EU Declaration of Conformity

EN

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Location: Moldova
MOLDOVA EUROPEANĂ

Declaration number	UR-MRK-DOC-C-08042K25
Name of the manufacturer	GEPR Energy Canada Inc.
Address of the manufacturer	650 Markland Street, Markham , Ontario, L6C 0M1, Canada
Address of authorised representative	Avenida Pinoa 10, 48170 Zamudio, Spain

This declaration of conformity is issued under the sole responsibility of the manufacturer.

Product / model	B30, B90, C30, C60, C70, D30, D60, F35, F60, G30, G60, L30, L60, L90, M60, N60, T35, T60
Object of the declaration	Universal Protection Relay (UR)

The object of the declaration described above is in conformity with the relevant Union harmonisation legislation:

2014/30/EU	EMC Directive	February 26, 2014
2014/35/EU	Low voltage Directive	February 26, 2014

References to the relevant harmonised standards used or references to the other technical specifications in relation to which conformity is declared:

Document Name		Issue
EN 60255-26	Electromagnetic compatibility requirements for measuring relays and protection equipment	2013
EN 60255-27	Measuring relays and protection equipment -Part 27: Product safety requirements	2014

Signed for and on behalf of:
GEPR Energy Canada Inc.

Place and Date: Markham Ont , 04/08/2025

Name: Roy Mao

Function: Consulting Engineer, Engineering Manager, GE Multilin Inc

Signature:

Name: Boris Kacmar

Function: Grid Solutions, Regulatory Compliance, Manager

Signature:

Declaration number UR-MRK-DOC-C-08042K25

Additional Information

Manufacturing Locations
1) GEPREnergy Canada Inc, 650 Markland Street, Markham ,Ontario, L6C 0M1 ,Canada . 2)CARIBE GE INTERNATIONAL RELAYS CORP, STATE RD 402 KM 1.5, PO BOX 1575 ,Anasco ,Puerto Rico 00610

Modules covered:

CPU	(UR3): 9A,9C,9D (UR6): 9E,9G,9H,9J,9K,9L,9M,9N,9M,9N,9S (UR7): 9T,9U,9V,9W
DSP	(UR3): 8A,8B, 8C,8D,8E (UR6 & UR7): 8F,8G,8H,8J,8L,8M,8N,8R,8K,8S (Hi Z DSP): 8Z (L60DSP): 8P
Digital I/O	4A,4B,4C,4D,4L,67,6A,6B,6C,6D,6E,6F,6G,6H,6K,6L,6M,6N,6P,6R,6S,6T,6U,6V,6W,6X,6Y
Front Panel	3C,3D,3R,3A,3P,3G,3S,3B,3K,3M,3Q,3U,3L,3N,3T,3V,3W,3Y,3I,3J,3H,3O,3Z,3X,3E
Communications:	2A,2B,2E,2F,2G,2H,72,73,74,75,76,77,7A,7B,7C,7D,7E,7F,7G,7H,7I,7J,7K,7L,7M,7N, 7P,7Q,7R,7S,7T,7V,7W
Transducer	5A,5C,5D,5E,5F
Power supply	RH, RL,SH, SL,TH,TL
Process card	81,85,86,87
Embedded switch	2S,2T

RoHS Compliance Statement:

Items listed in this declaration are excluded from the scope of RoHS2 Directive 2011-65-EU according to the Article 2, Paragraph 4(c) and (e).

Current issue date: 12 November 2025
Expiry date: 2 September 2027
Certificate identity number: 10727872

Original approval(s):
ISO 14001 - 18 September 2019

Certificate of Approval

This is to certify that the Management System of:

GE GRID SOLUTIONS

167 quai de la Bataille de Stalingrad, 92130 Issy-les-Moulineaux, France

has been approved by LRQA to the following standards:

ISO 14001:2015

Approval number(s): ISO 14001 – 00022030

This certificate is valid only in association with the certificate schedule bearing the same number on which the locations applicable to this approval are listed.

