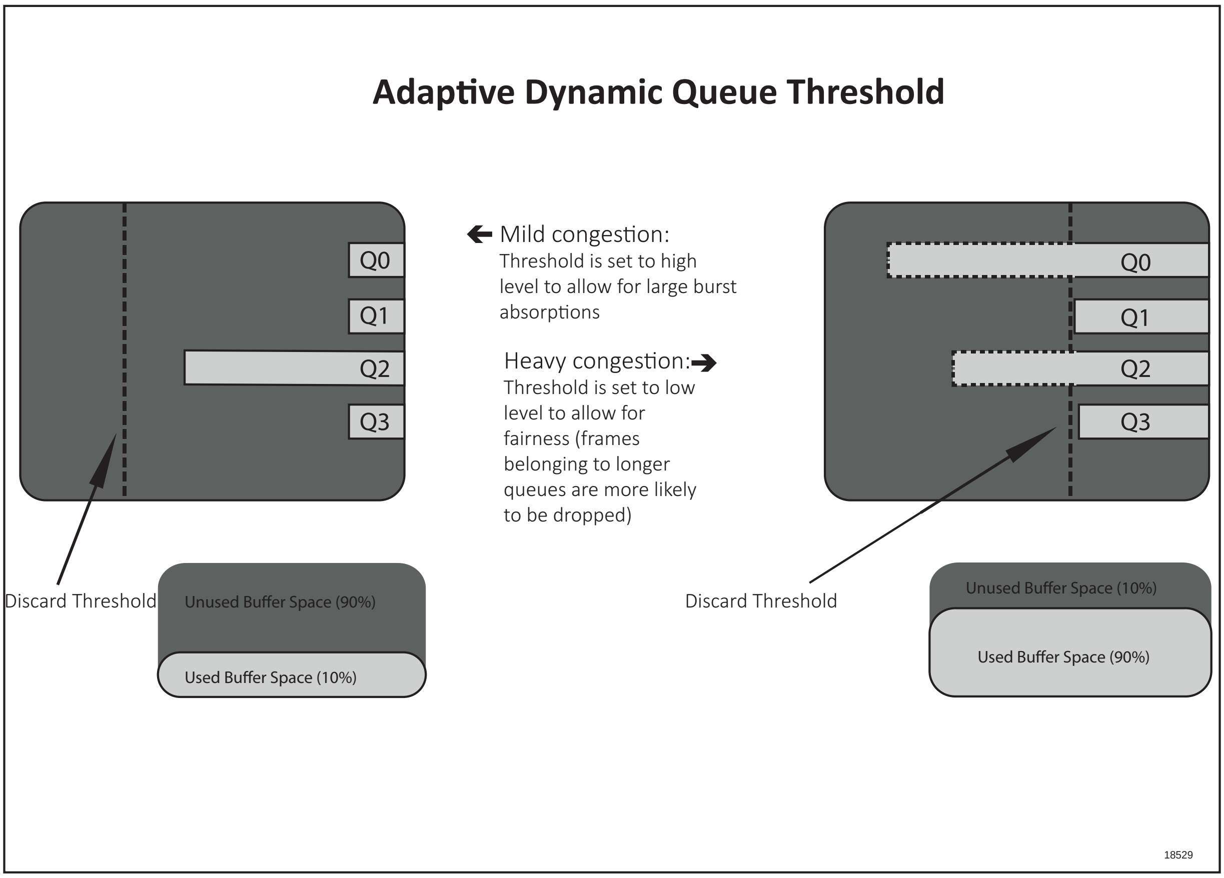

Figure 49 Adaptive Dynamic Queue Threshold

The recommended way of limiting queue size is either by configuring a user-defined queue size limit for tail-drop or by using WRED.

Deep Buffering

Deep Buffering is either enabled or disabled on an Ethernet interface and used to provide enough buffering capacity for handling traffic bursts. All radio link (WAN) interfaces are assigned to deep buffer, as a fading event might cause congestion. In case of LAN interfaces, it is platform dependent whether Deep Buffering is enabled or disabled by default, but it can be enabled by the operator

Time Stamp-Based Dropping/Aging

A timestamp is applied to the frame when it enters the TC queue buffer. Before exiting the TC buffer (that is, served by the scheduler) the timestamp is checked towards the aging timer. If the timestamp value exceeds limit for aging time from when the frame was stored in the queue, the frame is discarded. The aging time can be adjusted from the management interface based on the PCP priority value of the incoming frame.

Note: Aged frames consume egress bandwidth and can cause the transmitted traffic rate to drop below line rate.

WRED

To give a better understanding of WRED, some basics of the TCP protocol is described first.

The nature of a TCP connection is an increasing bandwidth until frames are lost. When the TCP protocol recognizes frame loss, the throughput is reduced by 50%. TCP then repeats the process by increasing the throughput until frames are lost. The throughput pattern is often referred to as saw tooth shape, see Figure 50.

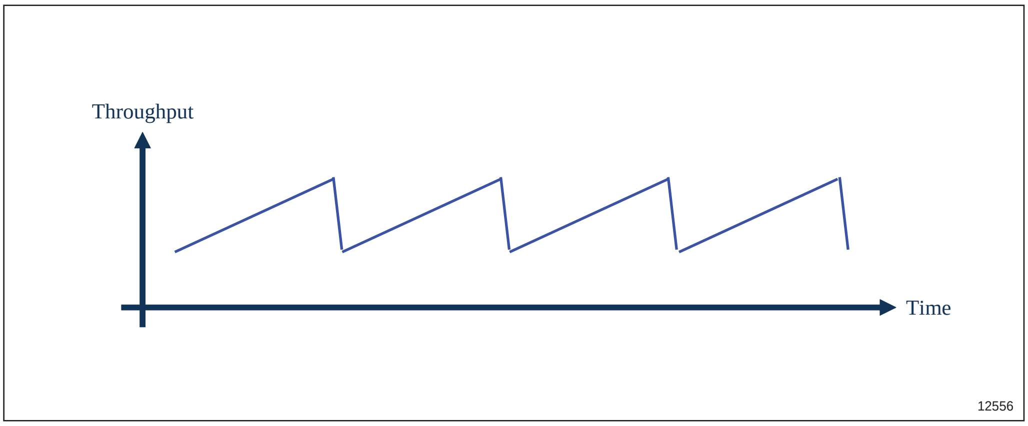

Figure 50 Saw Tooth Shaped TCP Throughput

When multiple TCP flows experience congestion in the same port, all TCP flows loose packets at the same time (tail drop). This means that all TCP flows simultaneously reduce throughput by 50%. The result is a link with low average throughput. With WRED activated, frames are randomly discarded at a configurable buffer filling threshold. This means that tail drop can be avoided and only a limited number of the TCP flows will experience frame loss and reduce the throughput. Thus, WRED can increase the average throughput by minimizing the throughput variations, see Figure 51.

WRED starts discarding frames when the buffer filling has reached a certain configurable threshold. If the buffer filling continues to increase the drop probability increases, see Figure 51. The buffer filling is calculated as an average value, estimated over a certain period of time. This is a more accurate way of measuring buffer than for instance instant measurements.

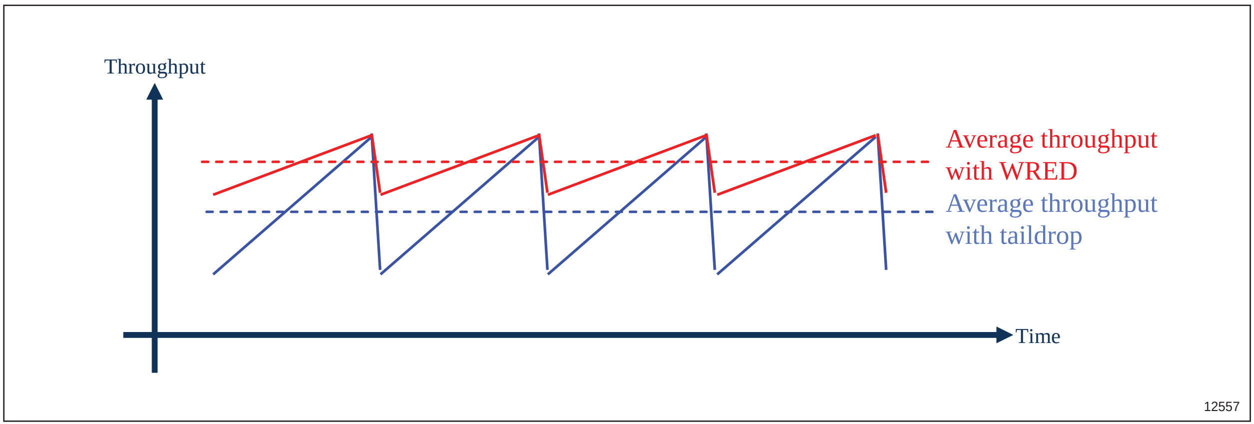

Figure 51 WRED Thresholds

WRED can be enabled on ports with deep buffer.

If Color-aware WRED is used to regulate a queue, then different WRED profiles can be applied for green and yellow traffic.

Note: WRED requires buffering, therefore it can only be set on interfaces with enabled deep-buffering.

Tail Drop

The tail drop discard mechanism is used when a TC buffer reaches the dynamically calculated discard threshold. In this case, the tail drop feature ensures that new frames are dropped at the entry point of the TC queue.

Tail drop is used to handle discarding of frames during long bursts that would completely fill up the available buffer space.

Tail drop queue user-defined size limitation is only effective when deep buffering enabled on the port.

Frame Discard Summary

Figure 52 illustrates how the different discard mechanisms are organized in MINI-LINK 6600.

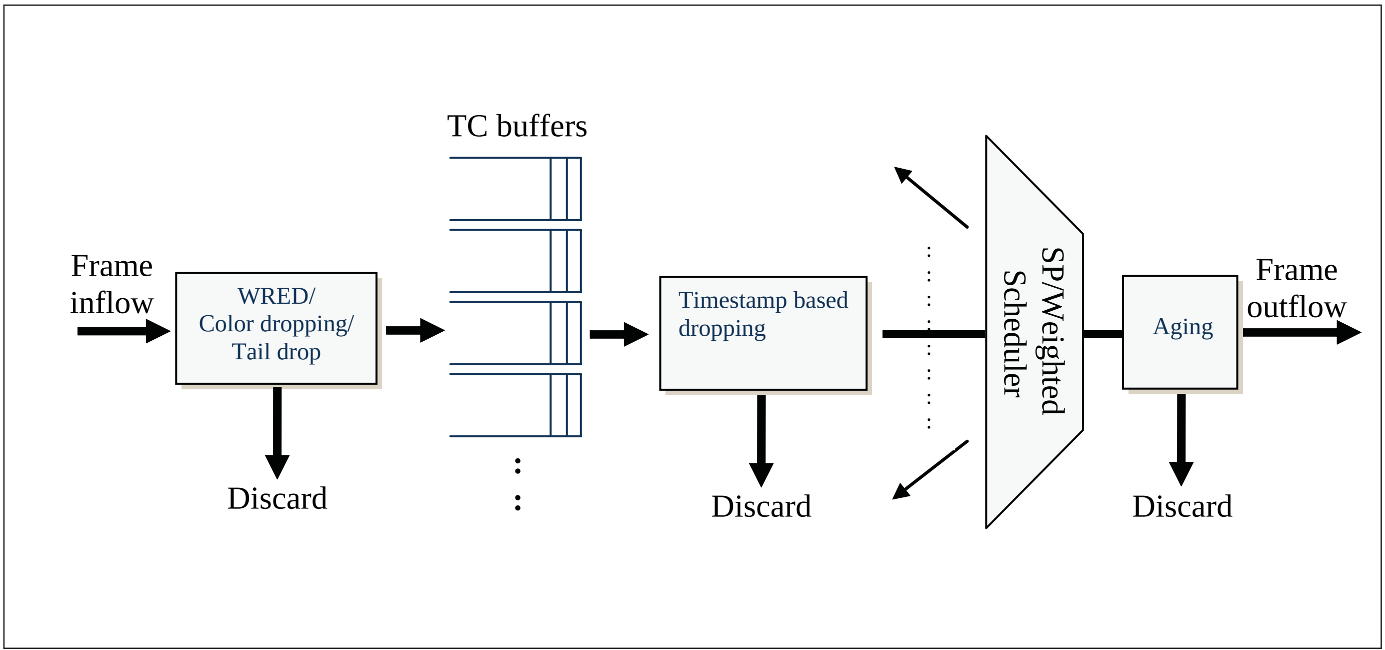

Figure 52 Discard Mechanisms in MINI-LINK

7.4 Scheduling (I-NNI and I-NNI (PN))

When an Ethernet port is congested the egress priority/TC buffers are filled up with Ethernet frames. To empty the buffers a scheduler must serve the buffers according to a predefined algorithm. MINI-LINK 6600 supports both Strict Priority (SP) and weighted scheduling algorithms (for example Deficit Weighted Round Robin (DWRR)) to empty the egress priority/TC buffers.

The SP algorithm is typically used for delay sensitive traffic like voice, video and sync packets. With SP, Ethernet frames in the buffer with the highest priority are always scheduled first, for example, all Ethernet frames with priority level 7 are scheduled before Ethernet frames with priority level 6.

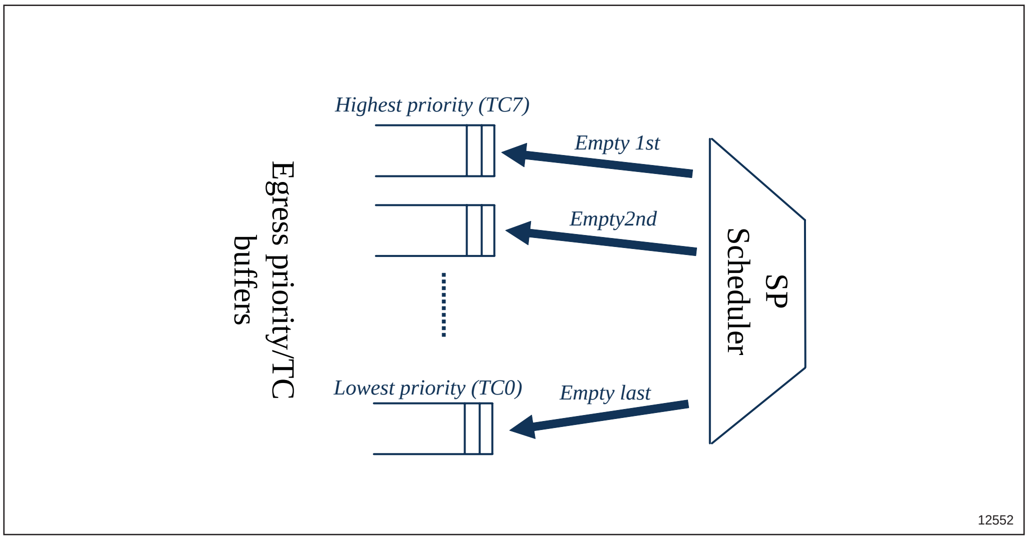

Figure 53 Strict Priority-Based Scheduling

The weighted scheduling algorithm is used when low latency is not crucial, but it is important to prevent starvation of buffers. With SP, buffers with lower priority will never get served if high priority queues are constantly being filled up. Weighted scheduler, however, will make sure that all queues are served according to the predefined weight ratio. The accuracy of the allocation is roughly 1%, where constant bit rate traffic is more accurate than burst traffic. Weighted scheduler is typically used for buffers with non delay sensitive data traffic.

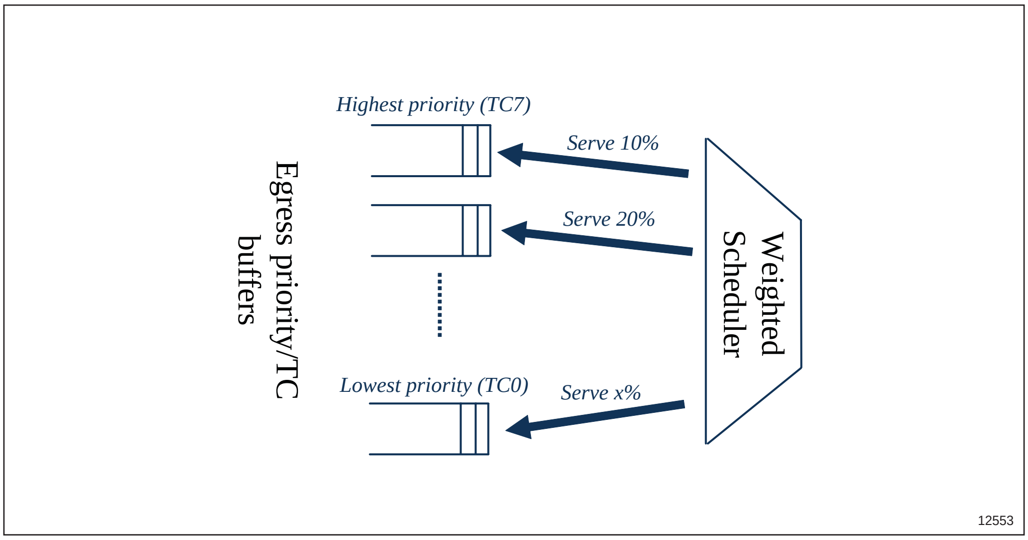

Figure 54 Weighted Scheduling

In a live network the SP and weighted scheduling algorithms are typically combined. In MINI-LINK 6600 the SP and weighted algorithms can be applied to different buffers as described in the example below. The size of the SP and weighted areas (x and y values) can differ but the SP/Weighted organization is fixed. The scheduler will serve the high priority SP area first and empty the buffers according to the SP algorithm. When the high priority SP area is empty the scheduler starts serving the weighted buffers according to individual weight.

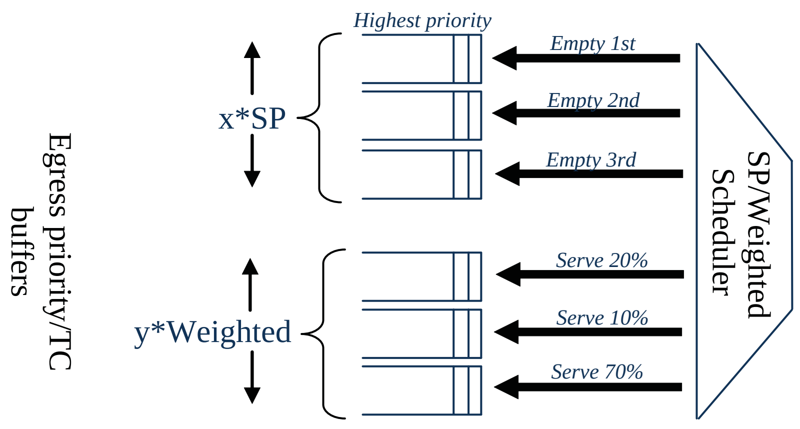

Figure 55 SP and Weighted Scheduling Combined in the Same Port

The SP and weighted schedulers can be configured individually per port from CLI and SNMP (not MINI-LINK Node GUI). However, to simplify the configuration effort the following predefined templates are supported. These templates can be selected individually from CLI, SNMP and MINI-LINK Node GUI,.

	Template 1	Template 2	Template 3	Template 4
TC7: High prio	SP	SP	SP	SP
	SP	SP	SP	SP
	SP	SP	SP	SP
	SP	Weighted (40	Weighted (100)	SP
	SP	Weighted (30)	Weighted (75)	Weighted (100)
	SP	Weighted (15)	Weighted (50)	Weighted (60)
	SP	Weighted (10)	Weighted (25)	Weighted (40)
TC0: Low prio	SP	Weighted (5)	Weighted (1)	Weighted (1)

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Figure 56 Scheduling Templates

7.5 Congestion Handling Summary

Congestion Handling in MINI-LINK can be summarized as follows:

— For trusted user domains, priority information is mapped from user/customer domain to network domain at the UNI.

— For untrusted user domains, default priority value is used as network priority in the network domain.

— Internally in the network domain the network priority settings are stored in the L2 PCP bits in the L2 header.

— Ethernet frames are mapped to egress TC buffer according to IEEE802.1D/Q or custom.

— In the egress TC buffer, frames are serviced according to a SP scheduler or weighted scheduler (DWRR), or both.

— Frames are dropped in the egress TC buffer due to tail dropping, color dropping, or WRED.

— WRED and color dropping are implemented for interfaces with deep buffer.

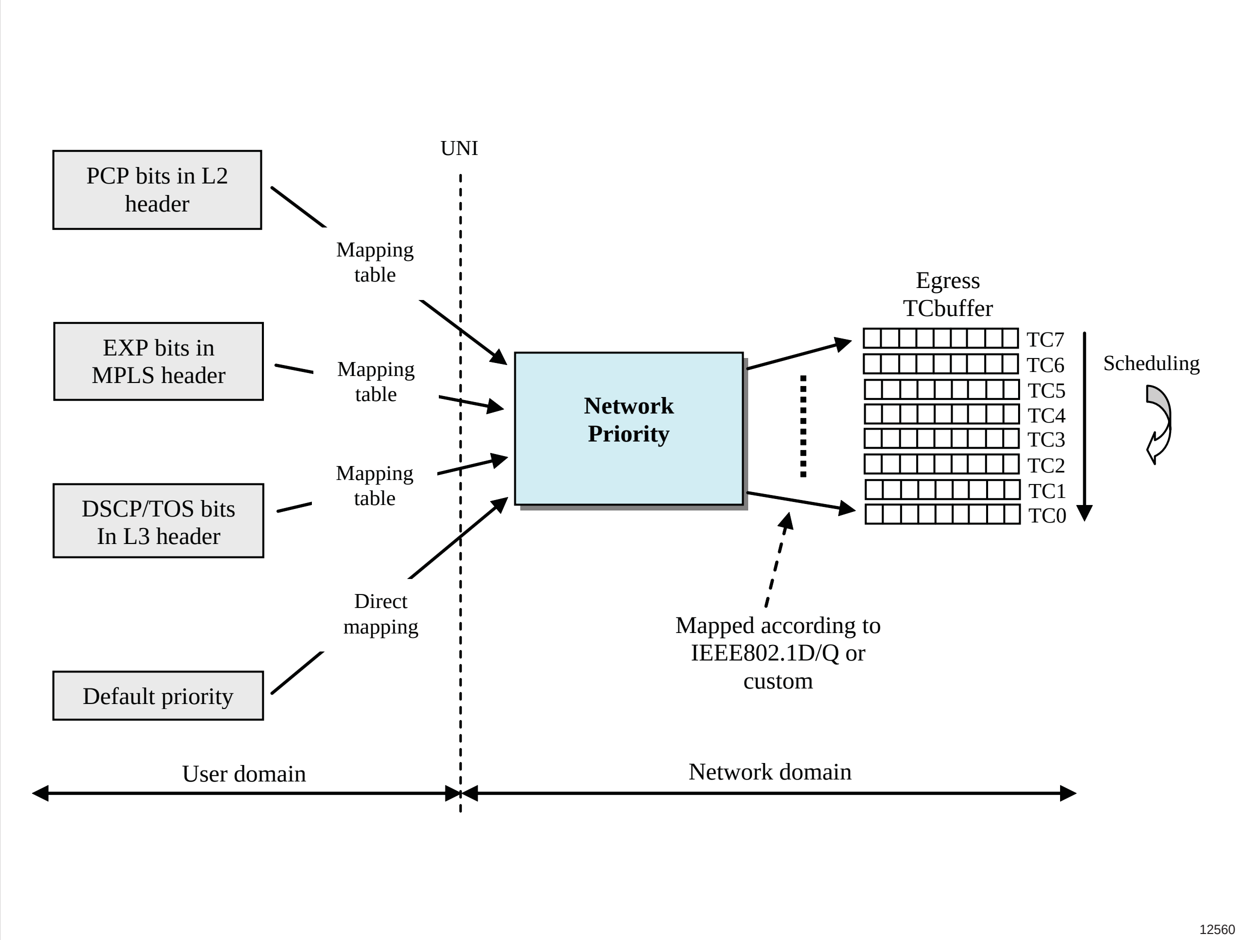


Figure 57 Congestion Handling in MINI-LINK

8 Hierarchical Quality of Service

Hierarchical QoS (HQoS) provides an additional level of traffic differentiation based on VLANs, therefore it enables that service quality can be ensured in a shared network scenario when multiple service providers share the same network, and also it helps to manage multiple RAN technologies separated by VLANs.

The traditional 2-level queue-port hierarchy can be extended to up to 4-level hierarchy, that is queue–node–node–port. The nodes can be configured to form the hierarchy according to the required use-case.

QoS features for HQoS are:

— VLAN based shaping: A maximum bandwidth can be set for a VLAN or a group of VLANs, that is, for an operator or an RBS.

— VLAN based scheduling: Both strict priority and deficit weighted round-robin are supported.

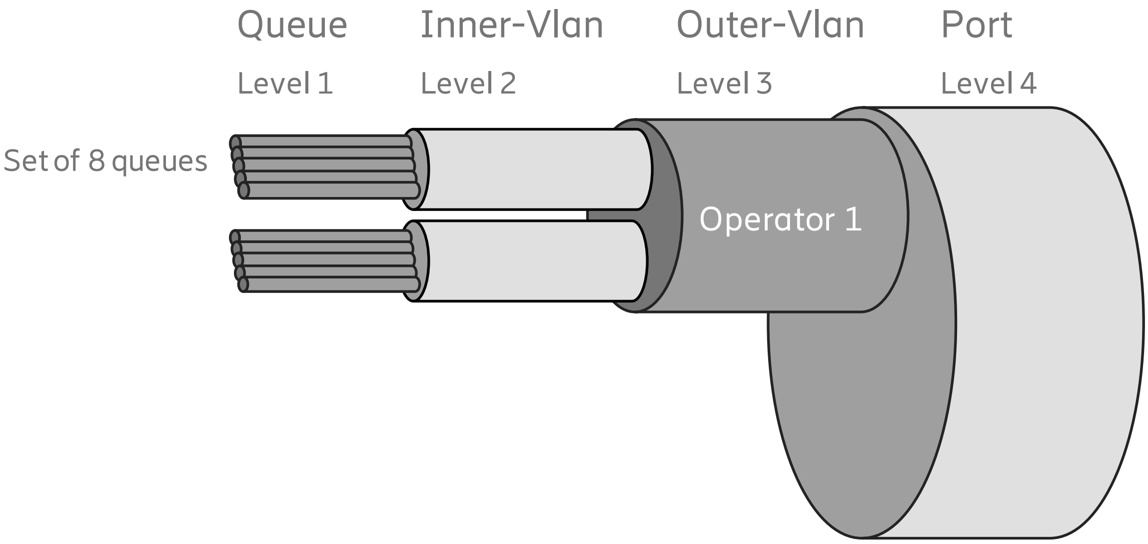


Figure 58 Principles of Hierarchical Quality of Service

9 Forwarding

9.1 Unicast Forwarding

MINI-LINK 6600 supports up to 1000 VLANs and storage and learning of 16K MAC addresses. It also supports an aging function, which discards MAC addresses that have been unused for a given time.

Each VLAN has individual learning, which in customer mode is performed on C-VLAN (EtherType 0×8100) and in provider mode performed on S-VLAN (EtherType 0×88a8). Each VLAN has a Filtering Database with dynamic and static entries.

Dynamic entries are automatically added and updated by the MAC learning process. Static entries are added manually and prevent flooding in case frames arrive for a destination address from which no Ethernet frames have arrived yet.

9.2 Multicast Forwarding

MINI-LINK 6600 supports a Layer 2 (MAC level) and a Layer 3 (IP level) multicast forwarding table.

— The L2 multicast table contains static entries. Each entry associates a (MAC address, VLAN) pair with a set of egress ports on that VLAN.

— The L3 multicast table is maintained dynamically by Internet Group Management Protocol (IGMP) and Multicast Listener Discovery (MLD) snooping. Each entry associates an IP multicast group (*, G, VLAN) or channel (S, G, VLAN) with a set of egress ports on that VLAN.

Note: The table lookup is based on the outer VLAN tag of the frame, that is, the C-VLAN in customer mode and the S-VLAN in provider mode.

IPv4 and IPv6 multicast packets are first looked up in the L3 multicast forwarding table by their source, destination (group) IP address, and VLAN ID. If a matching entry is found, the packet is forwarded to the ports in the entry, otherwise the packet is looked up in the L2 multicast forwarding table by its destination MAC address and VLAN Id. If no matching entry is found, the packet is classified as an Unregistered Multicast frame.

Non-IP Ethernet multicast frames are looked up by their destination MAC address and VLAN Id in the L2 multicast forwarding table. If a matching entry is found the frame is forwarded to the ports in the entry, otherwise it is classified as Unregistered Multicast.

Unregistered Multicast frames are either flooded to the VLAN or discarded. The handling is configurable per VLAN.

9.3 IGMP Snooping (IPv4) and MLD Snooping (IPv6)

IGMP for IPv4 and MLD for IPv6 are the protocols used by IPv4 and IPv6 hosts to report their IP multicast group memberships to neighboring multicast routers.

By default, a Layer 2 switch will flood multicast traffic to all ports in the VLAN (broadcast). The broadcast traffic can cause unnecessary bandwidth consumption in the network and extra processing load on host devices.

IGMP&MLD snooping uses the mechanism by which a Layer 2 device actively listens to Layer 3 IGMP&MLD messages between multicast hosts and routers. By parsing the messages passing through the switch, the Layer 2 switch learns the member status of multicast groups, and then builds a multicast table with this learned knowledge.

IGMP&MLD snooping switches will only forward multicast traffic to the ports where interested hosts are attached, thereby using link capacities in an efficient way.

MINI-LINK 6600 supports IGMP and MLD snooping for IGMPv2/v3 and MLDv1/v2 messages. Both Source-Specific Multicast (SSM) and Any-Source Multicast (ASM) service models are supported.

In MINI-LINK 6600, IGMP and MLD snooping is configured independently per VLAN instance. IGMP and MLD snooping can be simultaneously enabled on a VLAN. In customer mode, IGMP and MLD snooping can be activated on single C-tagged VLANs, while in provider mode both single S-tagged or S+C double-tagged VLANs are supported. IGMP and MLD snooping is disabled on all VLANs by default.

Note: In provider mode only the SVID is used in forwarding lookup, thus all CVIDs in an SVID share a common forwarding state. It is recommended to use only one CVID per SVID for multicast to avoid unwanted multicast traffic flooded to CEs.

The switch detects multicast router ports automatically based on the reception of IGMP and MLD general query and PIMv2 Hello messages.

When MINI-LINK 6600 detects an STP topology change and is the root bridge on the affected VLAN, a Query solicitation message is broadcasted to the Querier router to facilitate fast convergence of multicast forwarding state.

By default MINI-LINK 6600 operates in transparent snooping mode. In this mode the switch forwards all IGMP and MLD messages between hosts and routers transparently, and processes them to maintain the L3 multicast forwarding table.

The following is valid for IGMP and MLD snooping:

— Proxy Reporting

  Proxy reporting extends the basic snooping functionality aiming to minimize the IGMP and MLD protocol processing load on upstream multicast routers and IGMP and MLD snooping switches.

  When Proxy reporting is enabled, IGMP and MLD join reports for existing IGMP and MLD states are suppressed. Only the first IGMP and MLD join message is propagated towards routers. In addition, IGMP and MLD leave messages are forwarded from the hosts to the IGMP and MLD routers only when the last member leaves a group.

— Immediate-leave

  MINI-LINK 6600 supports Immediate-leave on individual VLAN ports. Upon receiving an IGMP and MLD leave message, IGMP and MLD snooping immediately removes the port from the forwarding table entry for that multicast group without sending out an IGMP and MLD group-specific query and waiting for its timeout.

  Note: Immediate-leave should only be enabled on VLAN ports to which a single host is attached. Otherwise, some hosts can be inadvertently dropped.

— Ethernet Switch Limits

  The L3 multicast forwarding table can accommodate up to 1000 multicast groups.

10 Ethernet Protection

MINI-LINK 6600 offers multiple redundancy features that fulfill different needs and operate both on plug-in unit and connection level.

10.1 RSTP/MSTP

Rapid Spanning Tree Protocol (RSTP) and Multiple Spanning Tree Protocol (MSTP) help build logical loop-free topology for Ethernet networks. The basic function is to prevent bridge loops and the broadcast radiation that results from them.

RSTP

The RSTP offers redundancy and rerouting of traffic if a node is out of service. The Ethernet transport network is typically divided in multiple RSTP domains. Within one RSTP domain a reconfiguration of the active Ethernet connections typically takes 50–100 ms without service impact.

MSTP

MSTP supports multiple concurrent topologies and spanning trees mapping VLANs into spanning trees. It uses basic RSTP mechanisms for topology calculation and rapid port state transitions.

MSTP configures a separate Spanning Tree for each VLAN group and blocks the links that are redundant within each Spanning Tree. This enables load balancing of network traffic across redundant links.

MSTP is backward compatible with RSTP and STP and the same performance requirements are applicable for MSTP as for RSTP.

10.2 Ethernet Ring Protection (ERP)

Ethernet Ring Protection (ERP) switching and Ethernet Linear Protection Switching (LPS) are supported according to ITU-T standards G.8031, G.8032v1, and G.8032v2.

10.2.1 ERP Single Ring

A single Ethernet ring consists of at least two NEs that are connected to each other in a ring configuration. One of the links is designated as the Ring Protection Link (RPL) which protects the entire ring.

To avoid loops, the RPL is inactive during normal operation. See Figure 59.

If one of the other links in the ring fails, the RPL is activated and the traffic is rerouted to avoid disturbances. See Figure 60.

When the failed link is restored, the RPL becomes inactive again.

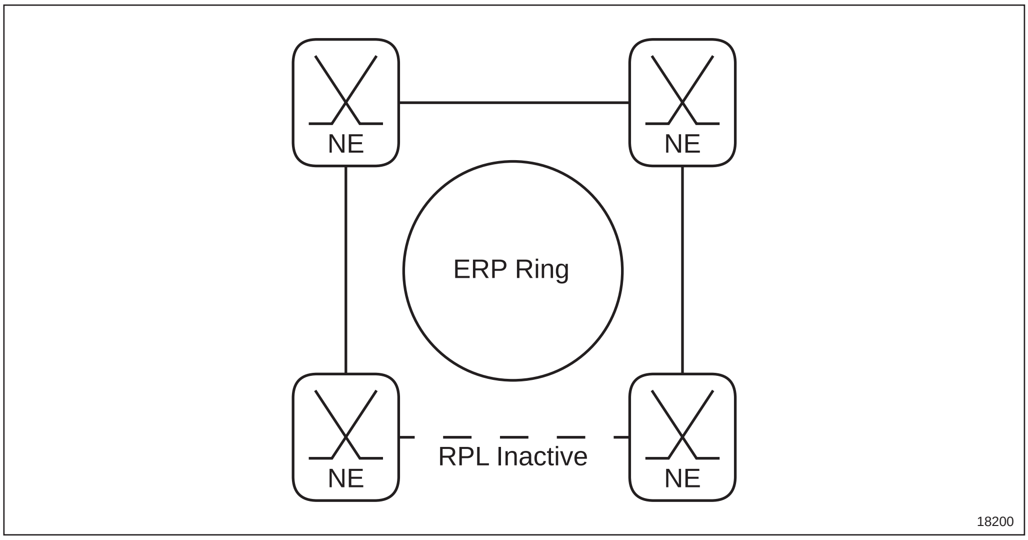


Figure 59 Single Ring, Normal Operation

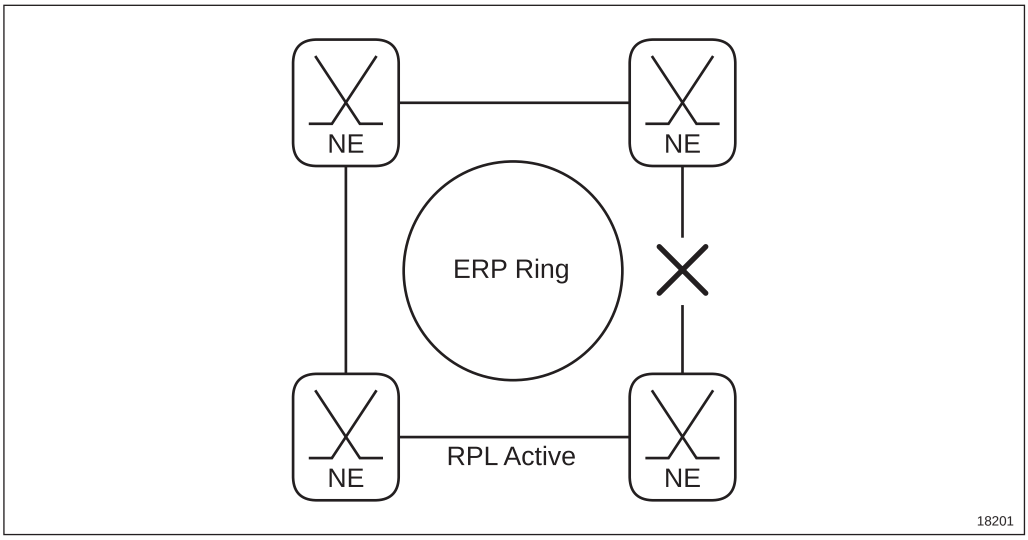


Figure 60 Single Ring, Link Failure

10.2.2 ERP Multiple Rings

Multiple Ethernet rings consist of NEs that are connected to each other in a configuration with two or more rings, one main ring and one or more sub-rings. In each ring, one of the links is designated as the Ring Protection Link (RPL) which protects that ring.

To avoid loops, the RPL is inactive during normal operation. See Figure 61.

If one of the other links in the ring fails, the corresponding RPL is activated and the traffic is rerouted to avoid disturbances. See Figure 62.

When the failed link is restored, the RPL becomes inactive again.

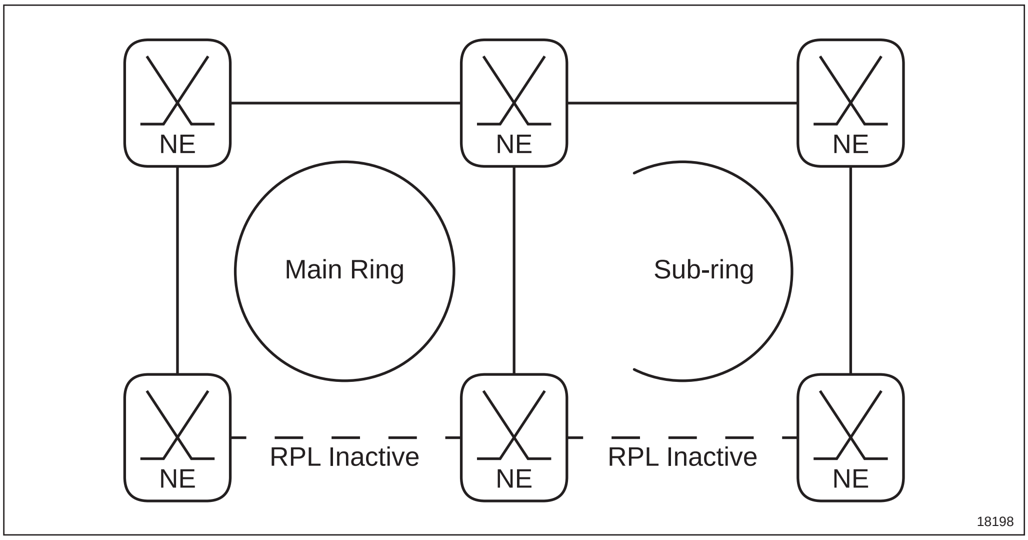


Figure 61 Multiple Rings, Normal Operation

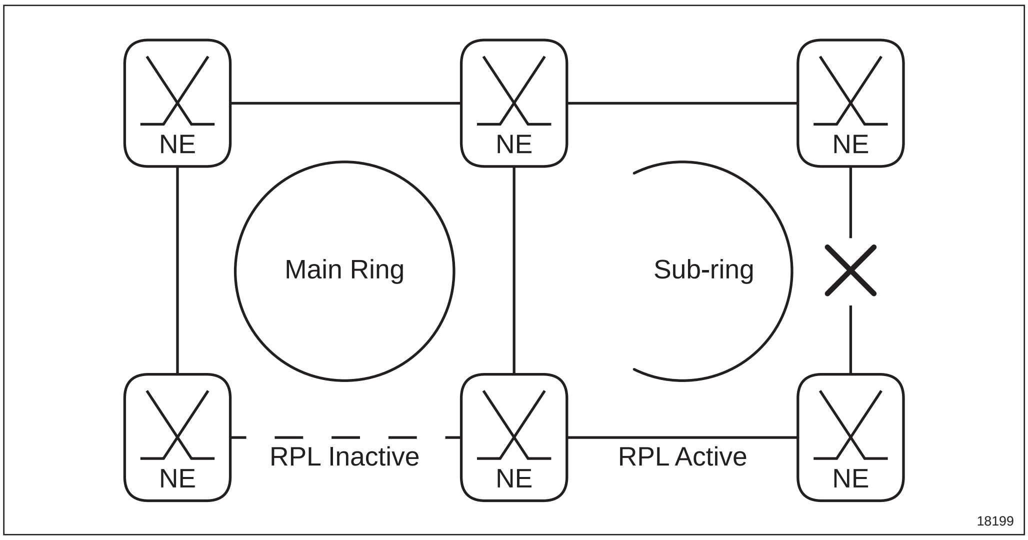


Figure 62 Multiple Rings, Link Failure

10.3 Link Aggregation Group (LAG) with LACP

This section presents the protection mechanisms available on Layer 2 connections.

Link Aggregation Group

MINI-LINK 6600 supports Link Aggregation Group (LAG) with Link Aggregation Control Protocol (LACP), which aggregates several external Ethernet links into one logical link and provides line protection.

A LAG supports a maximum of four links, but in case of NPU 1002 or NPU 1005 the number of links increase so that a LAG supports a maximum of eight links.

LACP has three operational modes:

— Static

  No LACP PDU communication. LAG hashing is governed by the port operational and administrative states or optionally by LinkOAM.

— Active

  LAG hashing is governed by the LACP state machine using the information inferred from LACP PDU communication.

— 1+1

  Al LAG-LACP operation applicable for 2-port LAGs, when LACP allows only one active port out of the 2 LAG member ports.

When a new LAG is created, the default LACP operation mode is Static.

Link Aggregation Control configures and controls the Link Aggregation sublayer using static or dynamic information, exchanged between the connected NEs by means of LACP. LACP enables dynamic configuration of LAG.

LACP is used by the nodes on either end of a LAG to automatically monitor and maintain adjoining LAG links between them.

On a regular basis, L2 Link Aggregation devices with running LACP advertise their capabilities and status on potential aggregation. The peering devices compare their own configuration and the configuration of their partner and states with each other, associated with each link of the LAG. Each peer can then decide what action to take in terms of setting a link traffic carrying status. Once in a steady state, LAGs are maintained by regular exchange of information between peers.

If a link in a LAG fails, traffic is redirected from the faulty link to the remaining links in the LAG using graceful degradation. The switch from active to passive path takes less than 50 ms for a bidirectional link failure and does not impact the traffic. A faulty link affects the total link capacity and traffic with low priority may be discarded to ensure that traffic with high priority is sent.

When a 2-port LAG is configured in LACP 1+1 mode, the LAG member ports form an active/standby pair. Generic Ethernet traffic is transmitted and received through the active port. LACP PDUs are exchanged through both ports.

Whenever there is a connectivity fault in the link connected to the former active port, then the former standby port is activated and Ethernet traffic is redirected to this port. When the link of the higher priority link is recovered, it regains the active role if revertive switching is enabled.

Whenever there is a connectivity fault in the link connected to the standby port, the Ethernet traffic through the active port remains undisturbed.

In MINI-LINK 6600, the LAG master port is assigned with the highest LACP port priority.

Which of the 2 LAG member ports becomes active is determined by negotiating the LACP port priorities between the two LACP hosts.

Note: The near end LACP host is configured with LACP 1+1, while the far-end host is configured with LACP Active, then the LAG will operated in active/standby manner and the active port will be arbitrated between the two LACP hosts according to the LACP standard.

Network rerouting according to Ethernet Ring Protection (ERP) and Rapid/Multiple Spanning Tree Protocol (RSTP/MSTP) is not triggered unless all physical links in an LAG fails.

ERP and RSTP/MSTP activates a redundant link in case of link failure and protects the network from infinite loops.

To improve the switch-over time for unidirectional faults, LAG should be combined with Link OAM. Link OAM will take down the link if a unidirectional fault is detected.

A Hashing Algorithm is used to identify the different traffic flows and assign them to the different ports, belonging to the same LAG.

Hashing algorithm is configurable and is based on different L2 or L3/L4 traffic parameters, according to Table 9.

Table 9 Hashing Algorithms

MINI-LINK Node GUI Parameter	CLI Parameter	Hashing Algorithm
srcMac	mac-sa	Source MAC address, VLAN ID, Ethertype, and source bridge port ID.
dstMac	mac-da	Destination MAC address, VLAN ID, Ethertype, and source bridge port ID.

MINI-LINK Node GUI Parameter	CLI Parameter	Hashing Algorithm
srcDstMac	mac-sa-da	Source MAC address, destination MAC address, VLAN ID, Ethertype, and source bridge port ID.
srcIp	ip-src	Source IP address and source TCP/UDP port.
dstIp	ip-dst	Destination IP address and destination TCP/UDP port.
srcDstIp	ip-src-dst	Source IP address, destination IP address, source TCP/UDP port, and destination TCP/UDP port.

The hashing algorithm selection allows an effective traffic load balancing between the different links belonging to an LAG.

10.3.1 LAG/LACP 1+1 Protection of MINI-LINK 6352

LAG/LACP 1+1 protection can be used in combination with a redundant E-Band link pair of two MINI-LINK 6352 according to Figure 63, so that the connectivity is protected against both E-band link faults and MINI-LINK 6352 equipment.

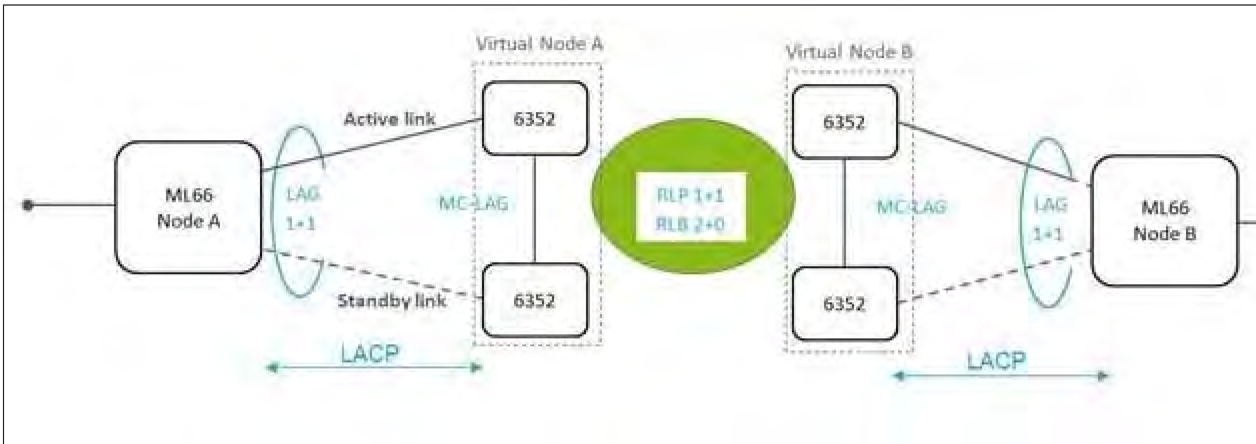


Figure 63 LAG/LACP 1+1 Protection of MINI-LINK 6352

For the details of the protection mechanism, please refer to the CPI library of MINI-LINK 6352.

10.4 Ethernet Layer 1 Protection Mechanisms

The Link Loss Forwarding (LLF) feature improves the protection switching time for Layer 1 connections by propagating connectivity loss information to both connection end points. LLF is not supported with ETU interfaces.

LLF can be split in two scenarios, broken WAN links or broken LAN links.

WAN Link Broken

When the terminating end points of the point to point connection detects that the WAN connection is lost, the Ethernet ports on both sides will be taken down (that is, disable line carrier).

LAN Link Broken

When a terminating end point of the point to point connection detects that the LAN connection is lost, the corresponding WAN port will be taken down. On the remote end, the disconnected WAN link is detected and the corresponding LAN port will be taken down.

11 Ethernet Operation & Maintenance

MINI-LINK 6600 have support for a number of Ethernet application related O&M functionalities.

11.1 Ethernet Performance Counters

For information on the performance counters supported for LAN/WAN Ethernet ports in MINI-LINK 6600, see Section 16.9.3 on page 248.

11.2 Ethernet Link OAM

MINI-LINK 6600 supports Ethernet in the First Mile (EFM) or Link OAM according to IEEE802.3ah for all LAN ports. Link OAM is a diagnostic tool that can be used in both online and offline configurations.

Note: Ethernet Link OAM is only supported for LAN interfaces (Layer 1 Connection and Layer 2).

The three main Ethernet Link OAM services are as follows:

— **Failure Notification**

  Notification of an Ethernet link failure to or from far end for an NE in operation.

  The following three types of failures are supervised:

  - Link fault (RDI)

The **Link fault (RDI)** alarm is generated when a failure in a physical layer has occurred in the receiving direction.

- Dying gasp

  The **Dying gasp** alarm is generated when a plug-in unit is about to restart or is going to operational state **Down**. This occurs when an unrecoverable failure has occurred.

  Note: Only supported in receiving direction (an event is raised).

- Critical event

  The **Critical event** is generated when an unspecified critical event has occurred.

  Note: Only supported in receiving direction (an event is raised).

— **Link Monitoring**

Link monitoring is used for event notification on errored frames at both near and far end and is used on NEs in operation. The notifications are based on a threshold crossing within a specific time window.

The following events are reported:

- Errored Symbol Period Event

  Generated when the number of symbol errors exceeds a threshold in a given time window, which is defined by a number of symbols.

- Errored Frame Event

  Generated when the number of errored frames exceeds a threshold in a given window, which is defined by a period of time.

- Errored Period Event

  Generated when the number of errored frames exceeds a threshold in a given window, which is defined by a number of frames.

- Errored Frame Seconds Summary Event

  Generated when the number of errored frame seconds exceeds a threshold in a given time period. An errored frame second is defined as a 1 second interval with one or more frame errors.

— **Remote Loopback**

Link OAM remote loopback can be used for fault localization and link performance testing on LAN interfaces. Statistics from both near end and far end NE can be requested and compared at any time while the far end NE is in O&M remote loopback mode. The requests can be sent before, during, or after loopback frames have been sent to the far end NE. The loopback frames in the O&M sublayer can be analyzed to determine which frames are being dropped due to link errors.

In the offline set up all traffic is halted for the affected ports. A loop is configured manually and a traffic generator sends test frames as indicated in Figure 64. PM measurements in the receiving end are compared with the submitted traffic from the test generator to detect errors. The manually configured loop can be set on either side of the connection.

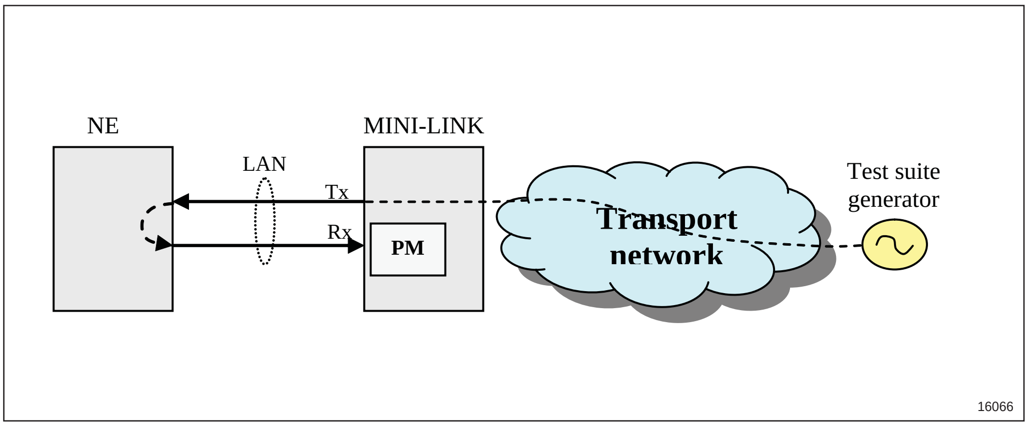


Figure 64 Link OAM Offline Configuration

As an online diagnostic tool, Link OAM is constantly monitoring the link status and detects unidirectional and bidirectional faults, see Figure 65. When a link fault is detected, for example, LOC, RDI is transmitted in the Tx direction. On the receiving side an alarm is triggered.

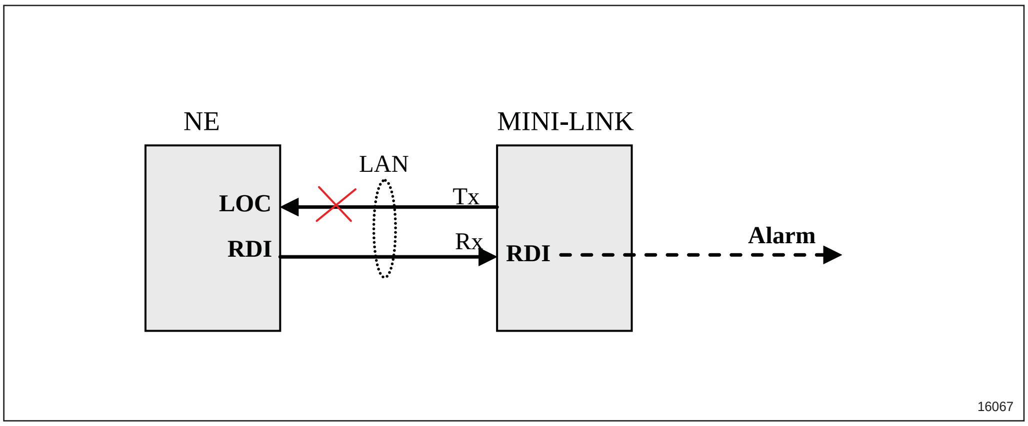


Figure 65 Link OAM Online Configuration

11.3 Ethernet Service OAM

Ethernet Service OAM is used to manage networks comprising of multiple LANs. It provides performance monitoring, according to ITU-T Y.1731 and Y.1730, and supports fault management on Ethernet links, according to IEEE 802.1ag.

Ethernet Service OAM can be used in both Customer mode and Provider mode, if Ethernet Service OAM PDUs are C- or S-VLAN tagged, and can be used in LAG and RSTP/MSTP scenarios.

The four main Ethernet Service OAM functions are as follows:

— **Continuity Check Monitoring**

  Continuity Check Monitoring detects service interruption between MEPs. Continuity Check Messages (CCMs) are sent from one MEP to another, enabling MEPs to locate other MEPs. CCM confirmation can also be requested by an MEP from a linked MEP, to ensure that the CCMs are sent and received without fault.

  The CCM intervals can be set at 3.3 ms, 10 ms, 100 ms, 1 s, 10 s, 1 min, or 10 min.

— **Remote Defect Indication**

  An MEP uses Remote Defect Indication (RDI) to communicate with linked MEPs that a fault has occurred, usually that CCM confirmation were not received. The RDI is an indication that a fault has occurred either at the far-end MEP or between the two MEPs.

— **Loopback**

  Loopback is a troubleshooting tool that verifies the connectivity of a MEP with linked MEPs and linked Maintenance Intermediate Points (MIPs).

— **Linktrace**

  Linktrace is a bidirectional continuity check used for fault localization. When a Linktrace Message (LTM) is sent to a destination MEP or MIP, a Linktrace Reply (LTR) is expected from all the intermediate MIPs along the path to the destination and from the destination MEP or MIP itself. Missing or misordered LTRs point out the location of a fault in an efficient way.

Ethernet Service OAM supports the following PM functions:

— Frame Delay

— Frame Delay Variation Measurement

— Frame Loss Measurement (ETH-LM)

— Ethernet Bandwidth Notification (ETH-BN)

A Maintenance Domain (MD) is defined as a network or sub-network, at the Ethernet level, within which OAM frames are exchanged. An MD determines the span of an OAM flow, across network administrative boundaries.

There are the following three types of MDs:

- Network Operator MD
- Service Provider MD
- Customer MD

MDs are hierarchal and as such, MDs of the same type do not overlap each other, for example, two MDs of the same level do not overlap each other. However, different MD types from different levels may overlap, for example, a Customer MD may overlap multiple Service Provider MDs, but the Customer MD cannot overlap another Customer MD.

An MD consists of the following components:

- Maintenance Entity (ME) – An OAM entity that requires management.
- Maintenance Association (MA) – A group of MEs that belong to the same service inside a common MD. An IEEE concept.
- MD Level – A way of distinguishing which MEs belong to the same MD. All MEs belonging to the same MD share the same MD Level. An IEEE concept.
- ME Group (MEG) – A group of MEs that belong to the same service inside a common MD. An ITU-T concept.
- MEG Level (MEL) – A way of distinguishing which MEs belong to the same MD. All MEs belonging to the same MD share the same MEG Level. An ITU-T concept.
- Maintenance End Point (MEP) – An OAM reference point that can initiate and terminate OAM frames, and that reacts to diagnostic OAM frames.
- Maintenance Intermediate Point (MIP) – An OAM reference point that reacts to diagnostic OAM frames initiated by MEPs.

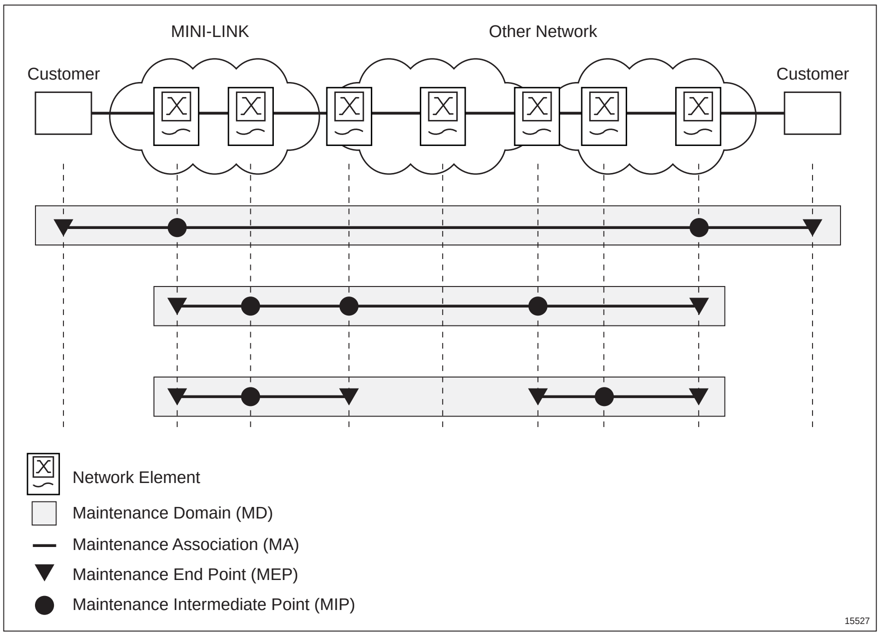


Figure 66 Ethernet Service OAM Network Overview

ETH-BN is supported according to ITU-T G.8013/Y.1731 and Y.1730.

ETH-BN reports bandwidth changes of a monitored WAN interface with Bandwidth Notification Message (BNM) frames. When a bandwidth change is detected, ETH-BN reports it after a configured hold time. BNM frames contain the nominal (licensed) bandwidth and the actual bandwidth of the link.

MINI-LINK implementation of ETH-BN relies on a MEP to be configured on the node. It is used to determine on which interfaces the BNM frames should be sent. The MEP could be on a different interface, together with the up/down status these are used to determine the outgoing interfaces. Up and down MEPs are defined in IEEE 802.1ag.

A down MEP sends BNM frames out on only one interface. See Figure 67.

An up MEP sends BNM frames towards the switch rather than the egress direction of the interface. In this way the VLAN switching can send the BNM frames towards multiple outgoing interfaces. See Figure 68.

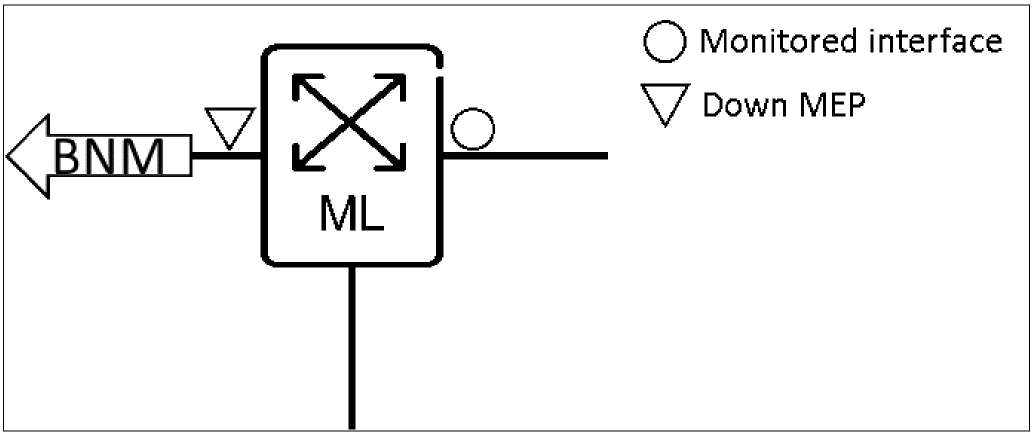


Figure 67 ETH-BN with Down MEP

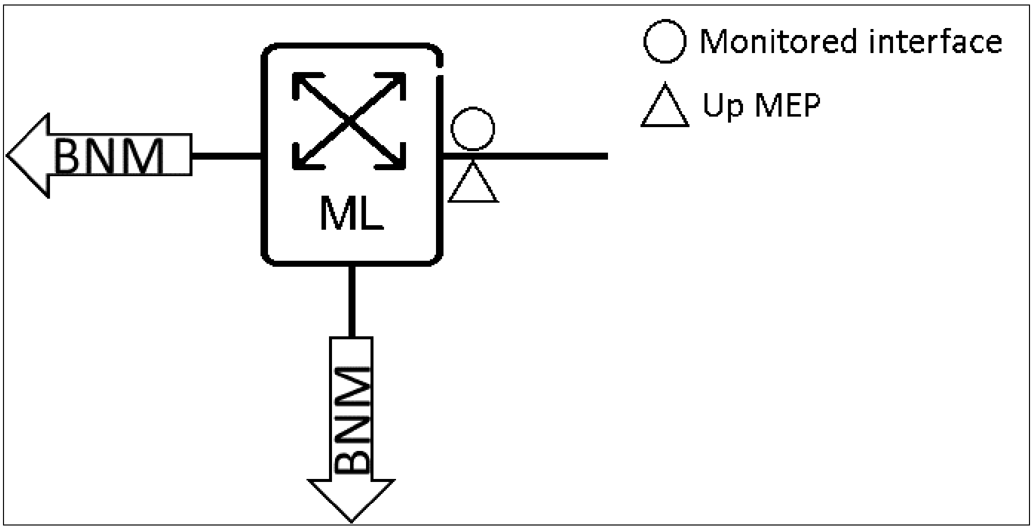


Figure 68 ETH-BN with Up MEP

By default, BNM frames are always sent, even when the link is at full speed or drops to zero. This behavior can be changed to sending only one BNM frame or no BNM frames when the link is restored to full speed, and the same configuration is possible for link failure.