The scope of this approval is applicable to:

Project management, procurement, installation, testing, automation, telecommunication, protection and control, measurement equipment, monitoring and diagnostics, commissioning and services related activities, for systems and equipment in the field of electrical grids and communications.

This certificate is a continuation of a previous approval from another certification body as follows:

Previous original ISO 14001 approval on 03-Sep-2018, certificate number 10198912

Marta Escudero

Regional Director, Europe

Issued by: LRQA Limited

UKAS MANAGEMENT SYSTEMS
0001

Current issue date: 12 November 2025
Expiry date: 2 September 2027
Certificate identity number: 10727871

Original approval(s):
ISO 45001 - 18 September 2019

Certificate of Approval

This is to certify that the Management System of:

GE GRID SOLUTIONS

167 quai de la Bataille de Stalingrad, 92130 Issy-les-Moulineaux, France

has been approved by LRQA to the following standards:

ISO 45001:2018

Approval number(s): ISO 45001 – 00022031

This certificate is valid only in association with the certificate schedule bearing the same number on which the locations applicable to this approval are listed.

The scope of this approval is applicable to:

Design, Engineering, Software & automation development, Project Management (including Turnkey projects), Manufacturing, Testing, Construction, Erection, Commissioning, Technical Training and Service related activities for systems and equipment in the field of electrical grids and communications.

This certificate is a continuation of a previous approval from another certification body as follows:

Previous original ISO 45001 approval on 03-Sep-2018, certificate number 10198912

Marta Escudero

Regional Director, Europe

Issued by: LRQA Limited

UKAS MANAGEMENT SYSTEMS
0001

Current issue date: 23 April 2025
Expiry date: 22 April 2028
Certificate identity number: 10682520

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ISO 9001 - 23 April 2017

Certificate of Approval

This is to certify that the Management System of:

GE GRID SOLUTIONS

167 quai de la Bataille de Stalingrad, 92130 Issy-les-Moulineaux, France

has been approved by LRQA to the following standards:

ISO 9001:2015

Approval number(s): ISO 9001 – 0079497

This certificate is valid only in association with the certificate schedule bearing the same number on which the locations applicable to this approval are listed.

The scope of this approval is applicable to:

Design, Engineering, Software & automation development, Project Management (including Turnkey projects), Manufacturing, Testing, Construction, Erection, Commissioning, Technical Training and Service related activities for systems and equipment in the field of electrical grids and communications.

Marta Escudero

Regional Director, Europe

Issued by: LRQA Limited

UKAS MANAGEMENT SYSTEMS
0001

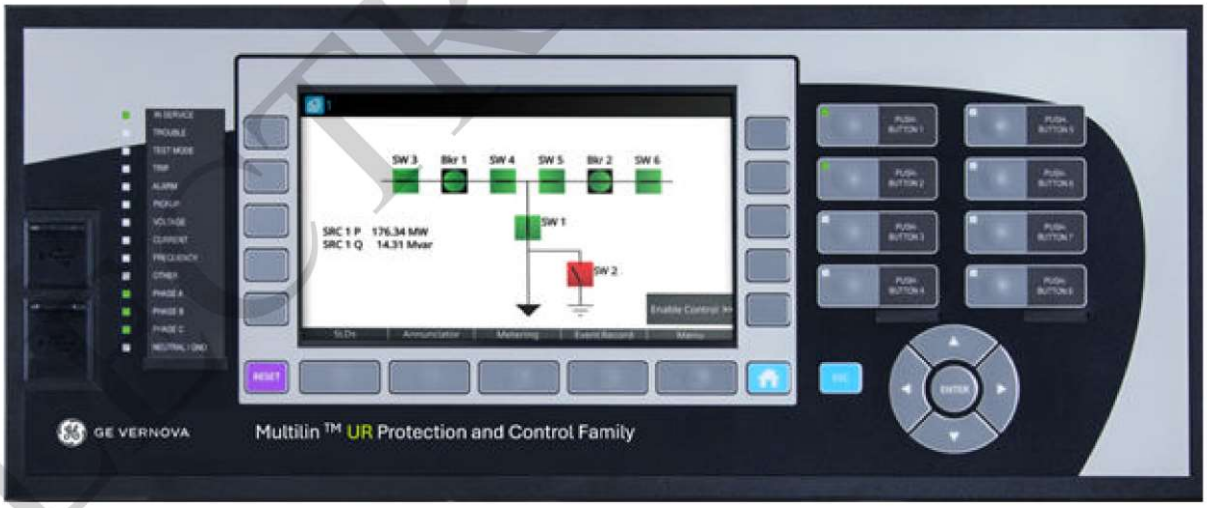
GE VERNOVA

UR Family L60

Instruction Manual

Line Phase Comparison System

Product Version: 8.71
Publication Reference: L60-1601-0082-87x-2



Copyright statement

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Disclaimer

It is the responsibility of the user to verify and validate the suitability of all GE Vernova products. This equipment must be used within its design limits. The proper application including the configuration and setting of this product to suit the power system assets, is the responsibility of the user, who is also required to ensure that all local or regional safety guidelines are adhered to. Incorrect application of this product could risk damage to property, the environment, personal injuries or fatalities and it is the sole responsibility of the person/entity applying and qualifying the product for use.

The content of this document has been developed to provide guidance to properly install, configure and maintain this product for its intended applications. This guidance is not intended to cover every possible contingency that may arise during commissioning, operation, service, or maintenance activities. Should you encounter any circumstances not clearly addressed in this document, please contact your local GE Vernova service site.

It is the sole responsibility of the user to secure their network and associated devices against cybersecurity intrusions or attacks. GE Vernova and its affiliates are not liable for any damages or losses arising from or related to such security intrusion or attacks.

The information contained in this document is subject to change without notice.

Warranty

GE Vernova warrants most of its manufactured products for 10 years from the date of shipping.

For warranty details including any limitations and disclaimers, see the Terms and Conditions at:

https://www.gevernova.com/grid-solutions/multilin/warranty.htm

Major changes

For information on the updates included in this release of the manual, please refer to the latest release notes.

Open source licenses

The optional IEC 61850-9-2LE/IEC 61869 Process Bus Modules include open source code. See the UR-OpenSourceLicense folder installed at the root level with the software, such as at C:\Program Files (x86)\GE Power Management\URPC

Contents

Chapter 11 Theory of Operation 752

Chapter 12 Maintenance 799

CHAPTER 1

INTRODUCTION

1.1 CHAPTER OVERVIEW

This chapter provides some critical safety information and some general information about the technical manual.

This chapter contains the following sections:

1.2 FOREWORD

This technical manual provides a functional and technical description of the relay, as well as a comprehensive set of instructions for using it. The level at which this manual is written assumes that you are already familiar with protection engineering and have experience in this discipline. The description of principles and theory is limited to that which is necessary to understand the product. For further details on general protection engineering theory, we refer you to the publication, Protection and Automation Application Guide, which is available online.

We have attempted to make this manual as accurate, comprehensive and user-friendly as possible. However we cannot guarantee that it is free from errors. Nor can we state that it cannot be improved. We would therefore be very pleased to hear from you if you discover any errors, or have any suggestions for improvement. Our policy is to provide the information necessary to help you safely specify, engineer, install, commission, maintain, and eventually dispose of this product. We consider that this manual provides the necessary information, but if you believe that more details are needed, please contact us.

1.2.1 TARGET AUDIENCE

This manual is aimed towards all professionals charged with installing, commissioning, maintaining, troubleshooting, or operating any of the products within the specified product range. This includes installation and commissioning personnel as well as engineers who will be responsible for operating the product.