Note: It is not recommended to turn off sending BNM frames for both full link speed and link failure.

In this case, once the ETH-BN stops sending BNM frames, the receiving router cannot determine whether the link is restored to full speed, or it failed.

11.4 Port Mirroring

Port mirroring can be used for packet traffic crossing in MINI-LINK 6600. The port mirroring feature sends a copy of all packets seen on one LAN/WAN switch port to a LAN test port, see Figure 69. The test port is named Mirror to Port (MTP).

Note: Deep buffering must be disabled for the MTP ports.

This is commonly used for network appliances that require monitoring of network traffic, such as an intrusion detection system and troubleshooting.

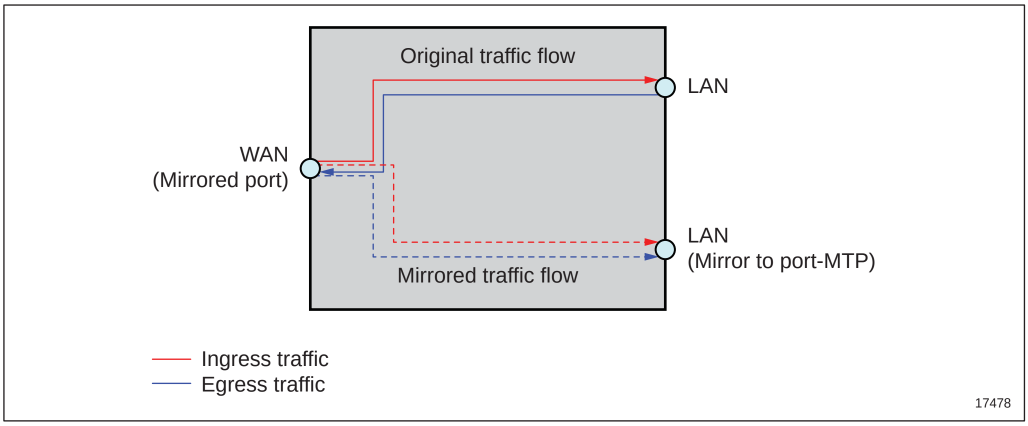


Figure 69 Port Mirroring – Mirroring a WAN Interface to a LAN Port

It is possible to enable ingress and egress port mirroring separately.

If the MTP VLAN tag is configured, both ingress and egress mirrored traffic is always tagged at the MTP with the MTP VLAN tag as outer tag.

12 L3 Services

The NE provides Layer 3 Virtual Private Network (L3VPN) for IPv4 and IPv6 services over an IPv4-based MPLS transport network.

Table 10 lists the features that are possible to configure for Layer 3 solutions.

Table 10 Configurable Features for Layer 3 Solutions

Business Application		Routing Options	Services
L3VPN	BGP/MPLS Layer 3 VPN (L3 PE router) P router	CE-PE routing options: OSPFv2 OSPFv3 Static eBGP Core routing options: iBGP MPLS LSP: LDP, RSVP-TE IGP: OSPFv2, IS-IS	QoS Route filters LAG or ECMP BFD MPLS OAM
Layer 3 IP Router		Core routing options: BGP IGP: OSPFv2, OSPFv3, IS-IS	QoS Route filters LAG or ECMP BFD

12.1 L3 IP Router

The NE supports standard IP routing that forwards packets to their final destination using intermediate nodes. Each node looks up the destination IP address and forwards the packet toward the destination through routes collected in a routing table.

On the NE, route information is collected from the different routing protocols in the RIB on the controller card, which calculates the best routes and downloads them to the FIB stored on the NE. The RIB process collects routes to directly attached devices, configured static IP routes, and routes learned dynamically from OSPF and BGP.

When a network event causes routes to go down or become unavailable, routers distribute routing update messages that are propagated across networks, causing a recalculation of optimal routes. Routing algorithms that converge slowly can cause routing loops or network outages.

12.2 L3VPNs

The NE provides the following Layer 3 services and solutions:

— End-to-end Layer 3 connection over an IP/Multiprotocol Label Switching (MPLS) core network

— Business Virtual Private Networks (VPNs), such as Border Gateway Protocol (BGP)/MPLS L3VPNs.

— Core routing solutions, such as P router, in an IP/MPLS core network

— Multiple virtual routing instances via Virtual Routing Forwarding (VRF)

— The NE can provide Layer 2 Ethernet transport services and Layer 3 unicast routing on the same NE without separate Layer 2 and Layer 3 devices.

Figure 70 illustrates MINI-LINK 6600 in a Layer 3 network with VPNs.

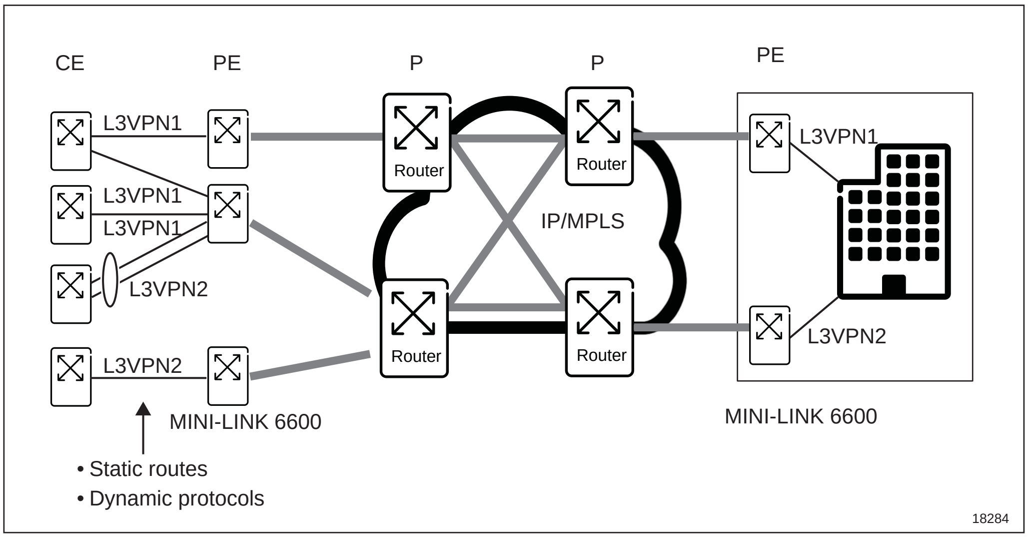


Figure 70 L3VPNs

12.3 Supported Routing Protocols

The NE supports the following routing protocols:

— **Static Routing**

— **OSPF**

OSPF is an Interior Gateway Protocol (IGP) that uses Link-State Advertisements (LSAs) to inform other routers of the state of the sender links. In a link-state routing protocol, each NE distributes information about its interfaces and neighbor relationships. The collection of the link states forms a database that describes the Autonomous System (AS) topology. As OSPF routers accumulate link-state information, they use the Shortest Path First (SPF) algorithm to calculate the shortest path to each node, which forms the basis for developing routing information for that AS.

The following summarizes the OSPF features:

- An NE can be a part of a non-stub area, stub area or totally stub area.
- An NE can act as an Internal Router (IR), as an Area Border Router (ABR), or as an Autonomous System Border Router (ASBR).
- Virtual links are supported, which is useful when an area needs to be split in two parts.
- Link summarization is supported, which is used in the ABR to minimize the routing information distributed to the backbone and/or other areas.

— **IS-IS**

Intermediate System to Intermediate System (IS-IS) is a routing protocol designed to move information efficiently within a computer network, a group of physically connected computers or similar devices. It accomplishes this by determining the best route for data through a packet-switched network.

IS-IS enables the separation of an IS-IS domain into separate areas, improving the scalability of the IS-IS network. IS-IS level 2 and level 1-2 node functionality is required on the borders of the areas.

A multi-area IS-IS network can be used for MPLS transport with inter-area (Label Switched Paths) (LSPs) either by using LDP (RFC 5283) or by using RSVP-TE (RFC 5151).

— **BGP**

BGP, an EGP based on distance-vector algorithms, uses TCP as its transport protocol. BGP operates between two BGP nodes, called BGP speakers. After a TCP connection is established, the two BGP speakers exchange dynamic routing information over the connection. The exchange of messages is a BGP session between BGP peers.

- Multiprotocol internal BGP (MP-iBGP) is used to exchange routing information and service label allocations between VPN endpoints in PE nodes in a L3VPN network.

- External BGP (eBGP) is run by routers that belong to different autonomous systems and exchange BGP updates. It can for example be used to exchange routing information between PE and CE nodes.

— **Routing Policies**

Routing policies allow network administrators to enforce various routing policy decisions on incoming, outgoing, and redistributed routes. The tools used to configure routing policies include BGP AS path lists, BGP community lists, IP-prefix lists, and route maps with match and set conditions.

12.4 MPLS Networking

The NE supports MPLS to forward packets through a network efficiently.

In a conventional IP Network, routers forward packets through the network from one NE to the next, with each NE making an independent forwarding decision by analyzing the packet header. Packet processing often causes considerable forwarding delay. With MPLS, the complete analysis of the packet header is performed only once when it enters an MPLS-enabled network.

12.4.1 MPLS-Based Solutions

The NE supports L3VPN solutions using MPLS networks in which customer connectivity among multiple remote sites is deployed across a shared central infrastructure and still provides the same access or security as a private network.

— **BGP/MPLS VPNs**

Layer 3 BGP/MPLS VPNs are a collection of policies that control connectivity among a set of sites. A customer site is connected to the service provider network, often called a backbone, by one or more ports. The service provider associates each port with a VPN context.

A BGP/MPLS VPN allows you to implement a wide range of policies. For example, within a VPN, you can allow every site to have a direct route to every other site (full mesh), or you can restrict certain pairs of sites from having direct routes to each other (partial mesh).

12.4.2 Label Distribution

To communicate labels and their meanings among LSRs, MPLS uses a label distribution protocol (LDP or RSVP-TE), which enable dynamic label allocation and distribution in an MPLS network.

- **LDP:** If an LSR is enabled with LDP, it can establish LSPs to other LSRs in the network. LDP creates label bindings by assigning labels to the connected routes. Then, LDP advertises these bindings to the neighbors. When LDP learns about a label binding from a neighbor, it advertises these label bindings to its own neighbors as well. When an LSR advertises a label binding for a route, the LSR is advertising the availability of an LSP to the destination of that route. LDP can learn several LSPs from different neighbors for the same route. LDP must be configured with an IGP, for example, OSPF. LDP only assigns a label to those routes which are selected by the underlying IGP. In a multi-area network, to eliminate the need for leaking "/32" loopback addresses, the LDP matches the longest IGP prefix according to RFC 5283.

- **RSVP-TE:** The LSRs can establish LSPs to other LSRs using RSVP-TE. The RSVP-TE allows the establishment of MPLS LSPs, considering the network constraint parameters, such as link coloring or available bandwidth. Unlike LDP, where LSP paths always follow the IGP topology, the RSVP-TE allows the definition of explicit paths defined by the user. To do so, use one of the following methods:

    - Fully specify the entire path, using strict hops.

    - Set the IS-IS Level 1-2 routers as loose hops, then let the nodes do the CSPF calculation for the remaining segments in the partial Explicit Route Object (ERO) of the LSP from the other IS-IS area (RFC 5151).

12.4.3 RSVP-TE Fast Reroute

RSVP-TE based MPLS networks can offer restoration times in the range of several seconds using reconvergence of the protocols in case of a link or node failure. To improve resiliency times to 50 ms or below, the Fast Reroute solution can be applied.

Fast Reroute (FRR) provides local protection, that is, FRR is used to protect local link or node failures. To protect a link failure, any router - except for the egress node - can set up a backup (bypass/ detour) LSP avoiding the protected link to its next-hop router. On the other hand, to protect a node failure, a router has to set up a backup LSP to its next-next-hop router.

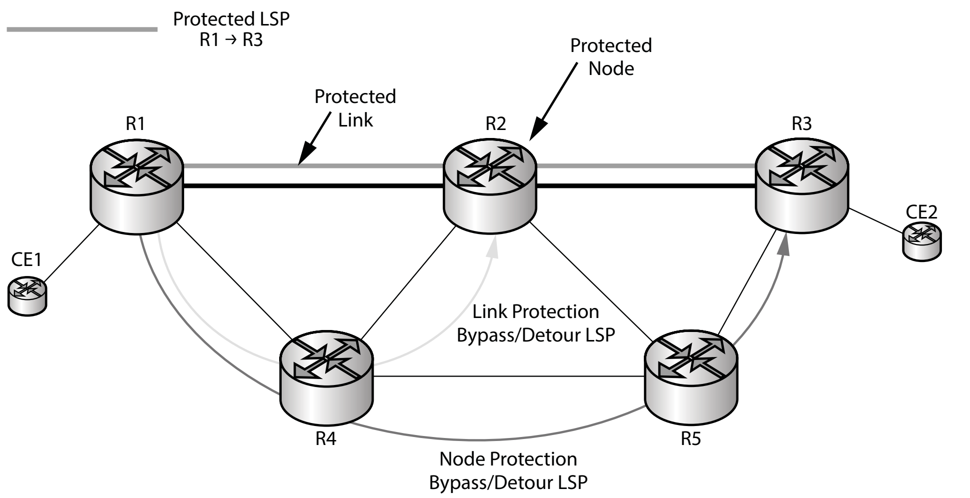


Figure 71 RSVP-TE Fast Reroute

The routers monitor the next hops by using Bidirectional Forwarding Detection (BFD), and immediately reroute to the backup LSP in case the BFD session is broken. Using BFD timers of 10 ms will result in detection times of 30 ms and rerouting times below 50 ms.

There are two schemes in RSVP-TE FRR, namely one-to-one backup and facility backup:

— In one-to-one backup, one backup LSP has to be established for every protected LSP. Specifically, if there are N protected LSPs, N backup LSPs are needed.

— In facility backup, one backup LSP can be used to protect all LSPs using the same outgoing interface/link; this requires pushing another (third) label to the packets.

Apparently, facility backup scales better than one-to-one backup, but the implementation is more complex due to the use of the extra label. In ML66, the one-to-one backup is supported.

Note: In ML66, the 50ms switchover time criterion is not guaranteed on managed node restart.

The backup LSP takes the traffic until the routing protocols reconverge and set up a new primary LSP (also with new backup LSPs). From that point, the new LSP takes over the traffic, while the old LSP and its backup LSPs are torn down.

12.4.4 RSVP-TE Path Protection

RSVP-TE Path Protection enables establishing primary and backup LSPs. In case of a failure along the primary LSP, the head-end will switch over to the backup LSP with a switchover time less than a second.

The primary and backup LSPs are manually established end-to-end between the head-end and tail-end nodes, using TE techniques such as explicit hops or administrative groups. One LSP is configured as primary and the other as secondary. In case of the failure of the primary LSP, the secondary LSP takes over the traffic, shown in Figure 72.

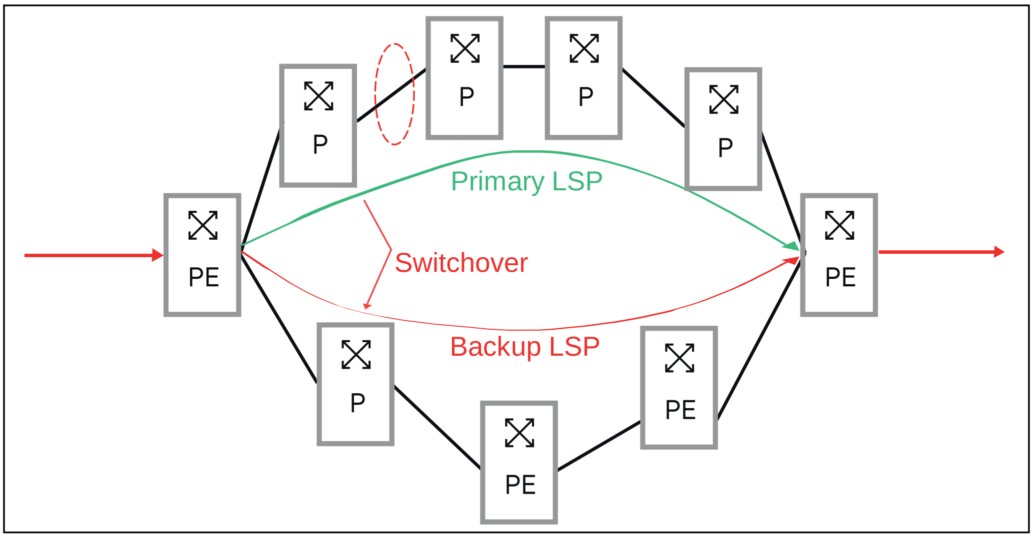


Figure 72 LSP Switchover

BFD over LSP (RFC5884) can be used for end-to-end connectivity monitoring of the primary LSP, enabling a switchover below 50ms.

This feature does not require any specific licenses.

12.4.5 BGP Alternate Path Routing

BGP Alternate Path Routing (APR) enables dual-homing of a Cell Site Provider Edge (CS-PE) node to two Switch Site Provider Edge (SS-PE) nodes, see Figure 73. The CS-PE has two routes to a destination and computes a primary and an alternate route to the two SS-PEs. The CS-PE downloads both the primary and alternate routes to the MPLS FTN Table. The alternate BGP remote nexthop is used only if the primary BGP remote nexthop is not reachable. By running multi-hop BFD to monitor the states of the BGP neighbors, the cell site PE can react very quickly to the failure of the primary SS-PE node and switch over to the alternate SS-PE node. Depending on the BFD timer settings, recovery time can be as low as a few 100 milliseconds.

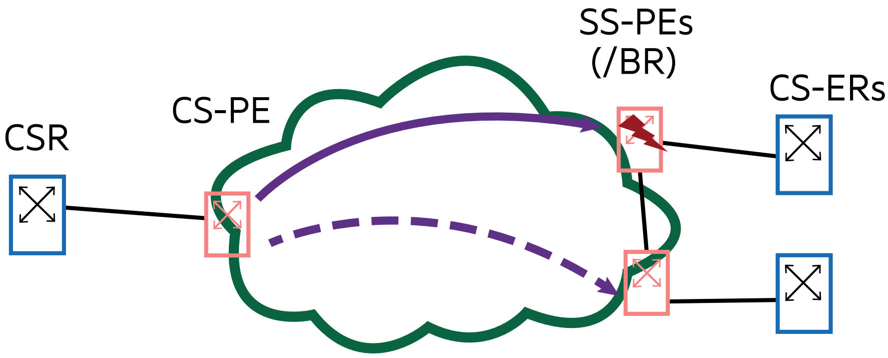


Figure 73 BGP Alternate Path Routing

12.4.6 Seamless MPLS

Seamless MPLS offers a solution for extending MPLS across Autonomous Systems. An additional label is added to the MPLS header that is used for label-switching the traffic at AS Border Routers. BGP Labeled Unicast (BGP-LU) is used to distribute label allocations from the AS borders towards the routers in the connected ASs.

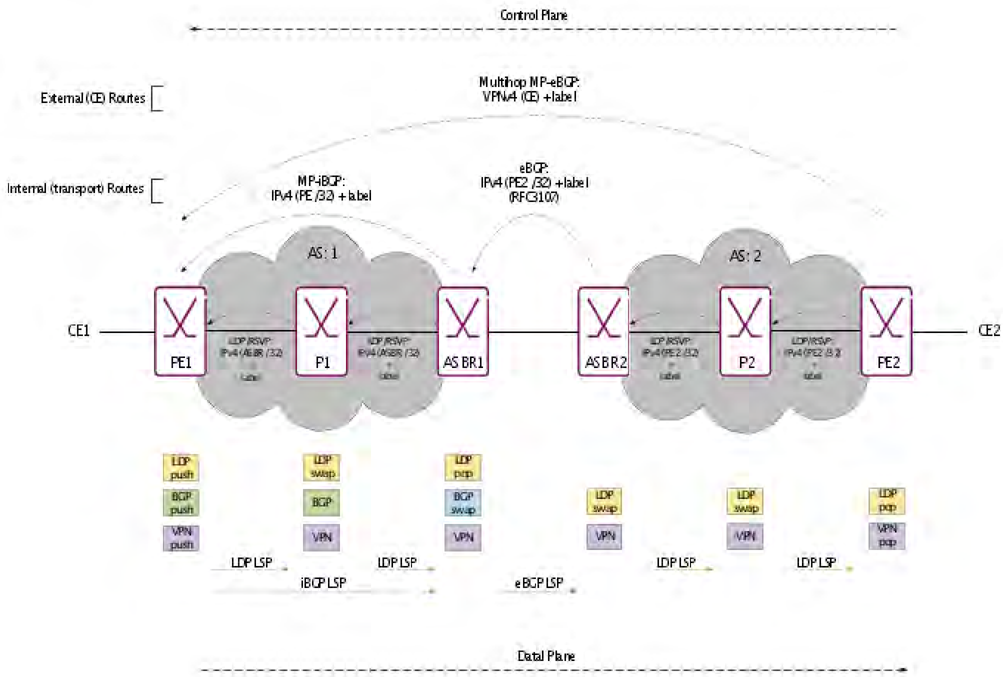


Figure 74 Seamless MPLS

12.5 Supported IP Protocols

The NE supports the following IP service protocols:

— **ARP**

The ARP implementation is consistent with RFC 826, An Ethernet Address Resolution Protocol, also called Converting Network Protocol Addresses to 48.bit Ethernet Address for Transmission on Ethernet Hardware. In addition, the NE provides a configurable ARP entry-age timer and the option to delete expired dynamic ARP entries automatically.

— **BFD**

The NE supports RFC 5880, BFD. BFD is a simple Hello protocol that is similar to the detection components of some routing protocols. A pair of routers periodically transmits BFD packets over each path between the two routers. If a system stops receiving BFD packets after a predefined time interval, a component in the bidirectional path to the neighboring NE is assumed to have failed. A path is declared to be operational only when two-way communication has been established between the systems. To establish BFD sessions, configure one or more BFD clients on the same interface as BFD. BFD clients are routing protocols, which use BFD events to detect link failures; for example, BFD clients can be BGP, OSPF, and other applications.

— **NDP**

The NDP implementation is based on RFC 4861.

— **NTP**

The NE supports versions 1, 2, and 3 of the Network Time Protocol (NTP). On the NE, NTP operates only in client mode. A remote NTP server can synchronize the NE, but the NE cannot synchronize remote clients.

Note: Before using NTP, the NE must be configured with the IP address of one or multiple NTP servers.

— **DHCP**

DHCP dynamically leases IP address information to host clients. The NE provides the following DHCP support.

- DHCPv4 relay server

  The NE acts as an intermediary between an external DHCPv4 server and the client. The NE forwards requests from the client to the DHCPv4 server and relays the responses from the server back to the client.

- DHCPv6 relay server (only for DCN)

The NE relays or passes client requests for IPv6 addresses and prefixes to an external server (third-party equipment). The external server then provides the IPv6 addresses or prefixes to the client.

13 TDM

MINI-LINK 6600 provides an E1/DS1 traffic routing function that facilitates the handling of PDH traffic aggregation. This function enables interconnection of E1/DS1 traffic connections going through the NE.

Plug-in units connect n×E1/DS1 to the backplane, where the traffic is cross-connected to another plug-in unit. The E1s/DS1s are unstructured with independent timing.

The traffic routing function is configured from MINI-LINK Node GUI, locally or remotely.

Note: For MINI-LINK 6651, only E1s for ETSI are supported. No support is available for DS1s (ANSI) or SDH/SONET in MINI-LINK 6651.

MINI-LINK 6600 provides STM-1 interfaces via LTU 1002 for SDH.

13.1 TDM Protection Mechanisms

This section describes the protection mechanisms provided by the Basic Node. Protection of the radio link is described in Radio Link.

13.1.1 Overview

To ensure high availability, MINI-LINK 6600 provides protection mechanisms on various layers in the transmission network as illustrated in Figure 75.

- Network layer protection using the 1+1 SNCP mechanism provides protection for the sub-network connection **a-b** in Figure 75. Network layer protection uses only signal failure as switching criterion.
- Physical link layer protection using MSP 1+1 indicated by the link **c** between two adjacent NEs **1** and **2** in Figure 75. Physical link layer protection uses both signal failure and signal degradation as switching criteria.
- By routing the protected traffic in parallel through different physical units, equipment protection can also be achieved. An example using two plug-in units is shown for the NEs **1** and **2** in Figure 75.

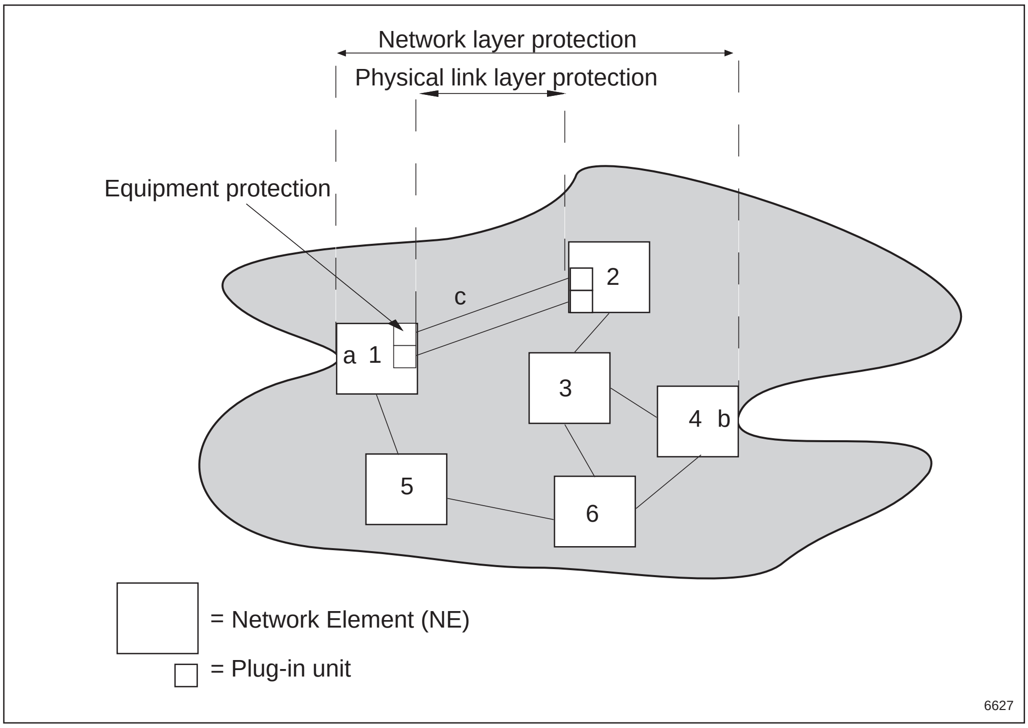


Figure 75 The NE Provides High Availability Through Various Protection Mechanisms

Network layer and physical link layer protection share the following characteristics:

Permanently Bridged Identical traffic is transmitted on the active and the passive physical link/connection.

Uni-directional Only the affected direction is switched to protection. The equipment terminating the physical link/connection in either end will select which line to be active independently.

Non-revertive No switch back to the original link/connection is performed after recovery from failure. The original active link/connection is used as passive link/connection after the protection is reestablished.

1+1 One active link/connection and one passive (standby) link/connection.

Automatic/Manual switching mode In automatic mode, the switching is done based on signal failure or signal degradation. Switching can also be initiated from the management system provided that the passive link/connection is free from alarms.

In manual mode, the switching is only initiated from the management system, regardless of the state of the links/connections.

13.1.2 Network Layer Protection

13.1.2.1 1+1 E1/DS1 SNCP

1+1 E1/DS1 Sub-Network Connection Protection (1+1 E1/DS1 SNCP) is a protection mechanism used for network protection on E1/DS1 level, between two NEs. It is based on the simple principle that one E1/DS1 is transmitted on two separate E1/DS1 connections.

The switching is performed at the receiving end where the two connections are terminated. It switches automatically between the two incoming E1s/DS1s in order to use the better of the two. The decision to switch is based on signal failure of the signal received (LOS or AIS).

At each end of the protected E1/DS1 connection, two E1/DS1 connections must be configured to form a 1+1 E1/DS1 SNCP group.

An operator may also control the switch manually.

The connections may pass through other equipment in between, provided that AIS is propagated end-to-end.

The 1+1 E1/DS1 SNCP function is independent of the 1+1 radio protection and the MSP 1+1.

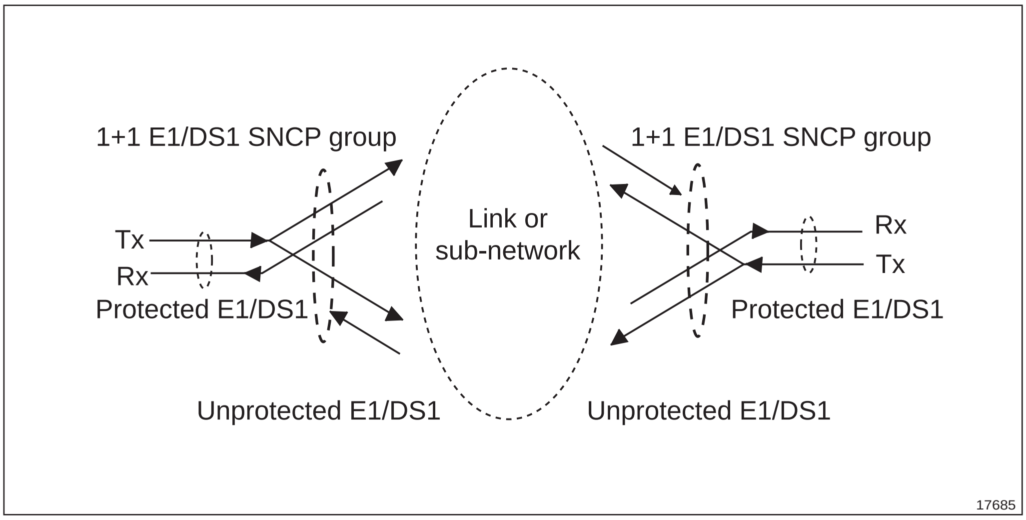


Figure 76 1+1 E1/DS1 SNCP Principle

Performance data is collected and fault management is provided for unprotected as well as protected VC/VT interfaces (that is the 1+1 E1/DS1 SNCP group). This gives accurate information on the availability of network connections.

13.1.2.2 Ring Protection for PDH and SDH

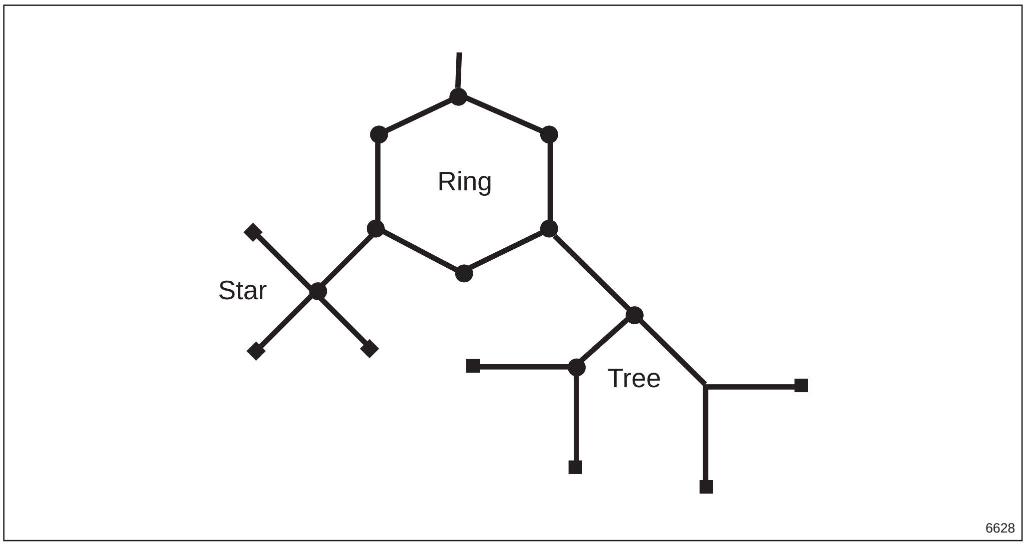


Figure 77 Network Topologies

The 1+1 SNCP mechanism described in the previous section can be used to create protected ring structures in the microwave network. In a ring topology, all nodes are connected so that two nodes always have two paths between them.

A connection entering a ring at one point and exiting at another point can therefore be protected with a 1+1 SNCP group configured at each end of the connection. The traffic is transmitted in both directions of the ring and the traffic is received from two directions at the termination point.

In this solution, the ring network can tolerate one failure without losing transmission. When the failure reoccurs, the affected connections are switched in the other direction.

In a MINI-LINK network, these ring structures can be built using PDH Radio Terminals with capacities of up to 80×2 Mbps, and using SDH Radio Terminals with LTU 1002 with capacities up to 63×2 Mbps.

Capacity is distributed from a common feeder node to the ring nodes where it is dropped off to star or tree structures as shown in Figure 78.

As an example, consider the nodes **A** and **E** in Figure 78. To protect the connection from **A** to **E** the two alternative connections from **A** to **E** must be defined as a 1+1 SNCP group at **A** and as a 1+1 SNCP group at **E**.

Similarly, to protect the connection from **A** to **C**, the two alternative connections between **A** and **C** must also be configured as two 1+1 SNCP groups at **A** and **C**.

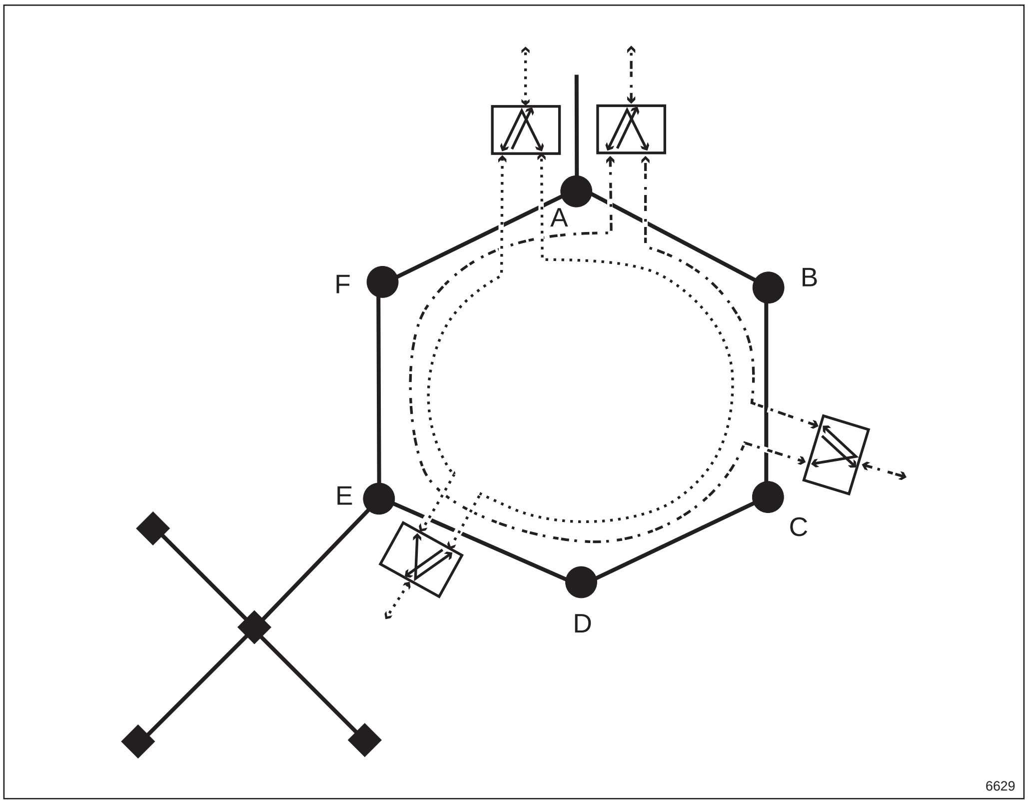


Figure 78 Example of Ring Protection with 1+1 SNCP

The 1+1 SNCP function can be used to build protection in more complex topologies than rings, using the same principle.

13.1.3 MSP 1+1 for SDH

Note: SDH is only available for ETSI, and not for ANSI (SONET).

The LTU 1002 STM-1 interface supports Multiplexer Section Protection (MSP) 1+1. This SDH protection mechanism provides both link protection and equipment protection. Its main purpose is to provide maximum protection at the interface between the microwave network and the optical network.

MSP 1+1 requires two LTU 1002 plug-in units configured to work in an MSP 1+1 pair, delivering only one set of 63×E1 to the backplane at a time as illustrated in Figure 79. The unit intercommunication is done over the BPI bus.

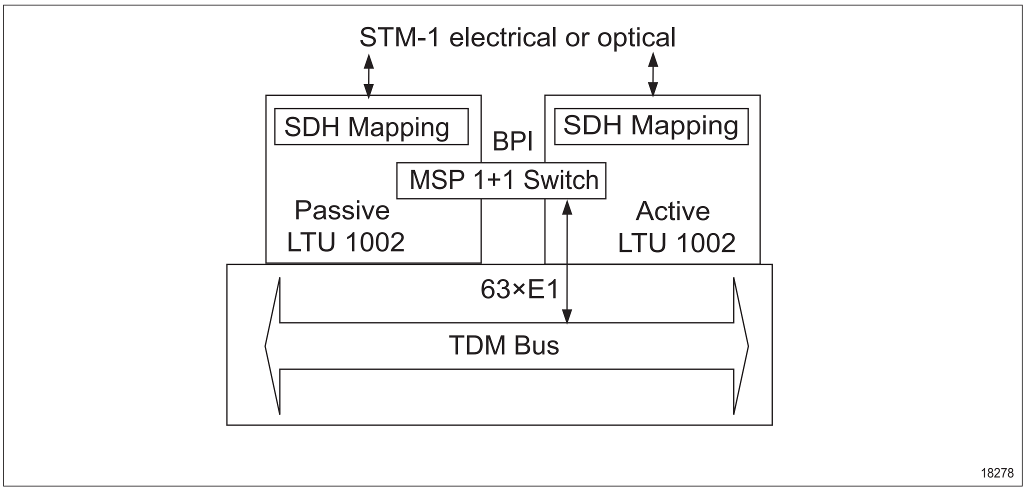


Figure 79 Two LTU 1002 Plug-In Units in an MSP 1+1 Configuration

The switching is done automatically if the following is detected:

- Signal Failure (SF): LOS, LOF, MS-AIS, or RS-TIM
- Signal Degradation (SD) based on MS-BIP Errors (BIP-24)
- Local equipment failure

The operator can also initiate the switching manually.

The switch logic for MSP 1+1 is handled by the Device Processor of the unit.

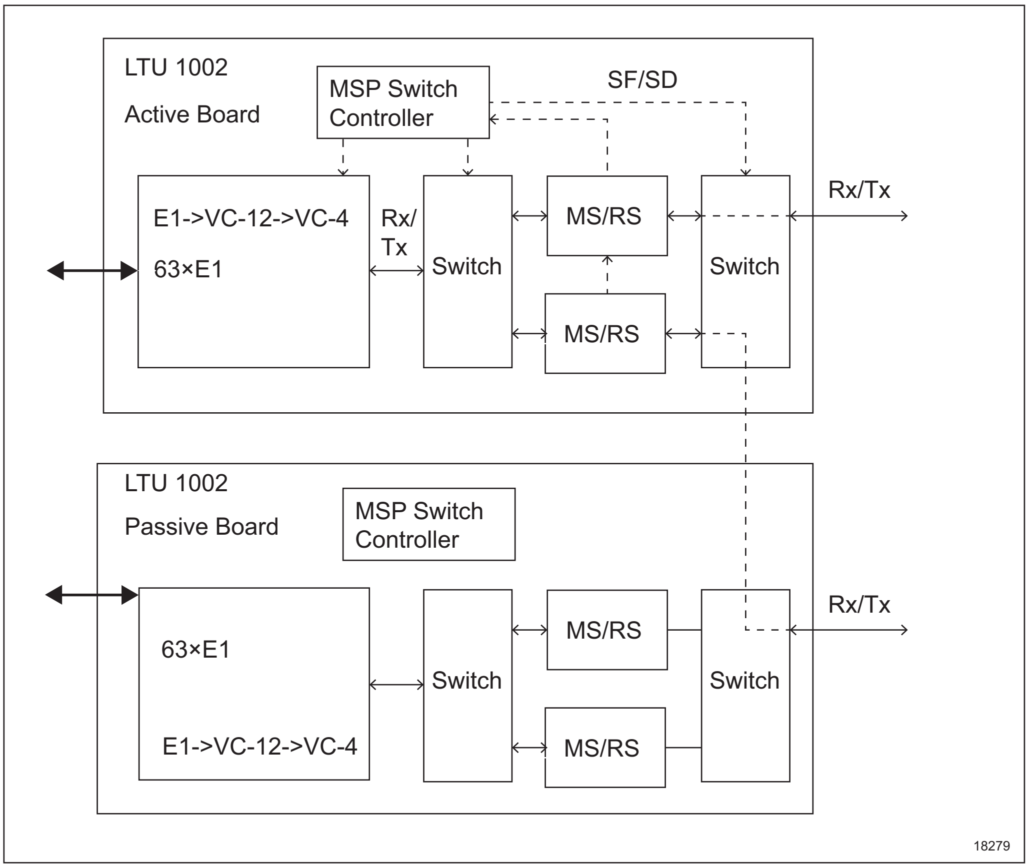


Figure 80 MSP 1+1 Principle for LTU 1002

13.2 TDM over Packet using CES

TDM traffic can be transported over Ethernet by using the Circuit Emulation Service (CES).

Note: CES is configurable in a MINI-LINK 6600 node that has an LTU 1002 installed or in a MINI-LINK 6651/4 node.

MINI-LINK supports both TDM and packet data transportation, with TDM being more traditional and packet-only networks slowly replacing old TDM or hybrid networks. CES enables a packet-only network to support TDM data transportation, meaning a hybrid network is not required. CES converts traditional TDM traffic at a node to Ethernet traffic and the traffic can then be sent over a packet network.

The MINI-LINK 6600, equipped with an LTU 1002, or the MINI-LINK 6651/4 converts the TDM traffic into a packet format and then it is sent over a Native Ethernet network.

CES adds an additional overhead to all data, due to the specific requirements of packet data.

The following TDM encapsulation mode is provided:

— **Structure Agnostic Model** — The complete E1/DS1 is encapsulated into a pseudowire.

Each TDM interface is transferred in a separate pseudowire. The pseudowires can be transported directly over Ethernet using MEF8 protocol headers. The underlying Ethernet network can operate in Customer Mode or Provider Mode. The customer VLAN tags are set per pseudowire.

LTU 1002 provides CES services with different options depending on the selected LTU 1002 profile. For details on the available board profiles, see Section 15.15 on page 211.

13.2.1 Synchronization of TDM Interface

One of the basic tasks of the CES function is to reconstruct the timing on the transported TDM service.

MINI-LINK 6600 supports the following methods to synchronize the TDM transmit clock at one end of the packet network, to the TDM receive clock at the other end of the packet network:

— **Loop Timing Method** — The TDM transmit clock is derived from the received TDM signal. It is required that the TDM network on both sides have access to the same network clock.

— **Adaptive Method** — TDM transmit clock is derived based on the packet arrival rate from the packet network.

— **Network Synchronization Method** — TDM transmit clock is derived from the SEC in network frequency synchronization mode.

The loop timing and adaptive methods are useful in scenarios when the TDM service has independent timing.

14 Synchronization

14.1 General Overview

Network synchronization is an important supporting function in telecommunication networks, since proper operation of different transport and radio technologies requires certain type and level of synchronization of the network equipment.

Different synchronization types are described in Figure 81.

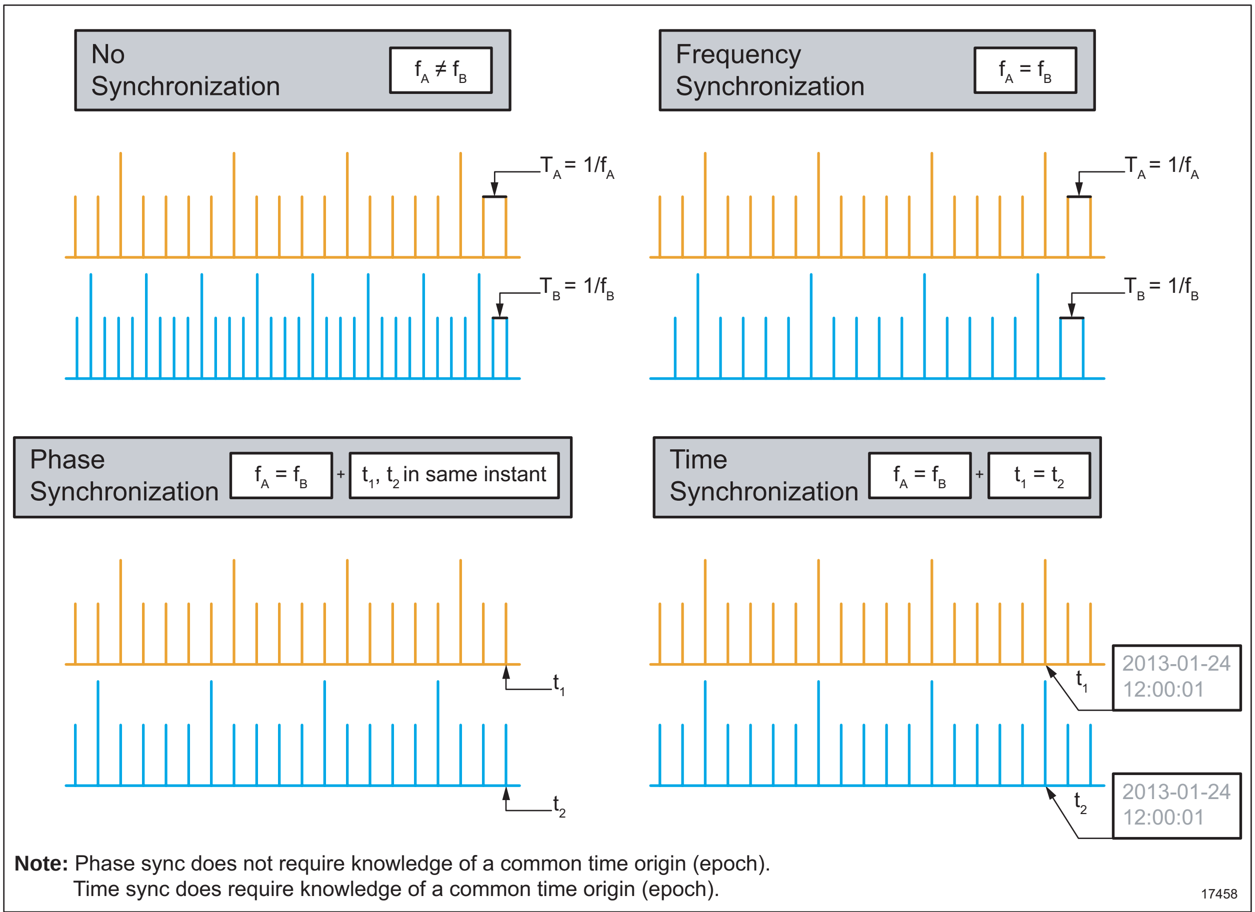


Figure 81 Different Synchronization Types

If there is no alignment between the time instances of two system clocks, then the two clocks are not synchronized (Figure 81, top left). If the periodicity (or rate of change) of the clock instances in two systems are equal, then the two clocks are frequency synchronized (Figure 81, top right). Phase synchronization means that time instances of the two remote system clocks occur at exactly the same time, but absolute time is not known by the systems, so their significant instances may be unaligned (Figure 81, bottom left). In case absolute time information is assigned to each time instance of the clocks and they are aligned, then the two clocks are time synchronized (Figure 81, bottom right).

Though phase and time synchronization do not exactly mean the same, they are usually used interchangeably in synchronization terminology and it always means time synchronization in telecommunication networks.

Frequency synchronization is required by TDM-based transport networks and FDD-based radio technologies (GSM, WCDMA, LTE-FDD, and so on), while time synchronization is required by some advanced radio technologies (LTE-TDD, eMBMS, and so on).

In MINI-LINK, frequency synchronization is handled by the Netsync function, that contains a Synchronous Equipment Timing Generator (SETG). The SETG can be frequency synchronized to any physical interface that can carry synchronization. The recovered clock is handed over to the Frequency synchronization function as frequency reference interface. Out of all potential synchronization reference interfaces, four interfaces can be selected to be connected to the synchronization source selection logic.

Time synchronization is provided by the PTP described in the IEEE1588-2008 standard. It can be used in G.8275.1 profile mode, and it synchronizes the Real Time Clock (RTC) of the node to an external time reference through exchange of PTP packets supported by HW timestamping. Time synchronization function relies on stable clock frequency that is provided using the Netsync function based on physical layer frequency synchronization signals. Therefore it is also prerequisite to enable and lock the Netsync function to a Primary Reference Clock (PRC)/Primary Reference Source (PRS) traceable synchronization signal before time synchronization is activated.

Since the PTP function communicates over standard traffic interfaces it is a prerequisite to create the traffic configuration of the interfaces that are intended for PTP usage.

Figure 82 shows the node operation when PTP is configured in G.8275.1 profile and time recovery is supported by the frequency synchronization function.

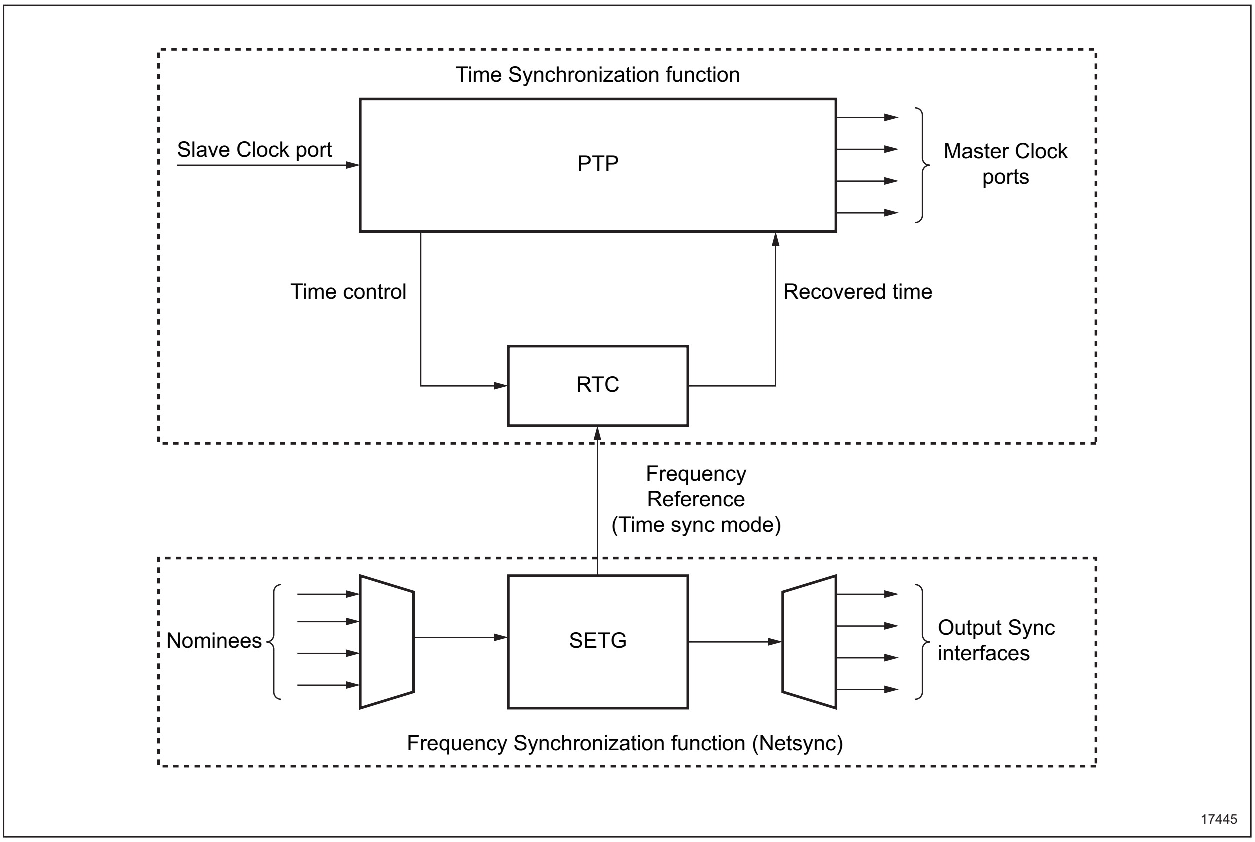


Figure 82 G.8275.1 Node Time Synchronization

14.2 Frequency Synchronization Technologies

MINI-LINK 6600 supports the following frequency synchronization functions:

— Sync over Radio Link

— Synchronous Ethernet

— Sync over SDH (only for ETSI)

— Sync over PDH

— Sync over 2 MHz/2048 kbps

— Sync over PTP (G.8265.1 Mode)

14.2.1 Sync over Radio Link

Quality Level (QL) is communicated over radio link side channel in order to support QL based reference selection.

14.2.2 Synchronous Ethernet

Synchronous Ethernet is supported on the various interfaces as shown in Table 11.

Table 11 SyncE Support on Ethernet Interfaces

	Interface					
Unit	**LAN RJ45 100 Mbps**	**LAN RJ45 1 Gbps**	**LAN SFPo 1 Gbps**	**LAN SFPo 2.5 Gbps**	**LAN SFPo 10 Gbps**	**LAN SFPe**
NPU 1002	Yes	Yes	Yes	No	Yes	No
NPU 1003	Yes	Yes	Yes	No	Yes	No
NPU 1005	Yes	Yes	Yes	No	Yes	No
PNM 1001	Yes	Yes	Yes	No	Yes	No
PNM 1002	Yes	Yes	Yes	No	Yes	No
ETU 1001	Yes	Yes	–	–	–	–
ETU 1002	–	–	Yes	–	Yes	–
MINI-LINK 6651/1, 6651/2, or 6651/3	Yes	Yes	Yes	Yes	–	No
MINI-LINK 6651/4	Yes	Yes	Yes	–	Yes	No

Synchronous Ethernet enables propagation of frequency synchronization clock over Ethernet interfaces. It also supports QL communication using Ethernet Synchronization Status Message (ESMC) messages according to ITU-T G.8264. The ESMC handling can be disabled for interfaces in order to provide interoperability to other equipment that do not support the ESMC protocol.

Note: Disabling ESMC handling is not recommended and such usage is under the responsibility of the operator.

The terms ‘‘ESMC’’ and ‘‘Synchronization Status Message (SSM)’’ are used interchangeably in the Synchronous Ethernet context in MINI-LINK documentation.

14.2.3 Sync over SDH

Note: Sync over SDH is not available for MINI-LINK 6651.

Note: LTU 1002 is required for MINI-LINK 6691, MINI-LINK 6692, MINI-LINK 6693, or MINI-LINK 6694 with NPU 1002, NPU 1003, or NPU 1005.

Frequency synchronization over SDH requires termination of the STM-1 in an LTU 1002.

Quality Level (QL) is communicated over SDH interfaces using Synchronization Status Message (SSM) in order to support QL based reference selection.

It is not supported to use a PDH carried inside an STM-1 as a sync source. The recommendation is to use the STM-1 as sync source instead.

14.2.4 Sync over PDH

Note: LTU 1001 or LTU 1002 is required for MINI-LINK 6691, MINI-LINK 6692, MINI-LINK 6693, or MINI-LINK 6694 with NPU 1002 or NPU 1005.

Note: Sync over PDH is not available for MINI-LINK 6651.

Any E1/DS1 interface can be used as frequency reference source.

E1s/DS1s are cross-connected transparently, that is the clock frequency on the outgoing E1/DS1 interface will always follow the clock frequency of its relevant E1/DS1 input.

QL forwarding on PDH interfaces is not supported. It is configurable to Squelch (AIS) outgoing PDH interfaces when frequency synchronization fails.

It is not supported to use a PDH carried in an STM-1 as a sync source. The recommendation is to use the STM-1 as sync source instead.

14.2.5 Sync over 2 MHz/2048 kbps

Sync over 2 MHz/2048 kbps is supported on the various interfaces as shown in Table 12.

Table 12 Sync over 2 MHz/2048 kbps Support

Unit	2 MHz/2048 kbps
NPU 1002	Yes
NPU 1003	Yes
NPU 1005	Yes
PNM 1001	Yes
PNM 1002	Yes
MINI-LINK 6651	No

The synchronization clock signal can be connected to external units by connecting the external units directly to an arbitrary 2 MHz/2048 kbps port. This can be used in the peripheral parts of the network where an RBS is connected to a MINI-LINK 6600.

QL forwarding on 2 MHz/2048 kbps interface is not supported. It is configurable to Squelch (AIS) outgoing signal when frequency synchronization fails.

14.2.6 Sync over PTP (G.8265.1 Mode)

On NPU 1002, NPU 1003, NPU 1005, PNM 1001, PNM 1002, and MINI-LINK 6651, the PTP protocol can be used to provide frequency synchronization of multiple slaves to a grandmaster according to the ITU-T G.8265.1 profile using UDP/IPv4 unicast transport. This profile does not require any PTP support from the network between the master and the slave. This means that transport nodes along the PTP packet path do not need to be aware of or to support the PTP protocol. However, when setting up a network for packet-based frequency synchronization following the G.8265.1 profile, the 1588 packets must be given the highest prioritization in the QoS hierarchy to minimize the packet delay variation of the PTP packets.

If the NE is configured as a frequency grandmaster, the frequency of the SETG clock is distributed.

If the NE is configured as a packet slave, the PTP recovered frequency is a candidate for the frequency synchronization source selection. In this profile, the delay request-response mechanism in two-way message exchange is supported. Peer-to-Peer operation is not supported.

The NE sends PTP event messages in one-step mode, while both one-step and two-step messages are accepted and processed properly. The only allowed encapsulation in this profile is IP unicast.

IP host functionality of the PTP entity is handled by the port-based L3 subinterfaces in the NE. The exact routing of the G.8265.1 PTP messages is determined by the L3 routing stack. The VLAN encapsulation is also determined by the L3 subinterface configuration.

Note: Only IPv4 is supported.

Only clock type Ordinary Clock (OC) is supported. Slave mode consists of a Single Slave-only OC (SOOC) instance.

To maximize the performance of the frequency synchronization, it is beneficial to forward the frequency by microwave link function, SyncE, PDH/SDH, or 2MHz inside the transport domain and hand the frequency over by G.8265.1 profile only at the edges of the transport domain, as it is shown in Figure 83. For this reason, G.8265.1 OC is supported only through LAN ports. On microwave links, the standard Netsync frequency forwarding is supported.

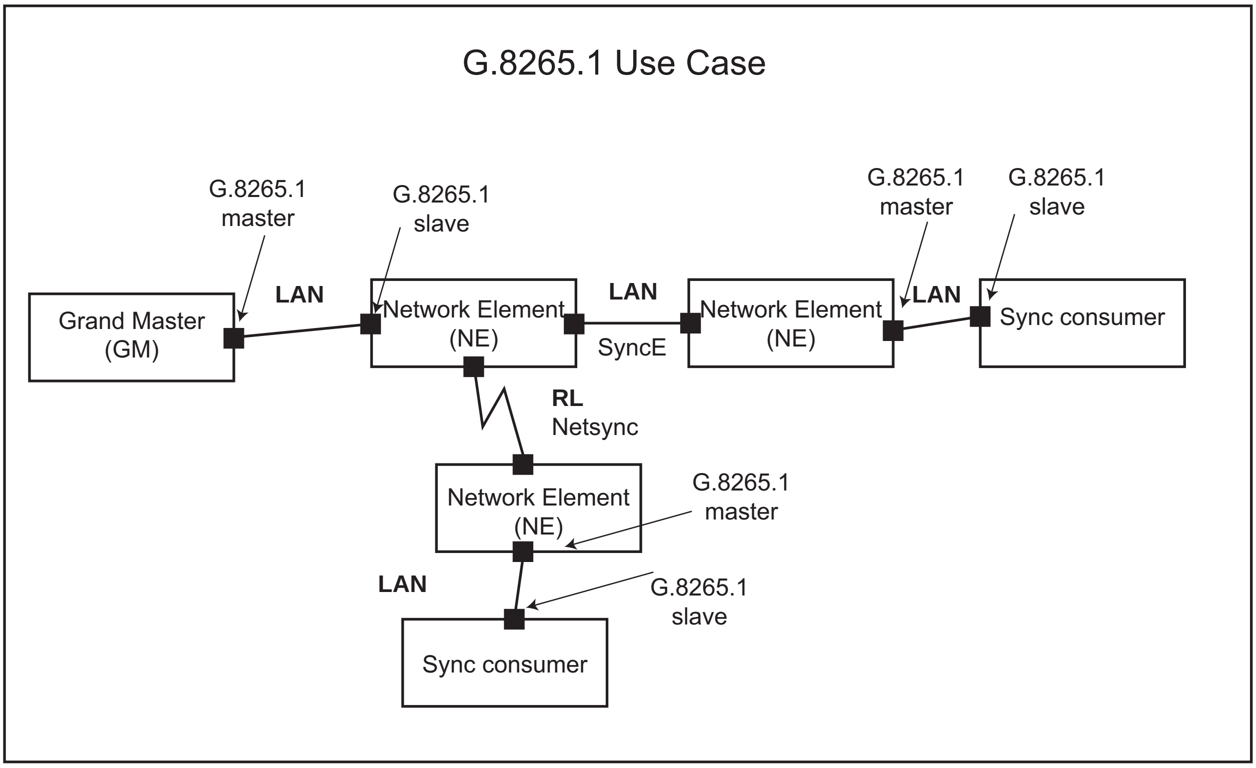


Figure 83 G.8265.1 Use Case

14.3 Time Synchronization Technologies

The time synchronization device is the Precision Time Protocol (PTP) entity that can receive packet based synchronization signal from any PTP capable interface, and can distribute the time synchronization information over any PTP capable interface or 1PPS/ToD output.

Note: The 1PPS/ToD interface is available on NPU 1002, NPU 1003, NPU 1005, PNM 1001, and PNM 1002.

To synchronize time via PTP, MINI-LINK 6600 requires a PRC/PRS-traceable frequency from the Frequency Synchronization function that is recovered from an L1 (non-PTP) source, for example Synchronous Ethernet or Sync over Radio Link, as described in the previous chapter.

When setting up a network for time synchronization, it is essential to configure PTP support throughout the synchronization path. In addition the PTP packets shall be given the highest prioritization in the QoS hierarchy in order to avoid PTP packet loss on congested links.

IEEE1588-2008 standard provides the general framework for packet-based time synchronization, including Boundary Clock (BC), Ordinary Clock (OC), and Transparent Clock (TC). However, in order to meet the functional and performance requirements of a certain application, further requirements defined in a so called “profile” need to be supported as well. Applicable performance requirements are defined in ITU-T G.8273.2 for telecom devices, and in G.8271.1 for end-to-end network limits.

14.3.1 Default PTP Profile

PTP can be used to provide time synchronization according to the IEEE1588-2008 Annex J using Ethernet multicast transport. This profile assumes full network timing support from the network. This means that all transport nodes along the time synchronization chain from the grandmaster to the end application must support PTP.

In this profile, MINI-LINK 6600 supports the delay request-response mechanism in two-way message exchange. Peer-to-Peer operation is not supported.

MINI-LINK 6600 sends PTP event messages in one-step mode, while both one-step two-step messages are accepted and processed properly.

Default encapsulation for MINI-LINK 6600 is Ethernet multicast. MINI-LINK 6600 always sends packets with the forwardable multicast address, while both the forwardable (01-1B-19-00-00-00) and the non-forwardable (01-80-C2-00-00-0E) multicast addresses are accepted. Ethernet unicast can also be configured.

MINI-LINK 6600 supports PTP packet exchange in Customer and Provider Bridge modes.

The following VLAN tagging options are supported for the default PTP profile:

— No VLAN tag

— Single VLAN tag (Customer mode, or Provider mode with S-tag only)

— Double VLAN tags (Provider mode with both S-tag and C-tag)

The following clock types are supported for the default PTP profile:

— Boundary Clock (BC)

— Ordinary Clock (OC)

— Transparent Clock (TC)

A PRC/PRS-traceable frequency from the Frequency Synchronization function that is recovered from an L1 (non-PTP) source is required in all operation modes.

In TC mode the node does not terminate the PTP protocol, just compensates for the residence time within the node of each PTP packet. The node clock is not synchronized in time, but is required to be synchronized in frequency via a physical layer technology.

14.3.2 ITU-T G.8275.1 Profile

PTP can be used to provide time synchronization according to the ITU-T G.8275.1 profile. This profile assumes full network timing support from the network. This means that all transport nodes along the time synchronization chain from the grandmaster to the end application must support PTP in G.8275.1 profile.

In this profile, MINI-LINK 6600 supports the delay request-response mechanism in two-way message exchange. Peer-to-Peer operation is not allowed in this profile.

MINI-LINK 6600 sends PTP event messages in one-step mode, while both one-step and two-step messages are accepted and processed properly.

The only allowed encapsulation in this profile is Ethernet multicast. MINI-LINK 6600 sends by default packets with the forwardable address, and non-forwardable packet sending can also be configured. Both the forwardable (01-1B-19-00-00-00) and the non-forwardable (01-80-C2-00-00-0E) multicast addresses are accepted.

MINI-LINK 6600 supports PTP packet exchange in Customer and Provider Bridge modes.

The following VLAN tagging options are supported for the ITU-T G.8275.1 profile:

- No VLAN tag
- Single VLAN tag (Customer mode, or Provider mode with S-tag only)
- Double VLAN tags (Provider mode with both S-tag and C-tag)

The following clock types are supported for the ITU-T G.8275.1 profile:

- Telecom Boundary Clock (T-BC)
- Telecom Time Slave Clock (T-TSC)
- Telecom Transparent Clock (T-TC)

A PRC/PRS-traceable frequency from the Frequency Synchronization function that is recovered from an L1 (non-PTP) source is required in all operation modes.

14.3.3 Time Error Generation

Timing characteristics requirements for Telecom Boundary Clocks and Telecom Slave Clocks are defined in G.8273.2 standard for networks with full timing support. The standard defines limits for maximum absolute time error (max|TE|), permissible range of constant time error (cTE), and dynamic time error (dTE).

Table 13 Performance Categories of the Recovered Clock

[ns]	**T-BC Class B (G.8273.2)** (1)	**1G LAN** (2)(3)(4)	**10G LAN** (2)(3)(4)	**Radio Link** (5)
max|TE|	70	70	70	70
Range of cTE	±20	±20	±20	±20
dTE	40	40	40	40

(1) ITU-T G.8273.2 is supported, except for clause 7.2.
(2) Timestamping in FE is not supported.
(3) SFP interfaces are validated only with officially supported SFP types. Performance is not guaranteed with 3rd party SFP types that is not on the official Ericsson list.
(4) While 1588 timestamping is supported on any type of SFPs, Synchronous Ethernet – which is prerequisite for phase synchronization – is not supported on electrical SFPs. However, 1588 phase synchronization in general can work, in case network synchronization is provided to the node over any other interface.
(5) For supported HW, see the compatibility document in the Planning folder

14.4 Precision Time Protocol

This chapter summarizes the general aspects of packet based synchronization based on the IEEE1588-2008 protocol.

IEEE Std 1588™-2008 is a standard for packet-based network synchronization that is suitable both for frequency and time synchronization. It describes hierarchical master-slave architecture for clock distribution. The title of the standard is Precision Time Protocol (PTP), and so the terms IEEE1588 and PTP are used interchangeably to refer to the standard and the protocol.

The standard defines different clock types, that are embedded into network elements and provides synchronization function to the devices. These devices maintain various data sets that describe clock device and clock signal properties. The clock devices exchange these data sets information that allows each device to identify peer clocks and autonomously decide master-slave hierarchy. When master-slave relationships are established, clocks start to periodically exchange timing messages that are used to maintain synchronization of the device clocks.

The protocol has the following operational phases in the normal execution of the protocol:

— Network configuration

  Transport network and IEEE1588 clocks need to be configured according to required application in order to provide connectivity between clock devices.

— Establishing master-slave hierarchy

  Clocks start to exchange clock quality information, run the reference selection algorithm locally and automatically decide on synchronization topology

— Synchronizing the clocks

  Clocks start to exchange time event messages and perform clock synchronization.

If there is a change in the network topology, clock states, or performance, the master-slave hierarchy is automatically re-established, which may lead to re-synchronization of clocks.

IEEE1588 standard defines the framework for packet-based network synchronization in general and does not restrict the usage for any application, as well as does not define any performance requirements that would be needed for certain applications. Instead it defines the concept of Profile, which – within the framework of the standard – allows organizations to specify certain parameter subsets and operational requirements that are needed to achieve proper performance of certain applications. A PTP profile is a set of required options, prohibited options, and the ranges and defaults of configurable attributes.

ITU-T defined several standards that provide detailed requirements for packet-based network synchronization for telecommunication networks including definition of terminology, network-level requirements, clock definitions with performance levels, and profiles.

In order to support IEEE1588-2008 packet-based synchronization in any supported profile, MINI-LINK 6600 requires at least an NPU (acting as clock device) and time stamping capable interfaces such as LAN and WAN ports.

If time recovery is active, MINI-LINK 6600 can jump to phase/time holdover state in order to maintain the accurate time information. The prerequisite of phase holdover is that MINI-LINK 6600 previously was in phase locked state and the underlying frequency synchronization is stable. The period of holdover time is configurable from 0 to infinite.

MINI-LINK can monitor the performance of PTP, for more information, see Section 16.9.8 on page 251.

In MINI-LINK 6600, all Ethernet interfaces support time stamping except LAN RJ45 ports running at 10 Mbps or 100 Mbps.

Table 14 summarizes the 1PPS/ToD interface availability.

Table 14 1PPS/ToD Support

	1PPS/ToD input	**1PPS/ToD output**
NPU 1002	HW prepared	Yes
NPU 1003	HW prepared	Yes
NPU 1005	HW prepared	Yes
PNM 1001	HW prepared	Yes

Table 14 1PPS/ToD Support

	1PPS/ToD input	1PPS/ToD output
PNM 1002	HW prepared	Yes
MINI-LINK 6651	HW prepared	HW prepared

15 Hardware

15.1 MINI-LINK 6651

MINI-LINK 6651 is a compact node with a dual carrier modem, suitable for tail sites.

It has a replaceable Fan Unit (FAU) that provides cooling for the indoor part.

There are four variants, MINI-LINK 6651/1 (Figure 84), MINI-LINK 6651/2 (Figure 85), MINI-LINK 6651/3 (Figure 86), and MINI-LINK 6651/4 (Figure 87).

MINI-LINK 6651/3 is single carrier (only 1+0 is possible) and has no fan unit.

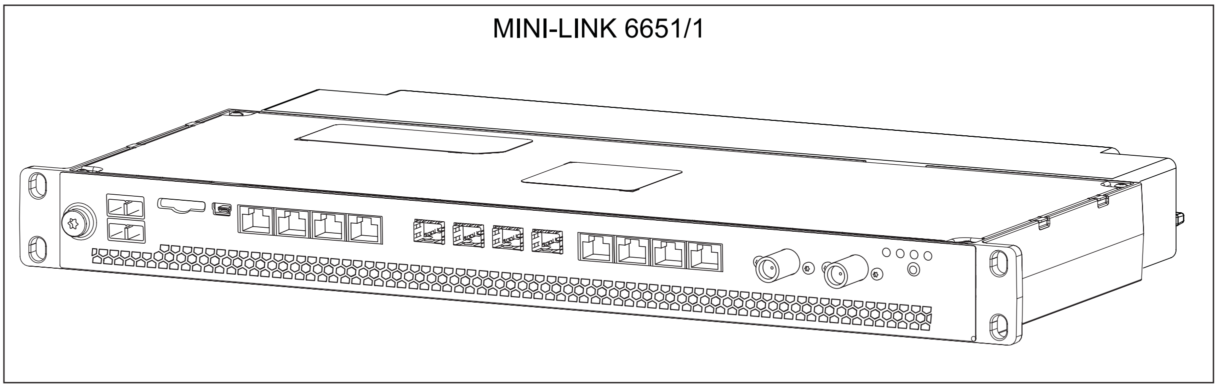


Figure 84 MINI-LINK 6651/1

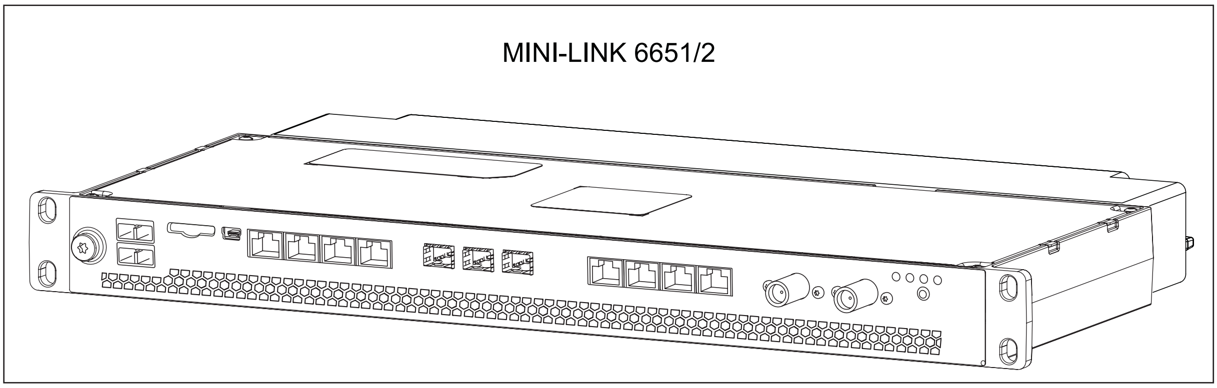


Figure 85 MINI-LINK 6651/2

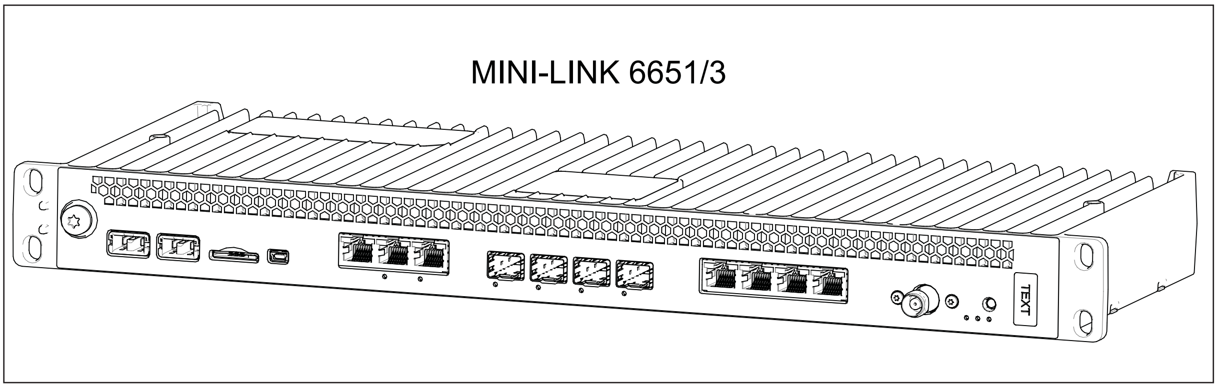


Figure 86 MINI-LINK 6651/3

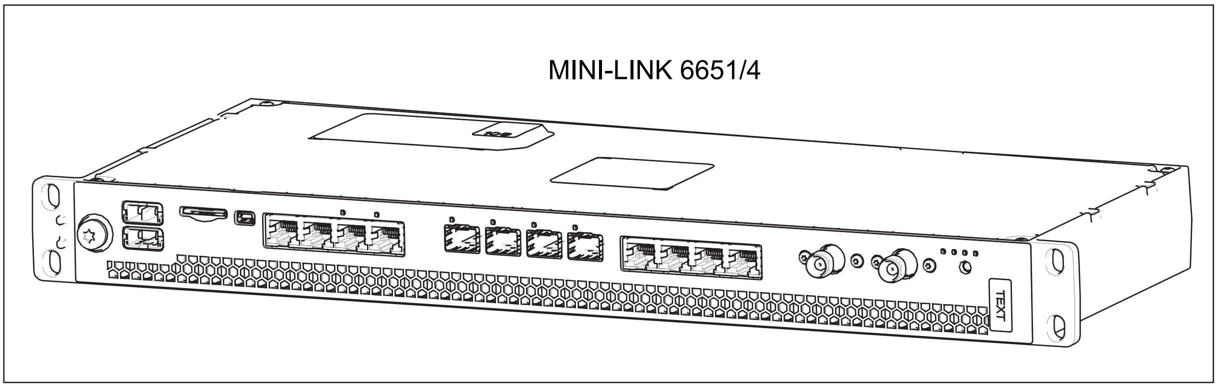


Figure 87 MINI-LINK 6651/4

MINI-LINK 6651 can be fitted in a standard 19" or metric rack. The height of a MINI-LINK 6651 is 1U.

MINI-LINK 6651 supports Single WAN 1+0. MINI-LINK 6651/1, MINI-LINK 6651/2, and MINI-LINK 6651/4 have a dual carrier modem and also support 2+0 Radio Link Bonding (RLB) and 1+1 Radio Link Protection (RLP). MINI-LINK 6651/2 and MINI-LINK 6651/4 also support Dual WAN 2x(1+0).

MINI-LINK 6651 can be configured in different ways:

— Single Direction 1+0

  Supported by all MINI-LINK 6651 variants (MINI-LINK 6651/1, MINI-LINK 6651/2, MINI-LINK 6651/3, and MINI-LINK 6651/4).

— Bonded Single Direction

  When configured as a bonded single direction link, the capacity of the two carriers are combined and only one switchport is used.

  Supported by MINI-LINK 6651/1, MINI-LINK 6651/2, and MINI-LINK 6651/4.

— Protected Single Direction

  When configured as 1+1 Radio Link Protection, both carriers are used for Radio Link path protection, and a single switchport is used.

  Supported by MINI-LINK 6651/1, MINI-LINK 6651/2, and MINI-LINK 6651/4.

— Dual Directions

  When configured as a 1+0 dual directions link, each carrier has its own connection to a switchport and both carriers can optionally be configured as a Hybrid radio link, that is combining TDM and Ethernet traffic on the same radio path.

  Supported by MINI-LINK 6651/2 and MINI-LINK 6651/4.

MINI-LINK 6651 has a high-capacity PDH/Ethernet modem with support for Adaptive Coding and Modulation (ACM), see Section 3.2 on page 12, and modulation schemes up to 8192 QAM.

MINI-LINK 6651/1, MINI-LINK 6651/2, and MINI-LINK 6651/4 supports Radio Link Bonding (RLB), see Section 3.5 on page 17 and XPIC (including XPIC Recovery and Restore), see Section 3.9 on page 28.

MINI-LINK 6651 provides physical layer Sync over Radio Link.

MINI-LINK 6651 carries PDH traffic and the Radio Link capacity is split between packet and circuit transport is configured with PDH capacity settings.

MINI-LINK 6651 supports control of the ratio between Ethernet and PDH traffic sent over Hybrid Radio Links. The Ethernet part of the aggregated capacity is set with E1 granularity.

MINI-LINK 6651/4 supports CES, enabling E1s being transported over packet. The following board profiles can be set for MINI-LINK 6651/4:

PDH only Provides 8×E1s through the front LAN port and 16×E1s over the radio.

CES only Provides 8×CES E1s transported over packet.

MINI-LINK 6651/2 and MINI-LINK 6651/4 supports Ethernet and TDM in two directions. MINI-LINK 6651/1 and MINI-LINK 6651/3 only supports traffic (Ethernet and TDM) in one direction.

MINI-LINK 6651 supports the following Ethernet-related features:

- Store and forward MAC (IEEE802.1D-2004) and VLAN-based switching (IEEE802.1Q-2005 and IEEE802.1ad-2005).
- Port-based VLAN (up to 1,000 VLANs in the range of 1–4094).
- MAC address table (32,000 entries) with learning and aging.
- IPv4 and IPv6
- Static unicast/multicast routes.
- Jumbo frames for LAN and Packet Link WAN ports.
- Multiple internal Layer 1 and Layer 2 Ethernet connections.
- MSTP/RSTP/LAG protection mechanism.
- Link Aggregation Control Protocol (LACP).
- Link Loss Forwarding for internal Layer 1 connections.
- Policing/color marking per ingress port with CIR/EIR and CBS/EBS.
- Policing/color marking per ingress port per QoS priority with CIR/EIR and CBS/EBS.
- Policing/color marking per ingress port per VLAN with CIR/EIR and CBS/EBS.
- Traffic shaping per egress port with CIR and CBS.
- Ethernet loop detection.
- Broadcast/multicast/destination lookup failure storm protection.
- Frame admission control.
- Classification/tagging of priority and VLAN ID.
- Congestion handling with eight priority queues (TC) per port.
    - Frame discard: WRED, color dropping, aging and tail drop.
    - TC scheduling: SP, WDRR.

— In-band management transport in Ethernet flow (DCN over VLAN).

— Management/diagnostics.

- PM counters.
- Link OAM.
- Ethernet Service OAM.
- Port mirroring.

MINI-LINK 6651/1 provides the interfaces presented in Figure 88.

MINI-LINK 6651/2 provides the interfaces presented in Figure 89.

MINI-LINK 6651/3 provides the interfaces presented in Figure 90.

MINI-LINK 6651/4 provides the interfaces presented in Page 128.

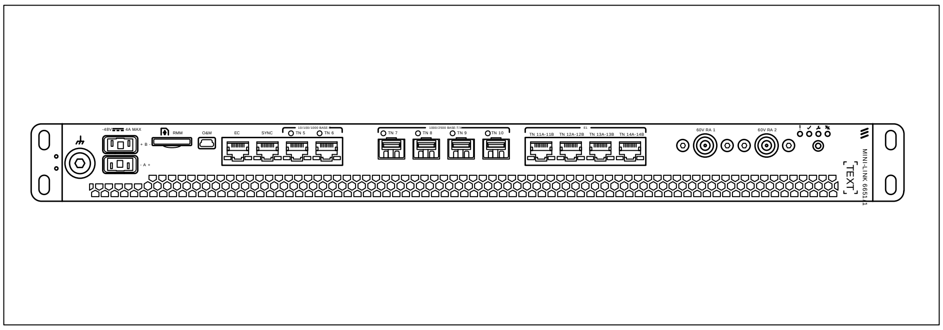


Figure 88 MINI-LINK 6651/1 Front Interfaces

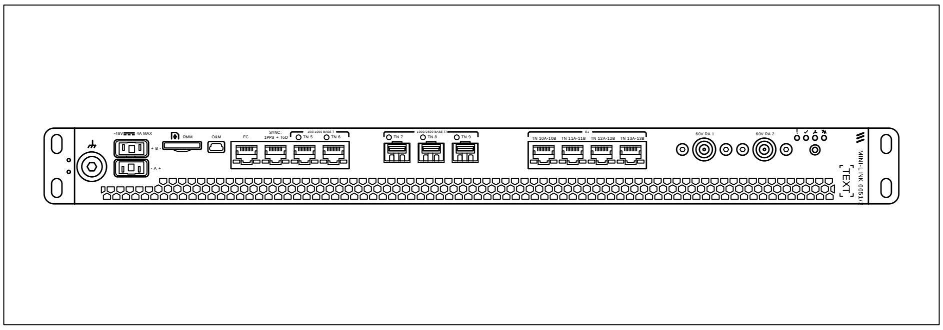


Figure 89 MINI-LINK 6651/2 Front Interfaces

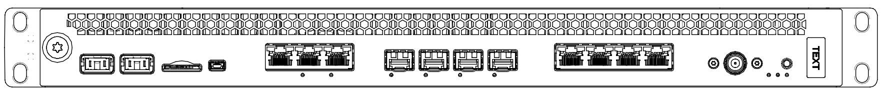


Figure 90 MINI-LINK 6651/3 Front Interfaces

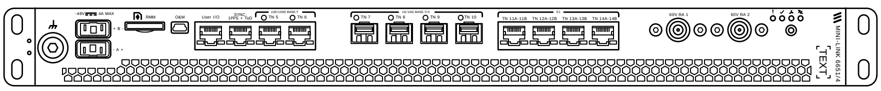


Figure 91 MINI-LINK 6651/4 Front Interfaces

PDH Traffic Interfaces

The front panel provides 8×E1 interfaces (4×(2×E1)) configured to 120 Ohm.

Note: Only E1s for ETSI are supported. No support is available for DS1s (ANSI) in MINI-LINK 6651.

Ethernet Traffic Interfaces

The front panel at MINI-LINK 6651/1 and MINI-LINK 6651/3 provides two fixed electrical 10/100/1000 BASE-T Ethernet interfaces and four 1000/2500BASE-T/X SFP+ interfaces. One of the fixed Ethernet ports can be configured as a site LAN port.

The front panel at MINI-LINK 6651/2 provides two fixed electrical 10/100/1000 BASE-T Ethernet interfaces and three 1000/2500BASE-T/X SFP+ interfaces. One of the fixed Ethernet ports can be configured as a site LAN port.

The front panel at MINI-LINK 6651/4 provides two fixed electrical 10/100/1000 BASE-T Ethernet interfaces and four 1000/10GBASE SFP/SFP+ interfaces. One of the fixed Ethernet ports can be configured as a site LAN port.

All 1000/2500BASE-T/X SFP+ interfaces are both electrical and optical.

The SFP/SFP+ cages can be equipped with Ericsson approved SFP/SFP+ modules, see MINI-LINK 6600 R1 Compatibility, Reference [1].

For the basic offering for MINI-LINK 6651, two Ethernet ports are enabled at the front. To get access to more ports, licenses are needed.

The high speed connections and the LAN ports enable MINI-LINK 6651 to aggregate traffic from multiple directions as well as dropping Ethernet traffic locally at the site.

MINI-LINK 6651 supports Packet Link WAN connections.

User Input/Output

Table 15 MINI-LINK 6651/4 User Input and Output Ports

Compact Node	Number of Input Signals	Number of Output Signals	Connector Type
MINI-LINK 6651/4	Two	One	RJ-45 connector

O&M Interface

A USB interface for an alternative MINI-LINK Node GUI connection is available.

RMM Interface

A SIM card slot is available for a Removable Memory Module (RMM).

Radio Interface

The front panel on MINI-LINK 6651/1, 6651/2, and 6651/4 provides two 60 V RAU connectors.

The front panel on MINI-LINK 6651/3 provides one 60 V RAU connector.

Note: The coaxial interface on modems and radios is equipped with built-in gas discharge tubes for lightning protection.

Adding components to this interface (for example, extra lightning protection) can impact function and performance and should only be considered after consulting with Ericsson.

Power

MINI-LINK 6651 provides two −48V DC connectors for power redundancy. Power redundancy is possible by using two external power sources, each of them connected to one of the two DC connectors on the MINI-LINK 6651 unit, through a dedicated power cable.

Radio Cables

The radio cables connecting the Radio with MINI-LINK 6651 are available in the following three diameters:

— Ø 7,6 mm, with lengths up to 100 m.

  This cable can be directly connected to the MINI-LINK 6651.

— Ø 10 mm, with lengths between 100 and 200 m.

— Ø 16 mm, with lengths between 200 and 400 m.

15.1.1 DC Supply Voltage

Normal service voltage range

The system is able to run at full operation in this range.

Abnormal service voltage range

No function is guaranteed, but no permanent damage will occur when operated in this range.

The system is restored to full operation when returning to normal service voltage range.

Table 16 DC Supply Voltage Ranges

Nominal voltage	−48 VDC
Normal service voltage range	−58.8 V to −40 V
Abnormal service voltage range	−60 V to −58.8 V −40 V to 0 V
Typical startup voltage	−44 V to −46 V
Typical shut-down voltage	−37.5 V to −39.5 V

15.1.2 Fan Unit

Note: MINI-LINK 6651/3 has no fan unit.

Air-cooling is provided by the Fan Unit, see Figure 92.

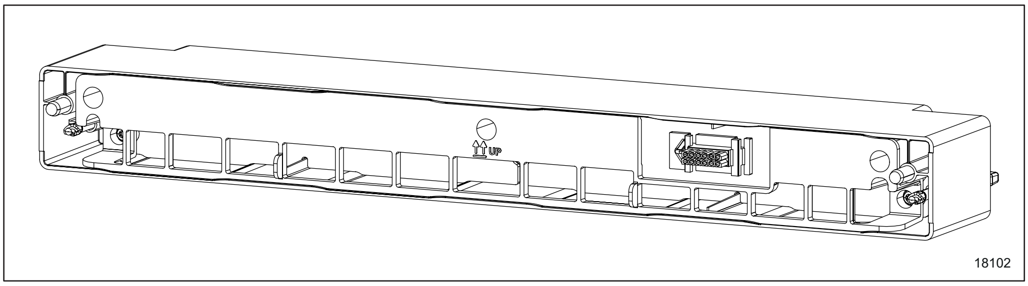


Figure 92 Fan Unit

The Fan Unit has an automatic fan speed control and houses four internal fans.

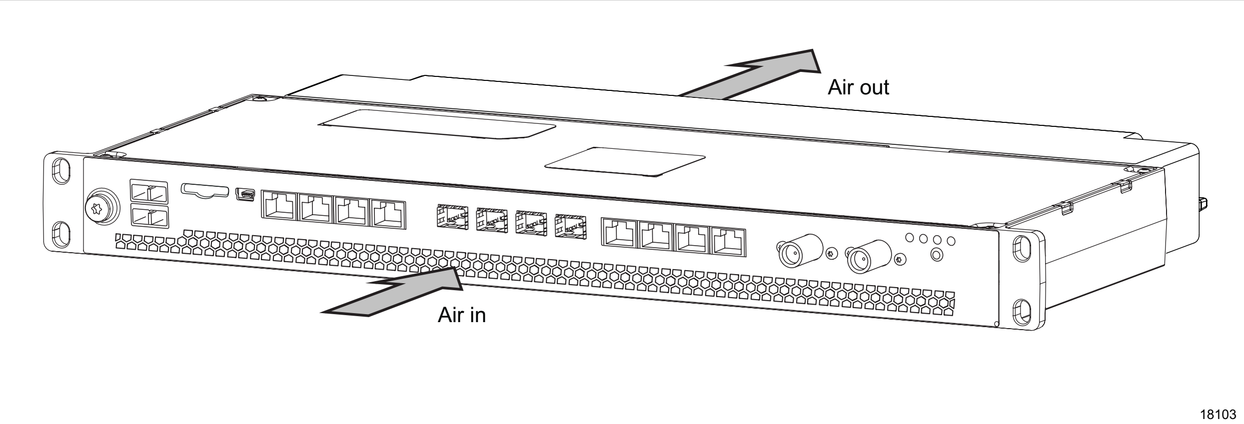


Figure 93 Cooling Airflow in MINI-LINK 6651

The air enters at the front of the MINI-LINK 6651 and exits at the back.

15.1.3 Traffic Capacities for MINI-LINK 6651

MINI-LINK 6651 is used for the traffic capacities specified in Table 17 and Table 18 (ETSI), or in Table 19 (ANSI).

Note: For ANSI, only Ethernet traffic is supported.

Table 17 Aggregated PDH and Ethernet Capacity for MINI-LINK 6651 Adaptive Physical Modes (ETSI)

Modulation	Capacity in Mbps						
	Channel Bandwidth						
	7 MHz	14 MHz	28 MHz	40 MHz	56 MHz	80 MHz	112 MHz
4 QAM STRONG	8	18	37	53	75	108	150
4 QAM	10	21	43	62	87	126	175
16 QAM STRONG	17	37	74	106	150	216	301
16 QAM	20	43	87	124	175	252	351

Modulation	Capacity in Mbps						
	Channel Bandwidth						
	7 MHz	14 MHz	28 MHz	40 MHz	56 MHz	80 MHz	112 MHz
32 QAM	26	54	109	156	220	317	441
64 QAM	32	68	136	195	276	397	553
128 QAM	38	80	161	231	326	469	653
256 QAM	44	92	186	266	377	541	754
512 QAM	47	99	198	284	402	577	804
512 QAM LIGHT	50	105	211	302	427	614	854
1024 QAM	53(1)	110	221	316	447	643	895
1024 QAM LIGHT	56(1)	116	233	334	472	679	945
2048 QAM	–	121(1)	243	347	491	706	983
2048 QAM LIGHT	–	127(1)	256	365	516	742	1033
4096 QAM	–	–	264	377	533	767(2)	1067(2)
4096 QAM LIGHT	–	–	276	395	558	803(2)(3)	–
8192 QAM (1)(3)(4)	–	–	283	405	–	–	–

(1) XPIC not supported.
(2) XPIC not supported on MINI-LINK 6651/1 and MINI-LINK 6651/3.
(3) Only supported by MINI-LINK 6651/2 and MINI-LINK 6651/4.
(4) 8192 QAM is not supported as static modulation. It is recommended to set radio output power to 0 dBm or higher.

Table 18 Maximum PDH Capacities for MINI-LINK 6651 Adaptive Physical Modes (ETSI)

Modulation	Capacity in E1s(1)						
	Channel Bandwidth						
	7 MHz	14 MHz	28 MHz	40 MHz	56 MHz	80 MHz	112 MHz
4 QAM STRONG	2×E1	6×E1	15×E1	23×E1	34×E1	40×E1	40×E1
4 QAM	3×E1	8×E1	18×E1	28×E1	40×E1	40×E1	40×E1
16 QAM STRONG	6×E1	15×E1	34×E1	40×E1	40×E1	40×E1	40×E1
16 QAM	7×E1	18×E1	39×E1	40×E1	40×E1	40×E1	40×E1
32 QAM	10×E1	24×E1	40×E1	40×E1	40×E1	40×E1	40×E1
64 QAM	13×E1	30×E1	40×E1	40×E1	40×E1	40×E1	40×E1
128 QAM	16×E1	36×E1	40×E1	40×E1	40×E1	40×E1	40×E1
256 QAM	19×E1	40×E1	40×E1	40×E1	40×E1	40×E1	40×E1
512 QAM	21×E1	40×E1	40×E1	40×E1	40×E1	40×E1	40×E1

Modulation	Capacity in E1s[1]						
	Channel Bandwidth						
	7 MHz	14 MHz	28 MHz	40 MHz	56 MHz	80 MHz	112 MHz
512 QAM LIGHT	22×E1	40×E1	40×E1	40×E1	40×E1	40×E1	40×E1
1024 QAM	23×E1[2]	40×E1	40×E1	40×E1	40×E1	40×E1	40×E1
1024 QAM LIGHT	25×E1[2]	40×E1	40×E1	40×E1	40×E1	40×E1	40×E1
2048 QAM	–	40×E1[2]	40×E1	40×E1	40×E1	40×E1	40×E1
2048 QAM LIGHT	–	40×E1[2]	40×E1	40×E1	40×E1	40×E1	40×E1
4096 QAM	–	–	40×E1	40×E1	40×E1	40×E1	40×E1
4096 QAM LIGHT	–	–	40×E1	40×E1	40×E1	40×E1[3]	–
8192 QAM[3]	–	–	40×E1[4]	40×E1[4]	–	–	–

(1) The table shows the capacity for MINI-LINK 6651/2. The capacities for MINI-LINK 6651/1 and 6651/3 are limited to 8×E1. The capacity for MINI-LINK6651/4 is limited to 16xE1.
(2) XPIC not supported.
(3) Only supported by MINI-LINK 6651/2 and MINI-LINK 6651/4.
(4) 8192 QAM is not supported as minimum modulation.

Table 19 Ethernet Capacity for MINI-LINK 6651 Adaptive Physical Modes (ANSI)

Modulation	Capacity in Mbps									
	Channel Bandwidth									
	10 MHz	20 MHz	28 MHz	30 MHz	40 MHz	50 MHz	56 MHz	60 MHz	80 MHz	112 MHz
4 QAM STRONG	12	26	37	39	53	67	75	81	108	150
4 QAM	14	30	43	46	62	78	87	94	126	175
16 QAM STRONG	25	52	74	79	107	135	150	162	216	301
16 QAM	29	61	87	93	125	157	175	189	252	351
32 QAM	36	77	109	116	157	197	220	237	317	441
64 QAM	46	96	136	146	197	247	276	297	397	553
128 QAM	54	114	161	173	233	292	326	351	469	653
256 QAM	63	131	186	199	268	337	377	405	541	754
512 QAM	67	140	198	213	286	360	402	432	577	804

Modulation	Capacity in Mbps									
	Channel Bandwidth									
	10 MHz	20 MHz	28 MHz	30 MHz	40 MHz	50 MHz	56 MHz	60 MHz	80 MHz	112 MHz
512 QAM LIGHT	71	149	211	226	304	382	427	459	614	854
1024 QAM	74[1]	156	221	237	319	400	447	481	643	895
1024 QAM LIGHT	79[1]	165	233	250	337	423	472	508	679	945
2048 QAM	–	171	243	260	350	440	491	528	706	983
2048 QAM LIGHT	–	180	256	273	368	462	516	555	742	1033
4096 QAM	–	–	264	282	380	477	533	574	767[2]	1067[2]
4096 QAM LIGHT	–	–	276	296	398	500	558	601	803[2][3]	–
8192 QAM[1][3][4]	–	–	–	304	409	–	–	–	–	–

(1) XPIC not supported.

(2) XPIC not supported by MINI-LINK 6651/1 and MINI-LINK 6651/3.

(3) Only supported by MINI-LINK 6651/2 and MINI-LINK 6651/4.

(4) 8192 QAM is not supported as static modulation. It is recommended to set radio output power to 0 dBm or higher.

15.1.4 Hardware Handling

The system offers several functions for easy operation and maintenance.

— The configuration file is stored non-volatile on the RMM, and can also be backed up and restored using a local or central FTP server. The RMM storage thus enables replacement without using an FTP server.

— When a radio is replaced, no new setup has to be performed.

— Various restarts can be ordered from the management system. A cold restart can be initiated for an NE, and this type of restart disturbs the traffic. A warm restart restarts the control system and does not affect the traffic, which is possible due to the separated control and traffic system.

— MINI-LINK 6651 is equipped with temperature sensors. Overheated parts that exceed limit thresholds, are put in out of service by the control system. This is to avoid hardware failures in case of over-temperature, for example, due to a fan failure or an ambient temperature that is too high. The MINI-LINK 6651 is automatically returned to normal operation when the temperature is below the high threshold level.

There are two thresholds:

- The high temperature threshold:

  The MINI-LINK 6651 raises a temperature alarm (critical). The MINI-LINK 6651 is still in full operation.

- The excessive temperature threshold:

  The MINI-LINK 6651 shuts down (out of service).

— Access to inventory data like software and hardware product number, serial number, and version. User defined asset identification is supported, enabling tracking of hardware.

— Ethernet SFPs can be replaced with minimal user intervention, without de-configuring port properties.

15.1.5 Ethernet Switch

The Ethernet switch functionality is shown in Table 20.

Table 20 Ethernet Switch Functionality

Modes	Port roles	Comment
Provider Bridge mode	CE-UNI	CEP, including default mapping rule
	CN-UNI	CNP
	I-NNI	–
Customer Bridge mode	UNI	Including QinQ termination, default mapping rule
	NNI	–

The switch is a managed VLAN switch (IEEE 802.1Q and IEEE 802.1D) and supports Provider mode (IEEE 802.1ad) and Customer mode (IEEE 802.1Q) switching.

The switch supports Jumbo frames. The Ethernet site LAN ports on MINI-LINK 6651 have interfaces that support auto-negotiation 10/100/1000/2500 Mbps and 10Gbps speed. The interfaces are physical RJ-45 or SFP connectors.

15.1.6 Ethernet LAN Ports

The Ethernet LAN ports are described in Table 21.

Table 21 Ethernet LAN Ports

Functionality	Description
Interface types	10/100/1000/2500 Mbps 2.5/10 Gbps Auto negotiation or manual setting (IEEE802.3-2005).
Duplex mode	Full duplex. Auto negotiation or manual setting (IEEE802.3-2005).
Connectors/cables	RJ-45 with MDI/MDIX support for all electrical i/f. Single/multi-mode fiber with LC connector for the optical i/f.
SFP modules	SFP/SFP+ plug-in modules are supported with 1 Gbps, 2.5 Gbps, and 10 Gbps optical and 100/1000 Mbps electrical interfaces. For more information regarding SFP/SFP+, see MINI-LINK 6600 R1 Compatibility, Reference [1].
LED indicators	Each Ethernet interface has one green LED for network link indication.
Standard frame sizes	Up to 2000 bytes when used as an external interface (IEEE802.3as-2006). Up to 2048 bytes when used as an internal interface.
Jumbo frames	9,216 byte frame size for data applications.
Buffer capacity	Ethernet ports share a 180 MB buffering capacity. The buffer capacity sharing among the traffic queues is based on a fair adaptive dynamic algorithm.
Flow control	MINI-LINK 6651 supports the IEEE 802.3x standard to handle temporary congestion on ports configured as Layer 2 connections (connected to the switch). MINI-LINK 6651 only supports asymmetrical flow control. When a congestion threshold is reached in an NE downstream, the NE generates a PAUSE signal and MINI-LINK 6651 temporarily halts the transmission of Ethernet frames, but MINI-LINK 6651 cannot generate PAUSE signals to control the transmission process on connected equipment.

15.2 MINI-LINK 6654

MINI-LINK 6654 supports Ethernet (packet link), PDH, and a mix thereof in a Hybrid Radio Link sending Ethernet and PDH traffic simultaneously.

It consists of a rack, Enclosure 1401, that must be equipped with a fan, FAU 1401, and a PNM board, either PNM 1001 or PNM 1002.

MINI-LINK 6654 can also be equipped with up to two MMU 1001/1002, two LTU 1001/1002, two ETU 1001/1002, or a combination thereof, see Figure 94.

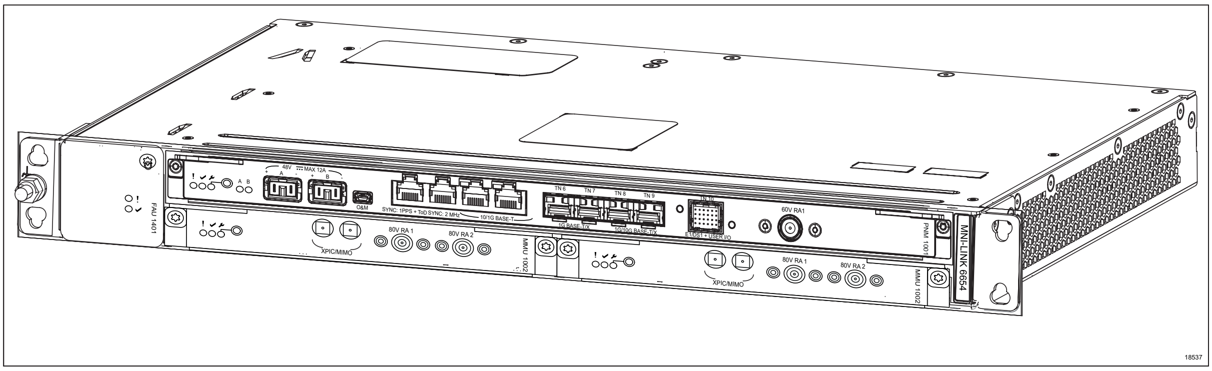


Figure 94   MINI-LINK 6654

Unused slots in MINI-LINK 6654 must be equipped with Dummy Units, as this is essential to maintain the cooling within the magazines and to meet EMC requirements.

MINI-LINK 6654 can be fitted in a standard 19" or metric rack. The height of a MINI-LINK 6654 is 1U, see Figure 95.

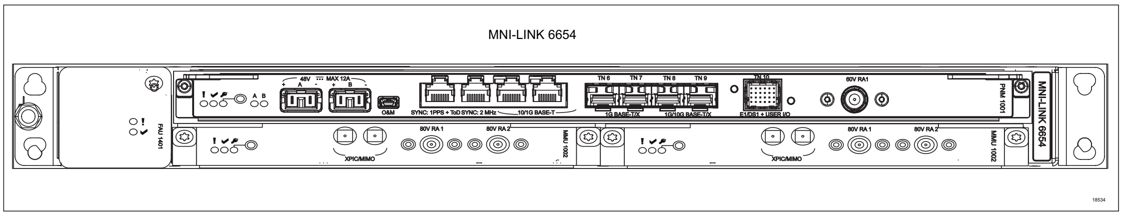


Figure 95   Front interfaces on the MINI-LINK 6654

The following slots are paired in MINI-LINK 6654:

— Slot 1 and Slot 3

Figure 96 shows the paired slots in MINI-LINK 6654.

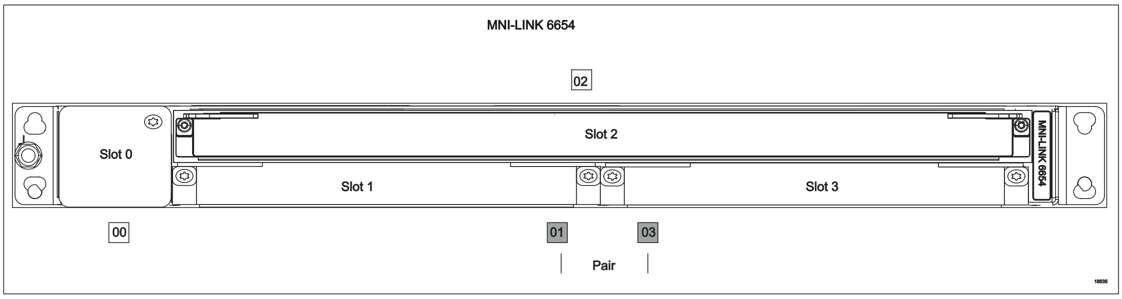


Figure 96   Interconnected slots in MINI-LINK 6654

15.2.1 PNM 1001

PNM 1001 is a board that is combo solution for PFU (Power-Filtering-Unit), NPU (Node-Processor-Unit) and MMU (Modem Unit), see Figure 97.

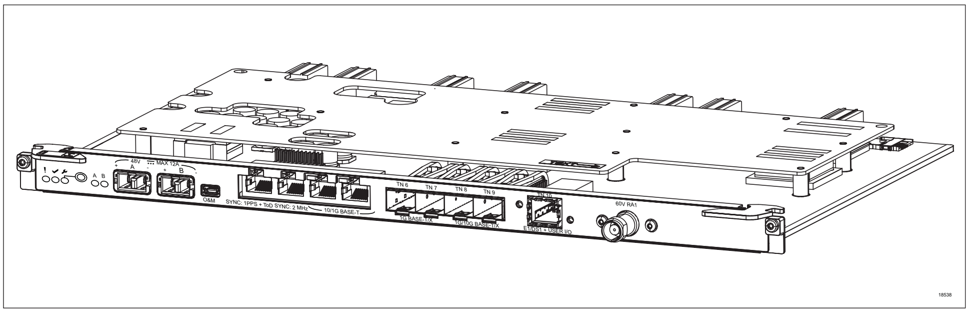


Figure 97 PNM 1001

The Modem part of PNM 1001 is a single carrier modem supporting single WAN (1+0). For modem capability please refer to MMU 1001 performance in 1+0.

PDH Traffic Interfaces

4×E1/DS1

User I/O (two users in, one user out)

Ethernet Traffic Interfaces

2×Electrical (10M/100M/1G)

2×SFP (1G)

2×SFP+ (1G/10G)

Sync Interfaces

1×2 MHz

1×1PPS+ToD

O&M Interface

1×USB interface for an alternative MINI-LINK Node GUI connection is available.

Radio Interface

1×60 V RAU connector.

Note: The coaxial interface on modems and radios is equipped with built-in gas discharge tubes for lightning protection.

Adding components to this interface (for example, extra lightning protection) can impact function and performance and should only be considered after consulting with Ericsson.

Power

2×−48V DC connectors for power redundancy.

Figure 98 shows the interfaces on the PNM 1001.

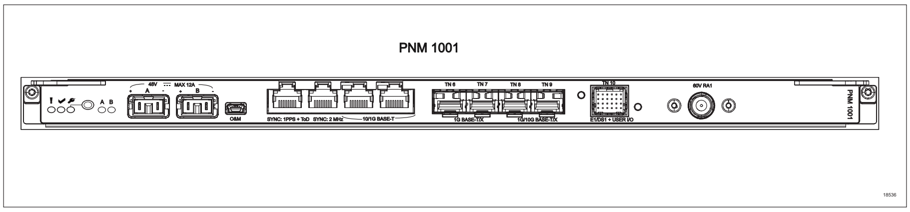


Figure 98 Front Interfaces on the PNM 1001

15.2.1.1 User Input/Output

The User Input ports can be used to connect user alarms to MINI-LINK Node GUI. Applications like fire alarms, burglar alarms, and low power indicators are easily implemented using these input ports. The User Input ports can be configured to be normally opened or closed.

The User Output ports can be used to export summary alarms of the accumulated severity in the NE to the supervision system of other equipment. The User Output ports can be controlled by the operator or triggered by one or several alarm severities.

Table 22 PNM 1001 User Input and Output Ports

Plug-In Unit	Number of Input Signals	Number of Output Signals	Connector Type
PNM 1001	Two	One	Male 24 pin SOFIX connector

15.2.1.2 Traffic Capacities for PNM 1001

PNM 1001 is used for the traffic capacities specified in Table 23 and Table 24 (ETSI), or Table 25 and Table 26 (ANSI).

Table 23 Aggregated PDH and Ethernet Capacity for PNM1001 Adaptive Physical Modes (ETSI)

Modulation	Capacity in Mbps						
	Channel Bandwidth						
	7 MHz	14 MHz	28 MHz	40 MHz	56 MHz	80 MHz	112 MHz
4 QAM STRONG	8	19	37	53	75	108	151
4 QAM	10	21	44	62	88	126	176
16 QAM STRONG	18	37	75	107	151	217	302
16 QAM	21	43	87	124	176	253	352
32 QAM	26	54	109	156	221	317	441
64 QAM	33	68	137	196	277	397	553
128 QAM	39	81	162	231	327	470	654
256 QAM	45	93	186	267	377	542	754
512 QAM	48	99	199	285	402	578	804
512 QAM LIGHT	51	105	211	302	427	614	855
1024 QAM	53(1)	110	221	317	448	643	895
1024 QAM LIGHT	56(1)	117	234	335	473	679	946
2048 QAM	–	121(1)	243	348	492	706	983
2048 QAM LIGHT	–	127(1)	256	366	517	742	1033
4096 QAM	–	–	264	378	534	767(1)	1068(1)
4096 QAM LIGHT	–	–	276	395	559	–	–
8192 QAM	–	–	–	–	–	–	–

(1) XPIC feature not supported by HW.

Table 24 Maximum PDH Capacities for PNM 1001 Adaptive Physical Modes (ETSI)

Modulation	Capacity in E1s						
	Channel Bandwidth						
	7 MHz	14 MHz	28 MHz	40 MHz	56 MHz	80 MHz	112 MHz
4 QAM STRONG	2×E1	6×E1	15×E1	23×E1	34×E1	49×E1	70×E1
4 QAM	3×E1	8×E1	18×E1	28×E1	40×E1	58×E1	80×E1
16 QAM STRONG	6×E1	15×E1	34×E1	49×E1	70×E1	80×E1	80×E1
16 QAM	7×E1	18×E1	33×E1	57×E1	71×E1	80×E1	80×E1
32 QAM	10×E1	24×E1	50×E1	73×E1	80×E1	80×E1	80×E1
64 QAM	13×E1	30×E1	63×E1	80×E1	80×E1	80×E1	80×E1

Modulation	Capacity in E1s						
	Channel Bandwidth						
	7 MHz	14 MHz	28 MHz	40 MHz	56 MHz	80 MHz	112 MHz
128 QAM	16×E1	36×E1	75×E1	80×E1	80×E1	80×E1	80×E1
256 QAM	19×E1	42×E1	80×E1	80×E1	80×E1	80×E1	80×E1
512 QAM	21×E1	45×E1	80×E1	80×E1	80×E1	80×E1	80×E1
512 QAM LIGHT	22×E1	48×E1	80×E1	80×E1	80×E1	80×E1	80×E1
1024 QAM	23×E1(1)	51×E1	80×E1	80×E1	80×E1	80×E1	80×E1
1024 QAM LIGHT	25×E1(1)	54×E1	80×E1	80×E1	80×E1	80×E1	80×E1
2048 QAM	–	56×E1(1)	80×E1	80×E1	80×E1	80×E1	80×E1
2048 QAM LIGHT	–	59×E1(1)	80×E1	80×E1	80×E1	80×E1	80×E1
4096 QAM	–	–	80×E1	80×E1	80×E1	80×E1(1)	80×E1(1)
4096 QAM LIGHT	–	–	80×E1	80×E1	80×E1	–	–
8192 QAM	–	–	–	–	–	–	–

(1) XPIC feature not supported by HW.

Table 25 Aggregated PDH and Ethernet Capacity for PNM 1001 Adaptive Physical Modes (ANSI)

Modulation	Capacity in Mbps									
	Channel Bandwidth									
	10 MHz	20 MHz	28 MHz	30 MHz	40 MHz	50 MHz	56 MHz	60 MHz	80 MHz	112 MHz
4 QAM STRONG	13	26	37	40	54	68	75	81	108	150
4 QAM	15	31	43	47	63	79	87	95	126	175
16 QAM STRONG	25	53	74	80	108	135	150	162	217	301
16 QAM	29	61	87	93	126	158	175	189	253	351
32 QAM	37	77	109	117	157	198	220	237	317	441
64 QAM	46	97	136	147	197	248	276	297	397	553
128 QAM	55	114	161	173	233	293	326	352	470	653
256 QAM	63	132	186	200	269	338	377	406	542	754
512 QAM	67	140	198	213	287	360	402	432	578	804

Modulation	Capacity in Mbps									
	Channel Bandwidth									
	10 MHz	20 MHz	28 MHz	30 MHz	40 MHz	50 MHz	56 MHz	60 MHz	80 MHz	112 MHz
512 QAM LIGHT	71	149	211	226	305	383	427	460	614	854
1024 QAM	75(1)	156	221	237	319	401	447	482	643	895
1024 QAM LIGHT	79(1)	165	233	251	337	423	472	509	679	946
2048 QAM	–	172	243	260	351	440	491	529	706	983
2048 QAM LIGHT	–	180	256	274	369	463	516	556	742	1033
4096 QAM	–	–	264	283	381	478	533	574	767(1)	1067(1)
4096 QAM LIGHT	–	–	276	296	398	500	558	601	–	–
8192 QAM	–	–	–	–	–	–	–	–	–	–

(1) XPIC feature not supported by HW.

Table 26 Maximum PDH Capacities for PNM 1001 Adaptive Physical Modes (ANSI)

Modulation	Capacity in DS1s									
	Channel Bandwidth									
	10 MHz	20 MHz	28 MHz	30 MHz	40 MHz	50 MHz	56MHz	60 MHz	80 MHz	112 MHz
4 QAM STRONG	5×DS1	14×DS1	21×DS1	23×DS1	32×DS1	40×DS1	45×DS1	49×DS1	66×DS1	80×DS1
4 QAM	7×DS1	17×DS1	25×DS1	27×DS1	37×DS1	47×DS1	54×DS1	58×DS1	78×DS1	80×DS1
16 QAM STRONG	13×DS1	31×DS1	45×DS1	48×DS1	66×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
16 QAM	16×DS1	36×DS1	53×DS1	57×DS1	77×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
32 QAM	21×DS1	46×DS1	67×DS1	72×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
64 QAM	27×DS1	59×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
128 QAM	32×DS1	70×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
256 QAM	37×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
512 QAM	40×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1

Modulation	Capacity in DS1s									
	Channel Bandwidth									
	10 MHz	20 MHz	28 MHz	30 MHz	40 MHz	50 MHz	56MHz	60 MHz	80 MHz	112 MHz
512 QAM LIGHT	43×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
1024 QAM	45×DS1(1)	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
1024 QAM LIGHT	48×DS1(1)	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
2048 QAM	–	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
2048 QAM LIGHT	–	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
4096 QAM	–	–	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1(1)	80×DS1(1)
4096 QAM LIGHT	–	–	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	–	–
8192 QAM	–	–	–	–	–	–	–	–	–	–

(1) XPIC feature not supported by HW.

15.2.2 PNM 1002

PNM 1002 is a board that is combo solution for PFU (Power-Filtering-Unit), NPU (Node-Processor-Unit) and MMU (Modem Unit), see Figure 99.

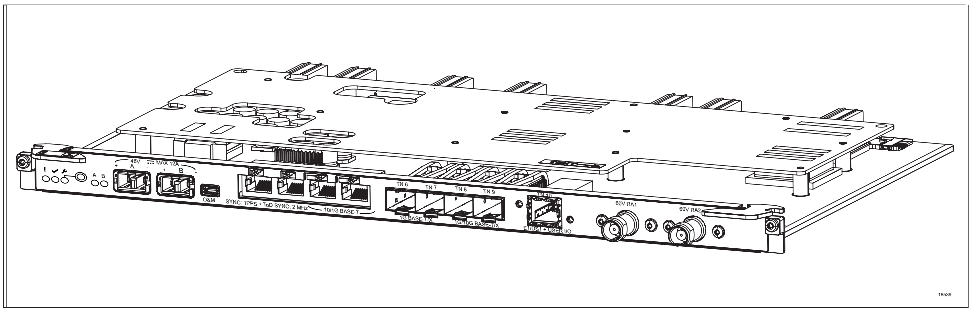


Figure 99 PNM 1002

The Modem part of PNM 1002 is a Dual carrier modem supporting dual WAN 1+0/2+0/1+1 and Dual WAN 2×(1+0). For modem capability please refer to MMU 1002 performance on a single modem.

PDH Traffic Interfaces

4×E1/DS1

User I/O (two users in, one user out)

Ethernet Traffic Interfaces

2×10M/100M/1G (Electrical)

2×1G SFP

2×1G/10GSFP+

Sync Interfaces

1×2 MHz

1×1PPS+ToD

O&M Interface

1×USB interface for an alternative MINI-LINK Node GUI connection is available.

Radio Interfaces

2×60 V RAU connector.

Note: The coaxial interface on modems and radios is equipped with built-in gas discharge tubes for lightning protection.

Adding components to this interface (for example, extra lightning protection) can impact function and performance and should only be considered after consulting with Ericsson.

Power

2×−48V DC connectors for power redundancy.

Figure 100 shows the interfaces on the PNM 1002.

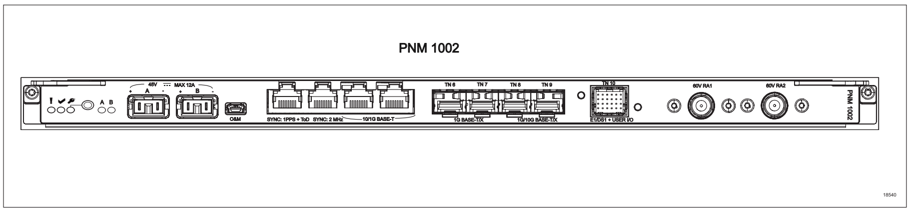


Figure 100 Front Interfaces of PNM 1002

15.2.2.1 User Input/Output

The User Input ports can be used to connect user alarms to MINI-LINK Node GUI. Applications like fire alarms, burglar alarms, and low power indicators are easily implemented using these input ports. The User Input ports can be configured to be normally opened or closed.

The User Output ports can be used to export summary alarms of the accumulated severity in the NE to the supervision system of other equipment. The User Output ports can be controlled by the operator or triggered by one or several alarm severities.

Table 27 PNM 1002 User Input and Output Ports

Plug-In Unit	Number of Input Signals	Number of Output Signals	Connector Type
PNM 1002	Two	One	Male 24 pin SOFIX connector

15.2.2.2 Traffic Capacities for PNM 1002

Table 28 Aggregated PDH and Ethernet Capacity for PNM 1002 Adaptive Physical Modes (ETSI)

Modulation	Capacity in Mbps						
	Channel Bandwidth						
	7 MHz	14 MHz	28 MHz	40 MHz	56 MHz	80 MHz	112 MHz
4 QAM STRONG	8	18	37/36 (1)	53	75/73 (1)	108	150
4 QAM	10	21	43/42 (1)	62	87/86 (1)	126	175
16 QAM STRONG	17	37	74/72 (1)	106	150/146 (1)	216	301
16 QAM	20	43	87/85 (1)	124	175/171 (1)	252	351
32 QAM	26	54	109/109 (1)	156	220/219 (1)	317	441
64 QAM	32	68	136/133 (1)	195	276/268 (1)	397	553
128 QAM	38	80	161/157 (1)	231	326/317 (1)	469	653
256 QAM	44	92	186/182 (1)	266	377/366 (1)	541	754
512 QAM	47	99	198/194 (1)	284	402/390 (1)	577	804
512 QAM LIGHT	50	105	211/206 (1)	302	427/415 (1)	614	854
1024 QAM	53 (2)	110	221	316	447/435 (1)	643	895
1024 QAM LIGHT	56 (2)	116	233	334	472/459 (1)	679	945
2048 QAM	–	121 (2)	243	347	491	706	983
2048 QAM LIGHT	–	127 (2)	256	365	516	742	1033

Modulation	Capacity in Mbps						
	Channel Bandwidth						
	7 MHz	14 MHz	28 MHz	40 MHz	56 MHz	80 MHz	112 MHz
4096 QAM	–	–	264	377	533	767	1067
4096 QAM LIGHT	–	–	276	395	558	803	–
8192 QAM[(2)(3)]	–	–	283	405	–	–	–

(1) MIMO supported. Smaller capacity applies for MIMO configuration.
(2) XPIC not supported.
(3) 8192 QAM is not supported as static modulation. It is recommended to set radio output power to 0 dBm or higher.

Table 29 Maximum PDH Capacities for PNM 1002 Adaptive Physical Modes (ETSI)

Modulation	Capacity in E1s[(1)]						
	Channel Bandwidth						
	7 MHz	14 MHz	28 MHz	40 MHz	56 MHz	80 MHz	112 MHz
4 QAM STRONG	2×E1	6×E1	15×E1/15×E1[(2)]	23×E1	34×E1/33×E1[(2)]	47×E1	70×E1
4 QAM	3×E1	8×E1	18×E1/18×E1[(2)]	28×E1	40×E1/39×E1[(2)]	56×E1	80×E1
16 QAM STRONG	6×E1	15×E1	34×E1/33×E1[(2)]	49×E1	70×E1/68×E1[(2)]	80×E1	80×E1
16 QAM	7×E1	18×E1	39×E1/38×E1[(2)]	57×E1	80×E1/80×E1[(2)]	80×E1	80×E1
32 QAM	10×E1	24×E1	50×E1/50×E1[(2)]	73×E1	80×E1/80×E1[(2)]	80×E1	80×E1
64 QAM	13×E1	30×E1	63×E1/62×E1[(2)]	80×E1	80×E1/80×E1[(2)]	80×E1	80×E1
128 QAM	16×E1	36×E1	75×E1/74×E1[(2)]	80×E1	80×E1/80×E1[(2)]	80×E1	80×E1
256 QAM	19×E1	42×E1	80×E1/80×E1[(2)]	80×E1	80×E1/80×E1[(2)]	80×E1	80×E1
512 QAM	21×E1	45×E1	80×E1/80×E1[(2)]	80×E1	80×E1/80×E1[(2)]	80×E1	80×E1
512 QAM LIGHT	22×E1	48×E1	80×E1/80×E1[(2)]	80×E1	80×E1/80×E1[(2)]	80×E1	80×E1
1024 QAM	23×E1[(3)]	51×E1	80×E1	80×E1	80×E1/80×E1[(2)]	80×E1	80×E1
1024 QAM LIGHT	25×E1[(3)]	54×E1	80×E1	80×E1	80×E1/80×E1[(2)]	80×E1	80×E1
2048 QAM	–	56×E1[(3)]	80×E1	80×E1	80×E1	80×E1	80×E1
2048 QAM LIGHT	–	59×E1[(3)]	80×E1	80×E1	80×E1	80×E1	80×E1
4096 QAM	–	–	80×E1	80×E1	80×E1	80×E1	80×E1

Modulation	Capacity in E1s[1]						
	Channel Bandwidth						
	7 MHz	14 MHz	28 MHz	40 MHz	56 MHz	80 MHz	112 MHz
4096 QAM LIGHT	–	–	80×E1	80×E1	80×E1	80×E1	80×E1
8192 QAM[3]	–	–	80×E1[4]	80×E1[4]	–	–	–

(1) The table shows the maximum capacity values for one direction. When the NE is configured for two directions, the capacity decreases to half of these values.
(2) MIMO supported. Smaller capacity applies for MIMO configuration.
(3) XPIC not supported.
(4) 8192 QAM is not supported as a minimum modulation.

Table 30 Aggregated PDH and Ethernet Capacity for PNM 1002 Adaptive Physical Modes (ANSI)

Modulation	Capacity in Mbps									
	Channel Bandwidth									
	10 MHz	20 MHz	28 MHz	30 MHz	40 MHz	50 MHz	56 MHz	60 MHz	80 MHz	112 MHz
4 QAM STRONG	12	26	37	39/39,0[1]	53/52,4[1]	67	75	81	108	150
4 QAM	14	30	43	46/45,8[1]	62/61,5[1]	78	87	94	126	175
16 QAM STRONG	25	52	74	79/78,0[1]	107/104,7[1]	135	150	162	216	301
16 QAM	29	61	87	93/91,0[1]	125/122,2[1]	157	175	189	252	351
32 QAM	36	77	109	116/117,0[1]	157/157,1[1]	197	220	237	317	441
64 QAM	46	96	136	146/143,0[1]	197/192,0[1]	247	276	297	397	553
128 QAM	54	114	161	173/169,0[1]	233/226,9[1]	292	326	351	469	653
256 QAM	63	131	186	199/195,0[1]	268/261,9[1]	337	377	405	541	754
512 QAM	67	140	198	213/208,0[1]	286/279,3[1]	360	402	432	577	804
512 QAM LIGHT	71	149	211	226/221,0[1]	304/296,8[1]	382	427	459	614	854
1024 QAM	74[2]	156	221	237	319	400	447	481	643	895
1024 QAM LIGHT	79[2]	165	233	250	337	423	472	508	679	945
2048 QAM	–	171	243	260	350	440	491	528	706	983

Modulation	Capacity in Mbps									
	Channel Bandwidth									
	10 MHz	20 MHz	28 MHz	30 MHz	40 MHz	50 MHz	56 MHz	60 MHz	80 MHz	112 MHz
2048 QAM LIGHT	–	180	256	273	368	462	516	555	742	1033
4096 QAM	–	–	264	282	380	477	533	574	767(2)	1067(2)
4096 QAM LIGHT	–	–	276	296	398	500	558	601	803	–
8192 QAM(2)(3)	–	–	–	304	409	–	–	–	–	–

(1) MIMO supported. The second capacity applies for MIMO configuration.