The level at which this manual is written assumes that installation and commissioning engineers have knowledge of handling electronic equipment. Also, system and protection engineers have a thorough knowledge of protection systems and associated equipment.

1.2.2 TYPOGRAPHICAL CONVENTIONS

The following typographical conventions are used throughout this manual.

- Description of software menu items, buttons, labels or hardware keys and buttons written in bold type and colored in Vernova dark green.
  For example: Select **Save** from the file menu
- The names for special keys, appear in in upper case bold type and colored in Vernova dark green.
  For example: **ENTER**
- Filenames, paths, code, and text that appears on a command line interface use the courier font
  For example: `Example\File.text`
- Special terminology is written with leading capitals
  For example: Line Differential Relay
- If reference is made to the relay's internal settings database on the relay's LCD screen, the menu items are written in bold italics
  For example: ***SECURITY*** (on the relay's LCD screen), or ***Security*** (in the EnerVista D&I Setup software)
- Menu paths are shown with **>** separators. This applies to both software menu paths and relay menu paths
  For example: ***SETTINGS > SYSTEM SETUP > AC INPUTS*** (for relay path), or **File > Save** (for software path)
- Setting values are written with the courier font and are italicized
  For example: *`Enabled`*
- The products, use Flexlogic operands. Flexlogic operands are written in dark Vernova green uppercase courier font
  For example: PUSHBUTTON 1 ON
- Sometimes it is beneficial to emphasize some words. Depending on the case in question, this may be done with bold, italic or upper case font attributes.
- Notes are written in italic in, and are surrounded by a border.
  For example:

Note:
This is a note

1.2.3 NOMENCLATURE

Due to the technical nature of this manual, many special terms, abbreviations and acronyms are used throughout the manual. Some of these terms are well-known industry-specific terms while others may be special product-specific terms used by GE Vernova. The first instance of any acronym or term used in a particular chapter is explained.

We would like to highlight the following changes of nomenclature however:

- The word *relay* and *IED* (Intelligent Electronic Device) are both used to describe the protection device. The term *IED* is associated with the IEC61850 standard, whereas the term *relay* is the long-used traditional term. It may also be referred to simply as the *device* or the *product*.
- American English and spelling is used throughout this manual.
- The term 'Earth' and American term 'Ground' are equivalent. You may find either used in the manual.
- When depicting a generic instance of a number of items, this manual uses <n> where n can be any integer.

1.3 CAUTIONS, WARNINGS AND NOTES

Before attempting to install or use the device, review all safety indicators in this document to help prevent injury, equipment damage, or downtime.

1.3.1 GENERAL CAUTIONS AND WARNINGS

The following general safety precautions and warnings apply.

Caution:
Before attempting to use the equipment, it is important that all danger and caution indicators are reviewed.
If the equipment is used in a manner not specified by the manufacturer or functions abnormally, proceed with caution. Otherwise, the protection provided by the equipment may be impaired and can result in impaired operation and injury.

Warning:
Hazardous voltages can cause shock, burns or death.

Caution:
Installation/service personnel must be familiar with general device test practices, electrical awareness and safety precautions must be followed.
Before performing visual inspections, tests, or periodic maintenance on this device or associated circuits, isolate or disconnect all hazardous live circuits and sources of electric power.

Warning:
Failure to shut equipment off prior to removing the power connections could expose you to dangerous voltages causing injury or death.
Ensure that all connections to the product are correct so as to avoid accidental risk of shock and/or fire, for example from high voltage connected to low voltage terminals.