(2) XPIC not supported.

(3) 8192 QAM is not supported as static modulation. It is recommended to set radio output power to 0 dBm or higher.

Table 31 Maximum PDH Capacities for PNM 1002 Adaptive Physical Modes (ANSI)

Modulation	Capacity in DS1s(1)									
	Channel Bandwidth									
	10 MHz	20 MHz	28MHz	30 MHz	40 MHz	50 MHz	56 MHz	60 MHz	80 MHz	112 MHz
4 QAM STRONG	5×DS1	14×DS1	21×DS1	23×DS1/22×DS1(2)	32×DS1/31×DS1(2)	40×DS1	45×DS1	49×DS1	66×DS1	80×DS1
4 QAM	7×DS1	17×DS1	25×DS1	27×DS1/26×DS1(2)	37×DS1/36×DS1(2)	47×DS1	54×DS1	58×DS1	78×DS1	80×DS1
16 QAM STRONG	13×DS1	31×DS1	45×DS1	48×DS1/47×DS1(2)	66×DS1/64×DS1(2)	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
16 QAM	16×DS1	36×DS1	53×DS1	57×DS1/55×DS1(2)	77×DS1/75×DS1(2)	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
32 QAM	21×DS1	46×DS1	67×DS1	72×DS1/72×DS1(2)	80×DS1/80×DS1(2)	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
64 QAM	27×DS1	59×DS1	80×DS1	80×DS1/80×DS1(2)	80×DS1/80×DS1(2)	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
128 QAM	32×DS1	70×DS1	80×DS1	80×DS1/80×DS1(2)	80×DS1/80×DS1(2)	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1

Modulation	Capacity in DS1s[1]									
	Channel Bandwidth									
	10 MHz	20 MHz	28MHz	30 MHz	40 MHz	50 MHz	56 MHz	60 MHz	80 MHz	112 MHz
256 QAM	37×DS1	80×DS1	80×DS1	80×DS1/80×DS1[2]	80×DS1/80×DS1[2]	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
512 QAM	40×DS1	80×DS1	80×DS1	80×DS1/80×DS1[2]	80×DS1/80×DS1[2]	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
512 QAM LIGHT	43×DS1	80×DS1	80×DS1	80×DS1/80×DS1[2]	80×DS1/80×DS1[2]	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
1024 QAM	45×DS1[3]	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
1024 QAM LIGHT	48×DS1[3]	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
2048 QAM	–	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
2048 QAM LIGHT	–	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
4096 QAM	–	–	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1[3]	80×DS1[3]
4096 QAM LIGHT	–	–	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	–	–
8192 QAM[2]	–	–	–	80×DS1[4]	80×DS1[4]	–	–	–	–	–

(1) The table shows the maximum capacity values for one direction. When the NE is configured for two directions, the capacity decreases to half of these values.
(2) MIMO supported. Smaller capacity applies for MIMO configuration.
(3) XPIC not supported.
(4) 8192 QAM is not supported as minimum modulation.

15.2.3 Enclosure 1401

Enclosure 1401 supports both Ethernet and PDH traffic simultaneously.

The Ethernet capacity is 2×2.5G for each APU slot.

15.2.4 Input Voltage Behavior

Figure 101 shows the input voltage behavior for MINI-LINK 6654. The different units turn on and off at different voltages.

To prevent the units from turning on and off repeatedly around a threshold (so called power flapping), there is a hysteresis for all units.

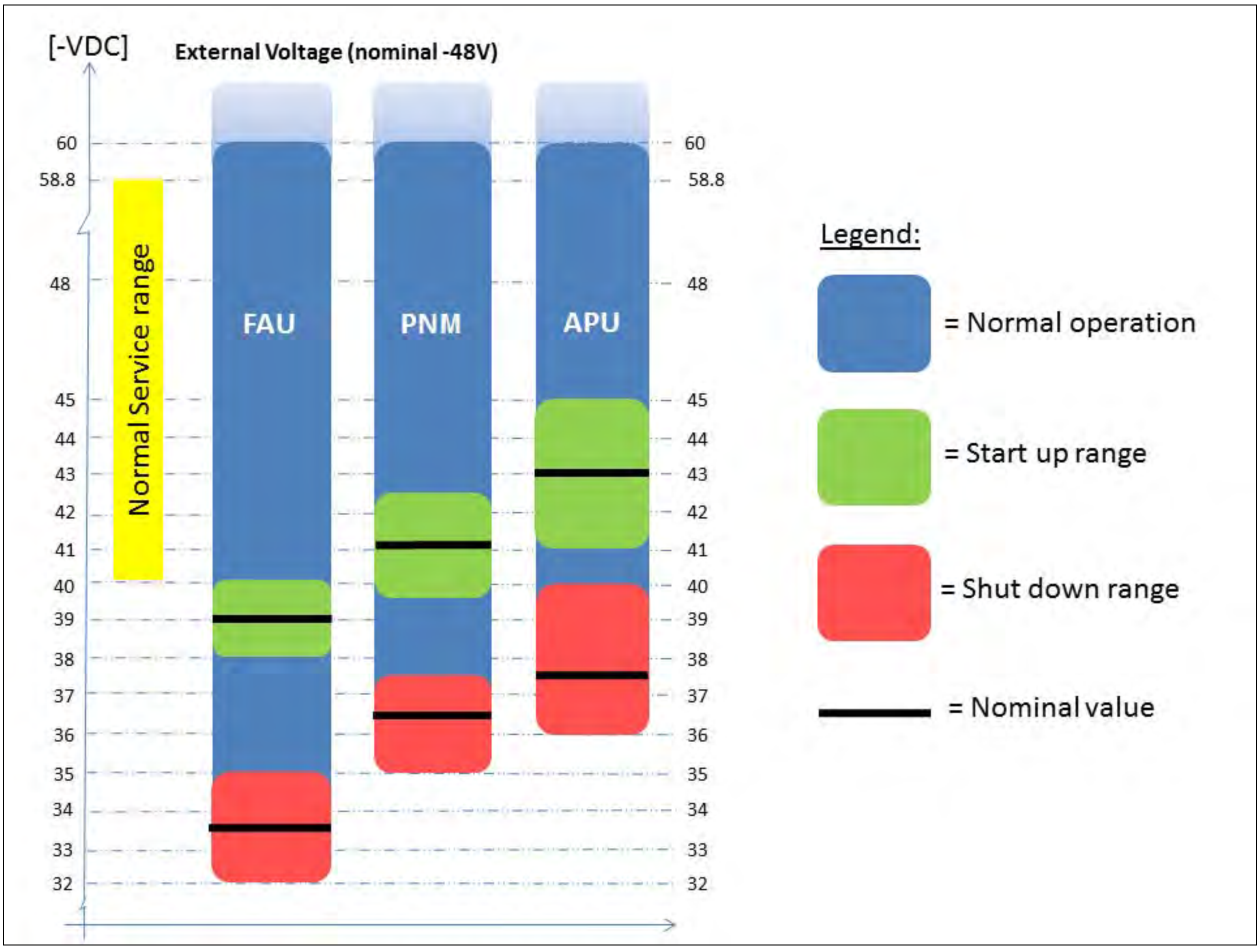


Figure 101 Start and Stop Voltages

15.3 MINI-LINK 6655

MINI-LINK 6655 supports Ethernet (packet link), PDH, and a mix thereof in a Hybrid Radio Link sending Ethernet and PDH traffic simultaneously.

It consists of a rack, Enclosure 1501, that must be equipped with a fan, FAU 1501, and a PNM board, PNM 1002. For the description of PNM 1002, see Section 15.2.2 on page 143.

MINI-LINK 6655 can also be equipped with up to four MMU 1001/1002, four LTU 1001/1002, four ETU 1001/1002, or a combination thereof.

Unused slots in MINI-LINK 6655 must be equipped with Dummy Units, as this is essential to maintain the cooling within the magazines and to meet EMC requirements.

MINI-LINK 6655 can be fitted in a standard 19" or metric rack. The height of a MINI-LINK 6655 is 1.5U, see Figure 102.

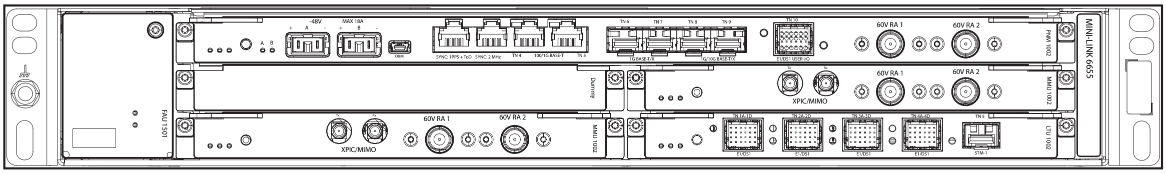


Figure 102 Front interfaces on the MINI-LINK 6655

The following slots are paired in MINI-LINK 6655:

— Slot 1 and Slot 2

— Slot 4 and Slot 5

15.3.1 Enclosure 1501

Enclosure 1501 supports both Ethernet and PDH traffic simultaneously.

The MMUs, LTUs and ETUs are placed in the Application Plug-in Unit (APU) slots, that is, slots 1–2 and 4–5. The available traffic capacity is dependent on the board types and their position in the enclosure. Traffic capacities are shown in Table 32.

Table 32 Enclosure 1501 Ethernet Capacities

Slot	Ethernet Capacity with PNM 1002 [Gbps]
5	1×2.5
4	1×2.5
2	2×2.5
1	2×2.5

15.3.2 Input Voltage Behavior

Figure 103 shows the input voltage behavior for MINI-LINK 6655. The different units turn on and off at different voltages.

To prevent the units from turning on and off repeatedly around a threshold (so called power flapping), there is a hysteresis for all units.

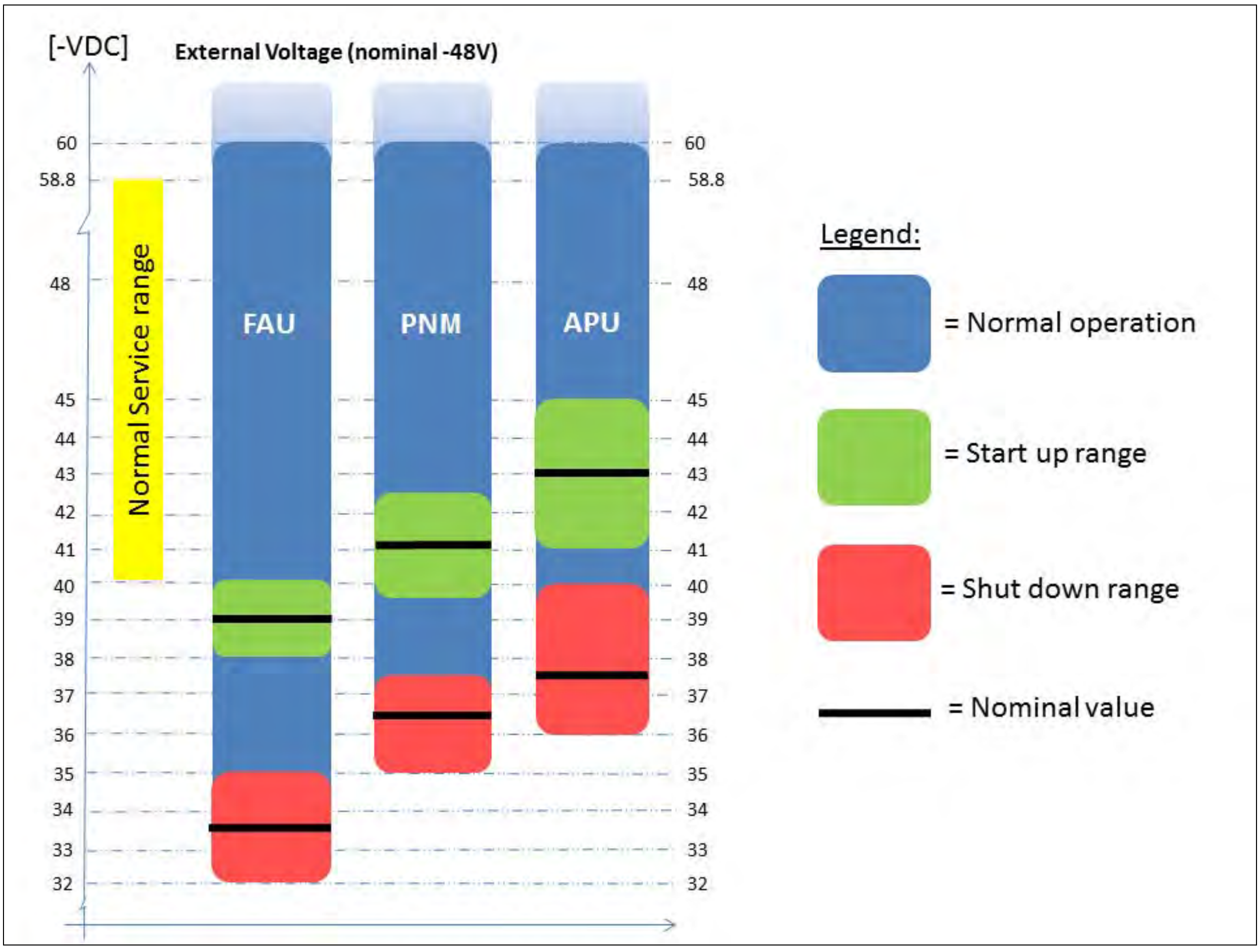


Figure 103 Start and Stop Voltages

15.4 MINI-LINK 6691

MINI-LINK 6691 is suitable for end site and repeater site applications as well as medium-sized hub sites or prioritized small-sites.

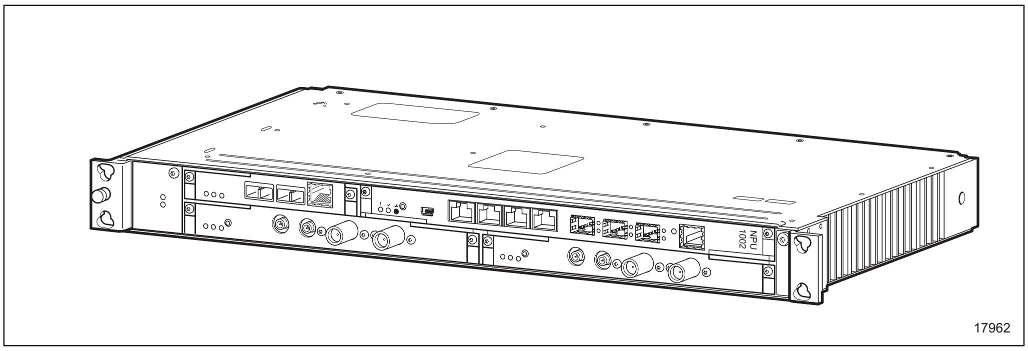


Figure 104 MINI-LINK 6691

MINI-LINK 6691 consists of a rack, Enclosure 1101, that must be equipped with a fan, FAU 1101, and power supply, PFU 1101.

MINI-LINK 6691 can also be equipped with one NPU 1002/1003/1005 and two MMU 1001/1002, or with one NPU 1002/1003/1005, one MMU 1001/1002, and one LTU 1001/1002. LTU 1001 provides E1/DS1 interfaces for PDH and LTU 1002 provides E1/DS1 and STM-1 interfaces for PDH and SDH. MINI-LINK 6691 can also be equipped with ETU 1001/1002, which provides additional Ethernet interfaces.

Unused slots in MINI-LINK 6691 must be equipped with Dummy Units, as this is essential to maintain the cooling within the magazines and to meet EMC requirements.

MINI-LINK 6691 can be fitted in a standard 19" or metric rack. The height of a MINI-LINK 6691 is 1U.

15.4.1 PFU 1101

Power handling and filtering is performed by the Power Filter Unit (PFU) 1101, see Figure 105.

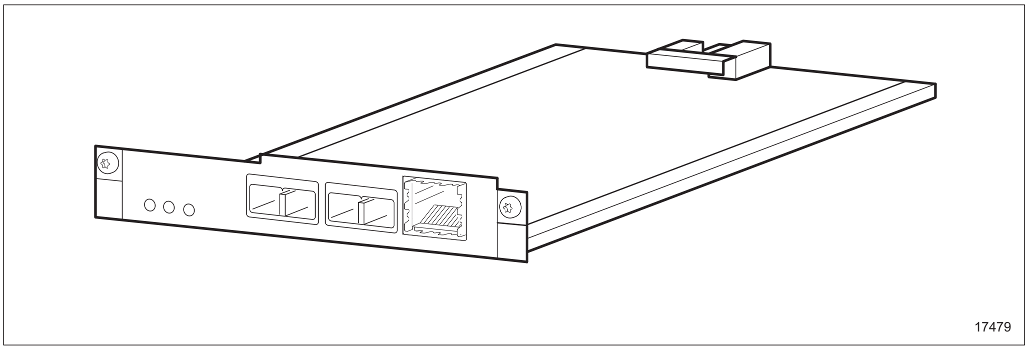


Figure 105 PFU 1101

To achieve redundant power, two power sources must be connected.

15.4.1.1 System Monitoring

The PFU supports the monitoring of the node power consumption by measuring the input current and voltage on the incoming −48V.

The following data can be read:

- The current and historical values of input voltage and the power consumption of the node.
- The accumulated and persistently stored energy consumption of the node.

15.4.2 FAU 1101

Air-cooling is provided by the FAU 1101, see Figure 106.

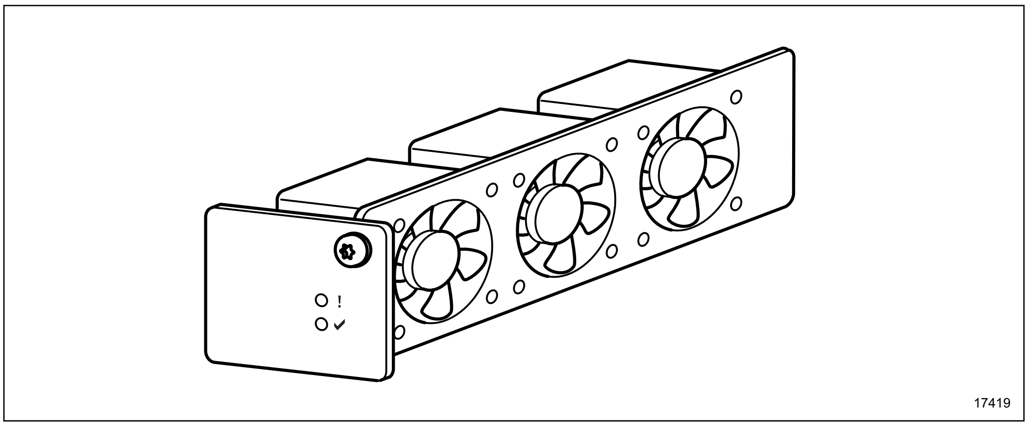


Figure 106 FAU 1101

FAU 1101 has an automatic fan speed control and houses three internal fans.

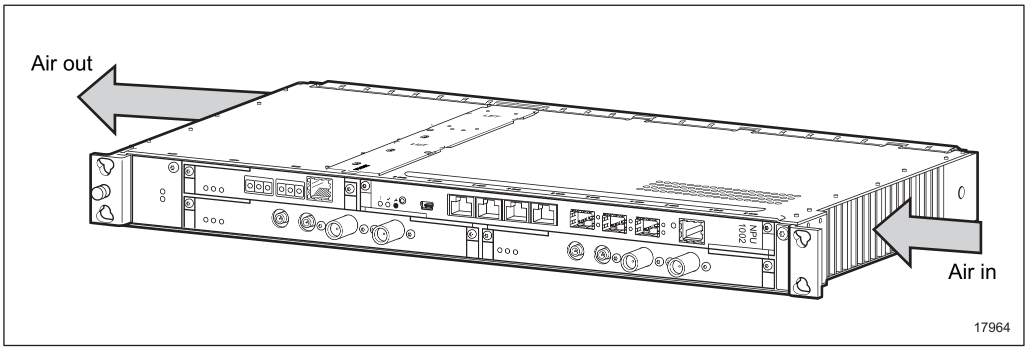


Figure 107 Cooling Airflow in MINI-LINK 6691

The air enters at the right side of the enclosure and exits at the left side of the enclosure.

15.4.3 Backplane Architecture

MINI-LINK 6691 with NPU 1002/1003/1005 provides high-speed connections of up to 10 Gbps between the NPUs, MMUs, ETUs and LTUs. The available traffic capacity is dependent on the board types and their position in the enclosure.

Slot	Ethernet capacity with NPU 1002 [Gbps]
3	1×10 or 4×2.5
1	2×2.5

Slot	Ethernet capacity with and NPU 1003 [Gbps]
3	1×10 or 4×2.5
1	2×2.5

Slot	Ethernet Capacity with NPU 1005 [Gbps]
3	1x10 or 4x2.5
1	1x10 or 4x2.5

The following pair of slots are interconnected (2-BPI) in the MINI-LINK 6691 backplane, and can be used for Modem Equipment Protection (EQP):

— Slots 1 and 3

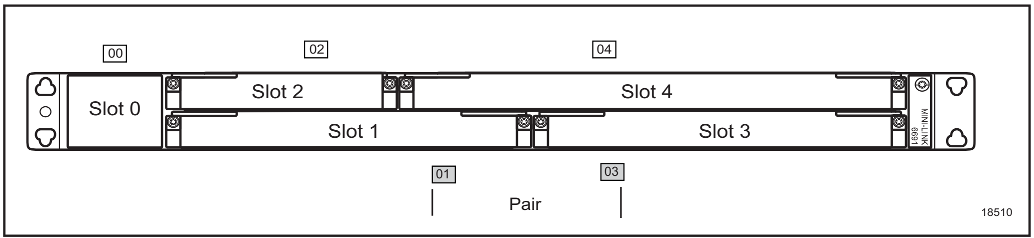


Figure 108 Interconnected Slots in MINI-LINK 6691

15.4.4 Hardware Handling

The system offers several functions for easy operation and maintenance.

— Plug-in units can be inserted while the NE is in operation. This enables adding of new Radio Terminals or other plug-in units without disturbing existing traffic.

— Plug-in units other than the NPU can be removed while the NE is in operation.

— When replacing a faulty plug-in unit, the new plug-in unit automatically inherits the configuration of the old plug-in unit.

— The configuration file is stored non-volatile both on the RMM and in a flash memory on the NPU, and can also be backed up and restored using a local or central FTP server. The RMM storage thus enables NPU replacement without using an FTP server.

— The backplane in all subracks has a digital serial number which is also stored on the RMM of the NPU. When inserting an NPU, for example, as a replacement, the serial numbers are compared on power up.

— Various restarts can be ordered from the management system. A cold restart can be initiated for an NE or single plug-in unit, and this type of restart disturbs the traffic. A warm restart is only available for the whole NE, and this restarts the control system and does not affect the traffic, which is possible due to the separated control and traffic system.

— All plug-in units are equipped with temperature sensors. Overheated boards that exceed limit thresholds, are put in out of service by the control system. This is to avoid hardware failures in case of over-temperature, for example, due to a fan failure or an ambient temperature that is too high. The plug-in unit is automatically returned to normal operation when the temperature is below the high threshold level.

  There are two thresholds:

  - The high temperature threshold:

    The NPU raises a temperature alarm (critical). The NPU is still in full operation.

    All plug-in units except NPUs raise a temperature alarm (minor). The plug-in unit is still in full operation.

  - The excessive temperature threshold:

    The NPU shuts down the entire NPU (out of service).

    All plug-in-units except NPUs raise a temperature alarm (critical) and shut down the entire plug-in unit (out of service).

— Access to inventory data like software and hardware product number, serial number, and version. User defined asset identification is supported, enabling tracking of hardware.

— Slot availability and capacity can be monitored by using MINI-LINK Node GUI, or CLI. In this way, choosing a slot for additional plug-in units is easier.

— Ethernet SFPs can be replaced with minimal user intervention, without de-configuring port properties.

15.4.5 Input Voltage Behavior

Figure 109 shows the input voltage behavior for MINI-LINK 6691. The different units turn on and off at different voltages.

To prevent the units from turning on and off repeatedly around a threshold (so called power flapping), there is a hysteresis for all units.

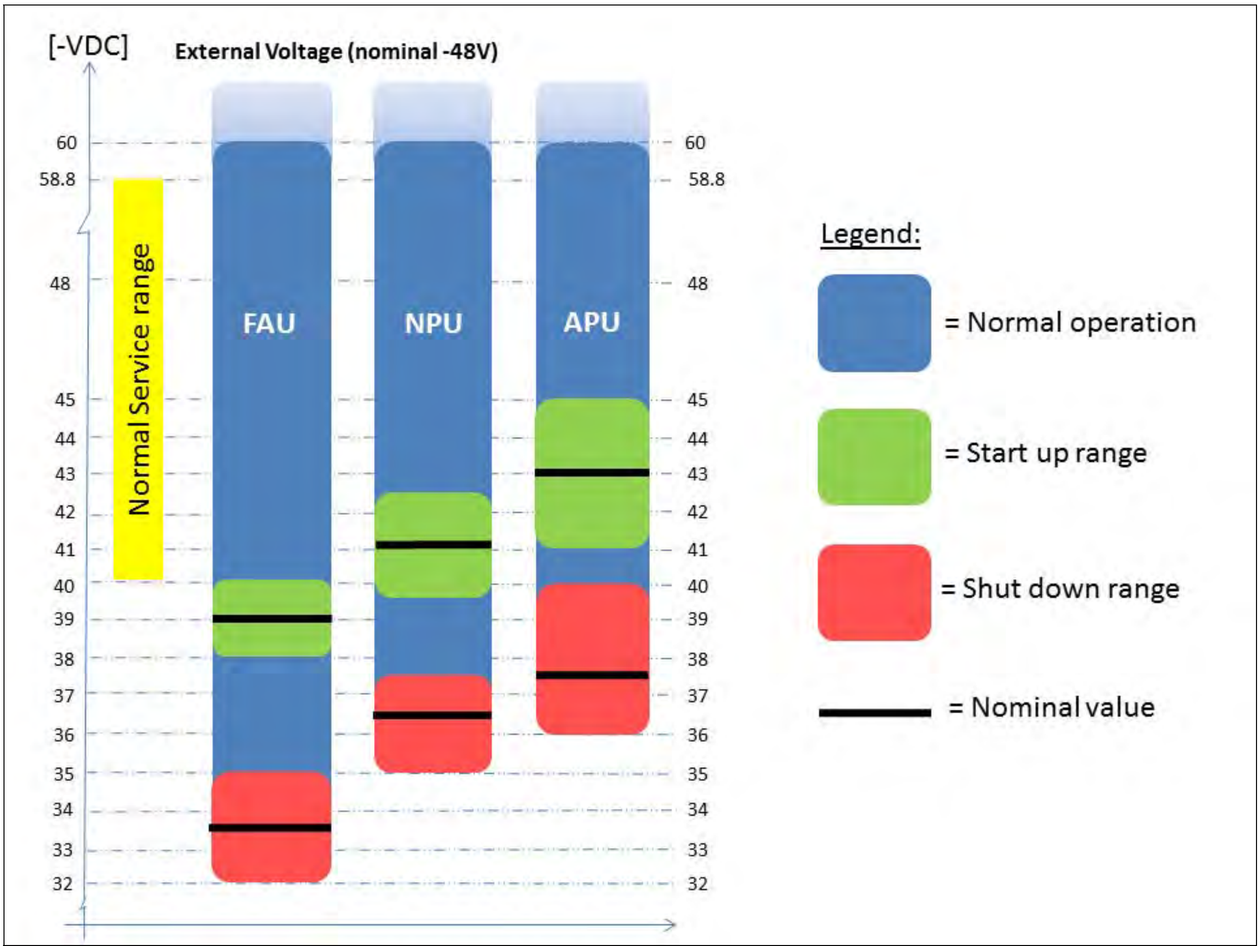


Figure 109 Start and Stop Voltages

15.5 MINI-LINK 6692

MINI-LINK 6692 is suitable for end site and repeater site applications as well as medium-sized hub sites or prioritized small-sites.

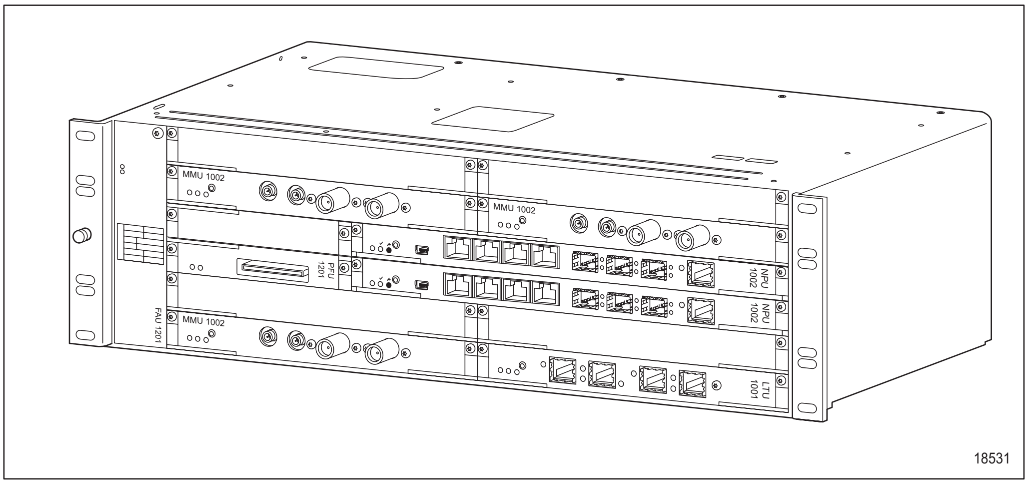


Figure 110 MINI-LINK 6692

MINI-LINK 6692 consists of a rack, Enclosure 1201, that must be equipped with a fan, FAU 1201, and power supply, PFU 1201.

MINI-LINK 6692 can also be equipped with one or two NPU 1002/NPU 1005, and up to eight MMU 1001/1002, LTU 1001/1002, or a combination thereof. It is not possible to combine NPU 1002 and NPU 1005 in the same magazine. LTU 1001 provides E1/DS1 interfaces for PDH and LTU 1002 provides E1 and STM-1 interfaces for PDH and SDH. MINI-LINK 6692 can also be equipped with ETU 1001/1002, which provides additional Ethernet interfaces.

To achieve NPU protection, two NPU 1002 or two NPU 1005 must be used. See Section 15.5.5 on page 163.

Unused slots in MINI-LINK 6692 must be equipped with Dummy Units, as this is essential to maintain the cooling within the magazines and to meet EMC requirements.

MINI-LINK 6692 can be fitted in a standard 19" or metric rack. The height of a MINI-LINK 6692 is 3U.

15.5.1 PFU 1201

Power handling and filtering is performed by the Power Filter Unit (PFU) 1201, see Figure 111.

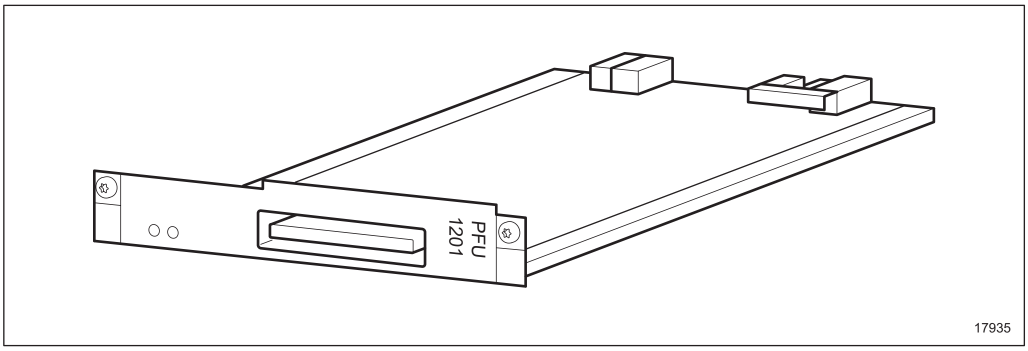


Figure 111 PFU 1201

To achieve redundant power, two PFU 1201 are needed, and two power sources, one connected to each PFU 1201.

15.5.1.1 System Monitoring

The PFU supports the monitoring of the node power consumption by measuring the input current and voltage on the incoming −48V.

The following data can be read:

— The current and historical values of input voltage and the power consumption of the node.

— The accumulated and persistently stored energy consumption of the node.

15.5.2 FAU 1201

Air-cooling is provided by the FAU 1201, see Figure 112.

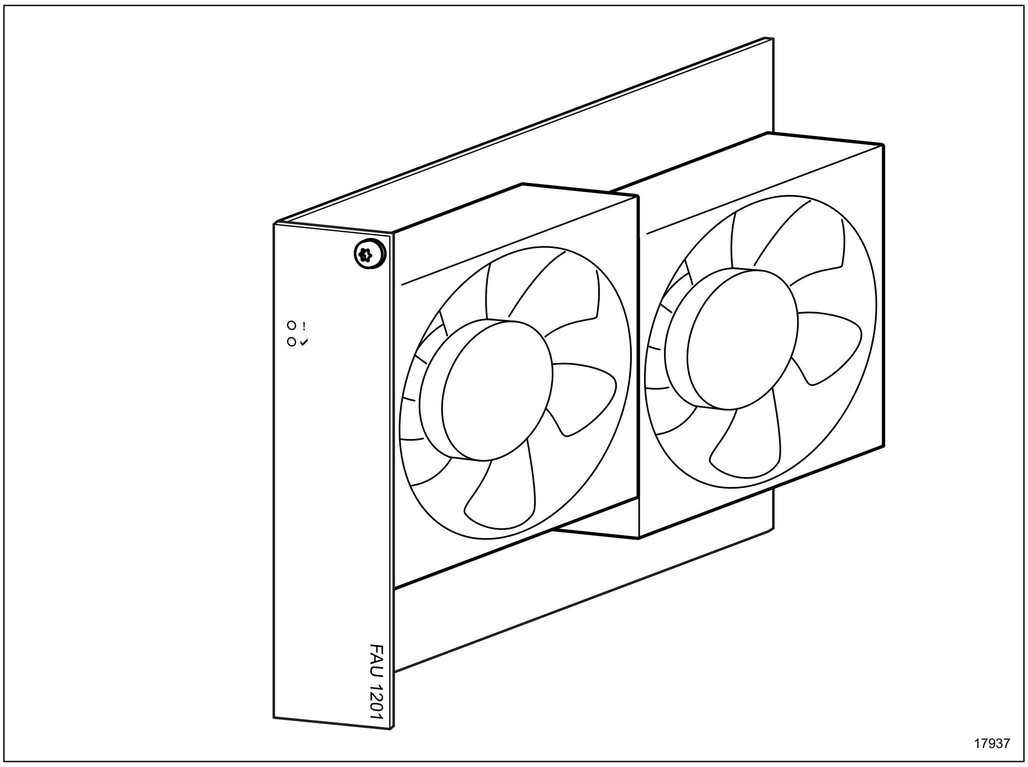


Figure 112 FAU 1201

FAU 1201 has an automatic fan speed control and houses three internal fans.

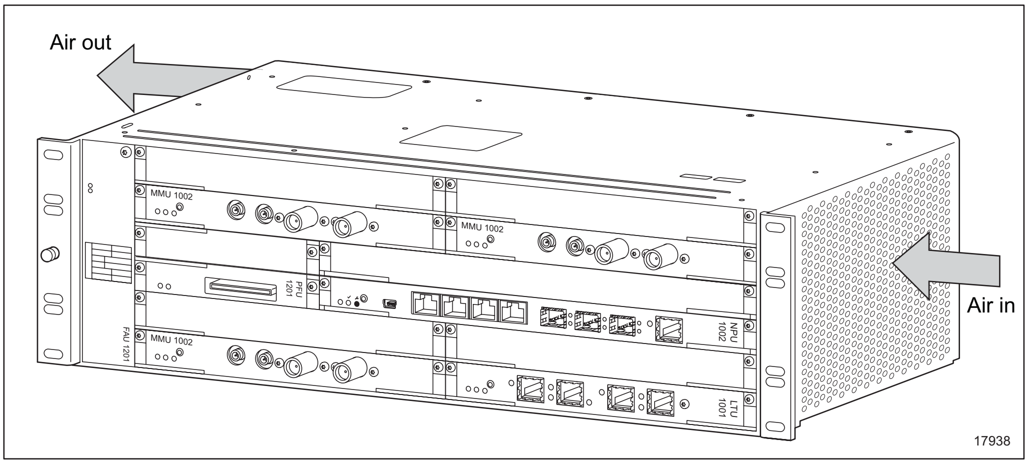


Figure 113 Cooling Airflow in MINI-LINK 6692

The air enters at the right side of the enclosure and exits at the left side of the enclosure.

15.5.3 Backplane Architecture

MINI-LINK 6692 provides high-speed connections of up to 10 Gbps between the NPUs, MMUs, ETUs and LTUs. The available traffic capacity is dependent on the board types and their position in the enclosure.

The MMUs, LTUs, and ETUs are placed in the Application Plug-in Unit (APU) slots, that is, slots 1–2, 5–8, and 11–12.

Slot	Ethernet capacity with NPU 1002 [Gbps]	Slot	Ethernet capacity with NPU 1002 [Gbps]
6	1×2.5 + 1×1	12	1×2.5 + 1×1
5	2×2.5	11	2×2.5
2	1×10G (4 lanes) or 4×2.5	8	1×10G (4 lanes) or 4×2.5
1	2×2.5	7	1×2.5

Slot	Ethernet capacity with NPU 1005 [Gbps]	Slot	Ethernet capacity with NPU 1005 [Gbps]
6	1×2.5	12	1×2.5
5	1×10G (4 lanes) or 4×2.5	11	1×2.5
2	1×10G (4 lanes) or 4×2.5	8	1×2.5
1	1×10G (4 lanes) or 4×2.5	7	1×2.5

The following pairs of slots are interconnected (2-BPI) in the MINI-LINK 6692 backplane, and can be used for Modem Equipment Protection (EQP):

— Slots 1 and 2

— Slots 5 and 6

— Slots 7 and 8

— Slots 11 and 12

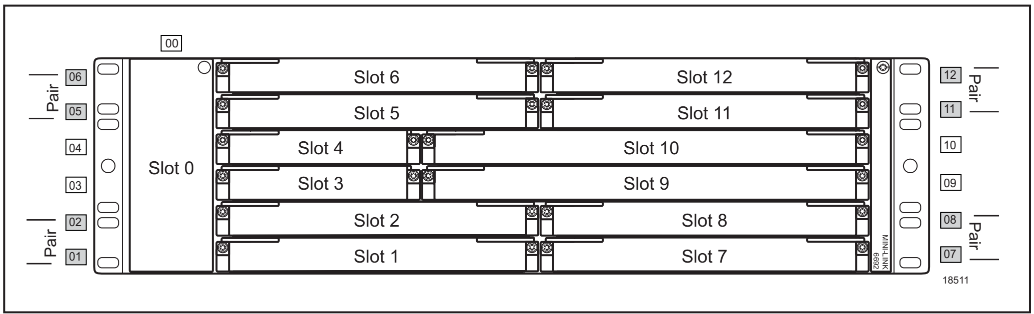


Figure 114 Interconnected Slots in MINI-LINK 6692

15.5.4 Hardware Handling

The system offers several functions for easy operation and maintenance.

- Plug-in units can be inserted while the NE is in operation. This enables adding of new Radio Terminals or other plug-in units without disturbing existing traffic.
- Plug-in units other than the NPU can be removed while the NE is in operation.
- When replacing a faulty plug-in unit, the new plug-in unit automatically inherits the configuration of the old plug-in unit.
- The configuration file is stored non-volatile both on the RMM and in a flash memory on the NPU, and can also be backed up and restored using a local or central FTP server. The RMM storage thus enables NPU replacement without using an FTP server.
- The backplane in all subracks has a digital serial number which is also stored on the RMM of the NPU. When inserting an NPU, for example, as a replacement, the serial numbers are compared on power up.
- Various restarts can be ordered from the management system. A cold restart can be initiated for an NE or single plug-in unit, and this type of restart disturbs the traffic. A warm restart is only available for the whole NE, and this restarts the control system and does not affect the traffic, which is possible due to the separated control and traffic system.
- All plug-in units are equipped with temperature sensors. Overheated boards that exceed limit thresholds are put in out of service by the control system. This is to avoid hardware failures in case of over-temperature, for example, due to a fan failure or an ambient temperature that is too high. The plug-in unit is automatically returned to normal operation when the temperature is below the high threshold level.

  There are two thresholds:

  - The high temperature threshold:

    The NPU raises a temperature alarm (critical). The NPU is still in full operation.

    All plug-in units except NPUs raise a temperature alarm (minor). The plug-in unit is still in full operation.

  - The excessive temperature threshold:

    The NPU shuts down the entire NPU (out of service).

    All plug-in-units except NPUs raise a temperature alarm (critical) and shut down the entire plug-in unit (out of service).

- Access to inventory data like software and hardware product number, serial number, and version. User defined asset identification is supported, enabling tracking of hardware.
- Slot availability and capacity can be monitored by using MINI-LINK Node GUI, or CLI. In this way, choosing the correct slot when adding additional plug-in units is made easier.
- Ethernet SFPs can be replaced with minimal user intervention, without de-configuring port properties.

15.5.5 NPU Protection

When two NPU 1002/NPU 1005 are inserted into MINI-LINK 6692, NPU Protection can provide board, port, and full functional redundancy for the NPU, if configured and licensed properly. It is not possible to combine NPU 1002 and NPU 1005 in the same magazine.

In case of a hardware or software fault in the master NPU, an automatic failover takes place, and the slave NPU becomes the master by inheriting all configuration. All user traffic and DCN access recovers after the failover.

When having two NPU 1002, the front LAN ports of the slave NPU can be extended and configured to be used for user traffic. This way the extended ports could have different configuration than the corresponding port of the master NPU and used in different setup. After fail or switchover the configuration remains on each port, but the ports of the new slave NPU will be handled as extended.

Note: The front LAN ports on the slave NPU cannot be extended on NPU 1005.

15.5.6 Input Voltage Behavior

Figure 115 shows the input voltage behavior for MINI-LINK 6692. The different units turn on and off at different voltages.

To prevent the units from turning on and off repeatedly around a threshold (so called power flapping), there is a hysteresis for all units.

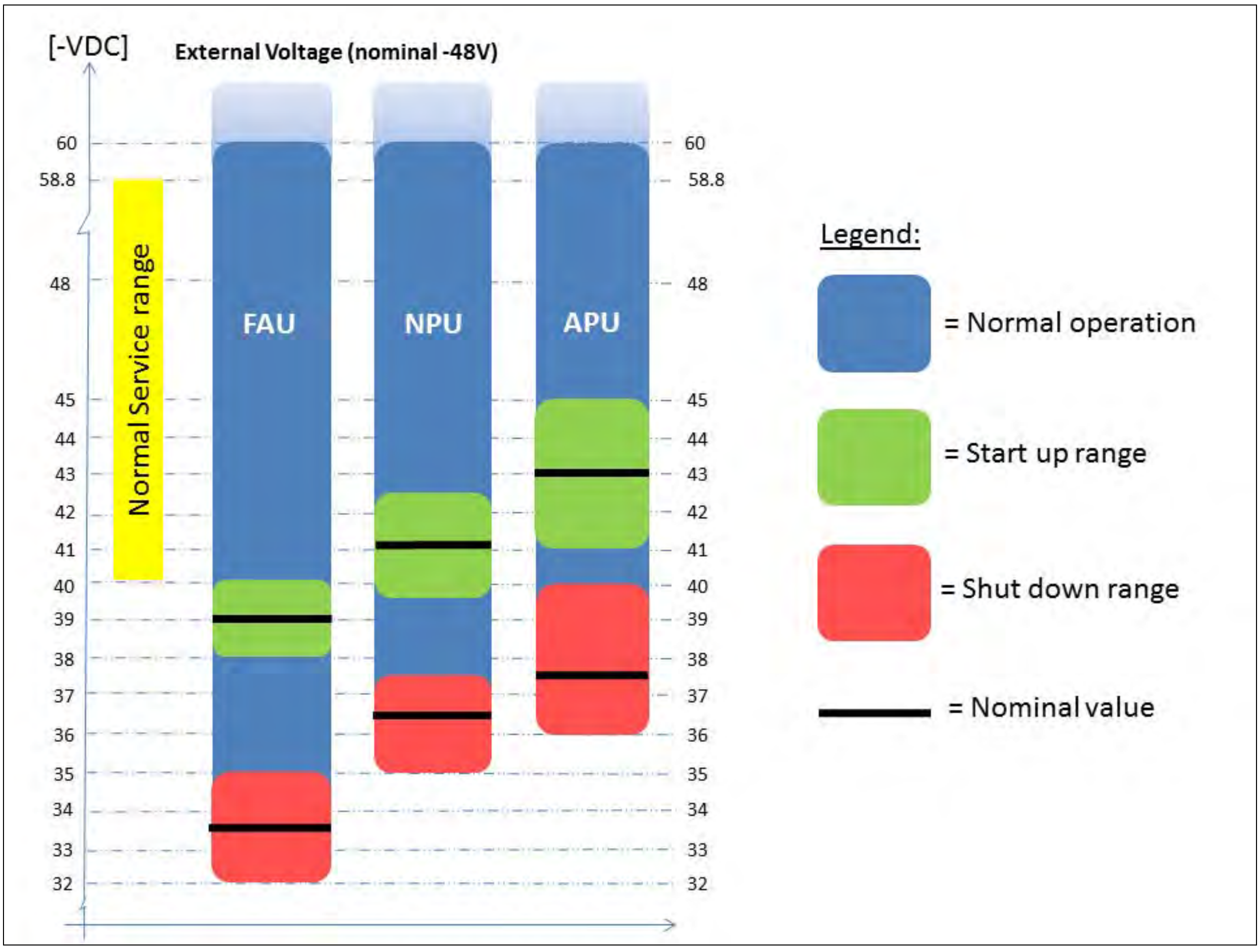


Figure 115 Start and Stop Voltages

15.6 MINI-LINK 6693

MINI-LINK 6693 is suitable for end site and repeater site applications as well as medium-sized hub sites or prioritized small-sites.

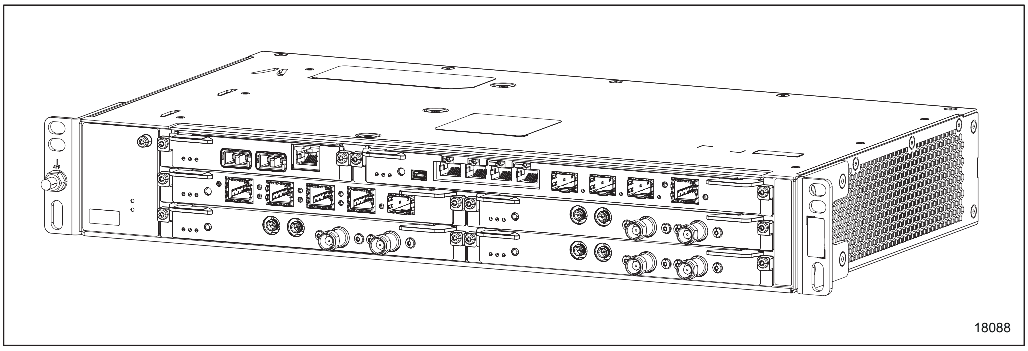


Figure 116 MINI-LINK 6693

MINI-LINK 6693 consists of a rack, Enclosure 1301, that must be equipped with a fan, FAU 1301, and power supply, PFU 1301.

MINI-LINK 6693 can also be equipped with one NPU 1002/1003/1005, and up to four MMU 1001/1002, LTU 1001/1002, or a combination thereof. LTU 1001 provides E1/DS1 interfaces for PDH and LTU 1002 provides E1/DS1 and STM-1 interfaces for PDH and SDH. MINI-LINK 6693 can also be equipped with ETU 1001/1002, which provides additional Ethernet interfaces.

Unused slots in MINI-LINK 6693 must be equipped with Dummy Units, as this is essential to maintain the cooling within the magazines and to meet EMC requirements.

MINI-LINK 6693 can be fitted in a standard 19" or metric rack. The height of a MINI-LINK 6693 is 1.5U.

15.6.1 PFU 1301

Power handling and filtering is performed by the Power Filter Unit (PFU) 1301, see Figure 117.

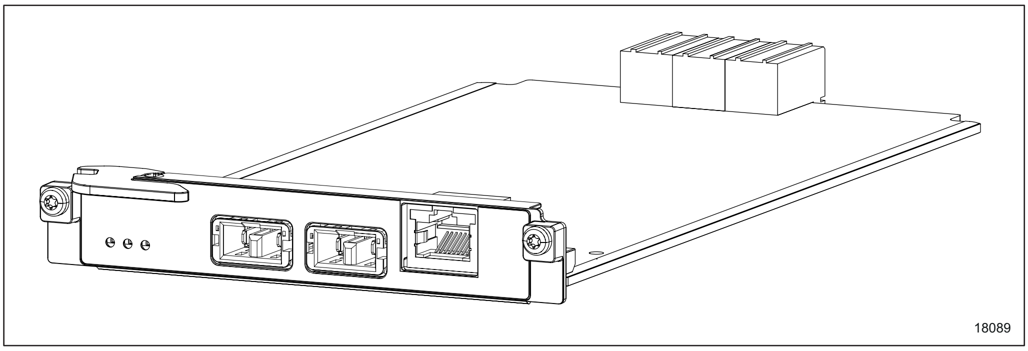


Figure 117 PFU 1301

To achieve redundant power, two power sources must be connected.

15.6.1.1 System Monitoring

The PFU supports the monitoring of the node power consumption by measuring the input current and voltage on the incoming −48V.

The following data can be read:

- The current and historical values of input voltage and the power consumption of the node.
- The accumulated and persistently stored energy consumption of the node.

15.6.2 FAU 1301

Air-cooling is provided by the FAU 1301, see Figure 118.

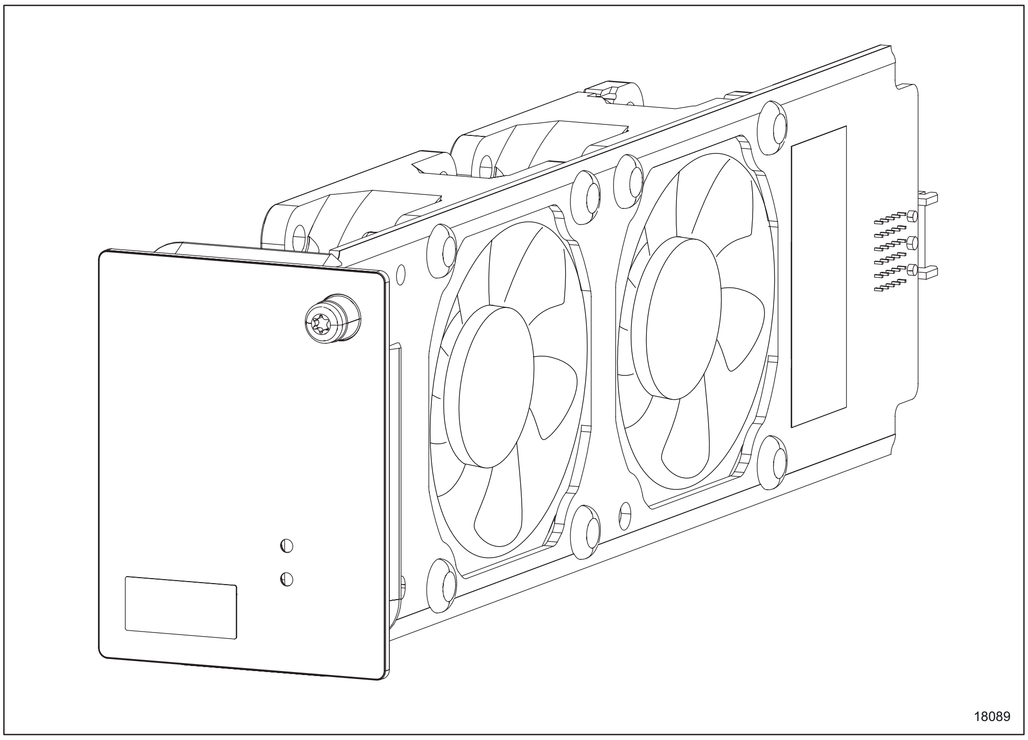


Figure 118 FAU 1301

FAU 1301 has an automatic fan speed control and houses two internal fans.

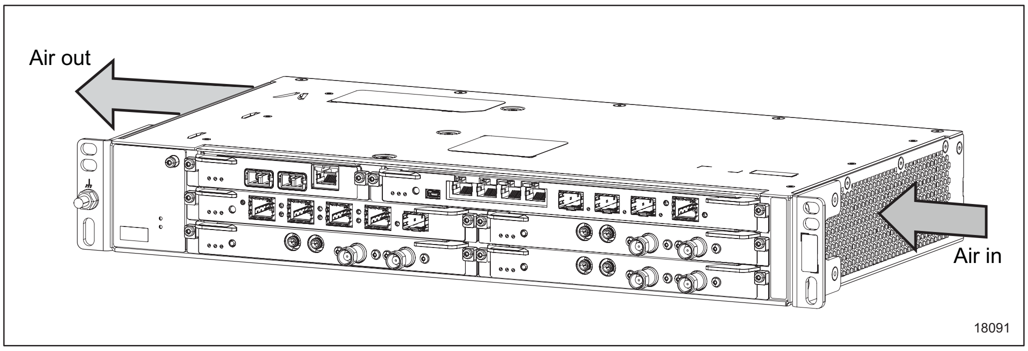


Figure 119 Cooling Airflow in MINI-LINK 6693

The air enters at the right side of the enclosure and exits at the left side of the enclosure.

15.6.3 Backplane Architecture

MINI-LINK 6693 provides high-speed connections of up to 10 Gbps between the NPUs, MMUs, ETUs and LTUs. The available traffic capacity is dependent on the board types and their position in the enclosure.

The MMUs, LTUs, and ETUs are placed in the Application Plug-in Unit (APU) slots, that is, slots 1–2 and 4–5.

Slot	Ethernet capacity with NPU 1002 [Gbps]
5	1×2.5 + 1×1
4	2×2.5
2	1×10 or 4×2.5
1	2×2.5

Slot	Ethernet capacity with NPU 1003 [Gbps]
5	2×2.5
4	1×2.5
2	1×10 or 4×2.5
1	2×2.5

Slot	Ethernet capacity with NPU 1005 [Gbps]
5	1×2.5
4	1×10 or 4×2.5
2	1×10 or 4×2.5
1	1×10 or 4×2.5

The following pairs of slots are interconnected (2-BPI) in the MINI-LINK 6693 backplane, and can be used for Modem Equipment Protection (EQP):

- Slots 1 and 2
- Slots 4 and 5

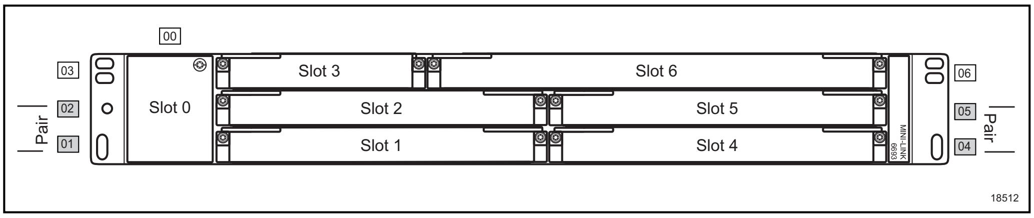


Figure 120 Interconnected Slots in MINI-LINK 6693

15.6.4 Hardware Handling

The system offers several functions for easy operation and maintenance.

- Plug-in units can be inserted while the NE is in operation. This enables adding of new Radio Terminals or other plug-in units without disturbing existing traffic.
- Plug-in units other than the NPU can be removed while the NE is in operation.
- When replacing a faulty plug-in unit, the new plug-in unit automatically inherits the configuration of the old plug-in unit.
- The configuration file is stored non-volatile both on the RMM and in a flash memory on the NPU, and can also be backed up and restored using a local or central FTP server. The RMM storage thus enables NPU replacement without using an FTP server.
- The backplane in all subracks has a digital serial number which is also stored on the RMM of the NPU. When inserting an NPU, for example, as a replacement, the serial numbers are compared on power up.
- Various restarts can be ordered from the management system. A cold restart can be initiated for an NE or single plug-in unit, and this type of restart disturbs the traffic. A warm restart is only available for the whole NE, and this restarts the control system and does not affect the traffic, which is possible due to the separated control and traffic system.
- All plug-in units are equipped with temperature sensors. Overheated boards that exceed limit thresholds are put in out of service by the control system. This is to avoid hardware failures in case of over-temperature, for example, due to a fan failure or an ambient temperature that is too high. The plug-in unit is automatically returned to normal operation when the temperature is below the high threshold level.

  There are two thresholds:

  - The high temperature threshold:

    The NPU raises a temperature alarm (critical). The NPU is still in full operation.

    All plug-in units except NPUs raise a temperature alarm (minor). The plug-in unit is still in full operation.

  - The excessive temperature threshold:

    The NPU shuts down the entire NPU (out of service).

    All plug-in-units except NPUs raise a temperature alarm (critical) and shut down the entire plug-in unit (out of service).

— Access to inventory data like software and hardware product number, serial number, and version. User defined asset identification is supported, enabling tracking of hardware.

— Slot availability and capacity can be monitored by using MINI-LINK Node GUI, or CLI. In this way, choosing the correct slot when adding additional plug-in units is made easier.

— Ethernet SFPs can be replaced with minimal user intervention, without de-configuring port properties.

15.6.5 Input Voltage Behavior

Figure 121 shows the input voltage behavior for MINI-LINK 6693. The different units turn on and off at different voltages.

To prevent the units from turning on and off repeatedly around a threshold (so called power flapping), there is a hysteresis for all units.

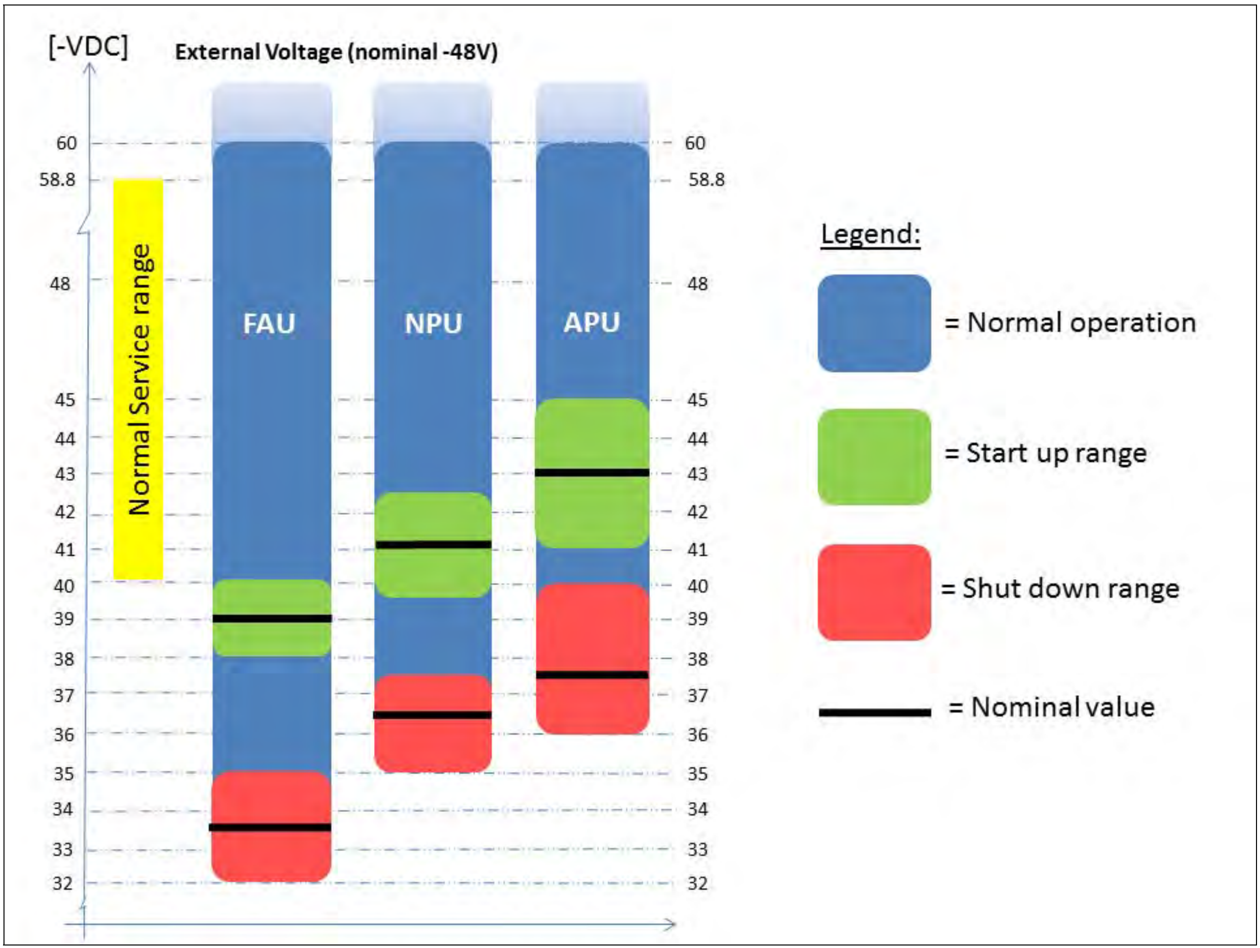


Figure 121 Start and Stop Voltages

15.7 MINI-LINK 6694

MINI-LINK 6694 is suitable for end site and repeater site applications as well as medium-sized hub sites or prioritized small-sites.

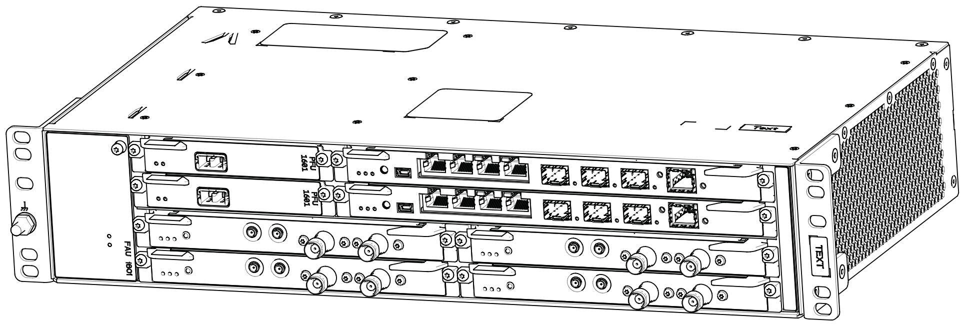


Figure 122 MINI-LINK 6694

MINI-LINK 6694 consists of a rack, Enclosure 1601, that must be equipped with a fan, FAU 1601, and power supply, PFU 1601.