Caution:
Follow the requirements of this manual, including adequate wiring size and type, terminal torque settings, voltage, current magnitudes applied, and adequate isolation/clearance in external wiring from high to low voltage circuits.
Use the device only for its intended purpose and application.
Ensure that all ground paths are un-compromised for safety purposes during device operation and service.
All recommended equipment that should be grounded and must have a reliable and un-compromised grounding path for safety purposes, protection against electromagnetic interference and proper device operation.
Equipment grounds should be bonded together and connected to the facility's main ground system for primary power.
Keep all ground leads as short as possible.
In addition to the safety precautions mentioned all electrical connections made must respect the applicable local jurisdiction electrical code.
It is recommended that a field external switch, circuit breaker be connected near the equipment as a means of power disconnect. The external switch or circuit breaker is selected in accordance with the power rating.
This product itself is not Personal Protective Equipment (PPE). However, it can be used in the computation of site specific Arc Flash analysis when the arc flash option is ordered. If a new appropriate Hazard Reduction Category code for the installation is determined, user should follow the cautions mentioned in the arc flash installation section.
The critical failure relay must be connected to annunciate the status of the device for ALL applications. This is particularly important for when the Arc Flash option is ordered.
Ensure that the control power applied to the device, the AC current, and voltage input match the ratings specified on the relay nameplate. Do not apply current or voltage in excess of the specified limits.
Only qualified personnel are to operate the device. Such personnel must be thoroughly familiar with all safety cautions and warnings in this manual and with applicable country, regional, utility, and plant safety regulations.

Warning:
Hazardous voltages can exist in the power supply and at the device connection to current transformers, voltage transformers, control, and test circuit terminals. Make sure all sources of such voltages are isolated prior to attempting work on the device.
Hazardous voltages can exist when opening the secondary circuits of live current transformers. Make sure that current transformer secondary circuits are shorted out before making or removing any connection to the current transformer (CT) input terminals of the device.

Caution:
For tests with secondary test equipment, ensure that no other sources of voltages or currents are connected to such equipment and that trip and close commands to the circuit breakers or other switching apparatus are isolated, unless this is required by the test procedure and is specified by appropriate utility/plant procedure.
When the device is used to control primary equipment, such as circuit breakers, isolators, and other switching apparatus, all control circuits from the device to the primary equipment must be isolated while personnel are working on or around this primary equipment to prevent any inadvertent command from this device.
Use an external disconnect to isolate the mains voltage supply.

Warning:
LED transmitters are classified as IEC 60825-1 Accessible Emission Limit (AEL) Class 1M. Class 1M devices are considered safe to the unaided eye. Do not view directly with optical instruments.

Note:
To ensure the settings file inside the relay is updated, wait 30 seconds after a setpoint change before cycling power.
This product is rated to Class A emissions levels and is to be used in Utility, Substation Industrial environments. Not to be used near electronic devices rated for Class B levels.

1.4 FOR FURTHER ASSISTANCE

For product support, contact us as follows:

GE Vernova

650 Markland Street

Markham, Ontario

Canada L6C 0M1

Worldwide telephone: +1 905 927 7070

Europe/Middle East/Africa telephone: +34 94 485 88 54

North America toll-free: 1 800 547 8629

Fax: +1 905 927 5098

Worldwide e-mail: ga.support@gevernova.com

Website: https://www.gevernova.com

1.4.1 REPAIRS

The firmware and software can be upgraded without return of the device to the factory.

For issues not solved by troubleshooting, the process to return the device to the factory for repair is as follows:

- Contact a GE Vernova Grid Solutions Technical Support Center. Contact information is found in the first chapter.
- Obtain a Return Materials Authorization (RMA) number from the Technical Support Center.
- Verify that the RMA and Commercial Invoice received have the correct information.
- Tightly pack the unit in a box with bubble wrap, foam material, or styrofoam inserts or packaging peanuts to cushion the item(s). You may also use double boxing whereby you place the box in a larger box that contains at least 5 cm of cushioning material.
- Ship the unit by courier or freight forwarder, along with the Commercial Invoice and RMA, to the factory.
- Customers are responsible for shipping costs to the factory, regardless of whether the unit is under warranty.
- Fax a copy of the shipping information to the GE Vernova Grid Solutions service department.