MINI-LINK 6694 can also be equipped with one or two NPU 1002/NPU 1005 or one NPU1003 and up to four MMU 1001/1002, LTU 1001/1002, or a combination thereof. It is not possible to combine NPU 1002 and NPU 1005 in the same magazine. LTU 1001 provides E1/DS1 interfaces for PDH, and LTU 1002 provides E1/DS1 and STM-1 interfaces for PDH and SDH. MINI-LINK 6694 can also be equipped with ETU 1001/1002, which provides additional Ethernet interfaces.

To achieve NPU protection, two NPU 1002 or two NPU 1005 must be used. See Section 15.7.4 on page 173.

Unused slots in MINI-LINK 6694 must be equipped with Dummy Units, as this is essential to maintain the cooling within the magazines and to meet EMC requirements.

MINI-LINK 6694 can be fitted in a standard 19" or metric rack. The height of MINI-LINK 6694 is 2U.

15.7.1 PFU 1601

Power handling and filtering is performed by the Power Filter Unit (PFU) 1601, see Figure 123.

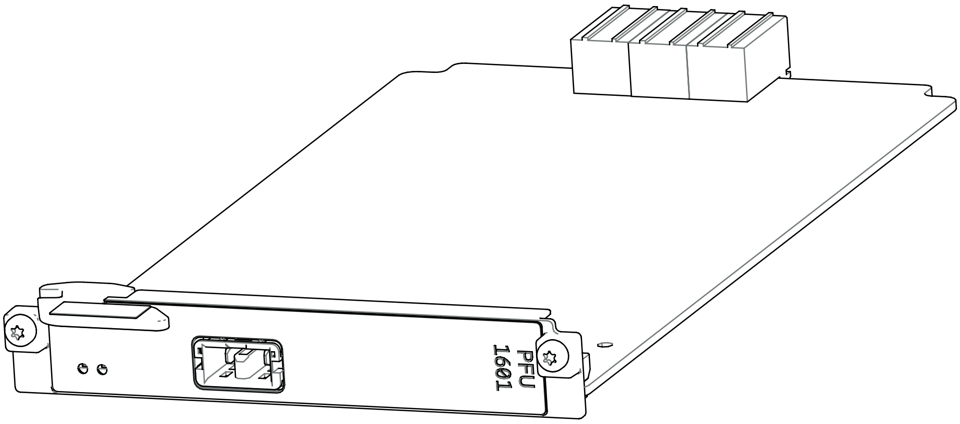


Figure 123 PFU 1601

To achieve redundant power, two PFU 1601 are needed, and two power sources, one connected to each PFU 1601.

15.7.1.1 System Monitoring

The PFU supports the monitoring of the node power consumption by measuring the input current and voltage on the incoming −48V.

The following data can be read:

— The current and historical values of input voltage and the power consumption of the node.

— The accumulated and persistently stored energy consumption of the node.

15.7.2 FAU 1601

Air-cooling is provided by FAU 1601, see Figure 124.

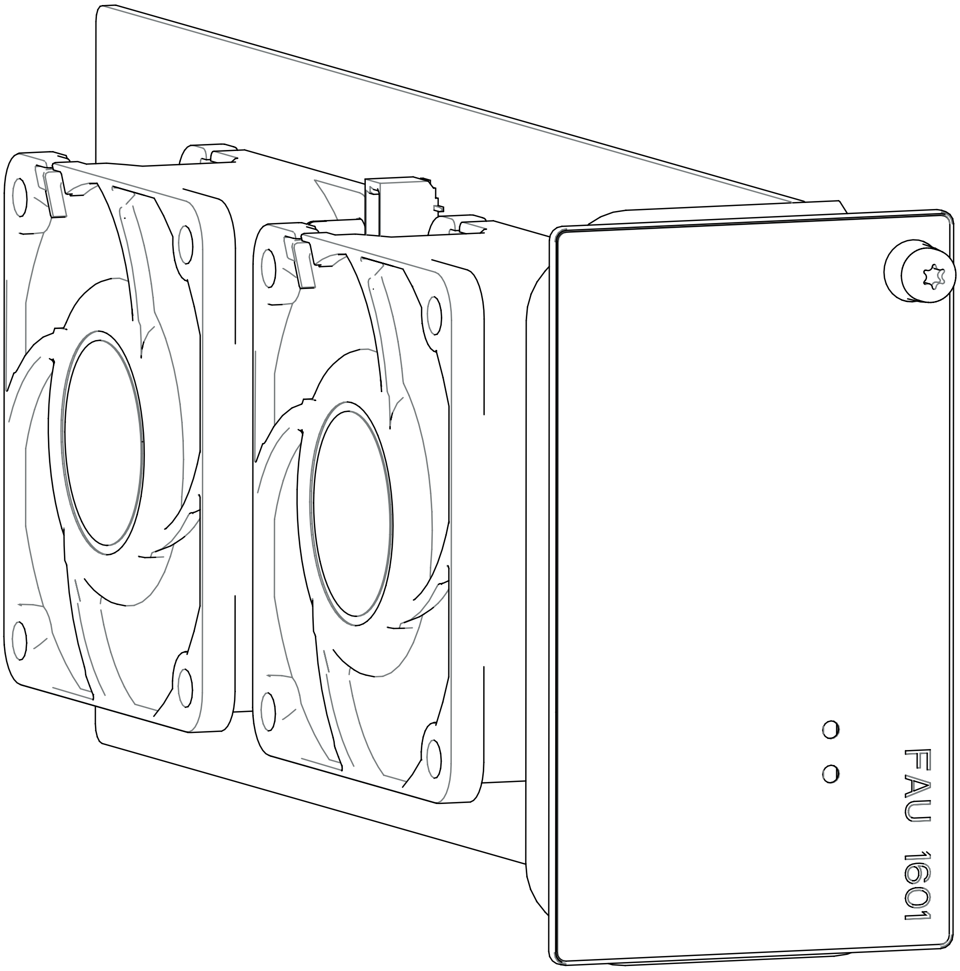


Figure 124 FAU 1601

FAU 1601 has an automatic fan speed control and houses two internal fans.

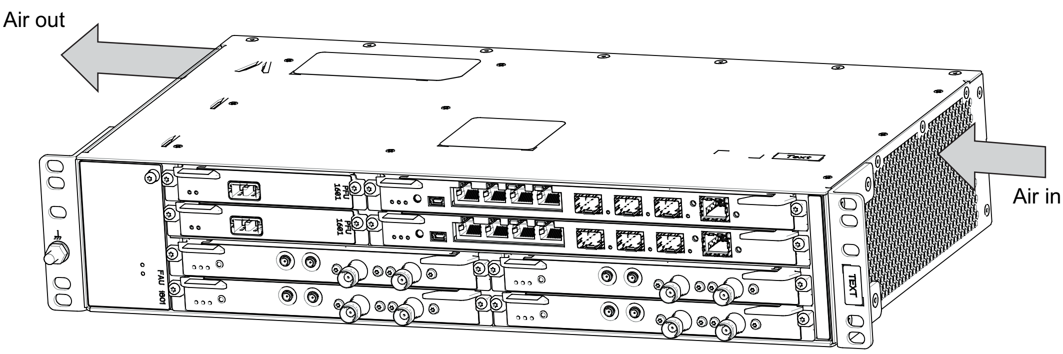


Figure 125 Cooling Airflow in MINI-LINK 6694

The air enters at the right side of the enclosure and exits at the left side of the enclosure.

15.7.3 Backplane Architecture

MINI-LINK 6694 provides high-speed connections of up to 10 Gbps between the NPUs, MMUs, ETUs and LTUs. The available traffic capacity depends on the board types and their positions in the enclosure.

The MMUs, ETUs, and LTUs are placed in the Application Plug-in Unit (APU) slots, that is, slots 1–2 and 5–6.

Slot	Ethernet Capacity with NPU 1002 [Gbps]
6	1×2.5 + 1×1
5	2×2.5
2	1×10 or 4×2.5
1	2×2.5

Slot	Ethernet Capacity with NPU 1003 [Gbps]
6	2×2.5
5	1×2.5
2	1×10 or 4×2.5
1	2×2.5

Slot	Ethernet Capacity with NPU 1005 [Gbps]
6	1×2.5
5	1×10 or 4×2.5
2	1×10 or 4×2.5
1	1×10 or 4×2.5

The following pairs of slots are interconnected (2-BPI) in the MINI-LINK 6694 backplane and can be used for Modem Equipment Protection (EQP):

— Slots 1 and 2

— Slots 5 and 6

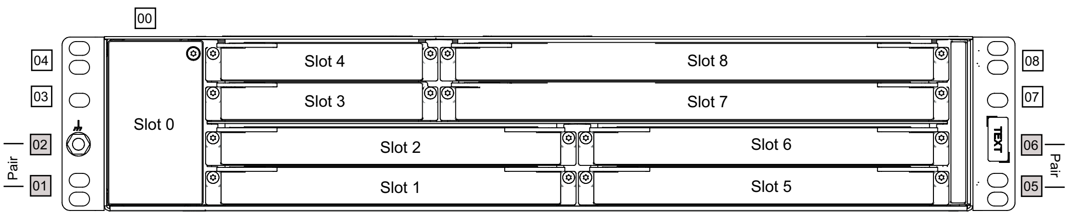


Figure 126 Interconnected Slots in MINI-LINK 6694

15.7.4 NPU Protection

When two NPU 1002/NPU 1005 are inserted into MINI-LINK 6694, NPU Protection can provide board, port, and full functional redundancy for the NPU, if configured and licensed properly. It is not possible to combine NPU 1002 and NPU 1005 in the same magazine.

In case of a hardware or software fault in the Master NPU, an automatic failover takes place, and the Slave NPU becomes the Master by inheriting all configurations. All user traffic and DCN access recovers after the failover.

When having two NPU 1002, the front LAN ports of the Slave NPU can be extended and configured to be used for user traffic. This way, the extended ports can have different configurations than the corresponding port of the Master NPU and can be used in different setups. After fail- or switchover, the configuration remains on each port, but the ports of the new Slave NPU are handled as extended.

Note: The front LAN ports on the slave NPU cannot be extended on NPU 1005.

15.7.5 Hardware Handling

The system offers several functions for easy operation and maintenance.

— Plug-in units can be inserted while the NE is in operation. This allows for adding new Radio Terminals or other plug-in units without disturbing the existing traffic.

— Plug-in units other than the NPU can be removed while the NE is in operation.

— When replacing a faulty plug-in unit, the new plug-in unit automatically inherits the configuration of the old plug-in unit.

— The configuration file is stored non-volatile both on the RMM and in a flash memory on the NPU and can also be backed up and restored using a local or central FTP server. The RMM storage thus enables NPU replacement without using an FTP server.

— The backplane in all subracks has a digital serial number which is also stored on the RMM of the NPU. When inserting an NPU, for example, as a replacement, the serial numbers are compared on power-up.

— Various restarts can be ordered from the management system. A cold restart can be initiated for an NE or a single plug-in unit, and it disturbs the traffic. A warm restart is only available for the whole NE, and it restarts the control system and does not affect the traffic due to the separated control and traffic systems.

— All plug-in units are equipped with temperature sensors. Overheated boards that exceed threshold limits are put in out-of-service by the control system. This is to avoid hardware failures in case of over-heating, for example, due to a fan failure or an ambient temperature that is too high. The plug-in unit is automatically returned to normal operation when the temperature is below the high threshold limit.

There are two thresholds:

- The high temperature threshold:

  The NPU raises a temperature alarm (critical). The NPU is still in full operation.

  All plug-in units except NPUs raise a temperature alarm (minor). The plug-in unit is still in full operation.

- The excessive temperature threshold:

  The NPU shuts down the entire NPU (out of service).

  All plug-in-units except NPUs raise a temperature alarm (critical) and shut down the entire plug-in unit (out of service).

— Access to inventory data like software and hardware product numbers, serial number, and version. User-defined asset identification is supported, enabling hardware tracking.

— Slot availability and capacity can be monitored by using MINI-LINK Node GUI or the CLI. In this way, choosing the correct slot when adding additional plug-in units is made easier.

— Ethernet SFPs can be replaced with minimal user intervention, without de-configuring port properties.

15.7.6 Input Voltage Behavior

Figure 127 shows the input voltage behavior for MINI-LINK 6694. The different units turn on and off at different voltages.

To prevent the units from turning on and off repeatedly around a threshold (so called power flapping), there is a hysteresis for all units.

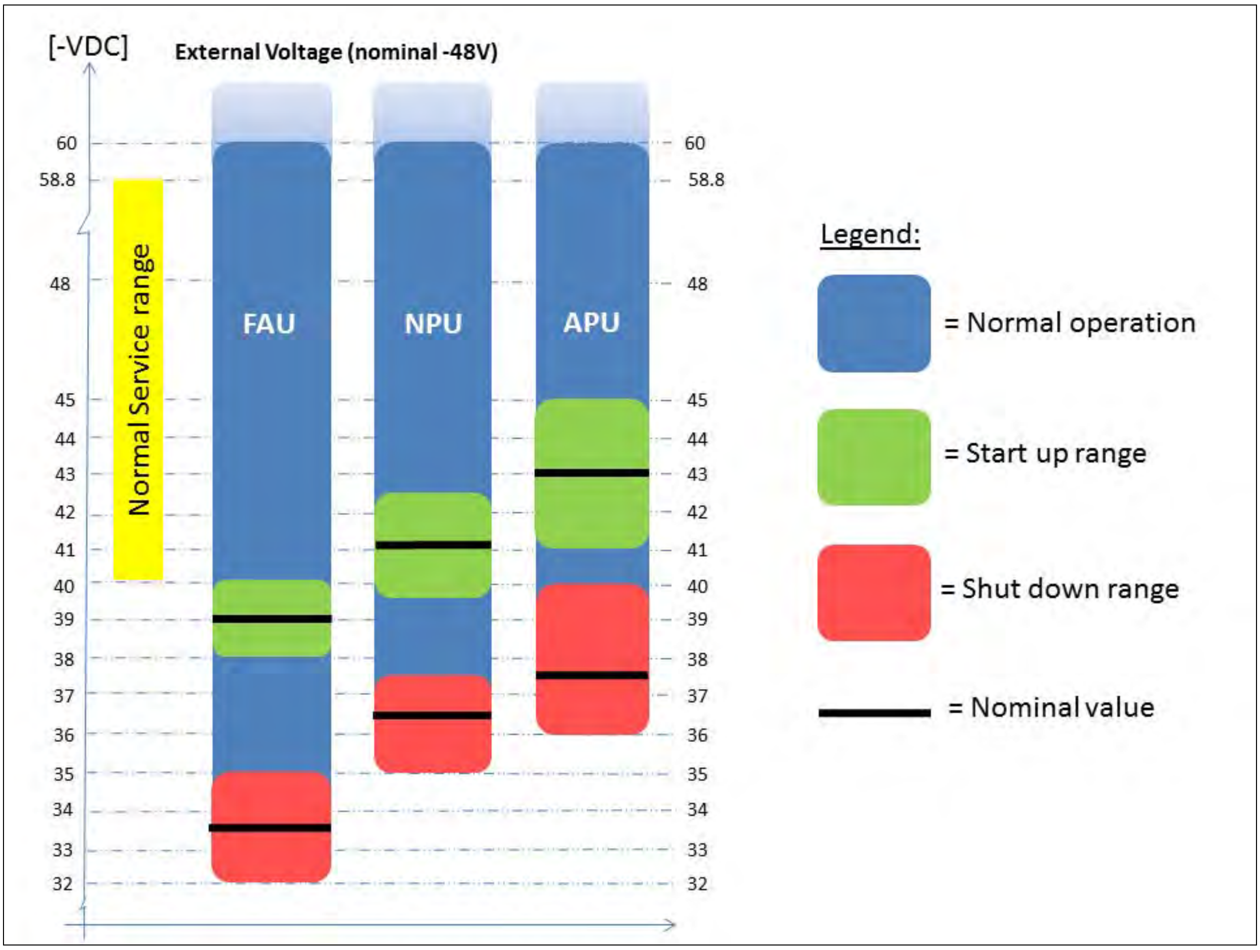


Figure 127 Start and Stop Voltages

15.8 NPU 1002

NPU 1002 is a full size processor board that fits in MINI-LINK 6691, MINI-LINK 6692, MINI-LINK 6693, and MINI-LINK 6694.

NPU 1002 contains an embedded Ethernet switch which makes it an ideal component at a medium or small Ethernet aggregation site. It also supports Synchronous Ethernet.

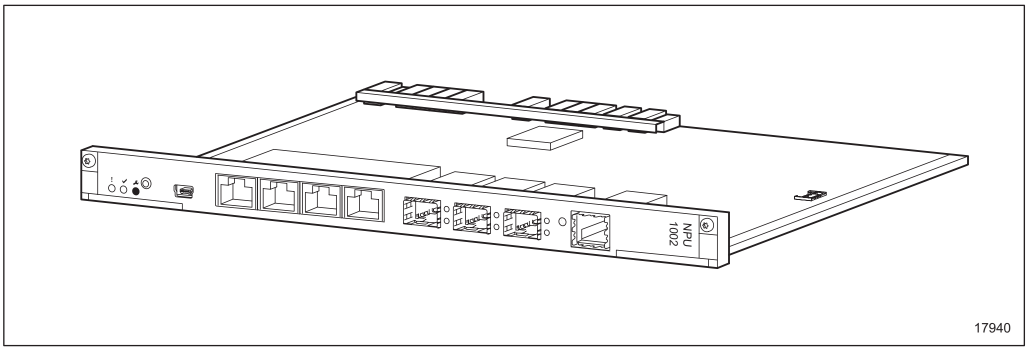


Figure 128 NPU 1002

The NPU 1002 supports the following Ethernet-related features:

- Store and forward MAC (IEEE802.1D-2004) and VLAN-based switching (IEEE802.1Q-2005 and IEEE802.1ad-2005).
- Port-based VLAN (up to 1,000 VLANs in the range of 1–4094).
- MAC address table (32,000 entries) with learning and aging.
- IPv4 and IPv6
- Static unicast/multicast routes.
- Jumbo frames for LAN and Packet Link WAN ports.
- Multiple internal Layer 1 and Layer 2 Ethernet connections.
- MSTP/RSTP/LAG protection mechanism.
- Link Aggregation Control Protocol (LACP).
- Link Loss Forwarding for internal Layer 1 connections.
- Policing/color marking per ingress port with CIR/EIR and CBS/EBS.
- Policing/color marking per ingress port per QoS priority with CIR/EIR and CBS/EBS.
- Policing/color marking per ingress port per VLAN with CIR/EIR and CBS/EBS.
- Traffic shaping per egress port with CIR and CBS.
- 2 MHz sync input/output.
- Ethernet loop detection.
- Broadcast/multicast/destination lookup failure storm protection.
- Frame admission control.
- Classification/tagging of priority and VLAN ID.

— Congestion handling with eight priority queues (TC) per port.
  - Frame discard: WRED, color dropping, aging and tail drop.
  - TC scheduling: SP, WDRR.
— In-band management transport in Ethernet flow (DCN over VLAN).
— Management/diagnostics.
  - PM counters.
  - Link OAM.
  - Ethernet Service OAM.
  - Port mirroring.

15.8.1 NPU 1002 Front Interfaces

— **O&M** – Mini USB port for Local Management.

— **SYNC: 1PPS + ToD** – HW prepared.

— **SYNC: 2 MHz** – 2 MHz/2048 Kbps sync input/output.

— **TN 4** & **TN 5** – 2 x RJ 45 10Mbps/100Mbps/1Gbps Ethernet ports. All LAN ports are SyncE capable.

— **TN 6** – 1 x SFP 1Gbps Ethernet port. SyncE capable except with SFPe.

— **TN 7** & **TN 8** – 2 x SFP/SFP+ 1Gbps or 10Gbps Ethernet ports. All LAN ports are SyncE capable except with SFPe.

— **USER I/O** – 6 user in, 3 user out.

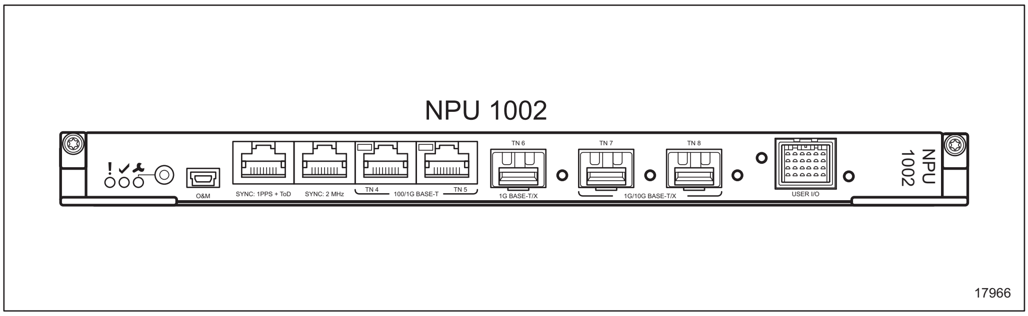


Figure 129 Front Interfaces on the NPU 1002

NPU 1002 has two fixed electrical LAN 10/100/1000BASE-T Ethernet interfaces, one SFP cage supporting 1 Gbps, and two SFP+ cages supporting up to 10 Gbps on the front. One of the fixed Ethernet ports can be configured as a site LAN port.

The SFP/SFP+ cages can be equipped with Ericsson approved SFP/SFP+ modules, see MINI-LINK 6600 R1 Compatibility, Reference [1].

The User I/O interface provides six User Input ports and three User Output ports.

For the basic offering for NPU 1002, two Ethernet ports are enabled at the front. To get access to more ports, licenses are needed. Licenses are also needed for the 10G ports.

NPU 1002 supports Packet Link WAN connections.

The high speed connections and the LAN ports enable NPU 1002 to aggregate traffic from multiple directions as well as dropping Ethernet traffic locally at the site.

15.8.1.1 User Input/Output

The User Input ports can be used to connect user alarms to MINI-LINK Node GUI. Applications like fire alarms, burglar alarms, and low power indicators are easily implemented using these input ports. The User Input ports can be configured to be normally opened or closed.

The User Output ports can be used to export summary alarms of the accumulated severity in the NE to the supervision system of other equipment. The User Output ports can be controlled by the operator or triggered by one or several alarm severities.

Table 33 NPU 1002 User Input and Output Ports

Plug-In Unit	Number of Input Signals	Number of Output Signals	Connector Type
NPU 1002	Six	Three	Male 24 pin SOFIX connector

15.8.2 Ethernet Switch

The Ethernet switch functionality is shown in Table 34.

Table 34 Ethernet Switch Functionality

Modes	Port roles	Comment
Provider Bridge mode	CE-UNI	CEP, including default mapping rule
	CN-UNI	CNP
	I-NNI	–

Modes	Port roles	Comment
Customer Bridge mode	UNI	Including QinQ termination, default mapping rule
	NNI	–

The switch is a managed VLAN switch (IEEE 802.1Q and IEEE 802.1D) and supports Provider mode (IEEE 802.1ad) and Customer mode (IEEE 802.1Q) switching.

The switch supports Jumbo frames. The Ethernet site LAN ports on NPU 1002 have interfaces that support auto-negotiation 10/100/1000 Mbps speed. The interfaces are physical RJ-45 connectors.

15.8.3 Ethernet LAN Ports

The Ethernet LAN ports are described in Table 35.

Table 35 Ethernet LAN Ports

Functionality	Description
Interface types	10/100/1000 Mbps 10 Gbps Auto negotiation or manual setting (IEEE802.3-2005).
Duplex mode	Full duplex. Auto negotiation or manual setting (IEEE802.3-2005).
Connectors/cables	RJ-45 with MDI/MDIX support for all electrical i/f. Single/multi-mode fiber with LC connector for the optical i/f.
SFP modules	SFP/SFP+ plug-in modules are supported with 1 Gbps and 10 Gbps optical and 100/1000 Mbps electrical interfaces. For more information regarding SFP/SFP+, see MINI-LINK 6600 R1 Compatibility, Reference [1].
LED indicators	Each Ethernet interface has one green LED for network link indication.
Standard frame sizes	Up to 2000 bytes when used as an external interface (IEEE802.3as-2006). Up to 2048 bytes when used as an internal interface.
Jumbo frames	9,216 byte frame size for data applications.

Table 35 Ethernet LAN Ports

Functionality	Description
Buffer capacity	Ethernet ports share a 720 MB buffering capacity. The buffer capacity sharing among the traffic queues is based on a fair adaptive dynamic algorithm.
Flow control	NPU 1002 supports the IEEE 802.3x standard to handle temporary congestion on ports configured as Layer 2 connections (connected to the switch). NPU 1002 only supports asymmetrical flow control. When a congestion threshold is reached in an NE downstream, the NE generates a PAUSE signal and NPU 1002 temporarily halts the transmission of Ethernet frames, but NPU 1002 cannot generate PAUSE signals to control the transmission process on connected equipment.

15.9 NPU 1003

NPU 1003 is a processor board that fits in MINI-LINK 6691 MINI-LINK 6693, and MINI-LINK 6694.

NPU 1003 contains an embedded Ethernet switch which makes it an ideal component at a medium or small Ethernet aggregation site. It also supports Synchronous Ethernet.

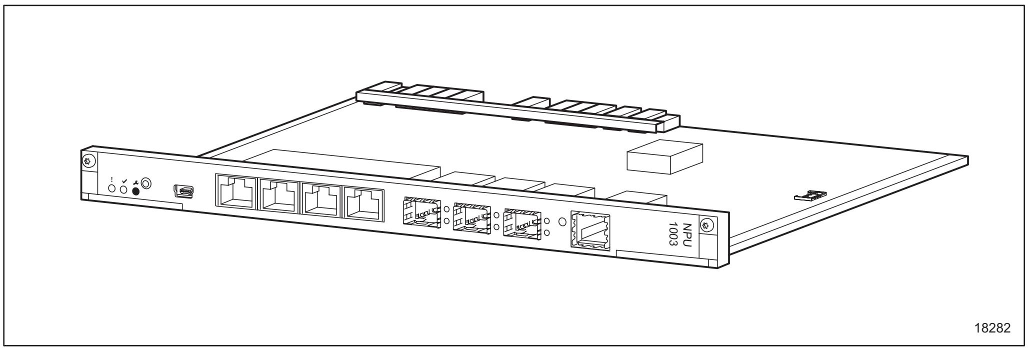


Figure 130 NPU 1003

The NPU 1003 supports the following Ethernet-related features:

- Store and forward MAC (IEEE802.1D-2004) and VLAN-based switching (IEEE802.1Q-2005 and IEEE802.1ad-2005).
- Port-based VLAN (up to 1,000 VLANs in the range of 1–4094).
- MAC address table (32,000 entries) with learning and aging.
- IPv4 and IPv6
- Static unicast/multicast routes.

- Jumbo frames for LAN and Packet Link WAN ports.
- Multiple internal Layer 1 and Layer 2 Ethernet connections.
- MSTP/RSTP/LAG protection mechanism.
- Link Aggregation Control Protocol (LACP).
- Link Loss Forwarding for internal Layer 1 connections.
- Policing/color marking per ingress port with CIR/EIR and CBS/EBS.
- Policing/color marking per ingress port per QoS priority with CIR/EIR and CBS/EBS.
- Policing/color marking per ingress port per VLAN with CIR/EIR and CBS/EBS.
- Traffic shaping per egress port with CIR and CBS.
- 2 MHz/2048 Kbps sync input/output.
- Ethernet loop detection.
- Broadcast/multicast/destination lookup failure storm protection.
- Frame admission control.
- Classification/tagging of priority and VLAN ID.
- Congestion handling with eight priority queues (TC) per port.
  - Frame discard: WRED, color dropping, aging and tail drop.
  - TC scheduling: SP, WDRR.
- In-band management transport in Ethernet flow (DCN over VLAN).
- Management/diagnostics.
  - PM counters.
  - Link OAM.
  - Ethernet Service OAM.
  - Port mirroring.

15.9.1 NPU 1003 Front Interfaces

- **O&M** – Mini USB port for Local Management.
- **SYNC: 1PPS + ToD** – HW prepared.
- **SYNC: 2 MHz** – 2 MHz/2048 Kbps sync input/output.

— **TN 4** & **TN 5** – 2 x RJ 45 10Mbps/100Mbps/1Gbps Ethernet ports. All LAN ports are SyncE capable.

— **TN 6** – 1 x SFP 1Gbps Ethernet port. SyncE capable except with SFPe.

— **TN 7** & **TN 8** – 2 x SFP/SFP+ 1Gbps or 10Gbps Ethernet ports. All LAN ports are SyncE capable except with SFPe.

— **TN 9** – 4 E1/DS1 and User I/O (2 user in, 1 user out). The E1 interface can be used as sync source.

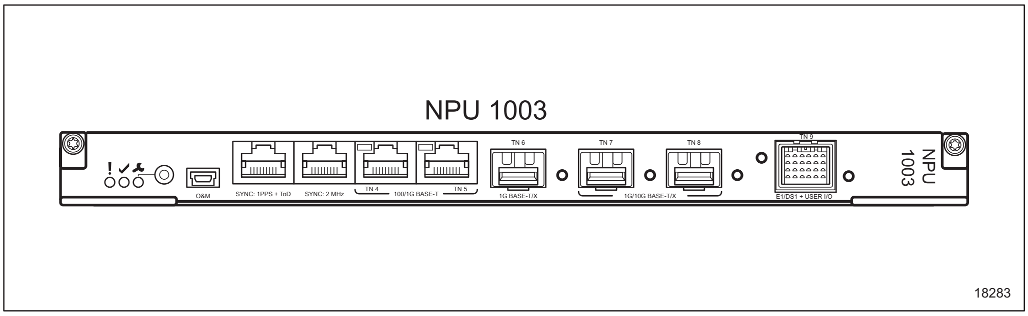


Figure 131 Front Interfaces on the NPU 1003

NPU 1003 has two fixed electrical LAN 10/100/1000BASE-T Ethernet interfaces, one SFP cage supporting 1Gbps, and two SFP+ cages supporting up to 10 Gbps on the front. One of the fixed Ethernet ports can be configured as a site LAN port. The NPU 1003 also has shared E1/DS1 and User I/O port.

The SFP/SFP+ cages can be equipped with Ericsson approved SFP/SFP+ modules, see MINI-LINK 6600 R1 Compatibility, Reference [1].

The User I/O interface provides two User Input ports and one User Output port.

For the basic offering for NPU 1003, two Ethernet ports are enabled at the front. To get access to more ports, licenses are needed. Licenses are also needed for the 10G ports.

NPU 1003 supports Packet Link WAN connections.

The high speed connections and the LAN ports enable NPU 1003 to aggregate traffic from multiple directions as well as dropping Ethernet traffic locally at the site.

15.9.1.1 User Input/Output

The User Input ports can be used to connect user alarms to MINI-LINK Node GUI. Applications like fire alarms, burglar alarms, and low power indicators are easily implemented using these input ports. The User Input ports can be configured to be normally opened or closed.

The User Output ports can be used to export summary alarms of the accumulated severity in the NE to the supervision system of other equipment. The User Output ports can be controlled by the operator or triggered by one or several alarm severities.

Table 36 NPU 1003 User Input and Output Ports

Plug-In Unit	Number of Input Signals	Number of Output Signals	Connector Type
NPU 1003	Two	One	Male 24 pin SOFIX connector

15.9.2 Ethernet Switch

The Ethernet switch functionality is shown in Table 34.

Table 37 Ethernet Switch Functionality

Modes	Port roles	Comment
Provider Bridge mode	CE-UNI	CEP, including default mapping rule
	CN-UNI	CNP
	I-NNI	–
Customer Bridge mode	UNI	Including QinQ termination, default mapping rule
	NNI	–

The switch is a managed VLAN switch (IEEE 802.1Q and IEEE 802.1D) and supports Provider mode (IEEE 802.1ad) and Customer mode (IEEE 802.1Q) switching.

The switch supports Jumbo frames. The Ethernet site LAN ports on NPU 1003 have interfaces that support auto-negotiation 10/100/1000 Mbps speed. The interfaces are physical RJ-45 connectors.

15.9.3 Ethernet LAN Ports

The Ethernet LAN ports are described in Table 35.

Table 38 Ethernet LAN Ports

Functionality	Description
Interface types	10/100/1000 Mbps 10 Gbps Auto negotiation or manual setting (IEEE802.3-2005).

Table 38 Ethernet LAN Ports

Functionality	Description
Duplex mode	Full duplex. Auto negotiation or manual setting (IEEE802.3-2005).
Connectors/cables	RJ-45 with MDI/MDIX support for all electrical i/f. Single/multi-mode fiber with LC connector for the optical i/f.
SFP modules	SFP/SFP+ plug-in modules are supported with 1 Gbps and 10 Gbps optical and 100/1000 Mbps electrical interfaces. For more information regarding SFP/SFP+, see MINI-LINK 6600 R1 Compatibility, Reference [1].
LED indicators	Each Ethernet interface has one green LED for network link indication.
Standard frame sizes	Up to 2000 bytes when used as an external interface (IEEE802.3as-2006). Up to 2048 bytes when used as an internal interface.
Jumbo frames	9,216 byte frame size for data applications.
Buffer capacity	Ethernet ports share a 180 MB buffering capacity. The buffer capacity sharing among the traffic queues is based on a fair adaptive dynamic algorithm.
Flow control	NPU 1003 supports the IEEE 802.3x standard to handle temporary congestion on ports configured as Layer 2 connections (connected to the switch). NPU 1003 only supports asymmetrical flow control. When a congestion threshold is reached in an NE downstream, the NE generates a PAUSE signal and NPU 1003 temporarily halts the transmission of Ethernet frames, but NPU 1003 cannot generate PAUSE signals to control the transmission process on connected equipment.

15.10 NPU 1005

NPU 1005 is a full size processor board that fits in MINI-LINK 6691, MINI-LINK 6692, MINI-LINK 6693, and MINI-LINK 6694.

NPU 1005 contains an embedded Ethernet switch which makes it an ideal component at a medium or small Ethernet aggregation site.

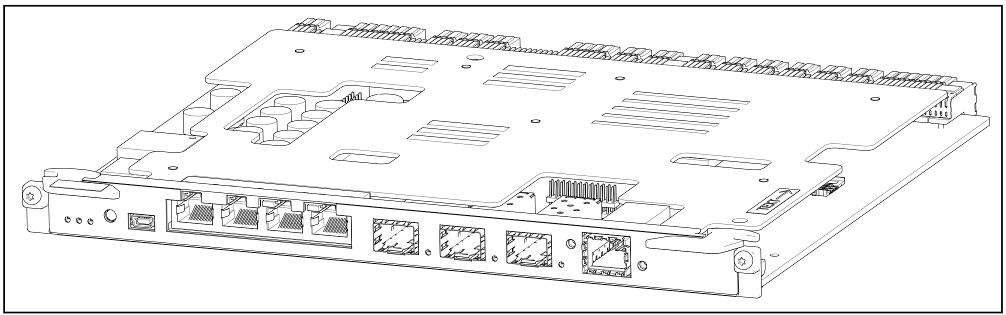


Figure 132 NPU 1005

The NPU 1005 supports the following Ethernet-related features:

— Synchronous Ethernet
— Hierarchical Radio Link Bonding (hRLB)
— Store and forward MAC (IEEE802.1D-2004) and VLAN-based switching (IEEE802.1Q-2005 and IEEE802.1ad-2005).
— Port-based VLAN (up to 1,000 VLANs in the range of 1–4094).
— MAC address table (32,000 entries) with learning and aging.
— IPv4 and IPv6
— Static unicast/multicast routes.
— Jumbo frames for LAN and Packet Link WAN ports.
— Multiple internal Layer 1 and Layer 2 Ethernet connections.
— MSTP/RSTP/LAG protection mechanism.
— Link Aggregation Control Protocol (LACP).
— Link Loss Forwarding for internal Layer 1 connections.
— Policing/color marking per ingress port with CIR/EIR and CBS/EBS.
— Policing/color marking per ingress QoS TC with CIR/EIR and CBS/EBS.
— Traffic shaping per egress port with CIR and CBS.
— 2 MHz sync input/output.
— Ethernet loop detection.
— Broadcast/multicast/destination lookup failure storm protection.
— Frame admission control.
— Classification/tagging of priority and VLAN ID.

— Congestion handling with eight priority queues (TC) per port.

  - Frame discard: WRED, color dropping, aging and tail drop.
  - TC scheduling: SP, WDRR.

— In-band management transport in Ethernet flow (DCN over VLAN).

— Management/diagnostics.

  - PM counters.
  - Link OAM.
  - Ethernet Service OAM.
  - Port mirroring.

15.10.1 Front Interfaces

O&M Mini USB port for Local management.

SYNC: 1PPS + ToD HW prepared.

SYNC: 2 MHz 2 MHz/2048 Kbps sync input/output.

TN 4 & TN 5 2 x RJ 45 10Mbps/100Mbps/1Gbps Ethernet ports. All LAN ports are SyncE capable.

TN 6 1 x SFP 1Gbps Ethernet port. SyncE capable, except when it is used with SFPe.

TN 7 & TN 8 2 x SFP/SFP+ 1Gbps or 10Gbps Ethernet ports. All LAN ports are SyncE capable, except when they are used with SFPe.

USER I/O 6 user in, 3 user out.

Figure 133 Front Interfaces on the NPU 1005

NPU 1005 has two fixed electrical LAN 10/100/1000BASE-T Ethernet interfaces, one SFP cage, and two SFP+ cages on the front. One of the fixed Ethernet ports can be configured as a site LAN port.

The SFP/SFP+ cages can be equipped with Ericsson approved SFP/SFP+ modules, see MINI-LINK 6600 R1 Compatibility, Reference [1].

The User I/O interface provides six User Input ports and three User Output ports.

For the basic offering for NPU 1005, two Ethernet ports are enabled at the front. To get access to more ports, licenses are needed.

NPU 1005 supports Packet Link WAN connections.

The high speed connections and the LAN ports enable NPU 1005 to aggregate traffic from multiple directions as well as dropping Ethernet traffic locally at the site.

15.10.2 Ethernet Switch

The Ethernet switch functionality is shown in Table 34.

Table 39 Ethernet Switch Functionality

Modes	Port roles	Comment
Provider Bridge mode	CE-UNI	CEP, including default mapping rule
	CN-UNI	CNP
	I-NNI	–
Customer Bridge mode	UNI	Including QinQ termination, default mapping rule
	NNI	–

The switch is a managed VLAN switch (IEEE 802.1Q and IEEE 802.1D) and supports Provider mode (IEEE 802.1ad) and Customer mode (IEEE 802.1Q) switching.

The switch supports Jumbo frames. The Ethernet site LAN ports on NPU 1005 have interfaces that support auto-negotiation 10/100/1000 Mbps speed. The interfaces are physical RJ-45 connectors.

15.10.3 Ethernet LAN Ports

The Ethernet LAN ports are described in Table 35.

Table 40 Ethernet LAN Ports

Functionality	Description
Interface types	10/100/1000 Mbps 10 Gbps Auto negotiation or manual setting (IEEE802.3-2005).

Table 40 Ethernet LAN Ports

Functionality	Description
Duplex mode	Full duplex. Auto negotiation or manual setting (IEEE802.3-2005).
Connectors/cables	RJ-45 with MDI/MDIX support for all electrical i/f. Single/multi-mode fiber with LC connector for the optical i/f.
SFP modules	SFP/SFP+ plug-in modules are supported with 1 Gbps and 10 Gbps optical and 100/1000 Mbps electrical interfaces. For more information regarding SFP/SFP+, see MINI-LINK 6600 R1 Compatibility, Reference [1].
LED indicators	Each Ethernet interface has one green LED for network link indication.
Standard frame sizes	Up to 2000 bytes when used as an external interface (IEEE802.3as-2006). Up to 2048 bytes when used as an internal interface.
Jumbo frames	9,216 byte frame size for data applications.
Buffer capacity	Ethernet ports share a 720 MB buffering capacity. The buffer capacity sharing among the traffic queues is based on a fair adaptive dynamic algorithm.
Flow control	NPU 1005 supports the IEEE 802.3x standard to handle temporary congestion on ports configured as Layer 2 connections (connected to the switch). NPU 1005 only supports asymmetrical flow control. When a congestion threshold is reached in an NE downstream, the NE generates a PAUSE signal and NPU 1005 temporarily halts the transmission of Ethernet frames, but NPU 1005 cannot generate PAUSE signals to control the transmission process on connected equipment.

15.11 MMU 1001

MMU 1001 is a single carrier modem.

On one modem, the following is supported:

— Single WAN 1+0

On two modems, the following is supported:

— 2+0 RLB with Equipment Protection (EQP)

— 1+1 RLP with EQP

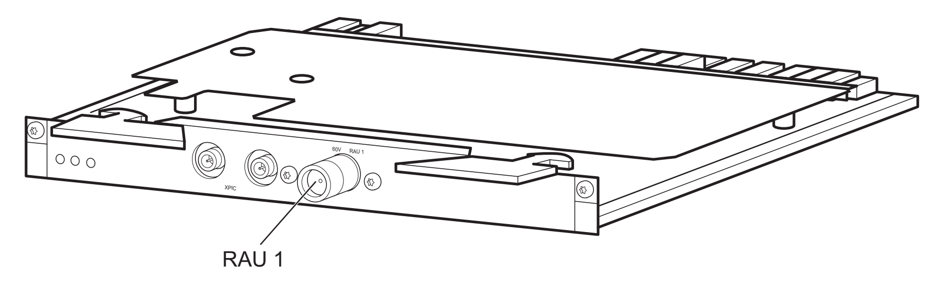


Figure 134 MMU 1001

Note: The coaxial interface on modem and radios is equipped with built-in gas discharge tubes for lightning protection.

Adding components to this interface (for example, extra lightning protection) can impact function and performance and should only be considered after consulting with Ericsson.

Table 46 shows the characteristics of the WAN ports.

Table 41

Ethernet WAN ports	Description
Interface types	1×Packet Link radio interface.
Frame size	An Ethernet over Packet Link WAN port is regarded as an internal MINI-LINK 6600 interface and supports up to 9,216 byte frames (jumbo frames).
Throughput	MMU 1001 supports simultaneous PDH and Ethernet transport over the same radio hop. The available bandwidth is split between the PDH and Ethernet traffic. The following maximum bit rate over the radio hop is supported: • ETSI: 1067 Mbps in a 112 MHz channel • ANSI: 767 Mbps in an 80 MHz channel See Table 42 and Table 43 (ETSI), orTable 44 and Table 45 (ANSI) for more information on capacity for MMU 1001.

Ethernet WAN ports	Description
Latency	The end to end latency for an Ethernet over Packet Link connection will differ based on different parameters, for example, link speed. Typical end to end latency contribution between two Ethernet ports on two nodes connected with Ethernet over packet Link with 558 Mbps link capacity is: • 0.23 ms for 64 byte frame size • 0.29 ms for 1518 byte frame size
Buffer capacity	All egress WAN ports are assigned to the centralized deep buffer. The available buffer space is shared between the traffic classes (priority queues) to provide an effective burst absorption capability in a fair manner. The buffer size of traffic class queues can be regulated by configuring a user defined queue-size limit for tail drop or using WRED.

MMU 1001 is a high-capacity PDH/Ethernet modem with Adaptive Coding and Modulation (ACM), see Section 3.2 on page 12, HW support for XPIC (including XPIC Recovery and Restore), see Section 3.9 on page 28, and modulation schemes up to 4096 QAM.

MMU 1001 has HW support for Radio Link Bonding (RLB). For more information, see Section 3.5 on page 17.

MMU 1001 provides physical layer Sync over Radio Link.

MMU 1001 enables Ethernet transport over a radio hop, that is, a Packet Link. MMU 1001 uses the high speed connections to communicate with the Ethernet switch on the NPU boards.

MMU 1001 carries PDH traffic and have an interface to the TDM bus. The capacity split between packet and circuit transport is configured individually per MMU 1001.

MMU 1001 supports control of the ratio between Ethernet and PDH traffic sent over Hybrid Radio Links. The Ethernet part of the aggregated capacity is set with E1/DS1 granularity.

MMU 1001 has a backplane capacity of up to 2.5 Gbps.

MMU 1001 is used for the traffic capacities specified in Table 42 and Table 43 (ETSI), orTable 44 and Table 45 (ANSI).

Table 42 Aggregated PDH and Ethernet Capacity for MMU 1001 Adaptive Physical Modes (ETSI)

Modulation	Capacity in Mbps						
	Channel Bandwidth						
	7 MHz	14 MHz	28 MHz	40 MHz	56 MHz	80 MHz	112 MHz
4 QAM STRONG	8	18	37	53	75	108	150
4 QAM	10	21	43	62	87	126	175
16 QAM STRONG	17	37	74	106	150	216	301
16 QAM	20	43	87	124	175	252	351
32 QAM	26	54	109	156	220	317	441
64 QAM	32	68	136	195	276	397	553
128 QAM	38	80	161	231	326	469	653
256 QAM	44	92	186	266	377	541	754
512 QAM	47	99	198	284	402	577	804
512 QAM LIGHT	50	105	211	302	427	614	854
1024 QAM	53(1)	110	221	316	447	643	895
1024 QAM LIGHT	56(1)	116	233	334	472	679	945
2048 QAM	–	121(1)	243	347	491	706	983
2048 QAM LIGHT	–	127(1)	256	365	516	742	1033
4096 QAM	–	–	264	377	533	767(1)	1067(1)
4096 QAM LIGHT	–	–	276	395	558	–	–

(1) XPIC feature not supported by HW.

Table 43 Maximum PDH Capacities for MMU 1001 Adaptive Physical Modes (ETSI)

Modulation	Capacity in E1s						
	Channel Bandwidth						
	7 MHz	14 MHz	28 MHz	40 MHz	56 MHz	80 MHz	112 MHz
4 QAM STRONG	3×E1	7×E1	16×E1	23×E1	34×E1	47×E1	70×E1
4 QAM	3×E1	8×E1	16×E1	27×E1	34×E1	56×E1	80×E1
16 QAM STRONG	7×E1	16×E1	34×E1	49×E1	71×E1	80×E1	80×E1
16 QAM	7×E1	19×E1	34×E1	57×E1	71×E1	80×E1	80×E1
32 QAM	11×E1	24×E1	51×E1	73×E1	80×E1	80×E1	80×E1
64 QAM	14×E1	31×E1	64×E1	80×E1	80×E1	80×E1	80×E1
128 QAM	17×E1	37×E1	76×E1	80×E1	80×E1	80×E1	80×E1

Modulation	Capacity in E1s						
	Channel Bandwidth						
	7 MHz	14 MHz	28 MHz	40 MHz	56 MHz	80 MHz	112 MHz
256 QAM	19×E1	43×E1	80×E1	80×E1	80×E1	80×E1	80×E1
512 QAM	21×E1	46×E1	80×E1	80×E1	80×E1	80×E1	80×E1
512 QAM LIGHT	21×E1	49×E1	80×E1	80×E1	80×E1	80×E1	80×E1
1024 QAM	24×E1(1)	51×E1	80×E1	80×E1	80×E1	80×E1	80×E1
1024 QAM LIGHT	24×E1(1)	54×E1	80×E1	80×E1	80×E1	80×E1	80×E1
2048 QAM	–	57×E1(1)	80×E1	80×E1	80×E1	80×E1	80×E1
2048 QAM LIGHT	–	60×E1(1)	80×E1	80×E1	80×E1	80×E1	80×E1
4096 QAM	–	–	80×E1	80×E1	80×E1	80×E1(1)	80×E1(1)
4096 QAM LIGHT	–	–	80×E1	80×E1	80×E1	–	–

(1) XPIC feature not supported by HW.

Table 44 Aggregated PDH and Ethernet Capacity for MMU 1001 Adaptive Physical Modes (ANSI)

Modulation	Capacity in Mbps									
	Channel Bandwidth									
	10 MHz	20 MHz	28 MHz	30 MHz	40 MHz	50 MHz	56 MHz	60 MHz	80 MHz	112 MHz
4 QAM STRONG	12	26	37	39	53	67	75	81	108	150
4 QAM	14	30	43	46	62	78	87	94	126	175
16 QAM STRONG	25	52	74	79	107	135	150	162	216	301
16 QAM	29	61	87	93	125	157	175	189	252	351
32 QAM	36	77	109	116	157	197	220	237	317	441
64 QAM	46	96	136	146	197	247	276	297	397	553
128 QAM	54	114	161	173	233	292	326	351	469	653
256 QAM	63	131	186	199	268	337	377	405	541	754
512 QAM	67	140	198	213	286	360	402	432	577	804
512 QAM LIGHT	71	149	211	226	304	382	427	459	614	854
1024 QAM	74(1)	156	221	237	319	400	447	481	643	895

Modulation	Capacity in Mbps									
	Channel Bandwidth									
	10 MHz	**20 MHz**	**28 MHz**	**30 MHz**	**40 MHz**	**50 MHz**	**56 MHz**	**60 MHz**	**80 MHz**	**112 MHz**
1024 QAM LIGHT	79[1]	165	233	250	337	423	472	508	679	945
2048 QAM	–	171	243	260	350	440	491	528	706	983
2048 QAM LIGHT	–	180	256	273	368	462	516	555	742	1033
4096 QAM	–	–	264	282	380	477	533	574	767[1]	1067[1]
4096 QAM LIGHT	–	–	276	296	398	500	558	601	–	–

(1) XPIC feature not supported by HW.

Table 45 Maximum PDH Capacities for MMU 1001 Adaptive Physical Modes (ANSI)

Modulation	Capacity in DS1s									
	Channel Bandwidth									
	10 MHz	**20 MHz**	**28 MHz**	**30 MHz**	**40 MHz**	**50 MHz**	**56 MHz**	**60 MHz**	**80 MHz**	**80 MHz**
4 QAM STRONG	5×DS1	14×DS1	21×DS1	23×DS1	32×DS1	40×DS1	45×DS1	49×DS1	66×DS1	80×DS1
4 QAM	7×DS1	17×DS1	25×DS1	27×DS1	37×DS1	47×DS1	54×DS1	58×DS1	78×DS1	80×DS1
16 QAM STRONG	13×DS1	31×DS1	45×DS1	48×DS1	66×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
16 QAM	16×DS1	36×DS1	53×DS1	57×DS1	77×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
32 QAM	21×DS1	46×DS1	67×DS1	72×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
64 QAM	27×DS1	59×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
128 QAM	32×DS1	70×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
256 QAM	37×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
512 QAM	40×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
512 QAM LIGHT	43×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
1024 QAM	45×DS1[1]	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1

Modulation	Capacity in DS1s									
	Channel Bandwidth									
	10 MHz	20 MHz	28 MHz	30 MHz	40 MHz	50 MHz	56 MHz	60 MHz	80 MHz	80 MHz
1024 QAM LIGHT	48×DS1[1]	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
2048 QAM	–	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
2048 QAM LIGHT	–	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
4096 QAM	–	–	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1[1]	80×DS1[1]
4096 QAM LIGHT	–	–	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	–	–

(1) XPIC feature not supported by HW.

It is possible to configure all Adaptive Coding and Modulation (ACM) physical modes as static physical modes, except for 4096 QAM, by setting **Max Capacity – Modulation** and **Min Capacity – Modulation** to the same value, using MINI-LINK Node GUI. The ACM physical modes configured as static can only be used in hops configured with MMU 1001 on both sides.

Ethernet WAN Buffers

The WAN port buffers in MINI-LINK 6600 have been designed to handle burst and congestion in order to provide a high link utilization and throughput for high-speed data traffic.

Since extensive buffering has a negative impact on frame delay variation, it is important to have the possibility to regulate buffer/queue size for different traffic classes independently. This can be achieved by using WRED or packet aging.

This means that queues configured to handle delay variation sensitive traffic such as synchronization traffic, shall be regulated accordingly.

In contrast, for traffic queues for less delay variation sensitive traffic the TCP/IP has a congestion avoidance mechanism that is based on buffer utilization. In order to provide a high link utilization and high TCP throughput, queues configured to handle this type of traffic needs to be in the area of hundreds of milliseconds at the smallest congestion point.

15.12 MMU 1002

MMU 1002 is a dual carrier modem.

With one modem, the following is supported:

— Single WAN 1+0

— Single WAN 2+0 Radio Link Bonding (RLB)

— Dual WAN 2×(1+0)

— Single WAN 1+1 Radio Link Protection (RLP)

With two modems, the following is supported:

— 1+1 RLP with Equipment Protection (EQP)

— 2+0 RLB with EQP

— 2 x (2+0) RLB with EQP

— 4+0 RLB with EQP

— 2+2 RLP with EQP

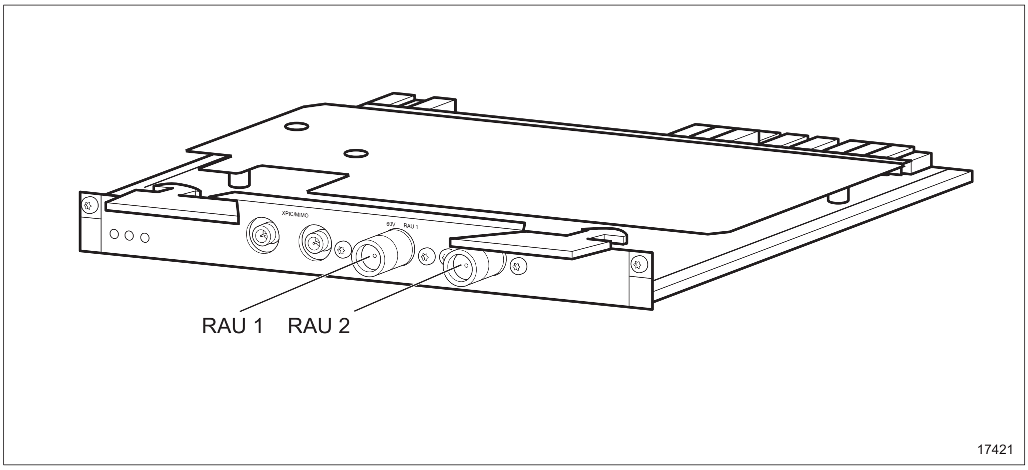


Figure 135 MMU 1002

Note: The coaxial interface on modem and radios is equipped with built-in gas discharge tubes for lightning protection.

Adding components to this interface (for example, extra lightning protection) can impact function and performance and should only be considered after consulting with Ericsson.

Table 46 shows the characteristics of the WAN ports.

Table 46

Ethernet WAN ports	Description
Interface types	2×Packet Link radio interface.

Ethernet WAN ports	Description
Frame size	An Ethernet over Packet Link WAN port is regarded as an internal MINI-LINK 6600 interface and supports up to 9,216 byte frames (jumbo frames).
Throughput	MMU 1002 supports simultaneous PDH and Ethernet transport over the same radio hop. The available bandwidth is split between the PDH and Ethernet traffic. The following maximum bit rate over the radio hop is supported: • ETSI: 1067 Mbps in a 112 MHz channel • ANSI: 803 Mbps in an 80 MHz channel See Table 47 and Table 48 (ETSI), or Table 49 and Table 50 (ANSI) for more information on capacity for MMU 1002.
Latency	The end to end latency for an Ethernet over Packet Link connection will differ based on different parameters, for example, link speed. Typical end to end latency contribution between two Ethernet ports on two nodes connected with Ethernet over packet Link with 558 Mbps link capacity is: • 0.23 ms for 64 byte frame size • 0.29 ms for 1518 byte frame size
Buffer capacity	All egress WAN ports are assigned to the centralized deep buffer. The available buffer space is shared between the traffic classes (priority queues) to provide an effective burst absorption capability in a fair manner. The buffer size of traffic class queues can be regulated by configuring a user defined queue-size limit for tail drop or using WRED.

MMU 1002 is a high-capacity PDH/Ethernet modem with support for XPIC (including XPIC Recovery and Restore), see Section 3.9 on page 28, Adaptive Coding and Modulation (ACM), see Section 3.2 on page 12, and modulation schemes up to 4096 QAM.

MMU 1002 supports Radio Link Bonding (RLB), see Section 3.5 on page 17.

MMU 1002 provides physical layer Sync over Radio Link.

MMU 1002 enables Ethernet transport over a radio hop, that is, a Packet Link. MMU 1002 uses the high speed connections to communicate with the Ethernet switch on the NPU boards.

MMU 1002 carries PDH traffic and have an interface to the TDM bus. The capacity split between packet and circuit transport is configured individually per MMU 1002.

MMU 1002 supports control of the ratio between Ethernet and PDH traffic sent over Hybrid Radio Links. The Ethernet part of the aggregated capacity is set with E1/DS1 granularity.

MMU 1002 has a backplane capacity of up to 2×2.5 Gbps.

MMU 1002 is used for the traffic capacities specified in Table 47 and Table 48 (ETSI), or Table 49 and Table 50 (ANSI).

Using two MMU 1002s, a 4 x 4 MIMO configuration with two separated cross-polarization antennas can provide very high spectral efficiency.

MMU 1002 supports Carrier Aggregation, when connected to a MINI-LINK 6364 or a MINI-LINK 6365 radio, see Section 3.11 on page 37.

Table 47 Aggregated PDH and Ethernet Capacity for MMU 1002 Adaptive Physical Modes (ETSI)

Modulation	Capacity in Mbps						
	Channel Bandwidth						
	7 MHz	14 MHz	28 MHz	40 MHz	56 MHz	80 MHz	112 MHz
4 QAM STRONG	8	18	37/36 (1)(2)	53 (2)	75/73 (1)(2)	108	150
4 QAM	10	21	43/42 (1)(2)	62 (2)	87/86 (1)(2)	126	175
16 QAM STRONG	17	37	74/72 (1)(2)	106 (2)	150/146 (1)(2)	216	301
16 QAM	20	43	87/85 (1)(2)	124 (2)	175/171 (1)(2)	252	351
32 QAM	26	54	109/109 (1)(2)	156 (2)	220/219 (1)(2)	317	441
64 QAM	32	68	136/133 (1)(2)	195 (2)	276/268 (1)(2)	397	553
128 QAM	38	80	161/157 (1)(2)	231 (2)	326/317 (1)(2)	469	653
256 QAM	44	92	186/182 (1)(2)	266 (2)	377/366 (1)(2)	541	754
512 QAM	47	99	198/194 (1)(2)	284 (2)	402/390 (1)(2)	577	804
512 QAM LIGHT	50	105	211/206 (1)(2)	302 (2)	427/415 (1)(2)	614	854
1024 QAM	53 (3)	110	221 (2)	316 (2)	447/435 (1)(2)	643	895

Modulation	Capacity in Mbps						
	Channel Bandwidth						
	7 MHz	14 MHz	28 MHz	40 MHz	56 MHz	80 MHz	112 MHz
1024 QAM LIGHT	56(3)	116	233(2)	334(2)	472/459 (1)(2)	679	945
2048 QAM	–	121(3)	243(2)	347(2)	491(2)	706	983
2048 QAM LIGHT	–	127(3)	256(2)	365(2)	516	742	1033
4096 QAM	–	–	264(2)	377	533	767	1067
4096 QAM LIGHT	–	–	276	395	558	803	–
8192 QAM(3)(4)	–	–	283	405	–	–	–

(1) MIMO supported. Smaller capacity applies for MIMO configuration.

(2) Carrier Aggregation supported.

(3) XPIC not supported.

(4) 8192 QAM is not supported as static modulation. It is recommended to set radio output power to 0 dBm or higher.

Table 48 Maximum PDH Capacities for MMU 1002 Adaptive Physical Modes (ETSI)

Modulation	Capacity in E1s(1)						
	Channel Bandwidth						
	7 MHz	14 MHz	28 MHz	40 MHz	56 MHz	80 MHz	112 MHz
4 QAM STRONG	2×E1	6×E1	15×E1/15 ×E1(2)(3)	23×E1(3)	34×E1/33 ×E1(2)(3)	47×E1	70×E1
4 QAM	3×E1	8×E1	18×E1/18 ×E1(2)(3)	28×E1(3)	40×E1/39 ×E1(2)(3)	56×E1	80×E1
16 QAM STRONG	6×E1	15×E1	34×E1/33 ×E1(2)(3)	49×E1(3)	70×E1/68 ×E1(2)(3)	80×E1	80×E1
16 QAM	7×E1	18×E1	39×E1/38 ×E1(2)(3)	57×E1(3)	80×E1/80 ×E1(2)(3)	80×E1	80×E1
32 QAM	10×E1	24×E1	50×E1/50 ×E1(2)(3)	73×E1(3)	80×E1/80 ×E1(2)(3)	80×E1	80×E1
64 QAM	13×E1	30×E1	63×E1/62 ×E1(2)(3)	80×E1(3)	80×E1/80 ×E1(2)(3)	80×E1	80×E1
128 QAM	16×E1	36×E1	75×E1/74 ×E1(2)(3)	80×E1(3)	80×E1/80 ×E1(2)(3)	80×E1	80×E1
256 QAM	19×E1	42×E1	80×E1/80 ×E1(2)(3)	80×E1(3)	80×E1/80 ×E1(2)(3)	80×E1	80×E1
512 QAM	21×E1	45×E1	80×E1/80 ×E1(2)(3)	80×E1(3)	80×E1/80 ×E1(2)(3)	80×E1	80×E1
512 QAM LIGHT	22×E1	48×E1	80×E1/80 ×E1(2)(3)	80×E1(3)	80×E1/80 ×E1(2)(3)	80×E1	80×E1
1024 QAM	23×E1(4)	51×E1	80×E1(3)	80×E1(3)	80×E1/80 ×E1(2)(3)	80×E1	80×E1
1024 QAM LIGHT	25×E1(4)	54×E1	80×E1(3)	80×E1(3)	80×E1/80 ×E1(2)(3)	80×E1	80×E1

Modulation	Capacity in E1s(1)						
	Channel Bandwidth						
	7 MHz	14 MHz	28 MHz	40 MHz	56 MHz	80 MHz	112 MHz
2048 QAM	–	56×E1(4)	80×E1(3)	80×E1(3)	80×E1(3)	80×E1	80×E1
2048 QAM LIGHT	–	59×E1(4)	80×E1(3)	80×E1(3)	80×E1	80×E1	80×E1
4096 QAM	–	–	80×E1(3)	80×E1	80×E1	80×E1	80×E1
4096 QAM LIGHT	–	–	80×E1	80×E1	80×E1	80×E1	80×E1
8192 QAM(4)	–	–	80×E1(5)	80×E1(5)	–	–	–

(1) The table shows the maximum capacity values for one direction. When the NE is configured for two directions, the capacity decreases to half of these values.
(2) MIMO supported. Smaller capacity applies for MIMO configuration.
(3) Carrier Aggregation supported.
(4) XPIC not supported.
(5) 8192 QAM is not supported as a minimum modulation.

Table 49 Aggregated PDH and Ethernet Capacity for MMU 1002 Adaptive Physical Modes (ANSI)

Modulation	Capacity in Mbps									
	Channel Bandwidth									
	10 MHz	20 MHz	28 MHz	30 MHz	40 MHz	50 MHz	56 MHz	60 MHz	80 MHz	112 MHz
4 QAM STRONG	12	26	37	39/39,0(1)(2)	53/52,4(1)(2)	67(2)	75	81	108	150
4 QAM	14	30	43	46/45,8(1)(2)	62/61,5(1)(2)	78(2)	87	94	126	175
16 QAM STRONG	25	52	74	79/78,0(1)(2)	107/104,7(1)(2)	135(2)	150	162	216	301
16 QAM	29	61	87	93/91,0(1)(2)	125/122,2(1)(2)	157(2)	175	189	252	351
32 QAM	36	77	109	116/117,0(1)(2)	157/157,1(1)(2)	197(2)	220	237	317	441
64 QAM	46	96	136	146/143,0(1)(2)	197/192,0(1)(2)	247(2)	276	297	397	553
128 QAM	54	114	161	173/169,0(1)(2)	233/226,9(1)(2)	292(2)	326	351	469	653
256 QAM	63	131	186	199/195,0(1)(2)	268/261,9(1)(2)	337(2)	377	405	541	754
512 QAM	67	140	198	213/208,0(1)(2)	286/279,3(1)(2)	360(2)	402	432	577	804

Modulation	Capacity in Mbps									
	Channel Bandwidth									
	10 MHz	20 MHz	28 MHz	30 MHz	40 MHz	50 MHz	56 MHz	60 MHz	80 MHz	112 MHz
512 QAM LIGHT	71	149	211	226/221,0(1)(2)	304/296,8(1)(2)	382(2)	427	459	614	854
1024 QAM	74(3)	156	221	237(2)	319(2)	400(2)	447	481	643	895
1024 QAM LIGHT	79(3)	165	233	250(2)	337(2)	423(2)	472	508	679	945
2048 QAM	–	171	243	260(2)	350(2)	440(2)	491	528	706	983
2048 QAM LIGHT	–	180	256	273(2)	368(2)	462	516	555	742	1033
4096 QAM	–	–	264	282(2)	380	477	533	574	767(3)	1067(3)
4096 QAM LIGHT	–	–	276	296	398	500	558	601	803	–
8192 QAM(3)(4)	–	–	–	304	409	–	–	–	–	–

(1) MIMO supported. The second capacity applies for MIMO configuration.

(2) Carrier Aggregation supported.

(3) XPIC not supported.

(4) 8192 QAM is not supported as static modulation. It is recommended to set radio output power to 0 dBm or higher.

Table 50 Maximum PDH Capacities for MMU 1002 Adaptive Physical Modes (ANSI)

Modulation	Capacity in DS1s(1)									
	Channel Bandwidth									
	10 MHz	20 MHz	28 MHz	30 MHz	40 MHz	50 MHz	56 MHz	60 MHz	80 MHz	112 MHz
4 QAM STRONG	5×DS1	14×DS1	21×DS1	23×DS1/22×DS1(2)(3)	32×DS1/31×DS1(2)(3)	40×DS1(3)	45×DS1	49×DS1	66×DS1	80×DS1
4 QAM	7×DS1	17×DS1	25×DS1	27×DS1/26×DS1(2)(3)	37×DS1/36×DS1(2)(3)	47×DS1(3)	54×DS1	58×DS1	78×DS1	80×DS1
16 QAM STRONG	13×DS1	31×DS1	45×DS1	48×DS1/47×DS1(2)(3)	66×DS1/64×DS1(2)(3)	80×DS1(3)	80×DS1	80×DS1	80×DS1	80×DS1
16 QAM	16×DS1	36×DS1	53×DS1	57×DS1/55×DS1(2)(3)	77×DS1/75×DS1(2)(3)	80×DS1(3)	80×DS1	80×DS1	80×DS1	80×DS1

Modulation	Capacity in DS1s[1]									
	Channel Bandwidth									
	10 MHz	**20 MHz**	**28 MHz**	**30 MHz**	**40 MHz**	**50 MHz**	**56 MHz**	**60 MHz**	**80 MHz**	**112 MHz**
32 QAM	21×DS1	46×DS1	67×DS1	72×DS1/72×DS1[2][3]	80×DS1/80×DS1[2][3]	80×DS1[3]	80×DS1	80×DS1	80×DS1	80×DS1
64 QAM	27×DS1	59×DS1	80×DS1	80×DS1/80×DS1[2][3]	80×DS1/80×DS1[2][3]	80×DS1[3]	80×DS1	80×DS1	80×DS1	80×DS1
128 QAM	32×DS1	70×DS1	80×DS1	80×DS1/80×DS1[2][3]	80×DS1/80×DS1[2][3]	80×DS1[3]	80×DS1	80×DS1	80×DS1	80×DS1
256 QAM	37×DS1	80×DS1	80×DS1	80×DS1/80×DS1[2][3]	80×DS1/80×DS1[2][3]	80×DS1[3]	80×DS1	80×DS1	80×DS1	80×DS1
512 QAM	40×DS1	80×DS1	80×DS1	80×DS1/80×DS1[2][3]	80×DS1/80×DS1[2][3]	80×DS1[3]	80×DS1	80×DS1	80×DS1	80×DS1
512 QAM LIGHT	43×DS1	80×DS1	80×DS1	80×DS1/80×DS1[2][3]	80×DS1/80×DS1[2][3]	80×DS1[3]	80×DS1	80×DS1	80×DS1	80×DS1
1024 QAM	45×DS1[4]	80×DS1	80×DS1	80×DS1[3]	80×DS1[3]	80×DS1[3]	80×DS1	80×DS1	80×DS1	80×DS1
1024 QAM LIGHT	48×DS1[4]	80×DS1	80×DS1	80×DS1[3]	80×DS1[3]	80×DS1[3]	80×DS1	80×DS1	80×DS1	80×DS1
2048 QAM	–	80×DS1	80×DS1	80×DS1[3]	80×DS1[3]	80×DS1[3]	80×DS1	80×DS1	80×DS1	80×DS1
2048 QAM LIGHT	–	80×DS1	80×DS1	80×DS1[3]	80×DS1[3]	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
4096 QAM	–	–	80×DS1	80×DS1[3]	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1[4]	80×DS1[4]
4096 QAM LIGHT	–	–	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	–
8192 QAM[4]	–	–	–	80×DS1[5]	80×DS1[5]	–	–	–	–	–

(1) The table shows the maximum capacity values for one direction. When the NE is configured for two directions, the capacity decreases to half of these values.
(2) MIMO supported. Smaller capacity applies for MIMO configuration.
(3) Carrier Aggregation supported.
(4) XPIC not supported.
(5) 8192 QAM is not supported as minimum modulation.

It is possible to configure all Adaptive Coding and Modulation (ACM) physical modes as static physical modes, except for 4096 QAM, by setting **Max Capacity – Modulation** and **Min Capacity – Modulation** to the same value, using MINI-LINK Node GUI. The ACM physical modes configured as static can only be used in hops configured with MMU 1002 on both sides.

Ethernet WAN Buffers

The WAN port buffers in MINI-LINK 6600 have been designed to handle burst and congestion in order to provide a high link utilization and throughput for high-speed data traffic.

Since extensive buffering has a negative impact on frame delay variation, it is important to have the possibility to regulate buffer/queue size for different traffic classes independently. This can be achieved by using WRED or packet aging.

This means that queues configured to handle delay variation sensitive traffic such as synchronization traffic, shall be regulated accordingly.

In contrast, for traffic queues for less delay variation sensitive traffic the TCP/IP has a congestion avoidance mechanism that is based on buffer utilization. In order to provide a high link utilization and high TCP throughput, queues configured to handle this type of traffic needs to be in the area of hundreds of milliseconds at the smallest congestion point.

15.13 MMU 1004

MMU 1004 is a dual carrier modem.

With one modem, the following is supported:

- Single WAN 1+0
- Single WAN 2+0 Radio Link Bonding (RLB)
- Dual WAN 2×(1+0)
- Single WAN 1+1 Radio Link Protection (RLP)

With two modems, the following is supported:

- 1+1 RLP with Equipment Protection (EQP)
- 2+0 RLB with EQP
- 2 x (2+0) RLB with EQP
- 4+0 RLB with EQP
- 2+2 RLP with EQP

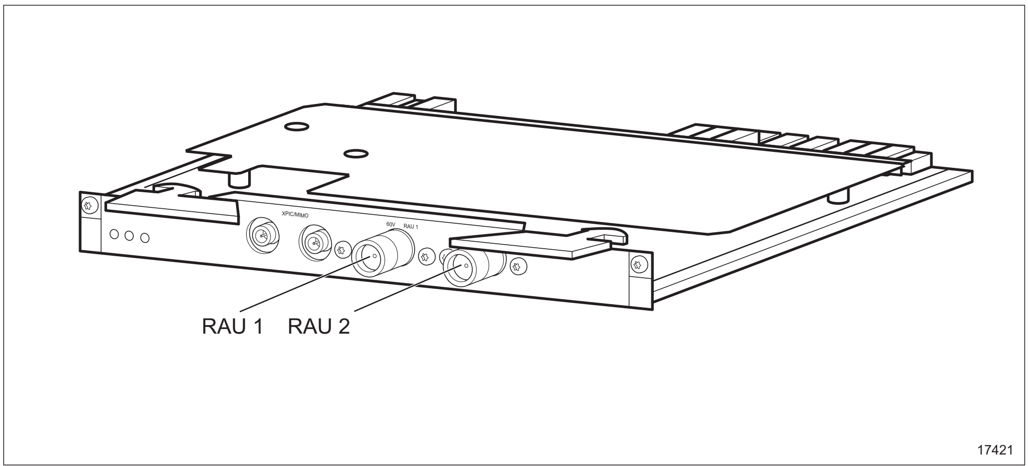


Figure 136 MMU 1004

Note: The coaxial interface on modem and radios is equipped with built-in gas discharge tubes for lightning protection.

Adding components to this interface (for example, extra lightning protection) can impact function and performance and should only be considered after consulting with Ericsson.

Table 51 shows the characteristics of the WAN ports.

Table 51

Ethernet WAN ports	Description
Interface types	2×Packet Link radio interface.
Frame size	An Ethernet over Packet Link WAN port is regarded as an internal MINI-LINK 6600 interface and supports up to 9,216 byte frames (jumbo frames).
Throughput	MMU 1004 supports simultaneous PDH and Ethernet transport over the same radio hop. The available bandwidth is split between the PDH and Ethernet traffic. The following maximum bit rate over the radio hop is supported: • ETSI: 1067 Mbps in a 112 MHz channel • ANSI: 803 Mbps in an 80 MHz channel See Table 47 and Table 48 (ETSI), or Table 49 and Table 50 (ANSI) for more information on capacity for MMU 1004.

Ethernet WAN ports	Description
Latency	The end to end latency for an Ethernet over Packet Link connection will differ based on different parameters, for example, link speed. Typical end to end latency contribution between two Ethernet ports on two nodes connected with Ethernet over packet Link with 558 Mbps link capacity is: • 0.23 ms for 64 byte frame size • 0.29 ms for 1518 byte frame size
Buffer capacity	All egress WAN ports are assigned to the centralized deep buffer. The available buffer space is shared between the traffic classes (priority queues) to provide an effective burst absorption capability in a fair manner. The buffer size of traffic class queues can be regulated by configuring a user defined queue-size limit for tail drop or using WRED.

MMU 1004 is a high-capacity PDH/Ethernet modem with support for XPIC (including XPIC Recovery and Restore), see Section 3.9 on page 28, Adaptive Coding and Modulation (ACM), see Section 3.2 on page 12, and modulation schemes up to 4096 QAM.

MMU 1004 supports Radio Link Bonding (RLB), see Section 3.5 on page 17.

MMU 1004 provides physical layer Sync over Radio Link.

MMU 1004 enables Ethernet transport over a radio hop, that is, a Packet Link. MMU 1004 uses the high speed connections to communicate with the Ethernet switch on the NPU boards.

MMU 1004 carries PDH traffic and have an interface to the TDM bus. The capacity split between packet and circuit transport is configured individually per MMU 1004.

MMU 1004 supports control of the ratio between Ethernet and PDH traffic sent over Hybrid Radio Links. The Ethernet part of the aggregated capacity is set with E1/DS1 granularity.

MMU 1004 has a backplane capacity of up to 2×2.5 Gbps.

MMU 1004 is used for the traffic capacities specified in Table 52 and Table 53 (ETSI), or Table 54 and Table 55 (ANSI).

Using two MMU 1004s, a 4 x 4 MIMO configuration with two separated cross-polarization antennas can provide very high spectral efficiency.

MMU 1004 supports Carrier Aggregation, when connected to a MINI-LINK 6364 or MINI-LINK 6365 radio, with up to maximum 2 x 112 MHz, see Section 3.11 on page 37.

Table 52 Aggregated PDH and Ethernet Capacity for MMU 1004 Adaptive Physical Modes (ETSI)

Modulation	Capacity in Mbps						
	Channel Bandwidth						
	7 MHz	14 MHz	28 MHz	40 MHz	56 MHz	80 MHz	112 MHz
4 QAM STRONG	8	18	37/36(1)(2)	53(2)	75/73(1)(2)	108(2)	150(2)
4 QAM	10	21	43/42(1)(2)	62(2)	87/86(1)(2)	126(2)	175(2)
16 QAM STRONG	17	37	74/72(1)(2)	106(2)	150/146(1)(2)	216(2)	301(2)
16 QAM	20	43	87/85(1)(2)	124(2)	175/171(1)(2)	252(2)	351(2)
32 QAM	26	54	109/109(1)(2)	156(2)	220/219(1)(2)	317(2)	441(2)
64 QAM	32	68	136/133(1)(2)	195(2)	276/268(1)(2)	397(2)	553(2)
128 QAM	38	80	161/157(1)(2)	231(2)	326/317(1)(2)	469(2)	653(2)
256 QAM	44	92	186/182(1)(2)	266(2)	377/366(1)(2)	541(2)	754(2)
512 QAM	47	99	198/194(1)(2)	284(2)	402/390(1)(2)	577(2)	804(2)
512 QAM LIGHT	50	105	211/206(1)(2)	302(2)	427/415(1)(2)	614(2)	854(2)
1024 QAM	53(3)	110	221(2)	316(2)	447/435(1)(2)	643(2)	895(2)
1024 QAM LIGHT	56(3)	116	233(2)	334(2)	472/459(1)(2)	679	945
2048 QAM	–	121(3)	243(2)	347(2)	491(2)	706	983
2048 QAM LIGHT	–	127(3)	256(2)	365(2)	516	742	1033
4096 QAM	–	–	264(2)	377	533	767	1067
4096 QAM LIGHT	–	–	276	395	558	803	–
8192 QAM(3)(4)	–	–	283	405	–	–	–

(1) MIMO supported. Smaller capacity applies for MIMO configuration.

(2) Carrier Aggregation supported.

(3) XPIC not supported.

(4) 8192 QAM is not supported as static modulation. It is recommended to set radio output power to 0 dBm or higher.

Table 53 Maximum PDH Capacities for MMU 1004 Adaptive Physical Modes (ETSI)

Modulation	Capacity in E1s[1]						
	Channel Bandwidth						
	7 MHz	14 MHz	28 MHz	40 MHz	56 MHz	80 MHz	112 MHz
4 QAM STRONG	2×E1	6×E1	15×E1/15 ×E1[2][3]	23×E1[3]	34×E1/33 ×E1[2][3]	47×E1[3]	70×E1[3]
4 QAM	3×E1	8×E1	18×E1/18 ×E1[2][3]	28×E1[3]	40×E1/39 ×E1[2][3]	56×E1[3]	80×E1[3]
16 QAM STRONG	6×E1	15×E1	34×E1/33 ×E1[2][3]	49×E1[3]	70×E1/68 ×E1[2][3]	80×E1[3]	80×E1[3]
16 QAM	7×E1	18×E1	39×E1/38 ×E1[2][3]	57×E1[3]	80×E1/80 ×E1[2][3]	80×E1[3]	80×E1[3]
32 QAM	10×E1	24×E1	50×E1/50 ×E1[2][3]	73×E1[3]	80×E1/80 ×E1[2][3]	80×E1[3]	80×E1[3]
64 QAM	13×E1	30×E1	63×E1/62 ×E1[2][3]	80×E1[3]	80×E1/80 ×E1[2][3]	80×E1[3]	80×E1[3]
128 QAM	16×E1	36×E1	75×E1/74 ×E1[2][3]	80×E1[3]	80×E1/80 ×E1[2][3]	80×E1[3]	80×E1[3]
256 QAM	19×E1	42×E1	80×E1/80 ×E1[2][3]	80×E1[3]	80×E1/80 ×E1[2][3]	80×E1[3]	80×E1[3]
512 QAM	21×E1	45×E1	80×E1/80 ×E1[2][3]	80×E1[3]	80×E1/80 ×E1[2][3]	80×E1[3]	80×E1[3]
512 QAM LIGHT	22×E1	48×E1	80×E1/80 ×E1[2][3]	80×E1[3]	80×E1/80 ×E1[2][3]	80×E1[3]	80×E1[3]
1024 QAM	23×E1[4]	51×E1	80×E1[3]	80×E1[3]	80×E1/80 ×E1[2][3]	80×E1[3]	80×E1[3]
1024 QAM LIGHT	25×E1[4]	54×E1	80×E1[3]	80×E1[3]	80×E1/80 ×E1[2][3]	80×E1	80×E1
2048 QAM	–	56×E1[4]	80×E1[3]	80×E1[3]	80×E1[3]	80×E1	80×E1
2048 QAM LIGHT	–	59×E1[4]	80×E1[3]	80×E1[3]	80×E1	80×E1	80×E1
4096 QAM	–	–	80×E1[3]	80×E1	80×E1	80×E1	80×E1
4096 QAM LIGHT	–	–	80×E1	80×E1	80×E1	80×E1	80×E1
8192 QAM[4]	–	–	80×E1[5]	80×E1[5]	–	–	–

(1) The table shows the maximum capacity values for one direction. When the NE is configured for two directions, the capacity decreases to half of these values.
(2) MIMO supported. Smaller capacity applies for MIMO configuration.
(3) Carrier Aggregation supported.
(4) XPIC not supported.
(5) 8192 QAM is not supported as minimum modulation.

Table 54 Aggregated PDH and Ethernet Capacity for MMU 1004 Adaptive Physical Modes (ANSI)

	Capacity in Mbps									
	Channel Bandwidth									
Modulation	10 MHz	20 MHz	28 MHz	30 MHz	40 MHz	50 MHz	56 MHz	60 MHz	80 MHz	112 MHz
4 QAM STRONG	12	26	37	39/39,0(1)(2)	53/52,4(1)(2)	67(2)	75	81(2)	108(2)	150
4 QAM	14	30	43	46/45,8(1)(2)	62/61,5(1)(2)	78(2)	87	94(2)	126(2)	175
16 QAM STRONG	25	52	74	79/78,0(1)(2)	107/104,7(1)(2)	135(2)	150	162(2)	216(2)	301
16 QAM	29	61	87	93/91,0(1)(2)	125/122,2(1)(2)	157(2)	175	189(2)	252(2)	351
32 QAM	36	77	109	116/117,0(1)(2)	157/157,1(1)(2)	197(2)	220	237(2)	317(2)	441
64 QAM	46	96	136	146/143,0(1)(2)	197/192,0(1)(2)	247(2)	276	297(2)	397(2)	553
128 QAM	54	114	161	173/169,0(1)(2)	233/226,9(1)(2)	292(2)	326	351(2)	469(2)	653
256 QAM	63	131	186	199/195,0(1)(2)	268/261,9(1)(2)	337(2)	377	405(2)	541(2)	754
512 QAM	67	140	198	213/208,0(1)(2)	286/279,3(1)(2)	360(2)	402	432(2)	577(2)	804
512 QAM LIGHT	71	149	211	226/221,0(1)(2)	304/296,8(1)(2)	382(2)	427	459(2)	614(2)	854
1024 QAM	74(3)	156	221	237(2)	319(2)	400(2)	447	481(2)	643(2)	895
1024 QAM LIGHT	79(3)	165	233	250(2)	337(2)	423(2)	472	508(2)	679	945
2048 QAM	–	171	243	260(2)	350(2)	440(2)	491	528(2)	706	983
2048 QAM LIGHT	–	180	256	273(2)	368(2)	462	516	555	742	1033
4096 QAM	–	–	264	282(2)	380	477	533	574	767(3)	1067(3)

Modulation	Capacity in Mbps									
	Channel Bandwidth									
	10 MHz	**20 MHz**	**28 MHz**	**30 MHz**	**40 MHz**	**50 MHz**	**56 MHz**	**60 MHz**	**80 MHz**	**112 MHz**
4096 QAM LIGHT	–	–	276	296	398	500	558	601	803	–
8192 QAM (3)(4)	–	–	–	304	409	–	–	–	–	–

(1) MIMO supported. The second capacity applies for MIMO configuration.
(2) Carrier Aggregation supported.
(3) XPIC not supported.
(4) 8192 QAM is not supported as static modulation. It is recommended to set radio output power to 0 dBm or higher.

Table 55 Maximum PDH Capacities for MMU 1004 Adaptive Physical Modes (ANSI)

Modulation	Capacity in DS1s (1)									
	Channel Bandwidth									
	10 MHz	**20 MHz**	**28 MHz**	**30 MHz**	**40 MHz**	**50 MHz**	**56 MHz**	**60 MHz**	**80 MHz**	**112 MHz**
4 QAM STRONG	5×DS1	14×DS1	21×DS1	23×DS1/22×DS1 (2)(3)	32×DS1/31×DS1 (2)(3)	40×DS1 (3)	45×DS1	49×DS1 (3)	66×DS1 (3)	80×DS1
4 QAM	7×DS1	17×DS1	25×DS1	27×DS1/26×DS1 (2)(3)	37×DS1/36×DS1 (2)(3)	47×DS1 (3)	54×DS1	58×DS1 (3)	78×DS1 (3)	80×DS1
16 QAM STRONG	13×DS1	31×DS1	45×DS1	48×DS1/47×DS1 (2)(3)	66×DS1/64×DS1 (2)(3)	80×DS1 (3)	80×DS1	80×DS1 (3)	80×DS1 (3)	80×DS1
16 QAM	16×DS1	36×DS1	53×DS1	57×DS1/55×DS1 (2)(3)	77×DS1/75×DS1 (2)(3)	80×DS1 (3)	80×DS1	80×DS1 (3)	80×DS1 (3)	80×DS1
32 QAM	21×DS1	46×DS1	67×DS1	72×DS1/72×DS1 (2)(3)	80×DS1/80×DS1 (2)(3)	80×DS1 (3)	80×DS1	80×DS1 (3)	80×DS1 (3)	80×DS1
64 QAM	27×DS1	59×DS1	80×DS1	80×DS1/80×DS1 (2)(3)	80×DS1/80×DS1 (2)(3)	80×DS1 (3)	80×DS1	80×DS1 (3)	80×DS1 (3)	80×DS1
128 QAM	32×DS1	70×DS1	80×DS1	80×DS1/80×DS1 (2)(3)	80×DS1/80×DS1 (2)(3)	80×DS1 (3)	80×DS1	80×DS1 (3)	80×DS1 (3)	80×DS1
256 QAM	37×DS1	80×DS1	80×DS1	80×DS1/80×DS1 (2)(3)	80×DS1/80×DS1 (2)(3)	80×DS1 (3)	80×DS1	80×DS1 (3)	80×DS1 (3)	80×DS1

Modulation	Capacity in DS1s[1]									
	Channel Bandwidth									
	10 MHz	**20 MHz**	**28 MHz**	**30 MHz**	**40 MHz**	**50 MHz**	**56 MHz**	**60 MHz**	**80 MHz**	**112 MHz**
512 QAM	40×DS1	80×DS1	80×DS1	80×DS1/80×DS1[2][3]	80×DS1/80×DS1[2][3]	80×DS1[3]	80×DS1	80×DS1[3]	80×DS1[3]	80×DS1
512 QAM LIGHT	43×DS1	80×DS1	80×DS1	80×DS1/80×DS1[2][3]	80×DS1/80×DS1[2][3]	80×DS1[3]	80×DS1	80×DS1[3]	80×DS1[3]	80×DS1
1024 QAM	45×DS1[4]	80×DS1	80×DS1	80×DS1[3]	80×DS1[3]	80×DS1[3]	80×DS1	80×DS1[3]	80×DS1[3]	80×DS1
1024 QAM LIGHT	48×DS1[4]	80×DS1	80×DS1	80×DS1[3]	80×DS1[3]	80×DS1[3]	80×DS1	80×DS1[3]	80×DS1	80×DS1
2048 QAM	–	80×DS1	80×DS1	80×DS1[3]	80×DS1[3]	80×DS1[3]	80×DS1	80×DS1[3]	80×DS1	80×DS1
2048 QAM LIGHT	–	80×DS1	80×DS1	80×DS1[3]	80×DS1[3]	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1
4096 QAM	–	–	80×DS1	80×DS1[3]	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1[4]	80×DS1[4]
4096 QAM LIGHT	–	–	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	80×DS1	–
8192 QAM[4]	–	–	–	80×DS1[5]	80×DS1[5]	–	–	–	–	–

(1) The table shows the maximum capacity values for one direction. When the NE is configured for two directions, the capacity decreases to half of these values.
(2) MIMO supported. Smaller capacity applies for MIMO configuration.
(3) Carrier Aggregation supported.
(4) XPIC not supported.
(5) 8192 QAM is not supported as a minimum modulation.

It is possible to configure all Adaptive Coding and Modulation (ACM) physical modes as static physical modes, except for 4096 QAM, by setting **Max Capacity – Modulation** and **Min Capacity – Modulation** to the same value, using MINI-LINK Node GUI. The ACM physical modes configured as static can only be used in hops configured with MMU 1004 on both sides.

Ethernet WAN Buffers

The WAN port buffers in MINI-LINK 6600 have been designed to handle burst and congestion in order to provide a high link utilization and throughput for high-speed data traffic.

Since extensive buffering has a negative impact on frame delay variation, it is important to have the possibility to regulate buffer/queue size for different traffic classes independently. This can be achieved by using WRED or packet aging.

This means that queues configured to handle delay variation sensitive traffic such as synchronization traffic, shall be regulated accordingly.

In contrast, for traffic queues for less delay variation sensitive traffic the TCP/IP has a congestion avoidance mechanism that is based on buffer utilization. In order to provide a high link utilization and high TCP throughput, queues configured to handle this type of traffic needs to be in the area of hundreds of milliseconds at the smallest congestion point.

15.14 LTU 1001

LTU 1001 is a Line Termination Unit (LTU) with 16 E1/DS1 ports for PDH.

LTU 1001 can be used in MINI-LINK 6691, MINI-LINK 6692, MINI-LINK 6693, MINI-LINK 6694, MINI-LINK 6654, and MINI-LINK 6655.

Table 56 LTU 1001 Interfaces

Interfaces	16×E1/DS1 • ETSI: 75 Ω or 120 Ω G.703 • ANSI: 100 Ω Balanced G.703

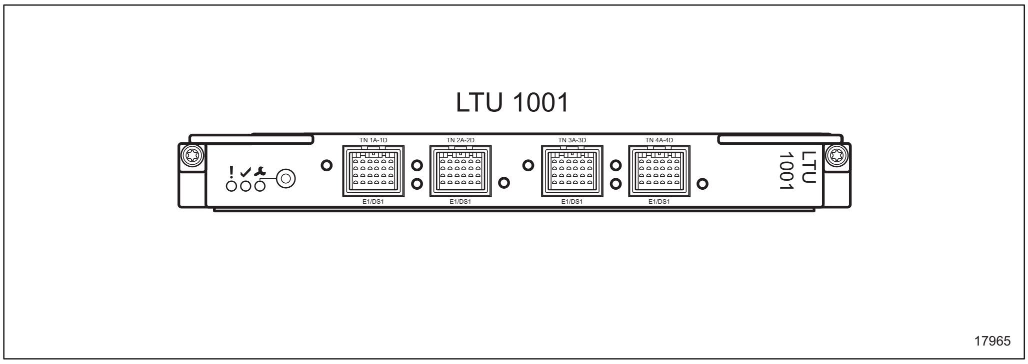


Figure 137 Front Interfaces on the LTU 1001

15.15 LTU 1002

LTU 1002 is a Line Termination Unit (LTU) with 16 E1/DS1 ports for PDH and an STM-1 port with up to 63×E1 for SDH. The 16 E1 ports and the STM-1 port with up to 63×E1s can all be used simultaneously. The actual number of supported ports depends on the selected board profile.

Note: SDH on LTU 1002 is only available for ETSI, and not for ANSI.

The following board profiles can be set for LTU1002:

PDH and SDH Provides 16×E1 front interfaces and one STM-1 front interface for up to 63×E1s.

PDH and CES Provides 16×E1/DS1 front interfaces and 16×CES E1/DS1s through the backplane.

CES only Provides 32×CES E1/DS1s through the backplane.

SDH48 and CES32

Provides one STM-1 front interface for up to 48×E1s, and 32×CES E1s through the backplane.

SDH63 and CES16

Provides STM-1 termination up to 63xE1s combined with 16xE1s circuit emulation towards the backplane.

PDH and SDH48 and CES16

Provides a combination of STM-1 (48xE1) and 16x physical E1 termination together with 16xE1s circuit emulation towards the backplane.

LTU 1002 can be used in MINI-LINK 6691, MINI-LINK 6692, MINI-LINK 6693, MINI-LINK 6694, MINI-LINK 6654, and MINI-LINK 6655.

The SDH functionality consists of front termination, terminal multiplexer, MSP protection and the possibility to send DCN traffic on DCC. The Terminal Multiplexer terminates one STM-1 with 63×E1 mapped asynchronously into 63×VC-12.

At aggregation nodes LTU 1002 acts as an interface between the optical domain and the microwave domain by providing an effective optical northbound interface using one STM-1 connection instead of n×E1 interfaces.

In ring configurations two LTU 1002 can be connected “back-to-back” to allow local add/drop of up to 63×E1. Using two LTU 1002 in a pair provides Multiplexer Section Protection (MSP) 1+1.

LTU 1002 has support for CES, enabling E1/DS1s being transported over packet.

Table 57 LTU 1002 Interfaces

Interfaces	1xSDH SFP (supporting STM-1 for up to 63×E1) 16xE1/DS1 • ETSI: 75 Ω or 120 Ω G.703 • ANSI:100 Ω Balanced G.703

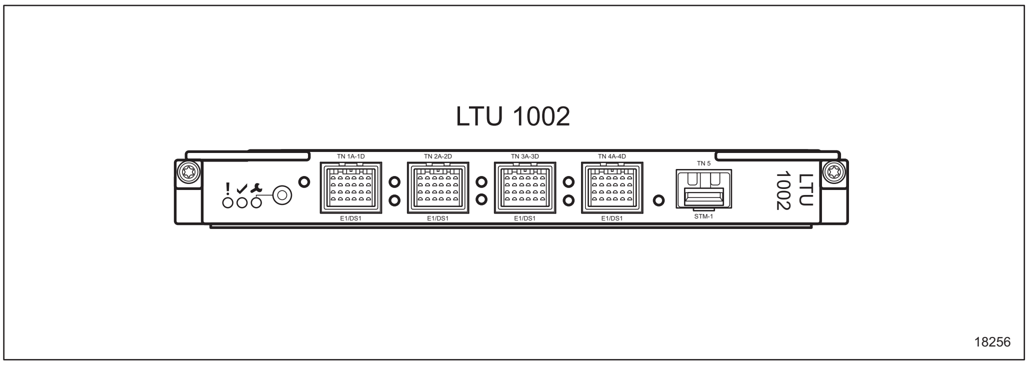


Figure 138 Front Interfaces on the LTU 1002

15.16 ETU 1001

ETU 1001 is an Ethernet Termination Unit (ETU) that supports up to four Ethernet ports. The actual number of ports depends upon the NPU type and which APU slot that is used.

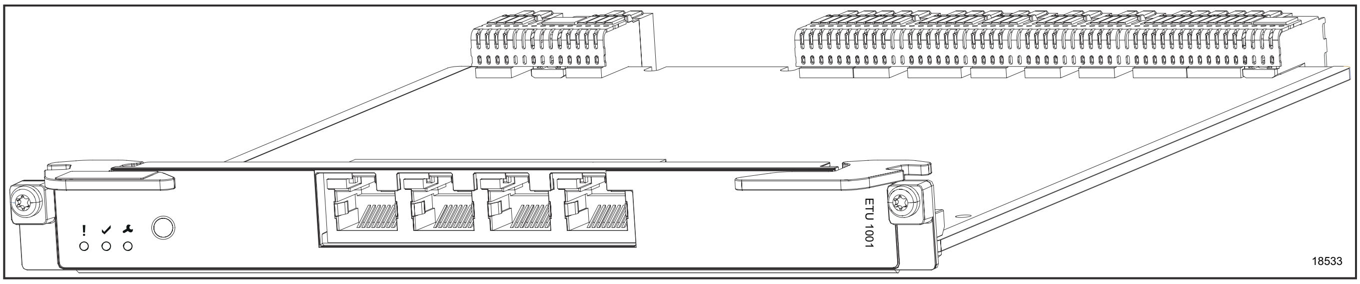


Figure 139 ETU 1001

ETU 1001 can be seen as a port extension to the NPU, where basically the same Ethernet L2 and L3 functionality as on the NPU is supported on the ETU.

ETU 1001 supports SyncE and 1588 Timestamping.

Figure 140 shows the available interfaces of the ETU 1001.

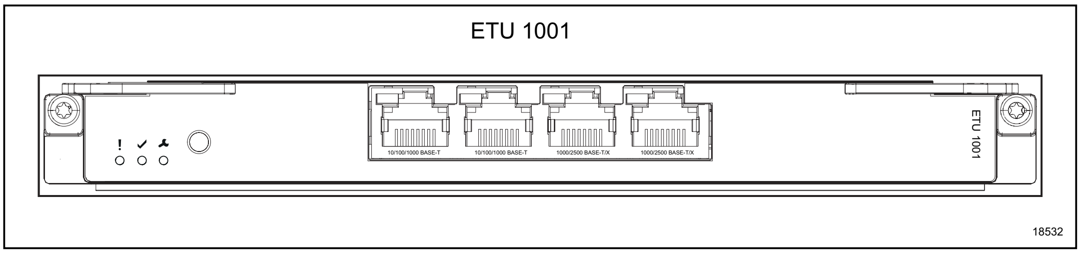


Figure 140 Front interfaces on the ETU 1001

15.17 ETU 1002

ETU 1002 is an ETU that supports up to four Ethernet ports. The actual number of supported ports depends upon the NPU type, the selected board profile, and which APU slot is used.

ETU 1002 can be seen as a port extension to the NPU or PNM, where basically the same Ethernet L2 and L3 functionality as on the NPU is supported on the ETU.

ETU 1002 has four SFP cages supporting 4x1G Ethernet, and one SFP+ cage supporting 10G Ethernet, on the front.

1G and 10G ports cannot be used simultaneously.

The following board profiles can be set for ETU 1002:

4X1G	Provides four 1G front interfaces.
1X10G	Provides one 10G front interface.

The 10G port can be used only in MINI-LINK 6691, MINI-LINK 6692, MINI-LINK 6693, and MINI-LINK 6694.

ETU 1002 supports SyncE and 1588 Timestamping on the 1GE and 10GE interfaces. When using the 10GE interface, ETU 1002 needs to be placed in a 10GE capable slot of the enclosure.

Note: SyncE is not supported on the SFPe interface.

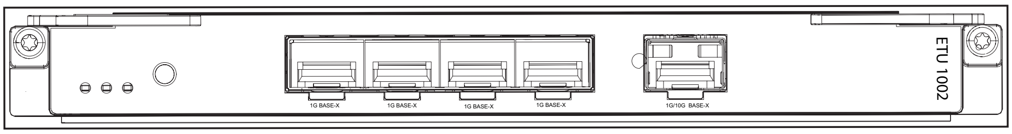


Figure 141 Front Interfaces of ETU 1002

15.18 Radio Units

15.18.1 Overview

The basic function of the radio is to generate and receive the RF signal and convert it to/from the signal format in the radio cable, connecting the radio and the MMU. It can be combined with a wide range of antennas in integrated or separate installation. The radio connects to the antenna at the waveguide interface. Disconnection and replacement of the radio can be done without affecting the antenna alignment.

There are several types of Radio Units that can be used together with MINI-LINK 6600:

- MINI-LINK 6363 (including support for E-band – 80 GHz), see Figure 142. MINI-LINK 6363 comes in two versions: MINI-LINK 6363, optimized for the highest system gain, and MINI-LINK 6363/2, optimized for the lowest power consumption.
- MINI-LINK 6364, see Figure 142, is a sub-band free radio optimized for highest output power and has support for Carrier Aggregation 2x28 MHz to 112 MHz when connected to MMU 1002 or MMU 1004.
- MINI-LINK 6365, see Figure 142, is optimized for highest system gain and has support for Carrier Aggregation from 2x28 MHz to 2x112 MHz when connected to MMU 1002 or MMU 1004.
- RAU2 X, see Figure 143.

DC power to the radio is supplied from the MMU through the radio cable.

The radio has a weather proof casing painted white (MINI-LINK 6363, MINI-LINK 6364, and MINI-LINK 6365) or light gray (RAU2 X), containing for example microwave electronics and a diplexer. It has mechanical features for easy installation on integrated antennas. It also has an optional handle (MINI-LINK 6363, MINI-LINK 6364, and MINI-LINK 6365) or an integral handle (RAU2 X) for simplified handling during installation.

The radio is independent of traffic capacity. The operating frequency is determined by the radio only and is set in advance at the factory and configured on site using MINI-LINK Node GUI. Frequency channel arrangements are available according to ITU-R and ETSI/FCC recommendations.

Note: The coaxial interface on radios and modems is equipped with built in gas discharge tubes, for lightning protection.

Adding components to this interface (for example, extra lightning protection) can impact function and performance and should only be considered after consulting with Ericsson.

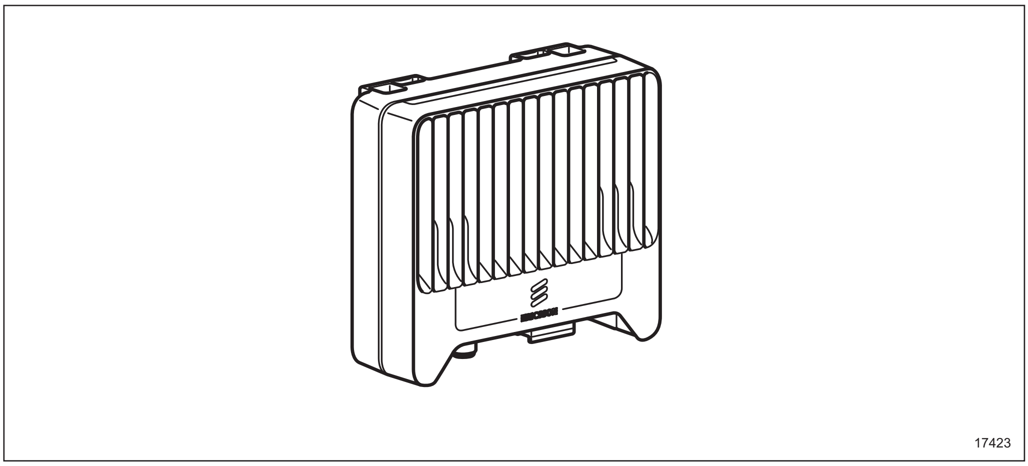


Figure 142 MINI-LINK 6363, MINI-LINK 6364, or MINI-LINK 6365 Mechanical Design

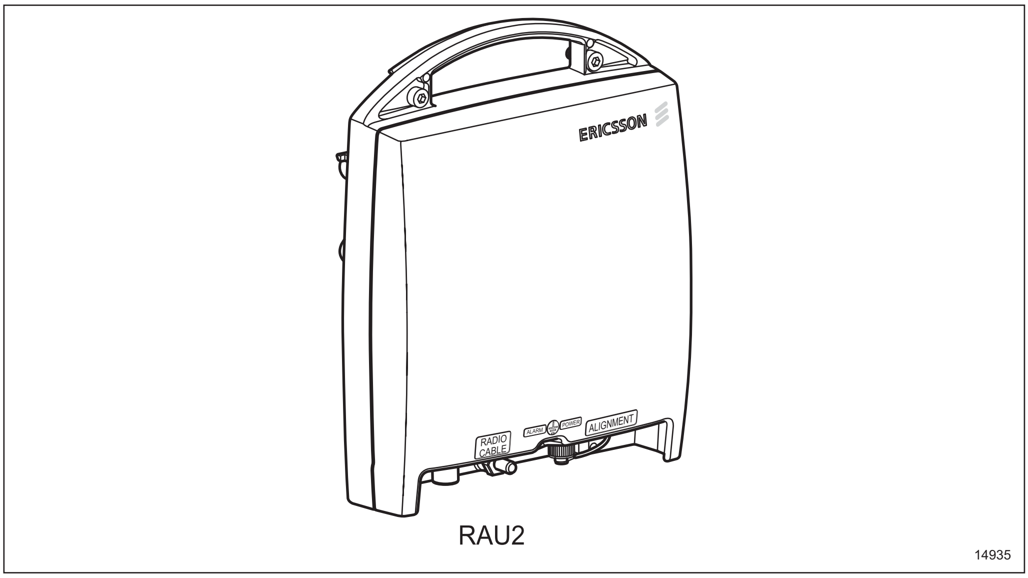


Figure 143 RAU2 X Mechanical Design

15.18.2 External Interfaces

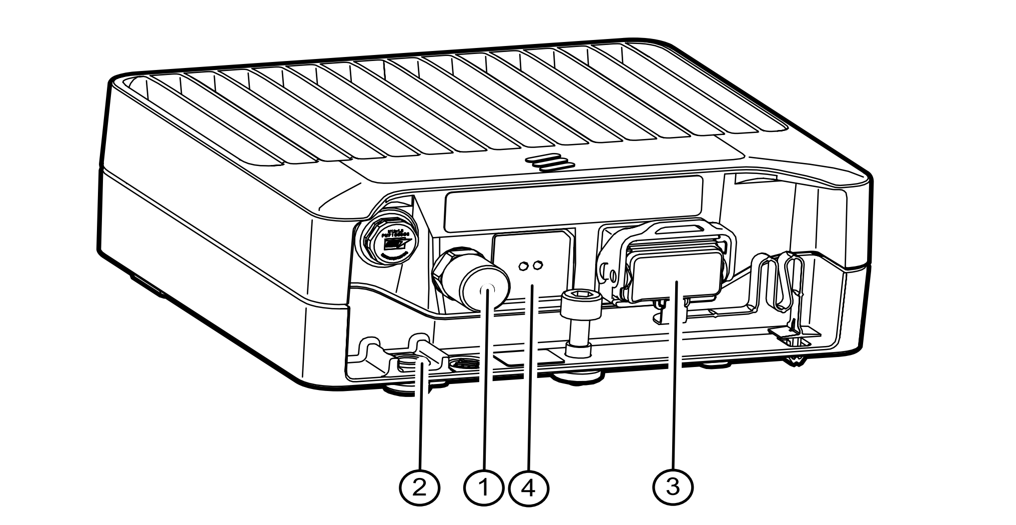


Figure 144 External Interfaces on the MINI-LINK 6363, MINI-LINK 6364, or MINI-LINK 6365

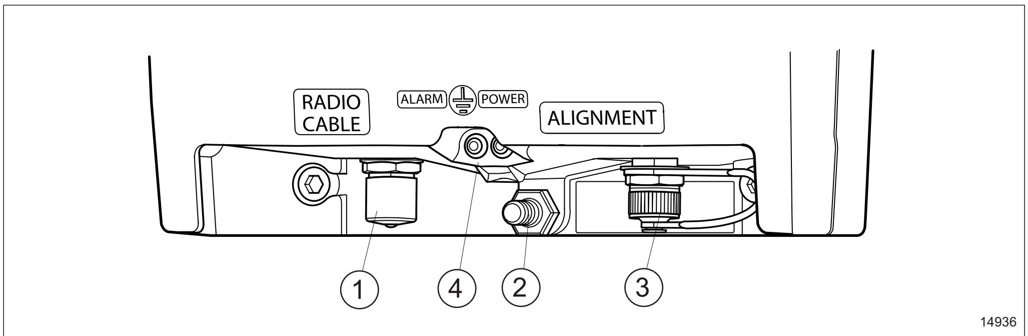


Figure 145 External Interfaces on the RAU2 X

Item	Description
1	Radio cable connection to the MMU, 50 Ω N-type connector. The connector interface is equipped with gas discharge tubes for lightning protection.
2	Protective ground point for connection to mast ground.
3	Test port for antenna alignment.
4	Red LED: Unit alarm. Green LED: Power on.

15.18.3 Radio Modulations

The radio hardware can generate and receive RF signal in single carrier mode.

The tables below show the supported modulations for the radio hardware in single carrier mode and the modulations that also support XPIC and MIMO.

All modulations that support single carrier mode are marked with x. These modulations also support XPIC unless otherwise stated.

MINI-LINK 6363 and MINI-LINK 6363/2 (ETSI)

Table 58 Supported Modulations for All Frequency Bands (Excluding E-band 80 GHz) with an R-state < R4A

Modulation	Channel Bandwidth						
	7 MHz	14/13,75 MHz	28/27,5 MHz	40 MHz	56/55 MHz	80 MHz	112/110 MHz
4 QAM	x	x	x(1)	x	x(1)	x	x
8 QAM	x	x	x(1)	x	x(1)	x	x
16 QAM	x	x	x(1)	x	x(1)	x	x
32 QAM	x	x	x(1)	x	x(1)	x	x
64 QAM	x	x	x(1)	x	x(1)	x	x
128 QAM	x	x	x(1)	x	x(1)	x	x
256 QAM	x	x	x(1)	x	x(1)	x	x
512 QAM	x	x	x(1)	x	x(1)	x	x
1024 QAM	x(2)	x	x	x	x(1)	x	x
2048 QAM	–	x(2)	x	x	x	x	x
4096 QAM	–	–	x	x	x	x	x

(1) MIMO supported.
(2) XPIC not supported.

MINI-LINK 6363 (ETSI)

Table 59 Supported Modulations for All Frequency Bands (Excluding E-band 80 GHz) with an R-state ≥ R4A

Modulation	Channel Bandwidth						
	7 MHz	14/13,75 MHz	28/27,5 MHz	40 MHz	56/55 MHz	80 MHz	112/110 MHz

4 QAM	x	x	x(1)	x	x(1)	x	x
8 QAM	x	x	x(1)	x	x(1)	x	x
16 QAM	x	x	x(1)	x	x(1)	x	x
32 QAM	x	x	x(1)	x	x(1)	x	x
64 QAM	x	x	x(1)	x	x(1)	x	x
128 QAM	x	x	x(1)	x	x(1)	x	x
256 QAM	x	x	x(1)	x	x(1)	x	x
512 QAM	x	x	x(1)	x	x(1)	x	x
1024 QAM	x(2)	x	x	x	x(1)	x	x
2048 QAM	–	x(2)	x	x	x	x	x
4096 QAM	–	–	x	x	x	x	x
8192 QAM(2)	–	–	x	x	–	–	–

(1) MIMO supported.
(2) XPIC not supported.

Table 60 Supported Modulations for E-band 80 GHz with an R-state ≥ R1A

Modulation	Channel Bandwidth	
	56/62,5 MHz	112/125 MHz
4 QAM	x	x
8 QAM	x	x
16 QAM	x	x
32 QAM	x	x
64 QAM	x	x
128 QAM	x	x
256 QAM	x	x
512 QAM	x	x
1024 QAM	x(1)	x(1)

2048 QAM	–	–
4096 QAM	–	–

(1) XPIC not supported.

MINI-LINK 6363 and MINI-LINK 6363/2 (ANSI)

Table 61 Supported Modulations for All Frequency Bands (Excluding E-band 80 GHz) with an R-state < R4A

Modulation	Channel Bandwidth						
	10 MHz	20 MHz	30 MHz	40 MHz	50 MHz	60 MHz	80 MHz
4 QAM	x	x	x(1)	x(1)	x	x	x
8 QAM	x	x	x(1)	x(1)	x	x	x
16 QAM	x	x	x(1)	x(1)	x	x	x
32 QAM	x	x	x(1)	x(1)	x	x	x
64 QAM	x	x	x(1)	x(1)	x	x	x
128 QAM	x	x	x(1)	x(1)	x	x	x
256 QAM	x	x	x(1)	x(1)	x	x	x
512 QAM	x	x	x(1)	x(1)	x	x	x
1024 QAM	x(2)	x	x	x	x	x	x
2048 QAM	–	x(2)	x	x	x	x	x
4096 QAM	–	–	x	x	x	x	x(2)

(1) MIMO supported.
(2) XPIC not supported.

MINI-LINK 6363 (ANSI)

Table 62 Supported Modulations for All Frequency Bands (Excluding E-band 80 GHz) with an R-state ≥ R4A

Modulation	Channel Bandwidth						
	10 MHz	20 MHz	30 MHz	40 MHz	50 MHz	60 MHz	80 MHz
4 QAM	x	x	x(1)	x(1)	x	x	x

8 QAM	x	x	x(1)	x(1)	x	x	x
16 QAM	x	x	x(1)	x(1)	x	x	x
32 QAM	x	x	x(1)	x(1)	x	x	x
64 QAM	x	x	x(1)	x(1)	x	x	x
128 QAM	x	x	x(1)	x(1)	x	x	x
256 QAM	x	x	x(1)	x(1)	x	x	x
512 QAM	x	x	x(1)	x(1)	x	x	x
1024 QAM	x(2)	x	x	x	x	x	x
2048 QAM	–	x(2)	x	x	x	x	x
4096 QAM	–	–	x	x	x	x	x
8192 QAM(2)	–	–	x	x	–	–	–

(1) MIMO supported.
(2) XPIC not supported.

Table 63 Supported Modulations for E-band 80 GHz with an R-state ≥ R1A

Modulation	Channel Bandwidth	
	60/62,5 MHz	80/125 MHz
4 QAM	x	x
8 QAM	x	x
16 QAM	x	x
32 QAM	x	x
64 QAM	x	x
128 QAM	x	x
256 QAM	x	x
512 QAM	x	x
1024 QAM	x(1)	x(1)
2048 QAM	–	–
4096 QAM	–	–

(1) XPIC not supported.

MINI-LINK 6364 Supported Modulations (ETSI)

Table 64 Supported Modulations for All Frequency Bands with an R-state ≥ R1A

Modulation	Channel Bandwidth						
	7 MHz	14/13,75 MHz	28/27,5 MHz	40 MHz	56/55 MHz	80 MHz	112/110 MHz
4 QAM	x	x	x(1)	x	x(1)	x	x
8 QAM	x	x	x(1)	x	x(1)	x	x
16 QAM	x	x	x(1)	x	x(1)	x	x
32 QAM	x	x	x(1)	x	x(1)	x	x
64 QAM	x	x	x(1)	x	x(1)	x	x
128 QAM	x	x	x(1)	x	x(1)	x	x
256 QAM	x	x	x(1)	x	x(1)	x	x
512 QAM	x	x	x(1)	x	x(1)	x	x
1024 QAM	x(2)	x	x	x	x(1)	x	x
2048 QAM		x	x	x	x	x	x
4096 QAM			x	x	x	x	x
8192 QAM(3)			x(2)	x(2)			

(1) MIMO supported.
(2) XPIC not supported.
(3) Static modulation is not supported.

MINI-LINK 6365 Supported Modulations (ETSI)

Table 65 Supported Modulations for All Frequency Bands with an R-state ≥ R1A

Modulation	Channel Bandwidth						
	7 MHz	14/13,75 MHz	28/27,5 MHz	40 MHz	56/55 MHz	80 MHz	112/110 MHz
4 QAM	x	x	x(1)(2)	x	x(1)(2)	x	x(2)

8 QAM	x	x	x(1)(2)	x	x(1)(2)	x	x(2)
16 QAM	x	x	x(1)(2)	x	x(1)(2)	x	x(2)
32 QAM	x	x	x(1)(2)	x	x(1)(2)	x	x(2)
64 QAM	x	x	x(1)(2)	x	x(1)(2)	x	x(2)
128 QAM	x	x	x(1)(2)	x	x(1)(2)	x	x(2)
256 QAM	x	x	x(1)(2)	x	x(1)(2)	x	x(2)
512 QAM	x	x	x(1)(2)	x	x(1)(2)	x	x(2)
1024 QAM	x(3)	x	x(2)	x	x(1)(2)	x	x(2)
2048 QAM	–	x(3)	x(2)	x	x(2)	x	x
4096 QAM	–	–	x(2)	x	x	x	x
8192 QAM(3)(4)	–	–	x	x	–	–	–

(1) MIMO supported.

(2) Carrier Aggregation supported.

(3) XPIC not supported.

(4) Supported frequencies: 7–23 GHz

MINI-LINK 6365 Supported Modulations (ANSI)

Table 66 Supported Modulations for All Frequency Bands with an R-state ≥ R1A

Modulation	**Channel Bandwidth**						
	10 MHz	20 MHz	30 MHz	40 MHz	50 MHz	60 MHz	80 MHz
4 QAM	x	x	x(1)(2)	x(1)	x(2)	x(2)	x(2)
8 QAM	x	x	x(1)(2)	x(1)(2)	x(2)	x(2)	x(2)
16 QAM	x	x	x(1)(2)	x(1)(2)	x(2)	x(2)	x(2)
32 QAM	x	x	x(1)(2)	x(1)(2)	x(2)	x(2)	x(2)
64 QAM	x	x	x(1)(2)	x(1)(2)	x(2)	x(2)	x(2)

128 QAM	x	x	x(1)(2)	x(1)(2)	x(2)	x(2)	x(2)
256 QAM	x	x	x(1)(2)	x(1)(2)	x(2)	x(2)	x(2)
512 QAM	x	x	x(1)(2)	x(1)(2)	x(2)	x(2)	x(2)
1024 QAM	x(3)	x	x(2)	x(2)	x(2)	x(2)	x(2)
2048 QAM	–	x(3)	x(2)	x(2)	x(2)	x(2)	x
4096 QAM	–	–	x(2)	x	x	x	x
8192 QAM(3)(4)	–	–	x	x	–	–	–

(1) MIMO supported.
(2) Carrier Aggregation supported.
(3) XPIC not supported.
(4) Supported frequencies: 8–23 GHz

RAU2 X Supported Modulations (ETSI)

Table 67 Supported Modulations in Single Carrier Mode for RAU2 X R-state ≥ R6A

Modulation	Channel Bandwidth				
	7 MHz	14 MHz	28 MHz	40 MHz	56 MHz
4 QAM	x	x	x	x	x
16 QAM	x	x	x	x	x
32 QAM	x	x	x	x	x
64 QAM	x	x	x	x	x
128 QAM	x	x	x	x	x
256 QAM	x	x	x	x	x
512 QAM	x	x	x	x	x
1024 QAM	x	x	x	x	x
2048 QAM	–	x	x	x	x
4096 QAM	–	–	x	x	x

RAU2 X Supported Modulations (ANSI)

Table 68 Supported Modulations in Single Carrier Mode for RAU2 X R-state ≥ R6A

Modulation	Channel Bandwidth					
	10 MHz	20 MHz	30 MHz	40 MHz	50 MHz	60 MHz
4 QAM	x	x	x	x	x	x
16 QAM	x	x	x	x	x	x
32 QAM	x	x	x	x	x	x
64 QAM	x	x	x	x	x	x
128 QAM	x	x	x	x	x	x
256 QAM	x	x	x	x	x	x
512 QAM	x	x	x	x	x	x
1024 QAM	x	x	x	x	x	x
2048 QAM	–	x	x	x	x	x
4096 QAM	–	–	x	x	x	x

15.19 Antennas

All antennas are ''compact'', that is the design is compact with a low profile. The antennas are made of aluminum and painted light gray. All antennas have a standardized waveguide interface. The feed can be adjusted for vertical or horizontal polarization.

All antennas are delivered with a mounting kit.

All high performance antennas have an integrated radome.

There are two sorts of antennas available:

— Modular antennas

— Antennas with fixed radio interface

Modular antennas range from 0.3 m – 1.8 m in diameter. The antenna is divided into two modules: the antenna module and the interface module. The interface module is available as Single polarized or as Dual polarized (OMT), and also with interfaces for ANT0 (separate installation), ANT2 (integrated installation for RAU2 X), and ANT3 (integrated installation for MINI-LINK 6363, MINI-LINK 6364, and MINI-LINK 6365). This makes it possible to upgrade a modular antenna from single to dual polarization and from one radio type to another, for capacity increase when needed and without having to re-align the antenna.

It is not possible to change the frequency band of the antenna by replacing the interface, since also other parts in the antenna are frequency dependent.

The interface module is included when ordering a modular antenna, and is also possible to order as a separate item.

Antennas with fixed radio interfaces range from 0.3 m – 3.7 m in diameter, in single and dual polarized versions, and are available with ANT0 or ANT2 interface.

15.19.1 MINI-LINK 6363, MINI-LINK 6364 and MINI-LINK 6365 Integrated Installation

For a 2+0 configuration, the MINI-LINK 6363, MINI-LINK 6364, or MINI-LINK 6365 is fitted directly to the rear of the antenna in an integrated installation. Single polarized antennas up to 1.8 m in diameter are normally fitted integrated with the MINI-LINK 6363, MINI-LINK 6364 or MINI-LINK 6365.

For a 1+1 configuration the MINI-LINK 6363, MINI-LINK 6364, or MINI-LINK 6365 can be fitted directly to an Integrated Power Splitter (IPS), see Figure 146.

An asymmetrical power splitter is mainly used for 1+1 hardware protection only. The IPS provides one main channel with low attenuation and one standby channel with higher attenuation.

A symmetrical power splitter is mainly used for 1+1 or 2+0 hardware protection and frequency diversity. The IPS provides equal attenuation in both channels.

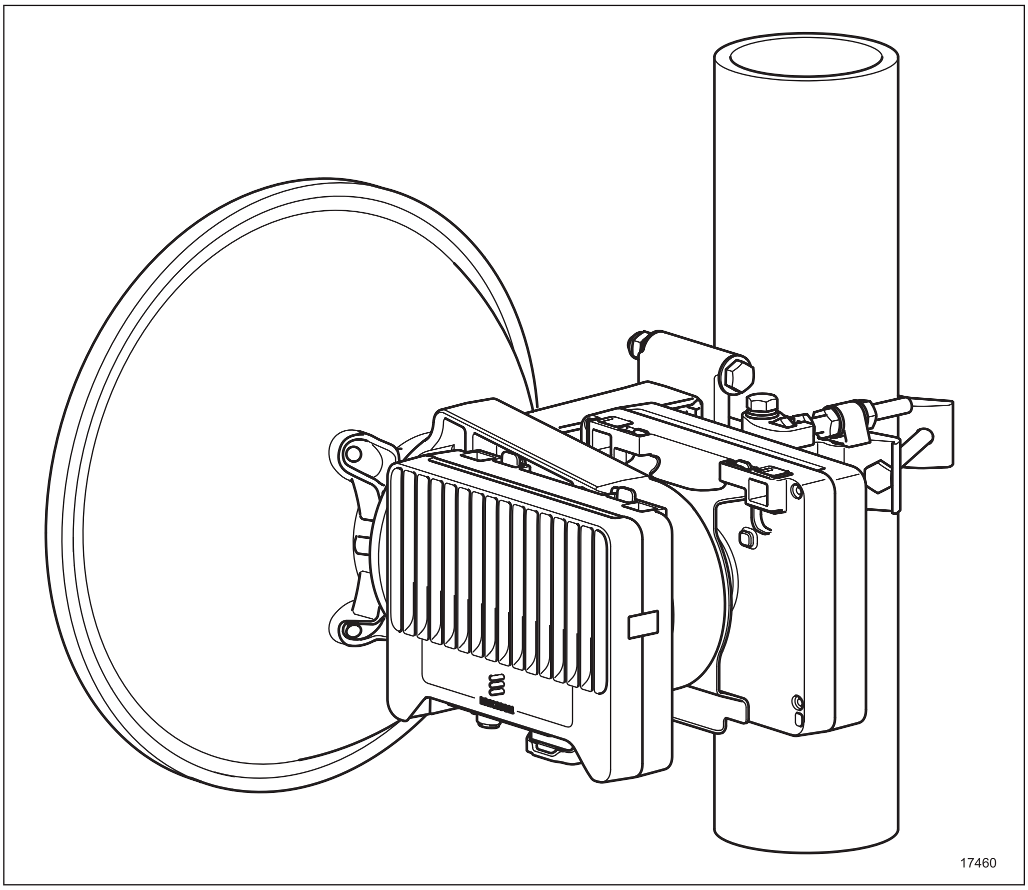


Figure 146 MINI-LINK 6363, MINI-LINK 6364, or MINI-LINK 6365 Fitted to an Integrated Power Splitter

The 0.3 m and 0.6 m integrated dual polarized antennas are used with two MINI-LINK 6363s, two MINI-LINK 6364s, or two MINI-LINK 6365s.

In an integrated installation, ANT3 or IPS3 can be used with the MINI-LINK 6363, MINI-LINK 6364, or MINI-LINK 6365.

Using an antenna adapter plate also enables antennas of type ANT2 or IPS2 to be connected to the MINI-LINK 6363, MINI-LINK 6364, or MINI-LINK 6365 radio. The antenna adapter plate is illustrated in Figure 147.

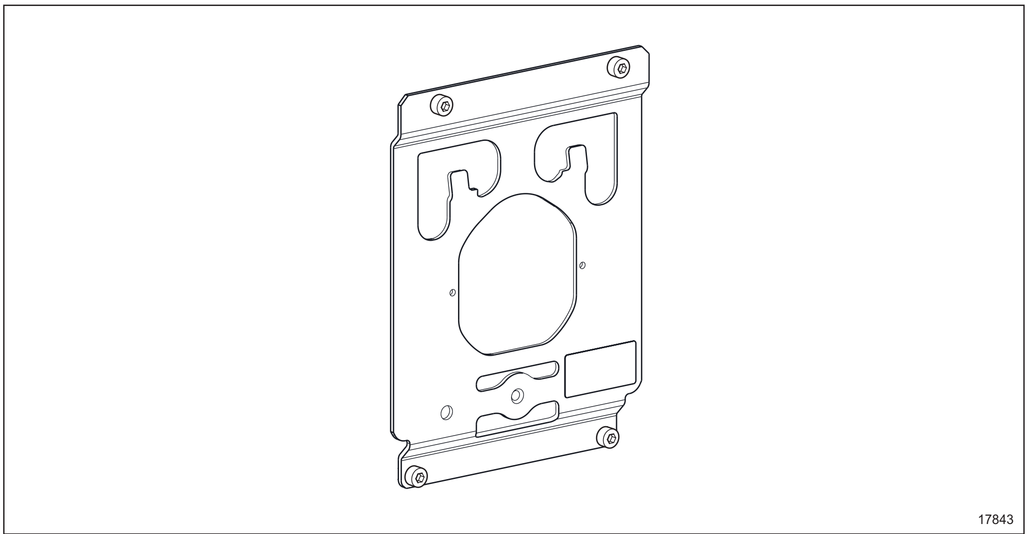


Figure 147 The Antenna Adapter Plate for MINI-LINK 6363, MINI-LINK 6364, or MINI-LINK 6365

15.19.2 RAU2 X Integrated Installation

For a 1+0 configuration, the RAU2 X is fitted directly to the rear of the antenna in integrated installation. Single polarized antennas up to 1.8 m in diameter are normally fitted integrated with the RAU2 X.

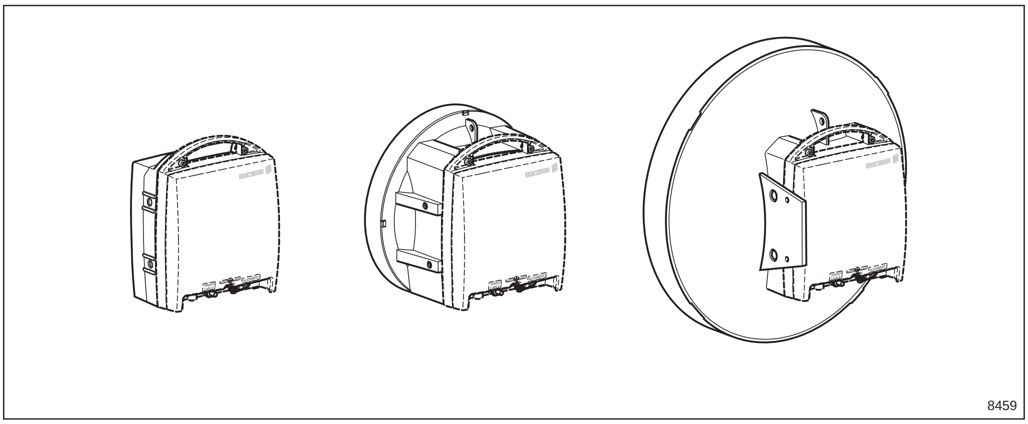


Figure 148 0.2 m, 0.3 m, and 0.6 m Compact Antennas Integrated with RAU2 X

For a 1+1 configuration the RAU2 X can be fitted directly to an Integrated Power Splitter (IPS).

An asymmetrical power splitter is mainly used for 1+1 hot standby configurations, that is, hardware protection only. The IPS provides one main channel with low attenuation and one standby channel with higher attenuation.

A symmetrical power splitter is mainly used for 1+1 working standby or 2+0 configurations, that is, hardware protection and frequency diversity. The IPS provides equal attenuation in both channels.

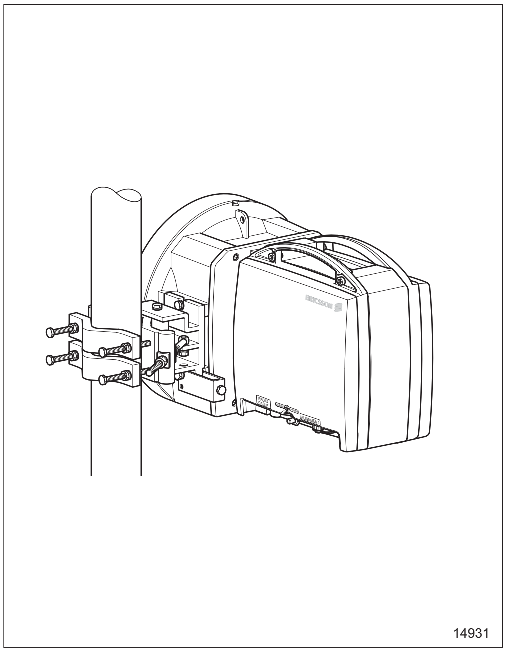


Figure 149 RAU2 X Fitted to an Integrated Power Splitter

The 0.3 m and 0.6 m integrated dual polarized antennas are used with two RAU2s.

In an integrated installation, ANT2 can be used with the RAU2 X, besides the antennas of type ANT2 with fixed radio interface or IPS2.

Using an antenna adapter plate also enables antennas of type ANT1 or IPS1 to be connected to the RAU2 X. The antenna adapter plate is illustrated in Figure 150.

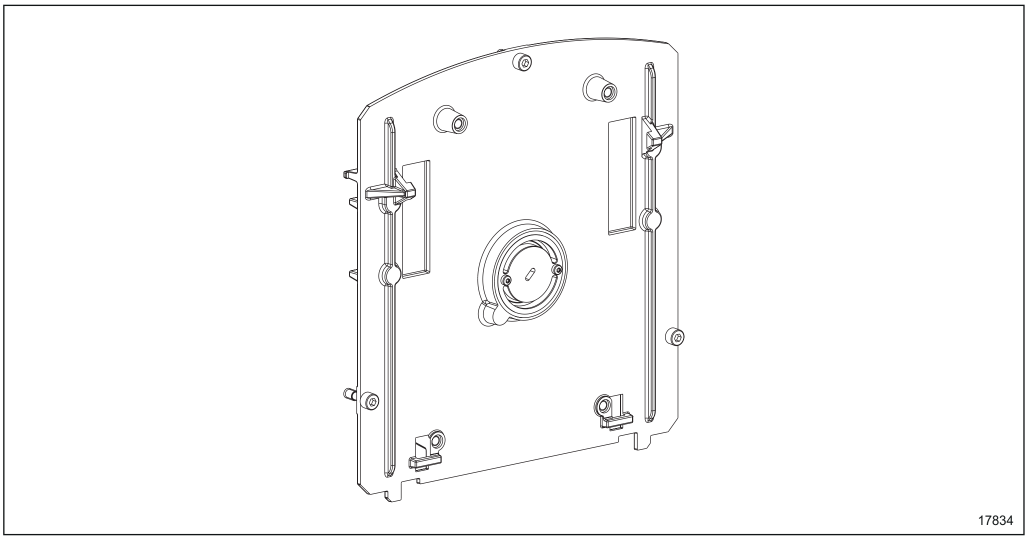


Figure 150 The Antenna Adapter Plate for RAU2 X

15.19.3 MINI-LINK 6363, MINI-LINK 6364, MINI-LINK 6365, and RAU2 X Separate Installation

All antennas have a standardized waveguide interface and can be installed separately, by using a flexible waveguide to connect to the MINI-LINK 6363, MINI-LINK 6364, MINI-LINK 6365, or RAU2 X. The 2.4–3.7 m dual polarized and single polarized antennas are always installed separately.

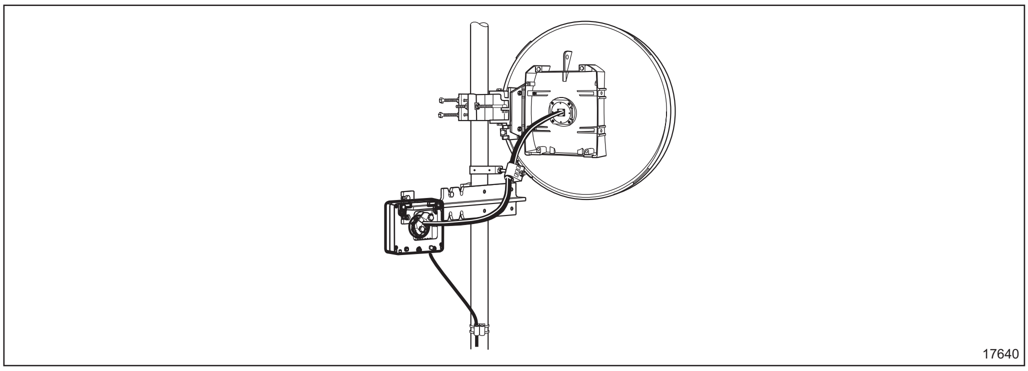


Figure 151 MINI-LINK 6363, MINI-LINK 6364, or MINI- LINK 6365 Separate Installation in a 1+0 Configuration

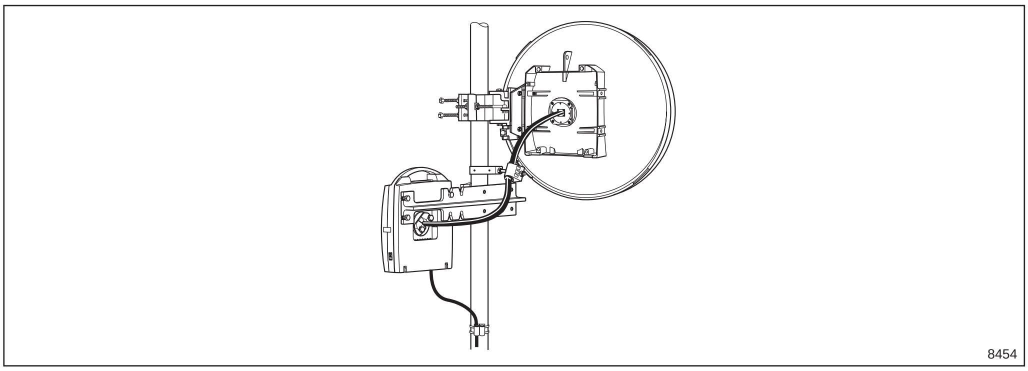


Figure 152 RAU2 X Separate Installation in a 1+0 Configuration

16 Management

16.1 DCN

This section covers the Data Communication Network (DCN) functions provided by the NE.

Since both IPv4 and IPv6 (only in DCN VLAN mode) are supported, this would imply using two independent DCN networks, one IPv4 and one IPv6, using different addressing and different routing. In one case, though, the two can interfere: when a node via IPv4 asks a DNS server for an IP address, the DNS server might respond with an IPv6 address.

16.1.1 IP Services

The following standard external IP network services are supported:

— All clocks, used, for example, for time stamping alarms and events, can be synchronized with a Network Time Protocol (NTP) server. NTP synchronization is supported.

— File Transfer Protocol (FTP) as well as SSH FTP (SFTP) are used as file transfer mechanisms for software upgrade, and for backup and restore of system configuration.

— Domain Name System (DNS) enables the use of host names.

— Dynamic Host Configuration Protocol (DHCP) is used to allocate IP addresses in the DCN. The NE has a DHCP relay agent for serving other equipment on the site LAN.

— Syslog is used to forward log messages in the network and log alarms and events to a central syslog server.

16.1.2 DCN Interfaces

MINI-LINK 6600 provides an IP-based DCN for transport of its O&M data. Each NE has an IP router for handling of the DCN traffic. A number of different alternatives to connect and transport DCN traffic are supported. This diversity of DCN interfaces provides the operator with a variety of options when deploying a DCN.

Each physical interface can support two IP hosts, one for IPv4 and one for IPv6.

The following connection options are supported:

— DCN over VLAN

— DCN over VLAN for L1 connections

— Routed DCN in default VRF

— DCN in L3VPN

— USB

— DCN over PPP

— DCN login to far-end via Radio link

16.1.2.1 DCCr/DCCm

Note: LTU 1002 is needed to provide STM-1 interfaces for DCCr/DCCm.

The DCCr/DCCm overhead sections in the STM-1 frame can be used to transport DCN traffic. A PPP connection is established over the overhead segments between two end points.

The default bandwidth is automatically established to DCCr=192 kbps and DCCm=192 kbps and DCCm is configurable to 384 kbps and 576 kbps.

For LTU 1002, the bandwidth is fixed to DCCr=192 kbps and DCCm=576 kbps.

The PPP connection in the overhead segments is implemented as PPP over bit synchronous HDLC. Any 3rd party equipment that complies with this and the channel bandwidth segmentation can interoperate with MINI-LINK 6600. DCCm can be used to connect MINI-LINK 6600 to MINI-LINK 6600 over an STM-1 connection. For this connection there can be no multiplexer between the two MINI-LINK 6600 NEs.

DCN in SDH

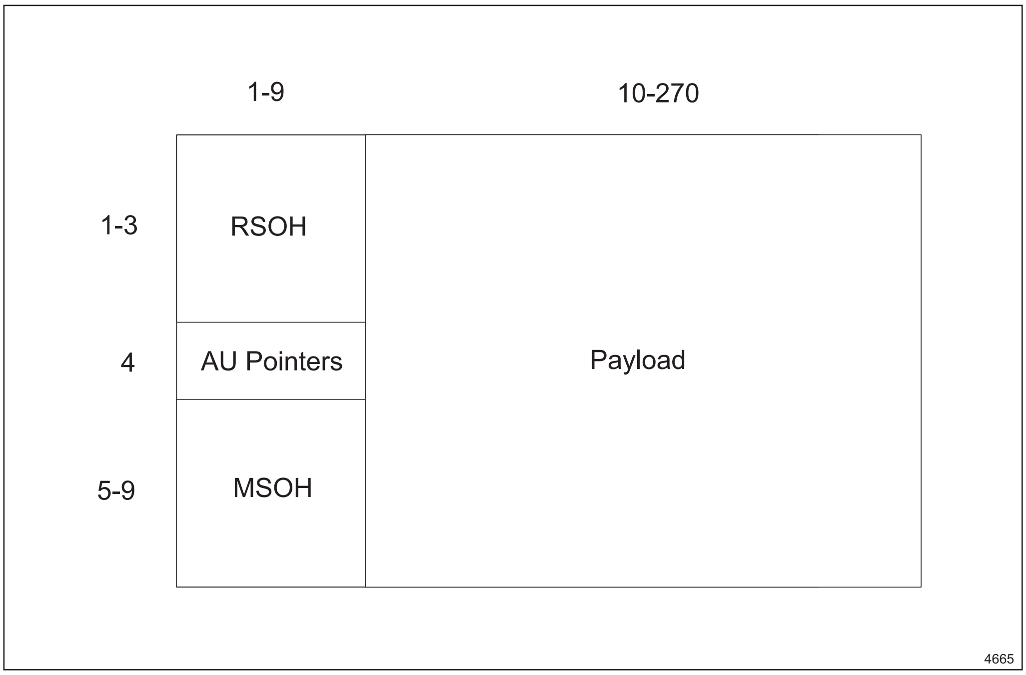


Figure 153 SDH Frame

The following channels can be used for DCN transportation in SDH:

- 128 kbps default proprietary channel available on radio side only.
- 192 kbps channel available on line side and radio side by using EOC or DCC bytes of the Regenerator Section Overhead Frame (RSOH) of the SDH frame.

16.1.2.2 10/100BASE-T

Each NE has a 10/100BASE-T Ethernet interface for connection to a site LAN. This interface offers a high speed DCN connection.

16.1.2.3 DCN over VLAN

The management traffic can be transported in a logically separated VLAN together with the Ethernet traffic. An internal switch port in MINI-LINK 6600 forwards the management traffic to the IP DCN router.

In Provider Mode, it is possible to separate DCN over VLAN from the rest of the traffic by configuring a default mapping rule into the C-VID registration table of a port.

16.1.2.4 DCN over VLAN for L1 Connections

The management traffic can be transported in a VLAN over an L1 connection. In MINI-LINK 6600, ports of L1 connection can be added to one VLAN, thus enabling L2 switching for that VLAN in the L2 connection. By the adding LAN-DCN port to the same VLAN, DCN over VLAN can be used over the L1 connection.

16.1.2.5 Routed DCN in Default VRF

High speed routing between multiple DCN VLANs is supported, providing enhanced DCN (compared to DCN over PPP).

The main benefits are:

— Increased bandwidth

— Routing between multiple L3 sub-interfaces

— Better protection of L2 traffic storms.

— Migration can be done remotely without affecting user traffic.

L3 Interfaces

The following L3 interfaces are available for Routed DCN:

— L3 VLAN subinterfaces

  L3 VLAN subinterfaces can be defined on Ethernet ports and can use VLAN tagging. L2 switching is not available for L3 VLAN subinterfaces.

— L3 VLAN interfaces - Bridge Virtual Interfaces (BVIs)

  L3 VLAN (BVI) interfaces can be defined on VLANs. L2 switching will operate on the VLAN ports while L3 traffic is handled by the L3 interface. This enables building a L2 DCN with dynamic routing, for example, OSPF.

— PPP interfaces

  PPP interfaces can be used on LTU1002 boards, to create a DCN link over the STM-1 link.

16.1.2.6 DCN in L3VPN

DCN can also be reached from a user-defined VRF, that is, DCN can be routed not only in the transport infrastructure, but also in the service layer (VPN).

In the default configuration, DCN is attached to the default VRF. By configuration, DCN can be attached to one single user-defined L3VPN VRF. From that point only that VRF can be used for DCN, the default VRF cannot.

Main benefits of the DCN in L3VPN feature are the following:

— Since L3VPN services can pass through the network end-to-end, the DCN in L3VPN feature enables easy DCN provisioning within the network.

— PPP connections, since they can only be used for DCN purposes, are automatically moved to the selected DCN VRF. Host address selection algorithm does not change, be either automatic or manual, but will apply to the interfaces of the selected DCN VRF.

16.1.2.7 USB

The USB interface is used for an O&M connection (MINI-LINK Node GUI, CLI session, or CLI Tool) using an IP address, according to the following:

— IPv4

  Local IP address.

— IPv6

  Either local (but not link-local) or globally routable IP address.

16.1.3 IP Addressing

The DCN of MINI-LINK 6600 supports both IPv4 and IPv6 (in DCN VLAN mode).

16.1.3.1 IPv4

As for generic IP services, DCN for IPv4 supports numbered IP interfaces, used for the Ethernet interface and IP interfaces configured as ABR. All other IP interfaces should be set up with unnumbered IP interfaces.

The use of unnumbered interfaces has several advantages:

- The use of IP addresses is limited. For a large aggregation site, this would imply a lot of addresses.
- The planning of the IP addresses is simplified.
- The amount of configuration is reduced because only one IP address is configured upon installation.

16.1.3.2 IPv6 (in DCN VLAN Mode)

Interfaces support both globally routable IP addresses and link-local addresses on IPv6. With some exceptions, this corresponds to IPv4 according to Table 69.

Table 69 Corresponding IPv4 and IPv6 Addressing

IPv4	IPv6
Unnumbered interfaces	Link-local addresses
Numbered interfaces	Globally routable addresses

16.1.4 IP Router

The IP router supports the following routing mechanisms:

- Open Short Path First (OSPF), which is normally used for routers within the MINI-LINK domain. OSPFv2 (for IPv4) is supported.
- Static routing

There are two different ways to configure the IP router, Command Line Interface (CLI) (see Section 16.3.3 on page 237) and MINI-LINK Node GUI (see Section 16.3.1 on page 236).

Most configurations are done using CLI, and complex router configuration and troubleshooting can only be performed with CLI.

16.1.4.1 OSPF Features

The following summarizes the OSPF features:

- An NE can be a part of a non-stub area, stub area or totally stub area.
- An NE can act as an Internal Router (IR) or an Area Border Router (ABR).
- Virtual links are supported, which is useful when an area needs to be split in two parts.
- Link summarization is supported, which is used in the ABR to minimize the routing information distributed to the backbone and/or other areas.

16.2 Link Layer Discovery Protocol (LLDP)

This section gives a brief overview of the LLDP that is used by network elements (NE) for advertising their identity, capabilities, and neighbors.

LLDP is a simplex protocol where each node periodically transmits information about itself. The protocol is stateless, with no confirmation mechanism. LLDP is specified in IEEE 802.1 AB.

Supported TLVs are as follows:

- ChassisID
- PortID
- Time To Live
- System Name
- Management Address

16.3 Management Tools and Interfaces

This section gives a brief overview of the management tools and interfaces used for MINI-LINK 6600.

16.3.1 MINI-LINK Node GUI

MINI-LINK Node GUI provides tools for on-site installation, configuration management, fault management, performance management and software upgrade. It is also used to configure the traffic routing function, protection and DCN.

MINI-LINK Node GUI is used for local management, that is the NE is accessed locally by connecting a PC to the node with a USB cable.

The NE can also be accessed over the site LAN or remotely over the DCN.

To access an NE remotely through MINI-LINK Node GUI, a MINI-LINK Node GUI license is required on that specific NE to ensure full functionality in MINI-LINK Node GUI.

16.3.2 SNMP

Each NE provides an SNMP agent enabling easy integration with any SNMP-based management system. The SNMP agent can be configured to support SNMPv1/v2c/v3 for get and set operations. SNMPv3 is default. The SNMP agent sends SNMPv1, SNMPv2c and SNMPv3 traps.

The system is built on standard MIBs as well as some private MIBs.

16.3.3 Command Line Interfaces

A CLI is provided for advanced IP router configuration and troubleshooting. This interface is similar to Cisco's industry standard router configuration and is accessed from a Command Prompt window using Telnet or SSH.

16.3.4 Syslog

Logging of alarms and events to syslog servers can be managed through MINI-LINK Node GUI, and CLI.

16.3.5 NETCONF

NETCONF protocol enabling integration with NETCONF-based management systems.

For more information, see NETCONF Interface.

16.4 Configuration Handling

The configuration can be managed locally and from the O&M center provided that the DCN is set up. The following list gives examples of configuration areas:

- Transmission interface parameters
- Traffic routing
- Radio Link Bonding (RLB)
- DCN parameters, such as host name, IP address
- Security parameters, such as enabling Telnet and SSH, enabling SNMPv3 with encryption, and using RADIUS and TACACS+ for AAA
- Radio Terminal parameters, such as frequency, output power, ATPC, and protection

16.4.1 Configuration File

The configuration file is stored non-volatile both on the RMM and in a flash memory on the NPU.

If an NPU needs to be replaced, the RMM from the faulty NPU can be inserted in the new NPU. In this scenario the user copies the configuration file from the RMM to the flash memory of the new NPU.

If an RMM is replaced, for example due to a license upgrade or downgrade, the user copies the configuration file from the flash memory to the new RMM.

16.4.2 Aligning the Node with the Network Management System

When the configuration of a node is changed, either through MINI-LINK Node GUI, or CLI, the node sends an event to the Network Management System (NMS).

It is possible to set a timer to decide how long after the configuration change that the event is sent to the NMS. If another configuration change is made before the event has been sent, the timer starts counting from zero again.

If the name of a node is changed, the node immediately sends a separate event to the NMS. Since a name change is also a configuration change, this triggers a configuration change event to be sent as well, but only after the timer value has been reached.

16.5 Software Management

The NE system software consists of different software modules for different applications. Software can be upgraded both locally and remotely. Software upgrade uses a local or remote FTP or SFTP server, to distribute the software to the NE. Using SFTP instead of FTP ensures that the entire session, including passwords, is encrypted.

All traffic continues while the software is being loaded. During the execution of the software download a progress indication is provided in the user interface. When the download is completed, the new software and the previous software versions are stored on the unit.

The downloaded software file is automatically checked for corruption with keyed-Hash Message Authentication Code (HMAC) and the Secure Hash Algorithm 1 (SHA-1), both to avoid erroneous transfer and to mitigate malware attacks.

The file integrity check monitors changes to the configuration file, password file, audit log, and Operating System (OS) files. Alarm notifications are generated and information about the captured changes is logged in a report. The operator can then investigate the report and take proper actions. The operator can view the report on the node or upload the report to an external secure server through SFTP.

Performing a restart of the NE activates the new software version. A warm restart only affects the control system. This restart can be performed immediately or scheduled at a later time. The restart, depending on the new functionality, may influence the traffic. When the restart with the new software is completed, the NE will wait for a “Commit” command from the management system. When the “Commit” command is received, the software upgrade process is completed.

The previous software revision remains stored on the unit in case a rollback is required. This may be the case if something goes wrong during the software upgrade or if no "Commit" command is received within 15 minutes after the restart.

If plug-in units with old software versions are inserted into the NE, they can be automatically upgraded.

16.5.1 Uploading Local Logs to a Remote FTP Server

The Local Log Upload feature secures the local log files generated on the node by persistently uploading them to a central FTP or SFTP server and making them available for debugging even if the logs on the node are lost due to overwrite, restart, power loss, or any other reasons.

If the feature is enabled, the local log files are automatically uploaded to the server when they are rotated and compressed.

In addition, forced upload can also be initiated manually, where all pending log files are uploaded to the FTP or SFTP server without a delay.

16.6 License Handling

The MINI-LINK 6600 features are divided into three types:

— Base Package

— Value Packages

— Capacity Licenses

The Base Package provides a fully functional Network Element (NE) and is a part of the standard product offering. Value Packages and Capacity Licenses, when enabled, enhance the functionality and the capacity of the NE.

The basic features are licensed through the Base Package. The Base Package is mandatory and is valid for the full MINI-LINK 6600 release.

License-controlled features have two licensing modes:

— Locked Mode

— Unlocked Mode

Under certain circumstances, the system or the user is entitled to an unlock period, during which license controlled features can be used without sufficient license.

Alarms are raised if a license-controlled feature is used without sufficient license on the NE.

License handling allows the user to track the license usage on slot/port level, getting detailed information on the state of license controlled features. The user can:

— Identify which port(s)/slot(s) has a missing license when the node license status is degraded.

— Get detailed information about license allocation on slot/port level.

16.7 Fault Management

All software and hardware in operation is monitored by the control system. The control system locates and maps faults down to the correct replaceable hardware unit. Faults that cannot be mapped to one replaceable unit result in a fault indication of all suspect units (this may be the whole NE).

Hardware errors are indicated with a red LED found on each plug-in unit and radio.

The control system will generally try to repair software faults by performing warm restarts on a given plug-in unit or on the whole NE.

16.7.1 Alarm Handling

The NE uses SNMP traps to report alarms to SNMP-based management system. Alarms can also be sent to a syslog server. To enable a management system to synchronize alarm status, there is a notification log (alarm history log) where all traps are recorded. There is also a list of current active alarms. Both these can be accessed by the management system using SNMP, or MINI-LINK Node GUI. The alarm status of specific managed objects can also be read.

In general, alarms are correlated to prevent alarm flooding. This is especially important for high capacity links, where a defect on the physical layer can result in many alarms at higher layer interface, like E1. Correlation will cause physical defects to suppress alarms, like AIS, at these higher layers.

Alarm notifications can be enabled/disabled for an entire NE, for an individual plug-in unit, and for individual interfaces. Disabling alarm notification means that no new alarms or event notifications are sent to the management systems.

Alarm and event notifications are sent as SNMPv2c/v3 traps with a format according to Ericsson's Alarm IRP SNMP solution set version 1.2. The following fields are included in such a notification:

— Notification identifier: uniquely identifies each notification.

— Alarm identifier: only applicable for alarms, identifies all alarm notifications that relate to the same alarm.

— Managed object class: identifies the type of the source, for example, E1, DS1, and so on.

— Managed object instance: identifies the instance of the source, for example 1/4/6A for an E1 on the NPU.

— Event time: time when alarm/event was generated.

— Event type: X.73x compliant alarm/event type like communications alarm and equipment alarm.

— Probable cause: M.3100 and X.733 compliant probable cause, for example, Loss Of Signal (LOS).

— Perceived severity: X.733 compliant severity, for example, critical or warning.

— Specific problem: free text string detailing the probable cause.

The system can also be configured to send SNMPv1 traps. These traps are translated from the IRP format using co-existence rules for v1 and v2/v3 traps (RFC 2576).

Alarm and event notifications can also be sent to (up to 3) syslog servers in the network. The information content is the same as for the SNMP traps. The messages use a fixed syslog facility of LOG_LOCAL6 and severity mapping and message text is based on RFC 5674 – Alarms in syslog.

16.7.2 Ethernet Link OAM

Ethernet Link OAM supports fault management on Ethernet links according to IEEE 802.3ah and provides link monitoring, fault notification, and loopback test.

16.7.3 Ethernet Service OAM

Ethernet Service OAM supports fault management on Ethernet links according to IEEE 802.1ag and is used to manage networks comprising of multiple LANs.

16.7.4 Loops

Loops can be used to verify that the transmission system is working properly or they can be used to locate a faulty unit or interface.

Note: On MINI-LINK 6651/1 and on MINI-LINK 6651/3, only IF and RF loops on the radio is supported.

16.7.4.1 Loops for Circuit Switched Traffic

The following loops are available on units with an E1/DS1 line interface.

Connection Loop This loop can be initiated for an E1/DS1. The traffic connection is looped in the TDM bus back to its origin, see Figure 154. If an E1/DS1 interface is traffic routed an AIS is sent to the other interface in the traffic routing.

A Connection Loop can be used in combination with a BERT in another NE to test a network connection including the termination plug-in unit, in case a Local Loop cannot be used due to the lack of a traffic routing.

Line Loop Loops an incoming line signal back to its origin. The loop is done in the plug-in unit, close to the line interface, see Figure 154. An AIS is sent to the TDM bus.

A Line Loop in combination with a BERT in an adjacent NE is used to test the transmission link between the two NEs.

Local Loop Loops a line signal received from the TDM bus back to its origin, see Figure 154. An AIS is sent to the line interface.

A Local Loop in combination with a BERT in another NE can be used to test a connection as far as possible in the looped NE.

The following loop is only supported on the modem/MMU.

Rx Loop This loop is similar to the Connection Loop but the loop is done in the plug-in unit close to the TDM bus, where a group of E1s in the traffic connection is looped back to its origin, Figure 154. Traffic on high-speed bus is not affected.

An Rx Loop can be used on the far-end modem/MMU to verify the communication over the radio path, see Figure 155.

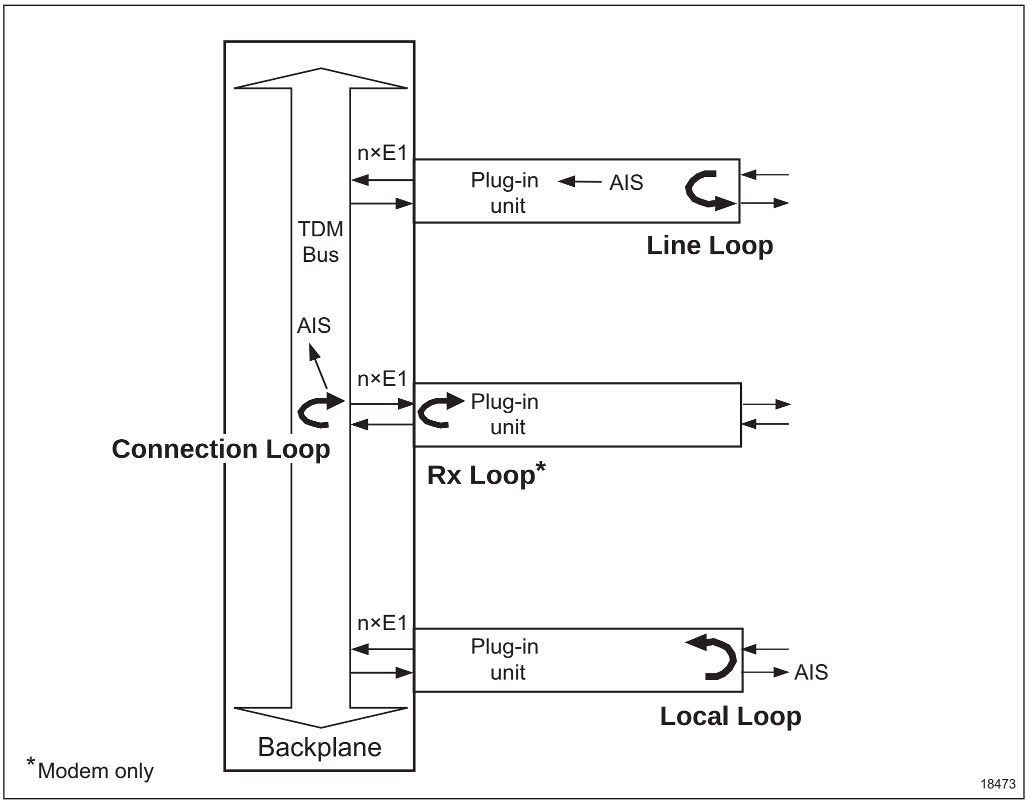


Figure 154 Loops

The following loops on the near-end Radio Terminal are supported in order to find out if the modem/MMU or radio is faulty.

IF Loop In the modem/MMU the traffic signal to be transmitted is, after being modulated, mixed with the frequency of a local oscillator and looped back for demodulation (on the receiving side). See Figure 155.

RF Loop In the radio, a fraction of the RF signal transmitted is shifted in frequency and looped back to the receiving side. See Figure 155.

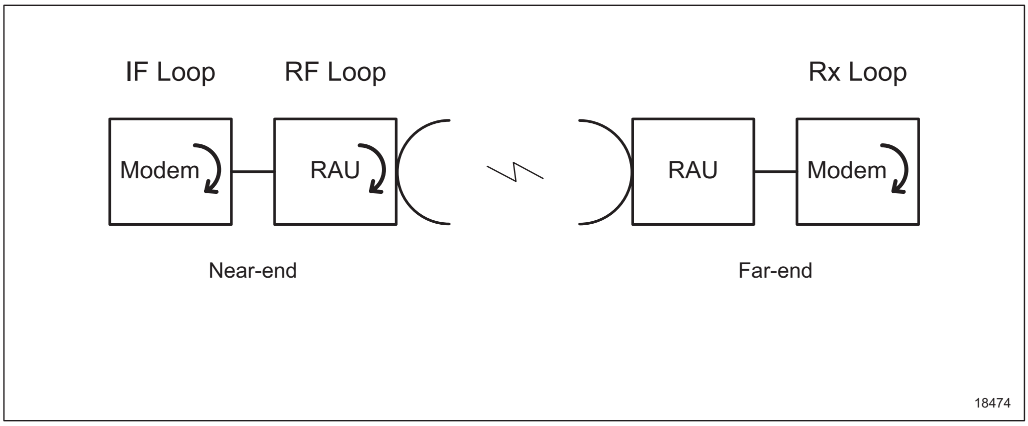


Figure 155 Radio Link Loops

16.7.4.2 Loops Impact for Packet Switched Traffic

Note: The Ethernet protocol does not have a mechanism that automatically discards frames when a loop occurs. Without a loop prevention mechanism, all traffic is returned back to the port causing problems with MAC address switching tables and possibly affecting the traffic in the entire network.

Loops for Ethernet traffic are considered to be very harmful and should be avoided.

For IF and RF loops, the looped traffic is discarded to prevent Ethernet loops. Thus, IF and RF loops can be set with Ethernet traffic running.

Loops on physical layers are only employed after disconnecting Ethernet services in order to avoid Ethernet loops. During installation and validation of a hop on radio level, it is recommended to perform measurements by installing loops on (temporary) PDH connection and test the point-to-point connection by configuring an Rx loop. After the hop has been installed and validated the (temporary) PDH connection is removed and the Ethernet services reconnected.

Spanning Tree Protocol (STP) or Rapid STP (RSTP) is not able to prevent looped Ethernet traffic flooding into the network for physical loops on the LAN ports or the WAN ports since own BPDU packets are discarded and therefore the looped traffic is passed through.

Test loops installed on physical and logical interfaces could influence Ethernet traffic as follows:

Physical loop Traffic can be looped with an external physical Tx-Rx loop. MINI-LINK 6600 does not have any built-in mechanism to prevent loops on LAN ports. All traffic will be returned back to the network.

The following loop is part of the Ethernet Link OAM functionality:

Remote Loopback Loops Ethernet traffic between two adjacent NEs, connected through a LAN interface, and is used for fault localization and link performance testing of Ethernet links. It is available on Ethernet traffic units with support for Ethernet Link OAM.

Remote loopback can only be performed on LAN interfaces.

16.7.4.3 MAC Swap Loopback

The source and destination MAC addresses in frames with a specified VLAN ID are swapped at ingress and the frame is looped back. MAC swap loopback can be used for troubleshooting and performance measurement.

The node can be configured to loopback specified L2 frames based on the following configurable parameters:

- Ingress port (LAN/WAN)
- Egress port (LAN/WAN)
- VLAN
- Src MAC address
- Dst MAC address

The src and dst MAC addresses of the specified frames are swapped in linerate (GE/10G).

When Destination MAC address filtering is disabled, the frames with any destination MAC address are looped back and their source MAC address is set to the own MAC address of the local switch.

In case of egress-lookup configuration, the traffic on the ingress port is checked for frames to be egressed on the egress port configured with MAC Swap Loopback. The frames to be egressed are looped back on the ingress port.

Because the loopback always takes place on the ingress port, latency time measurements are the same regradless of whether the latency time is measured for the egress or ingress port.

The following prerequisites must be fulfilled to be able to use the egress-lookup configuration:

- The dst MAC address must already be learnt by the switch to be able to identify the egress port
- The configured egress port **Oper Status** must be **Up**
- The configured egress port must be a member of the configured VLAN

Only one MAC swap loopback session is supported for the node.

Loop is automatically deactivated after the configurable timeout. The default timeout value is 300 seconds.

16.8 Spectrum Diagnostics Scan for Potential Interferer

The Spectrum Diagnostics scan used when verifying an installation and can then be activated by a user to automatically scan the frequency range of the configured radio channel or the complete radio sub-band. The test results in Received Signal Strength Indicator (RSSI) values, which are used to verify that there are no interfering signals. If the result indicates the presence of an interferer, further investigation is needed to conclude if this has impact on the radio-link performance or not.

The Spectrum Diagnostics scan can be performed using either CLI commands or MINI-LINK Node GUI.

Note: Running a spectrum diagnostics scan on a hop that is already taken into service impacts the traffic and can also lead to lost connection with the node as the transmitters are turned off during the scan.

16.9 Performance Measurements

Performance counters are available for 5-minute, 15-minute, and 24-hour intervals. The start time of a 24-hour interval is configurable.

The following counters are stored in the NE:

— (only for Ethernet PM counters) current 5 minutes and the previous 12×5 minutes,

— current 15 minutes and the previous 96×15 minutes,

— current 24 hours and the previous 24 hours.

Performance data is stored in a volatile memory. Therefore, all gathered data is lost at a restart.

Performance data is available for the following major features:

— Radio link (see Section 16.9.2 on page 247)

— Ethernet traffic (see Section 16.9.3 on page 248)

— PDH (see Section 16.9.4 on page 249)

— Bit Error Testing (see Section 16.9.5 on page 249)

— Ethernet Service OAM (see Section 16.9.6 on page 250)

— PTP Performance (see Section 16.9.8 on page 251)

— Power measurement PM data (see Section 16.9.9 on page 252)

All historical performance measurement data is available in form of XML files through the Bulk PM feature, see Section 16.9.1 on page 247.

16.9.1 Bulk PM

The Bulk Performance Management (PM) feature can replace the Ethernet PM or SOAM PM solutions. The difference between Bulk PM and the other PM solutions is that Bulk PM collects all counters from a node into a single XML file instead of using separate XML files.

The Bulk PM solution does not require a separate request for each counter through an SNMP interface; instead, it uses a single SNMP request to ask for all PM data of a single interval. Once it receives the requested PM data, the Bulk PM feature uploads a file to the specified FTP or SFTP server.

For more information on Bulk PM and for the configuration methods, see Bulk Performance Measurement.

16.9.2 Radio Link Performance Measurements

Radio Link PM makes it possible to compare actual performance with planned performance. The configuration of each microwave link is normally based on radio link planning criteria and RAN requirements (quality, delay, and availability) with the help of planning tools.

RF Input and Output Power

RF Input power can be used to identify underperforming radio links in terms of received signal levels, which could indicate a problem caused by, for example, bad RF planning, interference, incorrect configuration, or hardware faults.

RF Output power can be monitored when Automatic Transmit Power Control (ATPC) is activated.

Threshold alarms can be defined for Input and Output Power.

Radio Link Quality

G.826 is originally a standard for measurement of the quality of PDH links. In MINI-LINK nodes this measurement is also available on the continuously running serial data stream below any link layer such as Ethernet.

The G.826 PM, such as ES, SES and BBE, give an indication of the quality of the radio link.

The channel conditions are continuously monitored on the Rx side by measurement of Signal to Noise and Interference Ratio (SNIR).

Adaptive Coding and Modulation

When Adaptive Coding and Modulation (ACM) is configured counters are available that measure how much time that is spent in each modulation.

See also Section 3.2 on page 12.

16.9.2.1 Radio Cable Monitoring

If the communication between the modem and the radio is disturbed, it can cause intermittent traffic loss and result in the transmitter on the radio getting switched off.

By checking for any alarms on the RAU-MMU communication channel, the connection between the modem and the radio can be monitored and problems with cables between the modem and the radio can be detected.

16.9.3 Ethernet PM Counters

The Performance Monitoring function is used by the network operator to analyze the performance and usage of the Ethernet traffic to find unused capacity, congestion points and traffic lost due to congestion or faults. The analysis result is used to re-plan the network for better usage. The Performance Monitoring is also used when troubleshooting and performing functional tests of the equipment.

For Bandwidth and Traffic Performance measurements, the Ethernet PM counters are divided into the following intervals: 5-minute current PM, 15-minute current PM, 24-hour current PM, 5-minute history PM (12 intervals), 15-minute history PM (96 intervals), and 24-hour history PM. When the elapsed time reaches 5 minutes, 15 minutes, or 24 hours respectively, the data is moved into the history intervals and the oldest history data is deleted.

Note: For measurements made on VLAN basis, 5-minute intervals are not supported.

Bandwidth Counters

Bandwidth measurements are done on LAN and WAN interfaces in Tx and Rx direction.

WAN interfaces support the measurement on separate TC queues in Tx direction.

Bandwidth measurements (except for TC queue measurements) are also available on a per interface per VLAN basis. Bandwidth measurements for VLANs are disabled by default. For how to enable them, see Configuring an Ethernet Layer 2 Connection.

Average, maximum, and minimum bandwidth, as well as bandwidth histograms are available.

Traffic Performance Counters

Traffic performance measurements are done on LAN and WAN interfaces in Tx and Rx direction.

Some of the traffic performance counters in Tx direction are also available for separate Traffic Class queues on WAN interfaces.

Threshold Crossing Alarms for Ethernet PM Counters

It is possible to configure threshold crossing alarms for Ethernet PM counters on used interfaces. The thresholds are configured per interface, where ordinary LAN interfaces have a subset of the thresholds available for a buffered LAN or a WAN interface. The availability of thresholds are based on which counters are provided by the different interfaces.

XML File

The Ethernet performance data can be transferred to MINI-LINK Node GUI or to an external system, such as Ericsson Network Manager (ENM), in XML files. Upon a file transfer request the NE creates an XML file with the requested data, compresses the file and sends it to the selected FTP or SFTP Server.

The content of the file is based on data available in the NE at the time of the request.

In MINI-LINK Node GUI, it is possible to display historical Ethernet performance data without having an FTP Server installed on the host where MINI-LINK Node GUI is running.

16.9.4 PDH

The following performance counters are used for the E1/DS1 line interfaces:

- Errored Seconds (ES)
- Severely Errored Seconds (SES)
- Background Block Error (BBE) (only structured interfaces)
- Unavailable Seconds (UAS)

16.9.5 Bit Error Testing

Each NE has a built-in Bit Error Ratio Tester (BERT) in all plug-in units carrying traffic. The BERT is used for measuring performance on E1/DS1 interfaces according to ITU standard O.151. A Pseudo Random Bit Sequence (PRBS) with a test pattern 2^{15}–1 is sent through the selected interface.

As with loop tests, bit error testing may be used for system verification or for fault location.

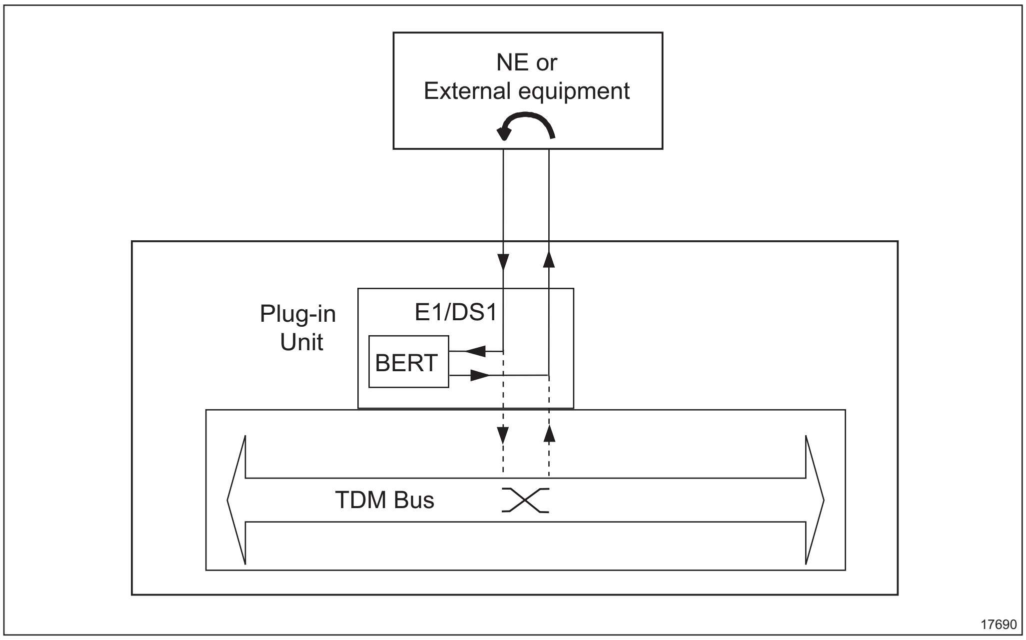


Figure 156 BERT in Combination with an External Loop

The BERT is started and stopped by the operator and the bit error rate as a function of the elapsed time is the test result. The test can be started and stopped locally or remotely using the management system.

Several BERTs can be executed concurrently, but only one BERT per plug-in unit.

16.9.6 Ethernet Service OAM

Ethernet Service OAM provides performance monitoring between MEPs, according to ITU-T Y.1731 and Y.1730. Ethernet Service OAM provides delay and delay variation information to the service provider, and ensures that the provided service is in accordance to the SLA.

Ethernet Service OAM supports the following PM functions:

— Frame Delay

— Frame Delay Variation Measurement

— Frame Loss Measurement

— XML File transfer

— Ethernet Bandwidth Notification

16.9.7 IP Performance Monitoring with TWAMP Reflector Light

Two-Way Active Measurement Protocol (TWAMP) is a Layer 3 protocol. It provides a flexible method for measuring two-way or round-trip IP performance between two nodes (sender and reflector) in an IP network.

TWAMP is specified in RFC 5357.

TWAMP can be used to measure two-way metrics like inter-packet delay (latency) and delay variation (jitter) between two endpoints, packet loss, far-end delay, far-end jitter, near-end delay, near-end jitter, duplicate packets, and so on, using UDP packets. The supported UDP port range is 863-65535 and the default UDP port number is 862.

TWAMP consists of two major parts; a control plane part and a data plane part. The control part sets up the TWAMP session by using TCP.

The test part is the an UDP based measurement. The sender transmits a test message and that is reflected from the reflector. Both endpoints timestamp the message.

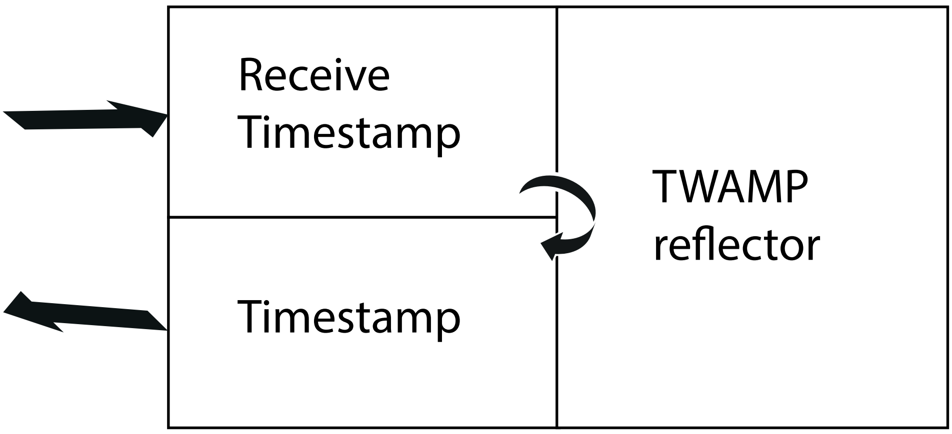


Figure 157 Reflector

The reflector never generates packets by itself, it only sends answers to packets. The reflector has a separate, configurable IP address. There is a special type of implementation for TWAMP with lower complexity that is called TWAMP Light where the control plane is removed and only the test messages are exchanged.

16.9.8 PTP Performance Monitoring

PTP Performance Counters

When enabled, MINI-LINK can collect a set of performance data in a PTP network. The user can enable PTP performance monitoring (and, when needed, clear its counters) using MINI-LINK Node GUI or the CLI.

PTP Performance Data Types

PTP performance monitoring collects the following types of data:

— `ClockPerformanceMonitoringData` measures data related to path delay on clock level. This data type indicates timestamping quality.

— `PortPerformanceMonitoringData` measures data related to messaging. This data type indicates network performance.

XML File

The performance data can be transferred to MINI-LINK Node GUI or to an external system, such as Ericsson Network Manager (ENM). Upon a file transfer request, the NE creates an XML file with the requested data, compresses the file, and sends it to the selected FTP or SFTP Server.

The content of the file is based on data available in the NE at the time of the request.

In MINI-LINK Node GUI, it is possible to display historical performance data without having an FTP Server installed on the host where MINI-LINK Node GUI is running.

16.9.9 Power Measurement PM

Power PM Counters

When enabled, MINI-LINK collects historical values of input voltage, power consumption, and consumed energy in 15-minute and 24-hour intervals. This feature is only available on MINI-LINK 6691, 6692, 6693, and 6694 nodes.

XML File

The Power PM data can be transferred to MINI-LINK Node GUI or to an external system, such as Ericsson Network Manager (ENM). During a file transfer request, the NE creates an XML file with the requested data, compresses the file, and sends it to the selected FTP or SFTP Server.

The content of the file is based on data available in the NE at the time of the request.

In MINI-LINK Node GUI, it is possible to display historical performance data without having an FTP Server installed on the host where MINI-LINK Node GUI is running.

16.10 Node Security

All management access to the NE is protected by a user name and a password.

The following user types are defined:

- view_user with read-only access
- oper_user with read and write access
- control_user with read and write access
- admin_user with read and write access

Note: Only the admin_user has full read and write access, the oper_user and control_user have full read access, but limited write access.

Only the admin_user can change the system time.

All user types have an associated password. Passwords can be changed using MINI-LINK Node GUI, CLI, or the SNMPv3 interface. Each local user can change their own password. Only an administrator can change password for other local users.

If a local user has the default password when they log in through the CLI or Node GUI, then the system forces them to change this default password. This applies to default passwords after reverting the node to factory settings as well as one-time passwords given by an administrator to a local user.

Note: Strong password feature is available and is enabled by default on the MINI-LINK Node GUI and CLI interfaces. Strong passwords require minimum 12 characters in length, and at least three of the following character types: lowercase, uppercase, numeral, non-alphanumeric characters.

The following security mechanisms are used on the various O&M interfaces:

- MINI-LINK Node GUI

  Local and remote MINI-LINK Node GUI access requires a user name and password.

  Note: The use of default password at USB connection can be allowed or disallowed by the user.

  It is possible to add a legal notice shown before logging on, to highlight the legal consequences of unauthorized access.

- SNMP

  For SNMPv3 access, the regular user name and password protection is used. In addition to this the User-based Security Model (USM) and View-based Access Model (VACM) are supported. This means that additional users and passwords might be defined by external SNMPv3 managers.

  The default security level is authentication/encrypted privacy where SHA-1 is used for authentication. Message Digest 5 (MD5) or SHA-2 can also be used for authentication. SNMPv3 can be configured to authentication with no privacy, using Data Encryption Standard (DES) or Advanced Encryption Standard (AES). An encrypted setting means that the management traffic is secure.

For SNMPv1/v2c access, the regular user name and password protection does not apply. Instead a community-based access protection is used. As default, a public and a private community are configured. The public community enables default read-access and the private community provides read and write access to MIB-II system information. These privileges can be extended through either MINI-LINK Node GUI, or SNMPv3 interface. The SNMPv1/v2c interface may be disabled.

— CLI

Access to the Telnet port using CLI commands is protected by the regular user name and password protection. The Telnet port can be disabled from MINI-LINK Node GUI.

Secure Shell (SSH) protocol can be used for more secure remote access and use of CLI commands. The SSH protocol is enabled as an alternative to the Telnet protocol, using MINI-LINK Node GUI or. When SSH is enabled telnet is automatically disabled and for security reasons can only be re-enabled if SSH is disabled.

It is possible to regenerate the automatically generated public-private key pairs in case the SSH keys have been compromised.

16.10.1 Authentication, Authorization, and Accounting

Authentication, Authorization, and Accounting (AAA) is a security architecture for distributed systems. The Authentication process makes sure that only accepted users can log on to the system, for example, using user names and passwords. The Authorization process gives authenticated users certain permissions, for example, based user roles. The Accounting process records information about access and use of the system.

There are three AAA policies in MINI-LINK: local, RADIUS, and TACACS+. RADIUS and TACACS+ are two types of centralized authentication.

Note: If the connection to the remote AAA server is interrupted, the NE falls back to local authentication. When the communication to the AAA server is working again, the centralized authentication (RADIUS or TACACS+) is automatically restored.

MINI-LINK 6600 devices support RADIUS or TACACS+ session accounting for all central and local users. RADIUS or TACACS+ servers for accounting are handled together with the authentication servers. The management sessions are logged by enabling the session accounting feature. When the management session is started, that is, the management user has logged on, the NE sends a RADIUS or TACACS+ accounting start message to the server. When the session is ended, that is, the management user has logged off, the NE sends a RADIUS or TACACS+ accounting stop message to the server. Both the beginning and the end of a session can be recorded. Accounting messages contain the IP address of the client from which the NE is accessed by the user.

16.10.1.1 Local Authentication

The local policy supports the following features:

— Authentication

  For local user authentication, it is necessary to supply authentication information in the form of a user name and password. During the authentication process, the NE searches its locally stored configuration for a user with a matching user name. If a matching user name cannot be found, the request is refused. The maximum number of local users supported is four.

  Note: When logging in through the CLI or Node GUI, if a local user has the default password, then the user is forced to change that default password.

— Authorization

  The NE uses local authorization information to distinguish which privileges belong to a role.

  The authorization process is based on the user role (system admin, network admin, operator, or guest).

16.10.1.2 Centralized Authentication

The two types of centralized authentication are RADIUS and TACACS+.

The system has two external interfaces, CLI and SNMPv3. Centralized users and authentication are fully supported for CLI and partially supported for SNMPv3. The local admin_user needs to set the AAA policy and configure the TACACS+ or RADIUS servers before attempting a centralized authentication.

The NE supports the User-based Security Model (USM) for SNMPv3. USM requires that the node knows the user before starting a SNMPv3 communication. Local users are always known by the NE but centralized users have to authenticate themselves on CLI first.

After a successful authentication, a user session is created and a SNMPv3 communication with the NE can start. The CLI connection can be terminated after the NE receives the first SNMPv3 message. If the CLI connection is terminated, the SNMPv3 messages keep the user session running.

SNMPv3 security protocols (authentication and privacy) are configurable by RADIUS/TACACS+ authorization parameters.

If centralized authentication is used, all local users (admin_user, view_user, control_user, and oper_user) are enabled. Passwords for centrally-authenticated user accounts cannot be changed using CLI, or MINI-LINK Node GUI.

It is possible to disable local users (admin_user, view_user, control_user, and oper_user) when TACACS+ is configured.

Note:

- Only admin_user can disable local users when centralized authentication is configured.
- If the connection to the remote AAA server is interrupted and the NE falls back to local authentication, then local users temporarily become available even if they were disabled.

It is recommended to set SSH as a secure CLI connection, to allow a fully-secure centralized authentication and authorization process.

A session timeout and a user message display, for example, welcome messages, legal banners, and so on, are supported. The timer value and the user messages must be properly configured in the external TACACS+ or RADIUS server. The user message is a text intended to be presented to the user when they connect to the node. The session timeout is the maximum time the user is allowed to stay connected. The audit logging functionality keeps track of the individual user name that has connected to the node.

RADIUS

The RADIUS protocol, which is based on a client-server model, enables remote access to networks and network services. When configured with the IP or host name of a RADIUS server, the NE can act as a RADIUS client. The format and validation of RADIUS packets is in accordance with the IETF protocol specification RFC 2865.

Both IPv4 and IPv6 are supported.

RADIUS uses UDP, which offers best-effort delivery.

RADIUS only encrypts the password in the Access-Request packet from the client to the server. The rest of the packet (for example, user name, authorized services, and accounting) is not encrypted.

RADIUS supports the following features:

- Authentication

  The NE supports centralized authentication using RADIUS. A user needs to have an account created on the external server before logging on. Once the account is created, the system can be configured to receive centralized authentication using RADIUS. For centralized authentication, all Local Users are enabled.

- Authorization

  The NE supports fetching the user roles through a RADIUS server. The NE uses local authorization information to distinguish which privileges belong to a role.

  The authorization process is based on the user role (system admin, network admin, operator, or guest). For authorization using RADIUS, the RADIUS server provides the user role when the user logs on to the NE. The NE can be managed in situations when a RADIUS server is unreachable. Therefore it ensures there is always at least one locally-authenticated system administrator account.

  The default is that all Local Users are enabled. The user must manually set them to Disabled, after choosing the centralized mode. If they are disabled, then they will be automatically re-enabled in case all RADIUS servers are down.

- Accounting

  The NE supports session accounting using RADIUS or TACACS+. The management sessions can be logged by enabling either the RADIUS or the TACACS+ accounting feature. When the session is started, that is, the management user is logged on, the NE sends an accounting start message to the RADIUS or TACACS+ server. When the session is ended, that is, the management user has logged off, the NE sends an accounting stop message to the RADIUS or TACACS+ server.

- RADIUS Server-Client Feature

  The NE supports up to six RADIUS servers. It connects to the servers one-by-one according to their priorities. If no server is reachable, the NE enables local authentication automatically. When the communication to any RADIUS server is working again, the centralized authentication is automatically restored.

  The NE supports three RADIUS packet types: Access-Request, Access-Accept, and Access-Reject.

  A RADIUS Access-Request message containing the authentication information is sent to a remote server. When the RADIUS server receives the request, it validates the client using a ‘‘shared secret’’. If the client is valid, the RADIUS server consults its user database to validate the access. The server responds to an Access-Request message with either an Access-Reject message or an Access-Accept message. On receipt of an Access-Reject message, the client refuses access to the user. On receipt of an Access-Accept message, the client grants access to the user.

  If the NE does not receive a RADIUS response to an Access-Request message within the configured timeout, it keeps retransmitting the request until it receives a response, or until the configured number of maximum transmissions has been reached.

TACACS+

The TACACS+ protocol enables the building of a system that secures remote access to networks and network services. TACACS+ is based on a client/server architecture. The TACACS+ servers are configured on a per-context basis, with a limit of six servers.

Both IPv4 and IPv6 are supported.

TACACS+ uses the Authentication, Authorization, and Accounting (AAA) architecture. This allows separate authentication solutions that can still use TACACS+ for authorization and accounting.

TACACS+ uses TCP, which offers connection-oriented transport.

TACACS+ encrypts the entire body of the packet.

TACACS+ supports the following features:

- Authentication

  The NE supports centralized authentication using TACACS+. A user needs to have an account created on the external server before logging on. Once the account is created, the system can be configured to receive centralized authentication using TACACS+.

- Authorization

  The NE supports fetching the user roles through a TACACS+ server, and the NE uses local authorization information to distinguish which privileges belong to a role.

  The authorization process is based on the user role (system admin, network admin, operator, or guest). For authorization using TACACS+, the TACACS+ server provides the user role when the user logs on to the NE. The NE can be managed in situations when a TACACS+ server is unreachable. Therefore it ensures there is always at least one locally-authenticated system administrator account. When the communication to any TACACS+ server is working again, the centralized authentication is automatically restored.

  The default is that all Local Users are enabled. The user must manually set them to Disabled, after choosing the centralized mode. If they are disabled, then they will be automatically re-enabled in case all TACACS+ servers are down.

- Accounting

  The NE supports session accounting using RADIUS or TACACS+. The management sessions can be logged by enabling either the RADIUS or the TACACS+ accounting feature. When the session is started, that is, the management user is logged on, the NE sends an accounting start message to the RADIUS or TACACS+ server. When the session is ended, that is, the management user has logged off, the NE sends an accounting stop message to the RADIUS or TACACS+ server.

The NE supports command accounting using TACACS+. User commands can be logged by enabling the TACACS+ command accounting feature. When the session is open, that is, the management user is logged on, the NE sends command accounting messages to the TACACS+ server.

16.10.2 NTP Authentication

To prevent manipulation of the time signal, MINI-LINK 6600 authenticates that the system is synchronized with the Network Time Protocol (NTP) server. An event is generated if the connection to the NTP server is lost.

The user is able to do the following:

— Enable/Disable authentication

— Set the external FTP server to download the Key File

  The Key File is a file with a number of cryptographic NTP keys that can be downloaded via SFTP from an external server.

— Download the Key File

16.10.3 SFTP

An SFTP server can be used to upgrade NE system software, instead of just using an FTP server. Using SFTP instead of FTP ensures that the entire session, including passwords, is encrypted. When adding a new FTP or SFTP server, it is possible to reserve that server for security tasks, so that only the admin_user is allowed to modify the server. Other users, for example control_user, can add the same server and use it for purposes that are not security related.

For more information about software management, see Section 16.5 on page 238

16.10.4 File Integrity Violation

File integrity violation raises an alarm if the internal files of the node are modified. Each node has a file integrity check available, that enhances protection against viruses and Trojan Horses. The file integrity check monitors for changes to files and directories in the system. It uses some cryptographic means that basically protect the configuration files it uses for that scope. When a change is captured, then a report is automatically generated and the user can check the reason for those changes, and then investigate and take proper actions. The user can view the report or upload the report to an external secure server through SFTP. An alarm is raised in case of integrity violations.

16.10.5 Security Audit Logging

The NE has an audit log that traces user-initiated events in the node back to the responsible user/operator. The audit log is a text file comprising the following information:

- Sequence number
- Timestamp
- User name
- IP address of the host associated with the event
- Operation including values (when applicable)

The alarm is raised when the audit log transfer to the externally-configured FTP or SFTP server is unsuccessful.

The audit log is not affected if the NE is restarted and it cannot be changed in MINI-LINK Node GUI. The audit log can be transferred to an FTP server on a regular basis.

16.10.6 Monitoring Local Users and Active Sessions

It is possible to view and download reports about local users and active sessions from MINI-LINK Node GUI.

Note: For viewing and downloading reports, admin_user is required.

About local users generated by the node, information on the previous session (start date and time) can be monitored.

About active sessions, the following parameters can be monitored:

- Information on the user
- IP address
- Session ID
- Interface used (CLI, NETCONF, SNMP, or MINI-LINK Node GUI)
- Start time of the active session

16.10.7 Syslog for Security Events

It is possible to send Security events to an external Syslog server in syslog format to trace security events and user actions.

The selected existing security events are sent in Syslog format, independently of the audit log file. “Event” means “setting” in this respect. For example, the protocol setting Telnet/SSH is considered a security event, and the change between Telnet/SSH will be notified to the external Syslog server once it is configured to do so.

16.10.8 Disable Local O&M Ports

It is possible to disable local access to an NE by disabling the local ports in terms of the USB port and the LAN port.

If both the USB and LAN port are disabled, it is no longer possible to access the DCN and the NE on-site. It is possible to disable the LAN port and the USB port independently. The only way to access the node is to access the DCN remotely, either from an OMC or from a remote node.

16.10.9 Notification on Logon

Through Notification on Logon, the OMC can react on an unexpected logon. Notification on Logon is available for local (USB) connections.

An event is sent to the management systems each time a user logs on to an NE. The notification contains a timestamp, the user name, the IP address, and information on whether a logon is through CLI or SNMP. Upon successful logon, the information associated with the last successful logon is displayed up to 30 days. The Security Issue on Logon alarm, which can be enabled using MINI-LINK Node GUI, is raised in case of three consecutively failed logon attempts. This alerts the management system of a potential security threat.

16.10.10 Password Cracking Defense: Setting Brute Force Threshold

Delayed logon is activated to protect against password cracking. When a suspected attack is performed against CLI, MINI-LINK Node GUI, NETCONF or SNMP interface, a delay is inserted in case of an authentication error. The delay is inserted when a certain number of authentication errors is reached during a time window (activation threshold). The normal behavior is restored only when no error is detected during the defense mode for a certain period of time (defense period). The functionality can be managed through the activation threshold setting.

Note: When brute force defense mode is activated, the following system response is applicable:

- Users with blacklisted user names or blacklisted IP addresses cannot access the NE.
- Non-blacklisted users can access the NE but can experience system slowdown.

It is possible to set a time limit for how long the brute force protection lockout is to be active after a failed login attempt. It is also possible to monitor and reset the locked sessions. These settings can be configured using either CLI or MINI-LINK Node GUI.

16.10.11 Firewall

A firewall is in place for packet filtering on the IP address and the range of the IP address. The packet filter option is protection from external traffic connections through each possible port or service by closing or opening commands. These options are only available to the admin_user.

Both IPv4 and IPv6 are supported.

16.10.12 Legal Notice

It is possible to add a legal notice shown before logging on, to highlight the legal consequences of unauthorized access. The legal notice can be customized according to local law.

16.10.13 Access Control Lists

IPv4 Access Control Lists (ACLs) can filter incoming or outgoing IPv4 packets on IP interfaces, based on the contents of the IPv4 header. Packets can be permitted or denied at line speed using hardware capabilities.

The supported filtering parameters are the following:

— Source IP address

— Destination IP address

— IP protocol type

— TCP/UDP source port

— TCP/UDP destination port

ACLs can be configured independently on each VLAN interface and VLAN subinterface. The total number of configurable ACLs is limited per node based on the type of the NPU.

Transit and originating or terminating IP packets are filtered by the access lists.

Note: ACLs are not supported for PPP and loopback interfaces.

17 Accessories

The MINI-LINK 6600 product program contains a comprehensive set of accessories for installation and operation. This section gives additional technical information for Small Form Factor Pluggable (SFP) and Small Form Factor Pluggable Plus (SFP+).

For a full list of approved SFP and SFP+, see MINI-LINK 6600 R1 Compatibility, Reference [1].

17.1 SFP

The SFP exists as electrical or optical transmitter/receiver for PDH/Ethernet, see Figure 158.

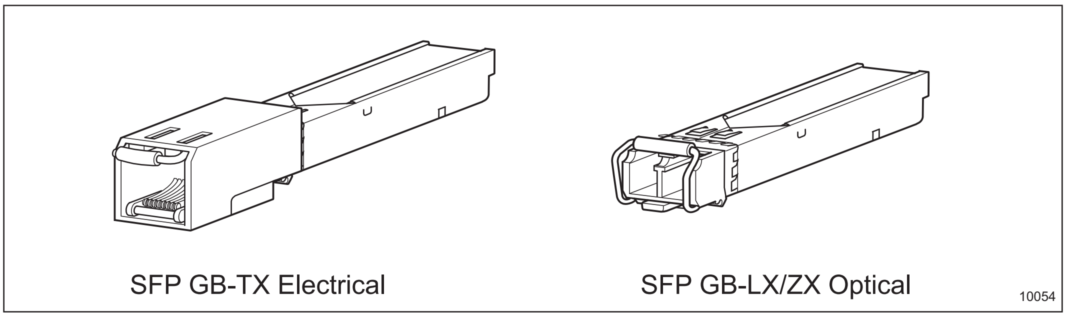


Figure 158 Electrical/Optical SFP

17.2 SFP+

The SFP+ exists as optical transmitter/receiver for Ethernet, see Figure 159.

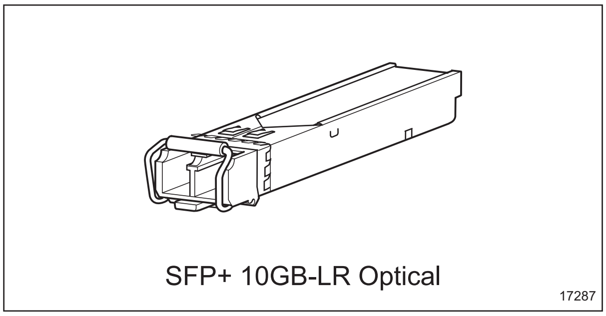


Figure 159 Optical SFP+

17.3 Tunable DWDM SFP+

The tunable SFP+ is a Dense Wavelength Division Multiplexing (DWDM) transceiver for Ethernet. Tunable DWDM SFP+ allows adjusting the transmission wavelength within the C-band DWDM International Telecommunication Union (ITU) Grid. The use of tunable DWDM SFP+ is supported in the 10G port of the ETU 1002 plug-in unit.

17.4 Direct-Attach Copper Cable

The Direct-Attach Copper Cable (DAC) is an electrical traffic cable that can be used to directly connect MINI-LINK 6600 with another product placed physically close. It is equipped with SFP+ modules at both ends, and it provides a 10 Gbps rate.

Reference List

[1] MINI-LINK 6600 R1 Compatibility, 1/221 02-HRA 901 20/11

[2] Physical/Electrical Characteristics of Hierarchy Digital Interface, ITU-T G.703 (11/2001)

MINI-LINK 6363

MINI-LINK 6000
With unmatched flexibility, MINI-LINK 6000 provides the right solution for each part of the network, all deployment scenarios and site types, enabling sound investments in line with the service providers' needs. The portfolio offers both split mount and all outdoor shorthaul as well as long haul solutions covering the complete microwave spectrum from 4 up to 80 GHz. MINI-LINK 6000 offers advanced packet functionality including advanced sync and L3 VPN, using IP/MPLS, as well as L2. All network scenarios are supported with superior performance combined with the lowest possible cost of ownership.

Ericsson is the market leader in microwave transmission and has over 40 years of microwave experience with more than 4.5 million radio units delivered to over 180 countries.

High capacities in a compact format
The MINI LINK 6363 is to be used in split systems together with nodes MINI-LINK 6000, MIN-LINK TN and MINI-LINK CN. It connects to the node via a coaxial cable. In a very compact format, it supports gigabit capacities in traditional frequency bands as well as in E-band. The high output power caters for the need of high capacities and high availability, providing superior network performance.

World's smallest high power radio
MINI-LINK 6363 builds on the strengths from the world´s most widely deployed microwave radio MINI-LINK RAU2 X. The footprint has been reduced by 65% and weight by 35% compared to RAU2 X. This enables easier and faster installations as well as less wind load on towers.

Two versions
MINI-LINK 6363 comes in two versions. MINI-LINK 6363, optimized for highest system gain, and MINI-LINK 6363/2 optimized for lowest power consumption.

Superior output power
MINI-LINK 6363 has the highest output power in the split mount radio market, that is maintained also for higher modulations. For 24-42 GHz the output power has been increased with up to 4 dB compared to RAU2 X's already high specification. This means more capacity, higher availability and smaller antennas. In combination with functionality in the node, a superior system gain is obtained. High output power is available as a SW license, which makes it possible to step up in modulation and capacity when needed, following a pay as you grow approach.

Best in class dynamic range
MINI-LINK 6363 has best in class dynamic range, which is crucial to reduce interference (using ATPC), reduce power consumption and to be able to install short hops.

Reduced power consumption
The power consumption in MINI-LINK 6363 has been reduced compared to RAU2 X. For 6-11 GHz by up to 10 W. For MINI-LINK 6363/2 the power consumption has been optimized even further, typically by an additional 25% vs MINI-LINK 6363.

High capacities in traditional frequency bands
The radio unit also supports 112 MHz wide channels and a modulation of 8k QAM (8192 QAM), which provides capacities over 1 Gbps.

World's first split mount E-band radio
MINI-LINK 6363 offers a cost efficient access to the E-band spectrum, with reuse of nodes and coaxial cabling. It supports both TDM and packet transport. Gigabit capacity is provided through 1024 QAM modulation support. It enables Multi-band Booster in split mount configurations, in combination with a traditional frequency band.

Increased ingress protection
The radio unit can be installed in very harsh environments as it fulfills IP66 protection against dust and water.

Backward compatibility
MINI-LINK 6363 is hop compatible with the MINI-LINK RAU2 X. If a radio unit needs to be upgraded, the antenna and radio cable can be reused.

ATEX certified
With ATEX certification MINI-LINK 6363 can be used in potentially explosive atmospheres (Zone 2).

Modular antennas and flat panel antennas
MINI-LINK 6363 uses the same antenna portfolio as MINI-LINK 6364 and MINI-LINK 6365. The 0.3-1.8 m reflector antennas are modular, making them upgradeable from single to dual polarization without the need for realignment. This is done by replacing the interface only. With high focus on visual appearance and minimized size, Ericsson has created the world's smallest outdoor unit (radio+antenna) in traditional bands with a range of flat panel antennas. Since antenna performance is key to secure network performance, the flat panel antennas are guaranteed to be ETSI class 3 compliant and typically close to ETSI class 4 compliance.

Technical specification MINI-LINK 6363

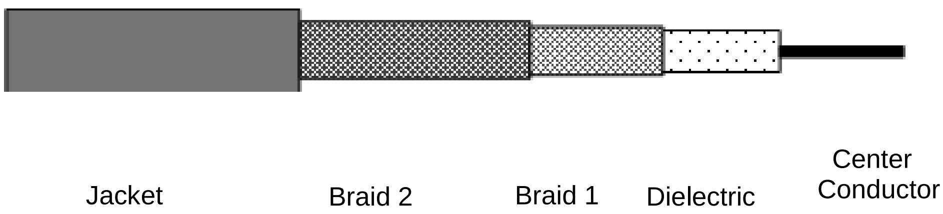
Radio link	Capacity: 1.4 Gbps Channels: 7 – 112/125 MHz Modulation: C-QPSK and 4 – 8k QAM TX power: -10 to +30 dBm
Frequencies	6 – 42 and 80 GHz (MINI-LINK 6363) 13, 15, 18, 23 and 38 GHz (MINI-LINK 6363/2)
Weight	2.5 kg / 5.5 lbs
Dimensions (H × W × D)	179 × 197 × 79 mm (2.8 liters) 7.0 × 7.8 × 3.1 in (170 in^3)
Power supply	+57 VDC
Power consumption	22 W (MINI-LINK 6363) 15 W (MINI-LINK 6363/2)
Reflector antennas	0.2 – 3.7 m / 9 in – 12 ft HP, HPX, SHP and SHPX
Flat panel antennas	0.1 m / 5 in SHP
Integrated configurations	1+0 to 4+0
Interfaces	Modem – Coaxial Antenna – Waveguide Alignment – 3.5 mm audio jack
Standards and recommendations	ETSI, ECC, FCC, IC, IEC, ITU, ATEX
Temperature range	-45 to +60 °C / -49 to +140 °F
Ingress protection	IP66
Nodes	MINI-LINK 6000 MINI-LINK TN MINI-LINK CN
Network management	ServiceOn Element Manager IP Transport NMS Ericsson Network Manager

Ericsson AB
SE-417 56 Göteborg, Sweden
www.ericsson.com

Technical Data Sheet

Rosenberger

COAX CABLE — RTK 400



Material and Dimensions

Center conductor	copper- clad aluminium wire	Ø 2.75 mm
Dielectric	foamed PE	Ø 7.2 mm
Braid 1	alulaminate foil overlapped	
Braid 2	tin plated copper wire	Ø 7.9 mm
Jacket	PE, black	Ø 10.2 ±0.20 mm

Printing: Rosenberger RTK 400 “internal lot number”

Electrical data

Impedance	50 Ω
Recommended frequency range	DC to 6 GHz
Return Loss (30-1500 MHz)	≥ 23dB
(1500-2700 MHz)	≥ 16dB
Insertion loss	see table
Velocity of propagation	85 %
Capacitance 800Hz	≈ 77 nF/km
Test voltage	≥ 2500 V rms
Screening effectiveness	≥ 90 dB up to 2.2 GHz
Conductor resistance	≤ 4.6 Ohm/km
Screen resistance	≤ 5.6 Ohm/km
Insulation resistance	≥ 10 GOhm*km

Mechanical data

Minimum bend radius:

Single	25.4 mm
Multible	50 mm
Bending Moment	0.7Nm
Flat Plate Crush resistance	690N/mm
Weight	100 kg/km

Attenuation

Attenuation and Power are typical values at 40°C ambient temperature and sea level.

Frequency (MHz)	100	200	500	1000	1500	2000	3000	5000
Attenuation (dB/100m)	4.1	5.8	9.4	13.5	16.8	19.6	24.5	32.8
Mean. Power (kW) 40°C)	1.9	1.3	0.8	0.6	0.45	0.4	0.3	0.2

Rosenberger Hochfrequenztechnik GmbH & Co. KG
P.O.Box 1260 D-84526 Tittmoning Germany
www.rosenberger.de

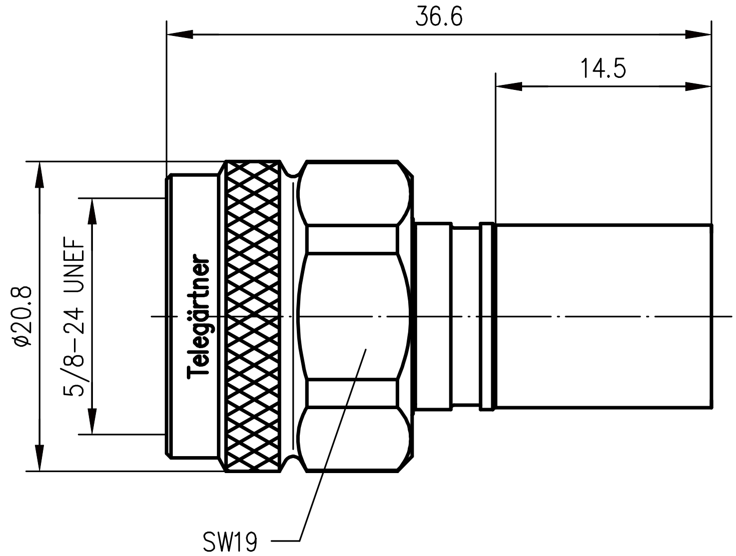
Tel. : +49 8684 18-0
Email : info@rosenberger.de

Environmental data

Operation Temperature	- 40 °C to + 80 °C
Installation Temperature	- 40 °C to + 80 °C
Storage Temperature	- 70 °C to + 80 °C
UV resistance	
2002/95/EC (RoHS)	compliant
Halogen free	

Rosenberger Hochfrequenztechnik GmbH & Co. KG
P.O.Box 1260 D-84526 Tittmoning Germany
www.rosenberger.de

Tel. : +49 8684 18-0
Email : info@rosenberger.de



Mechanical characteristics	**Mechanische Eigenschaften**		
cables	Kabel	ⓐ ⓑ ⓒ	G37: 2.7/7.3 AF, 2.7/7.3 CF, 213CRT7 LOW LOSS, 7810A, 9913, 9913F, C2FCP, C2FP, CNT–400, EC 400, HPF 400, LMR–400, MCR 400 AFB, SPEEDFOAM 400 HFJ, TZC 500 32, WBC–400, WCX400
interface dimensions acc. to	Steckgesicht nach		IEC 61169–16
assembly code	Montageanleitung		B3426

Components	***Bauteile***	***Materials / Material***	***Finish / Oberfläche***
centre contact	Innenkontakt	CuZn39Pb3	Cu2Ag5
crimp ferrule	Crimprohr	Cu SF w	CuSnZn3
other metal parts	sonstige Metallteile	CuZn39Pb3 / CuZn38Pb1.5	CuSnZn3
insulator	Isolierung	PTFE	
gasket	Dichtung	silicone/ Silikon	

Environmental	**Umgebung**	
RoHS compliant	RoHS konform	2002/95/EC

2000	Datum/date	Name/name	Werkstoff/ material
gez./drawn	27.09.	HM	
gepr./appr.	23.10.00	GJ	Oberfläche/ finish
Norm/stand.			

Änd./rev. Index	Änderungsmitteilung/ revision code	Datum/ date	Name/ name
c	21949	21.06.10	GB
b	20137	30.07.08	MA
a	15875	26.08.04	GE

Maßstab/scale: 2:1

Benennung/title:

N Straight Plug
N–Kabelstecker

Telegärtner

untol. Maße/ dim. without tolerances according to

Unterl./doc.type: K

Zeichnungsnr./drawing no.: J01020A0127

Maße/dimensions: mm

Original: DIN A4

Ersatz für/ replaces: J01020A0054

D–71144 Steinenbronn Lerchenstraße 35 Germany Phone: +49 7157 125–0 Fax: +49 7157 125–120 www.telegaertner.com

PRODUCT DATA SHEET

Features	Value	TEST
Compound Color	Black/Grey	-
Solids	100%	ASTM D 792
Specific Weight	1.4g/cm^3	ASTM D 1000
Peel adhesion 90°	>85 N	ISO 7390
Flowing at 70°C	0.0 cm	home test
Compression test	1.5 mm / 20 min	ASTM 2240
Hardness Shore A	22 index	ASTM D 3121
Rolling ball a 5°C	<5 cm	ASTM D 6195
Loop track test a 20°	> 80 N	ASTM D 2979
Probe track test a 20°	>7 N	ASTM D 3654 mod
Shear adesion (300gr.)	>500 min	ASTM C 772
vehicle bleed out	pass	ASTM C 907
Tensile adhesive strenght	7000 N/m^2	ASTM C 765
Flexibility	-40°C	ASTM C 908
Elongation	>700%	ASTM C 776
Application temperature	+5°C/ +40°C	-
Service temperature	-40°C/ +130°C	-

code	**6115031050**
article	**BUT 50**

RI	DATE	DR	DATE	AP
02				
01				
00	12/02/20	G.S.	12/02/20	A.V.
	1ST EMISSION			

Description:

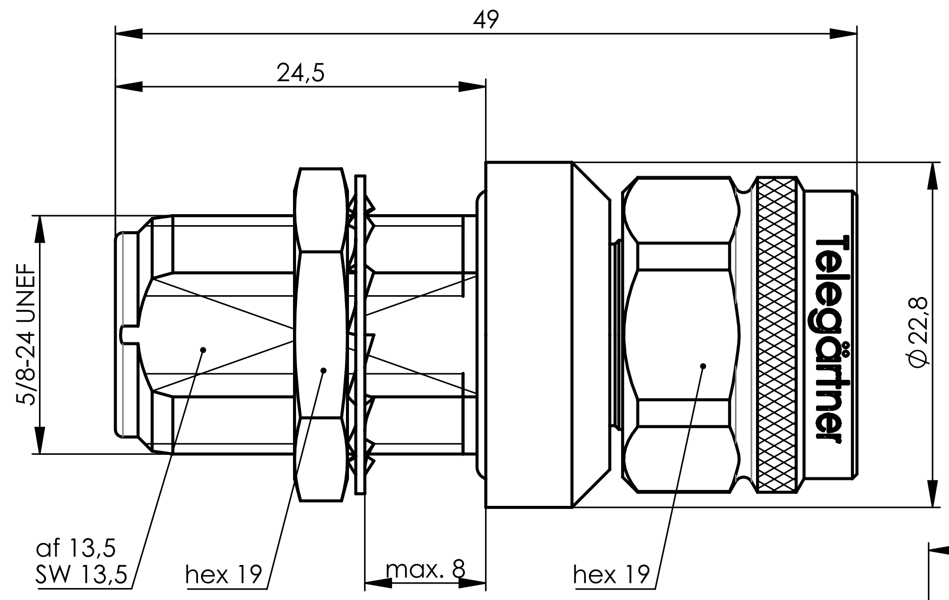
BUT 50 = Butyl Putty 0,05x0,6m

FIMO Setting Installation Standards

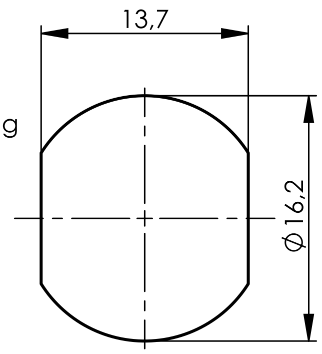
RoHS

Use:

Ideal to insulate, seal and protect



panel piercing
Montagebohrung



with label / mit Aufkleber

EMP Protector 150-250V
DC-6 GHz IP 68

Mechanical characteristics	**Mechanische Eigenschaften**		
interface dimensions acc. to	Steckgesicht nach	IEC 61169-16	
panel piercing	Montagebohrung	Z010	
Components	***Bauteile***	***Materials / Material***	***Finish / Oberfläche***
center contact	Innenkontakt	copper alloy / Kupferleg.	Cu2Ag5
outer contact	Außenkontakt	brass / Messing	CuSnZn3
serrated lock washer	Fächerscheibe	copper alloy / Kupferleg.	Ni
other metal parts	sonstige Metallteile	brass / Messing	CuSnZn3
insulator	Isolierung	PTFE	
gasket	Dichtung	silicone / Silikon	
Electrical characteristics	**Elektrische Eigenschaften**		
impedance	Wellenwiderstand	50 Ω	
frequency	Frequenz	0-6 GHz	
return loss	Rückflussdämpfung (d)	typ. 20 dB	
insertion loss	Einfügedämpfung (e)	typ.: 1 GHz<0,12 dB; 3 GHz<0,18 dB; 6 GHz<0,40 dB	
breakdown voltage	Zündspannung	150-250 V DC (100V/s)	
impulse discharge current	Stromableitungsvermögen	8/20 µs, 5 kA 10 times / 10 mal 8/20 µs, 10 kA 1 time / 1 mal	
max. power	max. Leistung	80 W (at / bei 40°C)	
residual pulse energy	Restimpulsenergie	typ. 400 µJ (4 kV, 1,2/50 µs; 2 kV, 8/20 µs)	
Environmental	**Umgebung**		
operating temp.	Betriebstemperatur	-40°C / +85°C	
protection class	Schutzklasse	IP 68 (2,5 bar/1 h) IEC 60529	
RoHS compliant	RoHS konform	2011/65/EU	

Änd./ rev. Index	Änderungs-Nr. / revision code	Datum/ date	Name/ name
e	31466	23.07.2020	HR
d	30390	25.03.2019	MA
c	27911	21.06.2016	MA
b	21655	08.03.2010	HR
a	18308	10.11.2006	HR

	Datum/ date	Name/ name	Gewicht/ weight [g] ca./approx.
gez./ drawn	21.06.2016	MA	81
gepr./ appr.	21.06.2016	KL	

Maßstab/ scale: 2:1

Benennung/ title:

N Surge Suppressor (m-f)
N-Überspannungsableiter

Telegärtner

untol. Maße/ dim. without tolerances according to

Unterl./doc. type: K

Zeichnungsnr./ drawing no.: J01028A0047

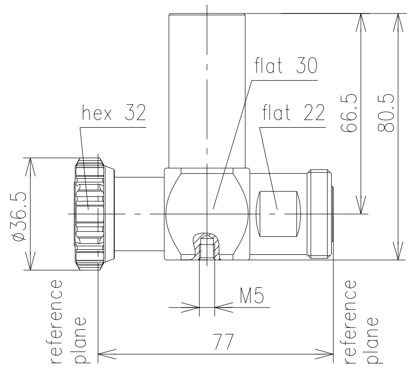
Maße/ dimensions: mm

Original : DIN A4

Ersatz für/ replaces: Zeichnung vom 06.04.2006

Blatt/ sheet 1 von/ of 1

Type 7-16 Plug / Socket Surge Protector with Quarter Wavelength Stub || BN 766419



all dimensions in millimeter

Interface type	7-16 plug/socket (50 Ω) per IEC 61169-4
VSWR, max.	1.20 @ 380 to 430 MHz 1.22 @ 380 to 512 MHz
Frequency range	380 to 512 MHz
Insertion loss, max.	0.1 dB
Average power capability, max.	3 kW
Allowed surge current	50 kA multiple (test pulse 8/20 µs)
Residual pulse energy	20 µJ (test pulse 4 kV 1.2/50 µs and 2 kA 8/20 µs)
Inner conductor material / surface finish	copper alloy / silver plated
Outer conductor material / surface finish	copper alloy / silver plated
Other metal parts / surface finish	copper alloy / bright nickel plated
Insulation	PTFE
Sealing	silicone rubber
IP protection level	IP67 per EN 60529 (in mated condition)
Weight, approx.	430 g
Operating temperature range	-45 to +75 °C

Data Sheet

HUBER+SUHNER

Sencity Special Communication
K862748

Description

Omni-directional Antenna
Frequency Range 380 - 400 MHz
Vertical Polarization
Gain 7.5 dBi

Product Configuration

Technical Data

Electrical Data

	Band 1
Frequency (MHz)	380 - 400
VSWR	1.5
Impedance (Ohm)	50
Gain (dBi)	7.5
Composite power max (W)	500
Ambient temperature (°C)	50

Ports

	Port 1
Port name	Tetra
Connector	7/16, jack (female)
Polarization	vertical
DC grounded	Yes

Connections

	Band 1
Port 1	X

General Data

Intermodulation IM3 < -150 dBc (2 x 43 dBm carrier)

Mechanical Data

Dimensions (mm)	2840 x 112 x 148 (Heigth x Width x Depth)
Weight (kg)	8
Windload	frontal: 200 N at 150 km/h , Wind speed survival: km/h

Environmental Data

Environmental conditions	outdoor
2011/65/EU (RoHS - including 2015/863 and 2017/2102)	compliant
WEEE 2012/19/EU	no special marking needed
REACH 1907/2006/EC	compliant

Material:
Radiator: Copper and brass.
Radome: Fiberglass, colour: Grey.
Base: Weather-proof aluminum.

Data Sheet

HUBER+SUHNER

Sencity Special Communication
K862748

Mounting kit, screws and nuts: Stainless steel.
Mounting: The antenna can be attached laterally at the tip of a tubular mast of 50-94 mm diameter with two U-bolt brackets supplied with the antenna (connecting cable runs outside the mast).

Anti-static protection: All metal parts of the antenna as well as the supplied clamp attachment are grounded. The inner conductor is capacitively coupled.

Lightning protection: The antenna is designed to withstand a lightning current of up to 150 KA (impulse: 10/350 µs), according to IEC 62305 parts 1-4 and VDE 0855-300, and thereby fulfils the requirements of lightning protection class II.
Grounding:
cross-section: 22 mm2 copper.

Material Data

Radome colour	grey
Back plate/base plate colour	grey
Back plate/base plate material	Aluminium

Related Products

738908 Side-mounting Clamp
737398 Side-mounting Bracket

Related Documents

Mounting instruction	DOC-0000871202
Security instruction	DOC-0000278984
Outline drawing	DOU-00397425

EVPÚ®

NOTIFIED BODY No. 1293

CERTIFICATE OF CONSTANCY OF PERFORMANCE

No. 1293 – CPR – 0637

In compliance with *Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011* (the Construction products Regulation or CPR), this certificate applies to the construction product

Conventional fire alarm optical-smoke detector
SensoMAG S30, Precise S30, Herald S30, RunwayLeo S30

For specifications see Annex to this certificate

placed on the market under the name or trade mark of

Teletek Electronics JSC
14A Srebarna Str., 1407 Sofia, Bulgaria

and produced in the manufacturing plant

Teletek Electronics JSC
14A Srebarna Str., 1407 Sofia, Bulgaria

This certificate attests that all provisions concerning the assessment and verification of constancy of performance described in Annex ZA of the standards

EN 54-7:2000
EN 54-7:2000/A1:2002
EN 54-7:2000/A2:2006

under system 1 for the performance set out in this certificate are applied and that the factory production control conducted by the manufacturer is assessed to ensure the

constancy of performance of the construction product.

This certificate was first issued on March 19th, 2019 and will remain valid as long as neither the harmonised standard, the construction product, the AVCP methods nor the manufacturing conditions in the plant are modified significantly, unless suspended or withdrawn by the notified product certification body.

EVPÚ, a.s. NOVÁ DUBNICA Notified Body No 1293

Nová Dubnica, March 19th, 2019

Marek Hudák
Director NB

053393

Annex to Certificate No. 1293 - CPR – 0637 from March 19th, 2019

General Information

The detector SensoMAG S30 and derived variants are compatible with any conventional Fire Panel with fire alarm threshold between 10mA and 15mA (between 10mA and 30mA with B24RD fire base).
The detector can be used with 4 base types:

B12L/U - Base with relay output (not covered by EN54-7);
B24 - Standard base;
B24D - Standard base with Schottky diode;
B24RD - Standard base with Schottky diode and increased alarm state current.

Technical specifications

Operating voltage range	9 - 30 V DC (Nom. 12/24VDC)
Average current consumption in quiescent state	< 50μA
Alarm state current	
- with base type B24 and B24D	20 mA / 12÷30V
- with base type B24RD	33 mA / 12V; 49mA/24V; 57mA/30V
- with base type B12L/U	18 mA / 9V; 29mA/12V; 32mA/15V
Output in alarm state at terminal RI	20mA (max) / -3.3V
Operation temperature	-10°C ÷ +60°C
Relative humidity	(93±3)% @ +40°C
Degree of protection	IP30
Dimensions	Φ 102mm h 42mm
Weight (incl. base)	160g

Essential charactertics	Test specification	Harmonised technical specifications	Performance
Nominal activation conditions / Sensitivity, response delay (response rime) and Performance under fire conditions	cl. 4.8, 5.2, 5.3, 5.4, 5.6, 5.7, 5.18	EN 54-7:2000 EN 54-7:2000/A1:2002 EN 54-7:2000/A2:2006	Pass
Operational reliability	cl. 4.2 to 4.5, 4.6=N/A, 4.7, 4.9 to 4.11	EN 54-7:2000 EN 54-7:2000/A1:2002 EN 54-7:2000/A2:2006	Pass
Tolerance to supply voltage	cl. 5.5	EN 54-7:2000 EN 54-7:2000/A1:2002 EN 54-7:2000/A2:2006	Pass
Durability of operational reliability and response delay: temperature resistance	cl. 5.8, 5.9	EN 54-7:2000 EN 54-7:2000/A1:2002 EN 54-7:2000/A2:2006	Pass
Durability of operational reliability: vibration resistance	cl. 5.13 to 5.16	EN 54-7:2000 EN 54-7:2000/A1:2002 EN 54-7:2000/A2:2006	Pass
Durability of operational reliability: humidity resistance	cl. 5.10, 5.11	EN 54-7:2000 EN 54-7:2000/A1:2002 EN 54-7:2000/A2:2006	Pass
Durability of operational reliability: corrosion resistance	cl. 5.12	EN 54-7:2000 EN 54-7:2000/A1:2002 EN 54-7:2000/A2:2006	Pass
Durability of operational reliability: electrical stability	cl. 5.17	EN 54-7:2000 EN 54-7:2000/A1:2002 EN 54-7:2000/A2:2006	Pass

EVPÚ, a.s. NOVÁ DUBNICA Notified Body No1293

Nová Dubnica, March 19th, 2019

Marek Hudák
Director NB

EVPÚ®

NOTIFIED BODY No. 1293

CERTIFICATE OF CONSTANCY OF PERFORMANCE

No. 1293 – CPR – 0639

In compliance with *Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011* (the Construction products Regulation or CPR), this certificate applies to the construction product

Conventional fire alarm Rate-of-Rise Heat Detector
SensoMAG R20, Precise R20, Herald R20, RunwayLeo R20

For specifications see Annex to this certificate

placed on the market under the name or trade mark of

Teletek Electronics JSC
14A Srebarna Str., 1407 Sofia, Bulgaria

and produced in the manufacturing plant

Teletek Electronics JSC
14A Srebarna Str., 1407 Sofia, Bulgaria

This certificate attests that all provisions concerning the assessment and verification of constancy of performance described in Annex ZA of the standards

EN 54-5:2000
EN 54-5:2000/A1:2002

under system 1 for the performance set out in this certificate are applied and that the factory production control conducted by the manufacturer is assessed to ensure the

constancy of performance of the construction product.

This certificate was first issued on March 19th, 2019 and will remain valid as long as neither the harmonised standard, the construction product, the AVCP methods nor the manufacturing conditions in the plant are modified significantly, unless suspended or withdrawn by the notified product certification body.

EVPÚ, a.s. NOVÁ DUBNICA Notified Body No 1293

Nová Dubnica, March 19th, 2019

Marek Hudák
Director NB

053394

Annex to Certificate No. 1293 - CPR – 0639 from March 19th, 2019

General Information
The detector SensoMAG R20 and derived variants are compatible with any conventional Fire Panel with fire alarm threshold between 10mA and 15mA (between 10mA and 30mA with B24RD fire base).
The detector can be used with 4 base types:
B12L/U - Base with relay output (not covered by EN54-5);
B24 - Standard base;
B24D - Standard base with Schottky diode;
B24RD - Standard base with Schottky diode and increased alarm state current.

Technical specifications

Operating voltage range	9 - 30 V DC (Nom. 12/24VDC)
Average current consumption in quiescent state	< 50µA
Alarm state current	
- with base type B24 and B24D	20 mA / 12÷30V
- with base type B24RD	33 mA / 12V; 49mA/24V; 57mA/30V
- with base type B12L/U	18 mA / 9V; 29mA/12V; 32mA/15V
Class (in accordance with EN 54-5)	A1/R
Output in alarm state at terminal RI	20mA (max) / -3.3V
Operation temperature	-10°C ÷ +60°C
Relative humidity	(93±3)% @ +40°C
Degree of protection	IP30
Dimensions	Φ 102mm h 42mm
Weight (incl. base)	160g

Essential characteritics	Test specification	Harmonised technical specifications	Performance
Nominal activation conditions / Sensitivity, Response delay (response rime) and Performance under fire conditions	cl. 4.2, 4.3, 5.2 to 5.4, 5.5=N/A, 5.6, 5.8, 6.1=N/A, 6.2	EN 54-5:2000 EN 54-5:2000/A1:2002	Pass
Operational reliability	cl. 4.4, 4.5=N/A, 4.6, 4.7, 4.8=N/A, 4.9 to 4.11	EN 54-5:2000 EN 54-5:2000/A1:2002	Pass
Tolerance to supply voltage	cl. 5.7	EN 54-5:2000 EN 54-5:2000/A1:2002	Pass
Durability of operational reliability and response delay: temperature resistance	cl. 5.9, 5.10=N/A	EN 54-5:2000 EN 54-5:2000/A1:2002	Pass
Durability of operational reliability: vibration resistance	cl. 5.14 to 5.17	EN 54-5:2000 EN 54-5:2000/A1:2002	Pass
Durability of operational reliability: humidity resistance	cl. 5.11, 5.12	EN 54-5:2000 EN 54-5:2000/A1:2002	Pass
Durability of operational reliability: corrosion resistance	cl. 5.13	EN 54-5:2000 EN 54-5:2000/A1:2002	Pass
Durability of operational reliability: electrical stability	cl. 5.18	EN 54-5:2000 EN 54-5:2000/A1:2002	Pass

EVPÚ, a.s. NOVÁ DUBNICA
Notified Body № 1293

Nová Dubnica, March 19th, 2019

Marek Hudák
Director NB

www.cet-power.com

TSI NOVA
230 В. ПЕРЕМ. ТОКА

0,75-6 кВА

ТЕЛЕКОММУНИКАЦИИ | ПЕРЕДАЧА ДАННЫХ | ОБЩЕСТВЕННЫЙ ТРАНСПОРТ | НЕФТЕГАЗОВАЯ ПРОМЫШЛЕННОСТЬ | ЭНЕРГЕТИЧЕСКИЕ КОМПАНИИ

МОДУЛЬНЫЙ ИНВЕРТОР
МОДУЛЬ

ПОЛНАЯ МОЩНОСТЬ 0,75 кВА
НАПРЯЖЕНИЕ НА ВХОДЕ 48 В пост. тока
ВЫХОДНОЕ НАПРЯЖЕНИЕ ПЕРЕМЕННОГО ТОКА — 230 В

ОПИСАНИЕ

NOVA — это компактный и масштабируемый модульный инвертор, обеспечивающий подачу напряжения переменного тока с формой выходного сигнала в виде чистого синуса. Что касается системы электропитания постоянного тока, она представляет собой отличное решение в качестве резервного источника переменного тока. В ней используются новейшие технологии производства инверторов, которые обеспечивают великолепную энергоэффективность при сохранении компактных размеров.

Благодаря технологии Twin Sine Innovation (двойное преобразование с внутренней буферизацией энергии, TSI) исключаются все возможные единичные отказы; можно параллельно подключать до 32 модулей, при этом достигается высокий КПД до 93 %, что обеспечивает снижение операционных затрат.

ОБЛАСТИ ПРИМЕНЕНИЯ

Все сферы применения, критичные с точки зрения бизнеса, а также возможность использования потребителей переменного тока любых типов. Конструкция является модульной и масштабируемой, поддерживающей функцию замены модулей без выхода из рабочего режима, что гарантирует высокое значение показателя среднего времени наработки до ремонта (MTTR), снижение затрат на обслуживание и соответствие требованиям в отношении проведения замены во исполнение планов будущего наращивания возможностей.

ОСНОВНЫЕ ОСОБЕННОСТИ

- Два вида источников входного напряжения (переменного и постоянного тока) с широким диапазоном значений входного напряжения переменного тока: от 150 до 265 В
- Компактная конструкция
- Высокая эффективность
- Время переключения сведено к 0
- до 3 кВА при размере 1 юнита

Leading AC Backup Technology

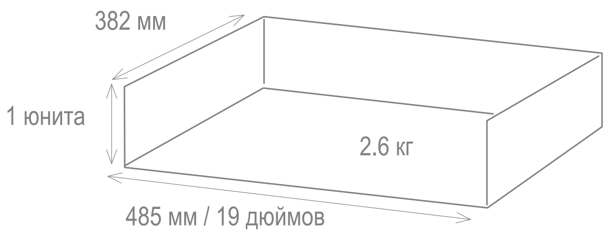
CE+T POWER

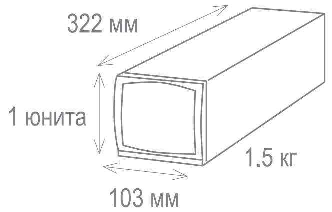
TSI NOVA

	48 / 230
ОБЩИЙ	
ЭМС (помехоустойчивость)	EN 61000-4-2 / EN 61000-4-3 / EN 61000-4-4 / EN 61000-4-5 / EN 61000-4-6 / EN 61000-4-8
ЭМС (помехоэмиссия) (класс)	EN 55022 (A)
Безопасность	EN62040-1
Охлаждение/изоляция	Принудительное/двойная
MTBF (время наработки на отказ)	200 000 ч (согласно MIL-217-F)
КПД (типичный): улучшенное преобразование энергии / оперативный режим	93% / 89%
Диэлектрическая прочность на пробой, постоянный/переменный ток	4300 В пост. тока
Соответствие системе истинного дублирования	3 уровня отключения на выходном порте электропитания переменного тока и входном порте электропитания постоянного тока 4 уровня отключения на выходном порте электропитания переменного тока
RoHS	Совместим
Вибрация	Вибрации в офисных условиях по стандарту GR63 от 0 до 100 Гц (0,1 g) / вибрации при транспортировке в диапазонах 5—100 Гц (0,5 g) и 100—500 Гц (1,5 g) / испытание на удар под падающим грузом
Условия эксплуатации	Предназначен для монтажа в условиях IP20 и IP21. При установке в местах с повышенным уровнем влажности или запыленности необходимо принимать соответствующие защитные меры (такие, например, как фильтрация воздуха и т. д.).
Высота над уровнем моря без снижения номинальных рабочих характеристик	Менее 1500 м / снижение номинальных характеристик на высоте более 1500 м: на 0,8% через каждые 100 м
Температура окружающего воздуха / хранения / относительная влажность	От −20 до 50° C / от −40 до 70° C / 95%, без конденсации
Материал (корпус)	Сталь с алюминиево-цинковым покрытием
МОЩНОСТЬ НА ВЫХОДЕ ПЕРЕМЕННОГО ТОКА	
Номинальная выходная мощность (ВА) / (Вт)	750 ВА / 525 Вт
Допустимая кратковременная перегрузка	135% (15 секунд), 105% (постоянная в пределах температурного диапазона)
Допустимый коэффициент мощности нагрузки	Полная мощность от нулевой индуктивной до нулевой емкостной
Контроль внутренней температуры и отключение	/
ТЕХНИЧЕСКИЕ ХАРАКТЕРИСТИКИ ВХОДА ПОСТОЯННОГО ТОКА	
Номинальное напряжение (пост. ток)	48 В
Диапазон напряжений (пост. ток)	40—60 В
Номинальный ток (при 48 В постоянного тока и выходной мощности 525 Вт)	12,5 А
Максимальная величина входного тока (в течение 15 секунд) / пульсация напряжения	22 А / < 2 мВ
Границы входного напряжения	/
ХАРАКТЕРИСТИКИ ВХОДА ПЕРЕМЕННОГО ТОКА	
Номинальное напряжение (пер. ток)	Номинальное напряжение (пер. ток) 220/230/240 В, 1- или 3-фазное (в случае 3-фазного напряжения требуется не менее 3 полок)
Диапазон напряжений (пер. ток)	150—265 В
Дефицит мощности	150—185 В
	438 Вт при 150 В перем. тока
Коэффициент мощности	> 99%
Диапазон частот (настраивается) / диапазон синхронизации	50/60 Гц: диапазоны 47—53 Гц / 57—63 Гц
ХАРАКТЕРИСТИКИ ВЫХОДА ПЕРЕМЕННОГО ТОКА	
Номинальное напряжение (пер. ток*)	220/230/240 В
Частота / точность частоты	50—60 Гц / 0,03%
Коэффициент искажения синусоидальности кривой напряжения (резистивная нагрузка)	< 3 %
Время восстановления толчка нагрузки	0,4 мс
Задержка при включении	20—40 с в зависимости от количества установленных модулей
Номинальный ток.	3,25 А
Коэффициент амплитуды при номинальной мощности	2,5 : 1
С защитой от коротких замыканий	
Возможность сброса коротких замыканий	10 x $I_н$ в течение 20 мс; сеть доступна на входном порте переменного тока С контролем величины
Ток короткого замыкания после задействования возможности сброса	1,89 I_n
ХАРАКТЕРИСТИКИ ПРЕОБРАЗОВАНИЯ	
Макс. продолжительность прерывания напряжения / общая продолжительность напряжения переходного процесса (максимальная)	0 с/0 с
СИГНАЛИЗАЦИЯ И КОНТРОЛЬ	
Дисплей	Мнемонический светодиодный индикатор
Вывод/контроль сигнала тревоги	Беспотенциальные контакты на полке / Используйте дополнительные устройства
Дистанционное включение/выключение	На клемме, расположенной с задней стороны полки, с помощью T2S ETH

TSI NOVA 230 — лист технических данных версии 1.3. Технические характеристики могут изменяться без уведомления. Новые данные будут опубликованы на нашем веб-сайте www.cet-power.com.

* Работа в сетях с низким напряжением приводит к ухудшению качества электропитания.





Иллюстрации могут быть неточными и не имеют юридической силы, поскольку на них могут быть изображены изделия не в стандартном исполнении.

Leading AC Backup Technology

CE+T POWER

SensoMAG

Teletek electronics

SensoMAG S30
Optical-Smoke Fire Alarm Detector

EN54-7

Description

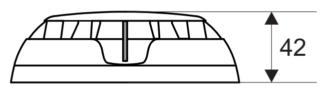
SensoMAG S30 is an optical-smoke detector with digital processing algorithm. The detector is designed to detect smoke in the very early stage of the fire situation. SensoMAG S30 is suitable for installing in any conventional fire alarm system designed with fire alarm panel with fire alarm threshold between 10mA and 15mA.

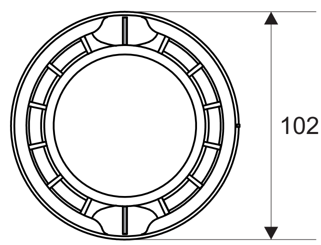
CE 19
1293
DoP No: 089

1293-CPR-0637

Technical and Environmental Specifications

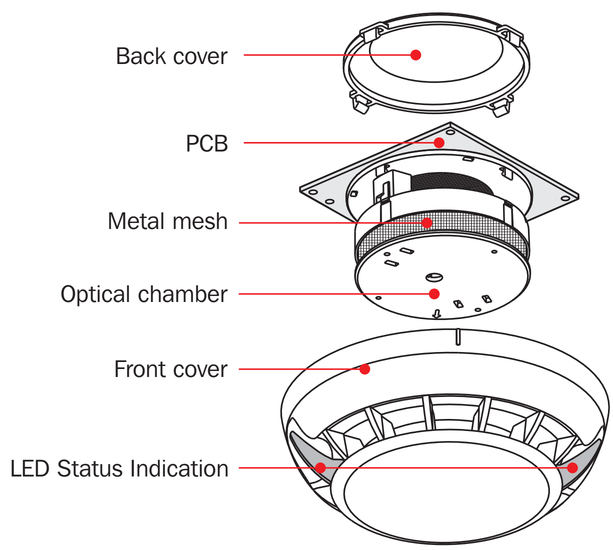
Operating Voltage Range	9 - 30 V DC (Nom. 12/24VDC)
Average current consumption in quiescent state	< 50μA
Alarm state current:	
- with base type B24 and B24D	20 mA / 12÷30V
- with base type B24RD	33 mA / 12V; 49mA/24V; 57mA/30V
- with base type B12L/U	18 mA / 9V; 29mA/12V; 32mA/15V
Output in alarm state at terminal RI	20mA (max)/ -3.3V
(Towards terminals +IN /+OUT)	
Degree of protection	IP30
Wire Gauge for terminals	$0.4mm^2 \div 2.0mm^2$
Operational temperature range	-10°C ÷ +60°C
Relative humidity resistance	(93 ± 3)% @ 40°C
Dimensions (incl. base)	ø102mm, h 42mm
Weight (incl. base)	160g





Application

SensoMAG S30 is a high sensitive optical smoke detector. It is suitable for applications where early detection of smoke or fire is with great importance, for example office buildings, supermarkets, schools, etc.



Contact Information:

Teletek Electronics JSC
14A Srebarna Str, 1407 Sofia, Bulgaria

Tel.:+359 2 9694 800
Fax: +359 2 9625 213

info@teletek-electronics.bg
www.teletek-electronics.com

SensoMAG

Teletek electronics

SensoMAG S30

Optical-Smoke Fire Alarm Detector

EN54-7

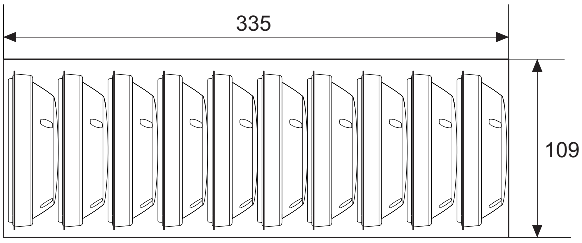
Packing Information

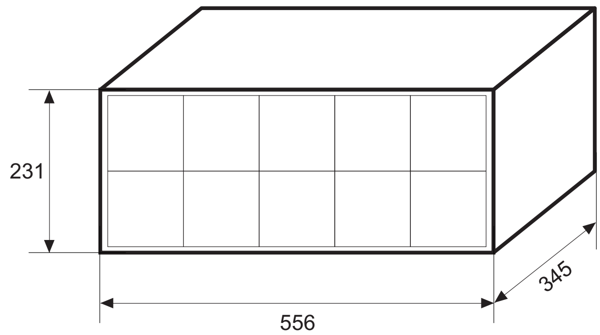
• **Master box** - 10 units SensoMAG S30, no bases included, dimensions 335 x 109 x 109 mm.

All detectors are protected with a plastic cap.

• **Carton box** - 100 units SensoMAG S30, (10 master boxes), no bases included, dimensions 556 x 345 x 231 mm.

All detectors are protected with a plastic cap.





Compatible Product Range

• **MAG2, MAG2P** - Conventional Fire Alarm Panel, 2 fixed zones
• **MAG4, MAG4P** - Conventional Fire Alarm Panel, 4 fixed zones
• **MAG8** - Conventional Fire Alarm Panel, 8 fixed zones
• **MAG8Plus** - Conventional Fire Alarm Panel, 8 fixed zones, expandable to 16
• **FRL-1** - Remote Fire Indicator
• **SensoMAG B24** - Standard Base
• **SensoMAG B24D** - Standard Base with Schottky diode
• **SensoMAG B24RD** - Standard Base with Schottky diode and increased alarm state current
• **SensoMAG B12L/U** - Base with relay output, 12V
• **Gasket ring** - Rubber gasket ring for extra protection of the smoke chamber
• **Deep Base** - Accessory for mounting on rough surfaces, outdoor pipelines, etc.

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14A Srebarna Str, 1407 Sofia, Bulgaria

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Fax: +359 2 9625 213

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SensoMAG

Teletek electronics

SensoMAG R20

Rate-of-rise Temperature Fire Alarm Detector

EN54-5

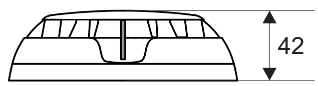
Description

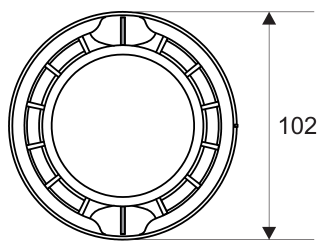
SensoMAG R20 is a rate-of-rise temperature detector with digital processing algorithm. The detector is designed to detect temperatures above 58°C (class A1R, according EN54-5).
SensoMAG R20 is suitable for installing in any conventional fire alarm system designed with fire alarm panel with fire alarm threshold between 10mA and 15mA.

CE 19
1293
DoP No: 051
1293-CPR-0639

Technical and Environmental Specifications

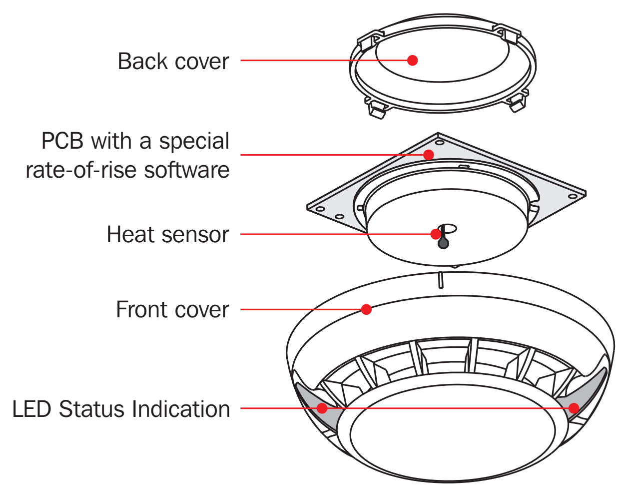
Operating Voltage Range	9 - 30 V DC (Nom. 12/24VDC)
Average current consumption in quiescent state	< 50μA
Alarm state current:	
- with base type B24 and B24D	20 mA / 12÷30V
- with base type B24RD	33 mA / 12V; 49mA/24V; 57mA/30V
- with base type B12L/U	18 mA / 9V; 29mA/12V; 32mA/15V
Class (in accordance with EN54-5)	A1R
Output in alarm state at terminal RI *(Towards terminals +IN /+OUT)*	20mA (max)/ -3.3V
Degree of protection	IP30
Wire Gauge for terminals	$0.4mm^2 \div 2.0mm^2$
Operational temperature range	-10°C ÷ +60°C
Relative humidity resistance	(93 ± 3)% @ 40°C
Dimensions (incl. base)	ø102mm, h 42mm
Weight (incl. base)	160g





Application

SensoMAG R20 is suitable for applications for locations in which different ambient temperatures occur (e.g. mechanical workshops, tool rooms, etc.). The innovative design makes it particularly suitable anywhere where dust, dirt (e.g. sawmills) or high humidity (e.g. wet cells) could affect the operation of traditional detectors.



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SensoMAG

SensoMAG R20

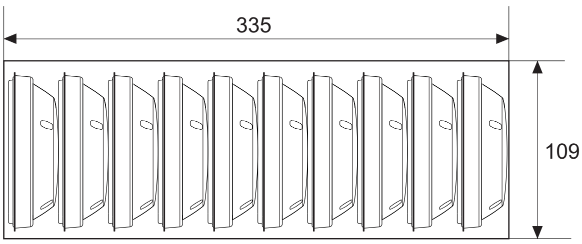
Rate-of-rise Temperature Fire Alarm Detector

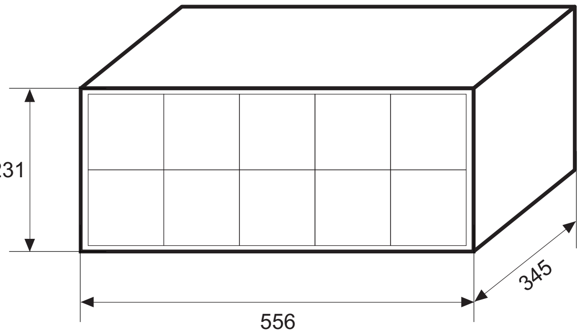
EN54-5

Packing Information

• **Master box** - 10 units SensoMAG R20, no bases included, dimensions 335 x 109 x 109 mm.
All detectors are protected with a plastic cap.

• **Carton box** - 100 units SensoMAG R20 (10 master boxes), no bases included, dimensions 556 x 345 x 231 mm.
All detectors are protected with a plastic cap.





Compatible Product Range

• **MAG2, MAG2P** - Conventional Fire Alarm Panel, 2 fixed zones
• **MAG4, MAG4P** - Conventional Fire Alarm Panel, 4 fixed zones
• **MAG8** - Conventional Fire Alarm Panel, 8 fixed zones
• **MAG8plus** - Conventional Fire Alarm Panel, 8 fixed zones, expandable to 16
• **FRL-1** - Remote Fire Indicator
• **SensoMAG B24** - Standard Base
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• **SensoMAG B12L/U** - Base with relay output, 12V
• **Deep Base** - Accessory for mounting on rough surfaces, outdoor pipelines, etc.

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High efficiency and reliable rectifier/converter

The most efficient power conversion module in the industry! Since the launch the Flatpack 2 family has expanded into a wide selection of power ratings and voltages.

The Flatpack2 48-60/2000 HE is a cost efficient rectifier for 48V and 60V lead acid battery systems as well as 48V NiCad.

Flatpack2 Rectifier

48-60/2000 HE

Doc 241115.705.DS3 – v9

APPLICATIONS

TELECOM

- Radio base stations / Cell sites
- LTE / 4G / WIMAX
- Distributed Antenna Systems
- Microwave / Broadband
- Central office

POWER UTILITIES

- Control & protection
- SCADA
- Communications equipment

RAIL & METRO

- Control & protection
- Signaling

MARINE & OFFSHORE

- Communications on ships

16kW Telecom system in outdoor cabinet

2U 8kW bulk feed power system

KEY FEATURES

- HIGH EFFICIENCY – 96.2 %
- PROVEN RELIABILITY
- HIGH POWER DENSITY
- APPLICATION FLEXIBILITY, 2KW TO MULTICABINET INSTALLATIONS
- MODULAR DESIGN
- MTTR < 5MINS
- ACCEPTS DC INPUT (DC/DC CONVERTER)
- GLOBAL COMPLIANCE (CE, UL, NEBS)
- MARINE & OFFSHORE CERTIFICATIONS
- PATENTED TECHNOLOGY

1U 8kW power shelf

Flatpack2 Rectifier

Doc 241115.705.DS3 – v9

Model	48-60/2000 HE
Part number	241115.705
INPUT DATA	
Voltage (nominal)	185 - 275 V_{AC} / 185 - 275 V_{DC}
Voltage (operating range)	85 - 300 V_{AC} / 80 - 300 V_{DC}
Current (maximum) @ nominal input, full load	11.6 A_{RMS}
Frequency	45 - 66 Hz / 0 Hz
Power Factor	> 0.99 at 50% load or more
THD	< 5% at 100% load
Protection	Fuse in L & N, Varistor, Shutdown when input voltage is out of operating range
OUTPUT DATA	
Voltage (default) [1)]	53.5 V_{DC} (67 V_{DC} in 60V mode)
Voltage (adjustable range) [1)]	39.9 - 72 V_{DC}
Power (maximum) @ nominal input	2000 W (@V_{OUT} ≥ 48V_{DC})
Power @ 85 VAC	750 W
Current (maximum) @ nominal input	41.6 A (@V_{OUT} < 48V_{DC})
Hold up time, 1500W output power	>20ms; output voltage > 53.5 V_{DC} (60V mode)
Current sharing (10 - 100% load)	±5% of maximum current from 10 to 100% load
Static Voltage regulation (10 - 100% load)	±0.5%
Dynamic Voltage regulation	±5.0% for 10-80% or 80-10% load variation, regulation time < 50ms
Ripple & noise	< 150 mV_{PP} , 30 MHz bandwidth / < 2 mV_{RMS} psophometric
Protection	Fuse , Short circuit proof, High temperature protection, Over voltage Shutdown
OTHER SPECIFICATIONS	
Efficiency	96.2 %
Isolation	3.0 kV_{AC} - input to output, 1.5 kV_{AC} - input to earth, 500 V_{DC} - output to earth
Alarms: Red LED	Low / high input voltage shutdown, High / low temperature shutdown, Rectifier Failure, Overvoltage shutdown on output, Fan failure, Low output voltage alarm, CAN bus failure
Warnings: Yellow LED	Rectifier in power de-rate mode, Remote output current limit activated, Input voltage out of range, flashing at overvoltage, Loss of CAN communication with controller
Normal operation: Green LED	
MTBF (Telcordia SR-332 Iss.I method III (a))	>350 000 (@ $T_{ambient}$: 25 °C)
Operating temp. (5-95% RH n.cond. hum.)	-40 to + 75°C [-40 to +167°F]
Max output power de-rates above temp / to	45°C [113°F] / 1200W @ 75°C[167°F]
Storage temperature	-40 to +85°C (-40 to +185°F), humidity 0 - 99% RH non-condensing
Dimensions[WxHxD] / Weight	109 x 41.5 x 327mm (4.25 x 1.69 x 13") / 1.950 kg (4.3lbs)
DESIGN STANDARDS	
Electrical safety	EN 60950-1:2006+A11:2009+A1:2010+A12:2011+A2:2013, IEC 60950-1:2013 UL 60950-1:2011
EMC	EN 61000-6-1:2007, -6-2:2005, -6-3:2007 + A1:2011, -6-4:2007 + A1:2011, IEC 61000-6-5: 2015, ETSI EN 300 386:2.1.1
Marine	DNVGL-CG-0339[2)]
Environment	ETSI EN 300 019: 2-1 (Class 1.2) & 2-2 (Class 2.3) 2011/65/EU (RoHS) & 2012/19/EU (WEEE) Normal operating conditions as per IEC 62040-5-3:2016 clause 4.2. Other operating conditions as per IEC 62040-5-3:2016 clause 4.3, must be advised

1) OVS setting from controller select mode: OVS≤59.5V = 48V mode (42-58V), 59.5V<OVS<70.85 = 48V NiCad mode (39.9-66V) and OVS≥70.85V = 60V mode (52.5-72V). When de-energized module will return to 48V mode.
2) Only valid for part number 241115.705M

Specifications are subject to change without notice

Характеристики	
Модель	PD-P03
Напряжение (В)	220-240
Номинальный ток (А)	25
Рабочая температура (°C)	-10 °C +40
Размеры (мм)	70x90
Степень защиты	IP54
Тип	Фотореле
Частота (Гц)	50/60

DSC Digital PIR and Glassbreak Detector with Pet Immunity

LC-102-PIGBSS

Whether it's a residential or commercial installation, the LC series of detection devices readies a security system for the unexpected by providing protection for every room, corner and corridor. The LC-102-PIGBSS combines proven digital PIR and glassbreak detection technology with intelligent ASIC signal analysis.

Product Features:

- Form 'A' alarm contact and tamper switch
- Digital signal analysis
- Slim profile design
- Features ABS plastic for shock and impact protection
- Exceptional white light immunity
- Pet immunity up to 25 kg (55 lbs)
- Quad Linear Imaging Technology for sharp analysis of body dimensions and differentiation from backgrounds and pets
- Separate PIR and glassbreak sensitivity adjustment
- 2 independent relay outputs for glassbreak and PIR alarm signals
- Advanced ASIC-based electronics

DSC Digital PIR and Glassbreak Detector with Pet Immunity

LC-102-PIGBSS

Reliable Protection
Advanced ASIC-based processing provides both superior detection and false alarm rejection to help keep people and possessions secure. Quad Linear Imaging Technology provides sharp analysis of body dimensions and differentiation from backgrounds and pets.

Digital Signal Processing
Effective motion detection is dependent on a sensor's ability to identify intruders and provide true false alarm resistance. The LC series of detection devices pinpoints intruders through digital signal processing. Digital information is more accurately analyzed using software and is not subject to signal degradation caused by amplification, noise, distortion or signal clipping.

Fast and Easy Installation
Once the detector is installed at the recommended height, installers simply conduct a brief walk-test, make any necessary adjustments, and the unit is ready to perform. Highly visible LEDs can be viewed at a glance and help the installer identify the detection range from any distance or angle within the coverage pattern.

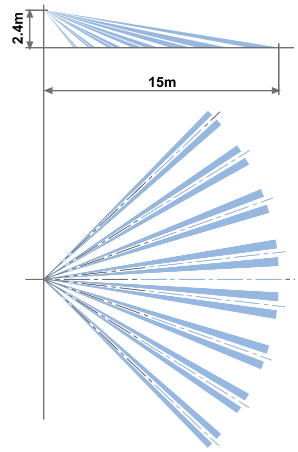
Locating the Detector
When choosing a location for the detector, be sure to consider the following:

- Do not aim the detector at reflective surfaces
- Avoid locations that are subject to direct high air flow
- Do not locate the detector in the path of direct or reflected sunlight
- Do not place next to large obstructions that may limit the coverage area

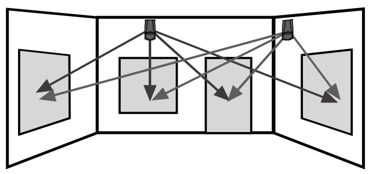
Detection Range Adjustment
The detection range of the motion detector is adjustable to about 3 m to 12 m (10' to 40'). A potentiometer can be adjusted clockwise or counter-clockwise to increase or decrease the range respectively. For optimum performance, range should be adjusted so that it effectively protects the dimensions of the intended area. The LC-102-PIGBSS is factory-set for 57%.

Ordering Information:	
LC-102-PIGBSS	Digital PIR and Glassbreak Detector with Pet Immunity
AFT-100	Glassbreak Simulator

Coverage Pattern



Detector Mounting



Glassbreak Simulator
The AFT-100 glassbreak simulator provides the most reliable and accurate indication of the correct mounting location for the detector. Do not install the detector beyond the maximum recommended range, even if the glassbreak simulator reports additional range. Future changes in room acoustics could reduce any additional range.

Specifications

Dimensions	118 mm x 62.5 mm x 41 mm (4.65" x 2.46" x 1.61")
Weight	97 gr (3.42 oz)
Detection Method	Quad (Four Element) PIR
Power Input	8.2 to 16 VDC
Current Draw (Standby)	18 mA
Current Draw (Active)	25.5 mA
Tamper Switch: Contact Rating	0.1 Amp @ 28 VDC
RFI Protection	30 V/m 10-1000 MHz
EMI Protection	50,000 V

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For product information
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