Use the detailed return procedure outlined at

https://www.gevernova.com/grid-solutions/return-procedures

The current warranty and return information are outlined at

https://www.gevernova.com/grid-solutions/multilin/warranty

CHAPTER 2

PRODUCT DESCRIPTION

2.1 CHAPTER OVERVIEW

This chapter contains the following sections:

2.2 PRODUCT OVERVIEW

The L60 is part of the Universal Relay (UR) family of products. It provides a simple phase-comparison principle successfully employed by analog and static relays for many years, along with the significant advantages of a modern microprocessor-based relay. The phase comparison element performs the following calculations:

- Samples and filters three-phase AC currents at a rate of 64 samples per cycle
- Computes sequence components of the current
- If two CT/VT modules are employed for breaker-and-a-half applications, the relay sums up two currents and performs the breaker-and-the-half logic calculations
- Forms a composite signal from current components according to a user-defined setting
- Forms local positive and negative squares from the composite signal sent to remote terminal and used locally along with the channel delay value
- Samples received from remote terminal squares 64 samples per cycle measuring magnitude of the pulse voltage
- Processes received samples to compensate for asymmetry and distortions in the signal
- Detects fault condition with the fault detector
- Compares coincidence of local and remote squares which indicate the presence of internal or external faults
- Detects transient conditions to block the phase comparison function

All processed signals, including transmitted and received pulses, are available in oscillography for commissioning, maintenance, and analysis. The Product integrates received pulses on a sample-per-sample basis, similar to the analog phase-comparison principle, making the relay exceptionally robust on noisy channels. All permissive and blocking schemes, as well as single and dual phase comparison, are incorporated into a single protection element and can be selected with a relay setting. The Product supports two and three-terminal applications, can be used for single- and three-pole tripping applications, and supports breaker-and-a-half applications. Multiple backup functions include three-zone phase and ground distance, directional overcurrent, pilot schemes, and current and voltage elements.

Control features include synchrocheck, autoreclosure, and control for two breakers. Monitoring features include CT failure detector, VT fuse failure detector, breaker arcing current, disturbance detector and continuous monitor.

Voltage and current metering are built into the relay as standard features. Parameters are available as total waveform root mean square (RMS) magnitude, or as fundamental frequency only RMS magnitude and angle (phasor).

Diagnostic features include:

- An event recorder capable of storing 1024 time-tagged events
- Oscillography capable of storing up to 64 records with programmable trigger, content, and sampling rate
- The internal clock used for time-tagging can be synchronized with an IRIG-B signal, using the Simple Network Time Protocol (SNTP) over the Ethernet port, or using the Precision Time Protocol (PTP). This precise time stamping allows the sequence of events to be determined throughout the system.
- Events can also be programmed (via FlexLogic equations) to trigger oscillography data capture that can be set to record the measured parameters before and after the event for viewing on a computer.

These tools significantly reduce troubleshooting time and simplify report generation in the event of a system fault.

Several options are available for communication.

- An RS232 port (or a USB port with the graphical front panel) is provided for connection with a PC to program settings and monitor actual values.
- All serial ports support the Modbus RTU protocol.
- A rear RS485 port allows independent access by operators and engineering staff. It can be connected to system computers with baud rates up to 115.2 kbps.

- The RS485 interface also supports DNP, IEC 60870-5-103 and IEC 60870-5-104, whereby only one of these can be enabled at any time. When the IEC 60870-5-103 protocol is chosen, the RS485 port has a fixed even parity and the baud rate can be either 9.6 kbps or 19.2 kbps.
- The 100Base-FX or 100Base-TX Ethernet interface provides fast, reliable communications in noisy environments.
- The Ethernet port supports IEC 61850, Modbus/TCP, TFTP, and PTP (according to IEEE Std. 1588-2008 or IEC 61588), and it allows access to the relay via any standard web browser.
- The Ethernet port supports the IEC 60870-5-104 protocol
- The Ethernet port supports the Parallel Redundancy Protocol (PRP) of IEC 62439-3 (clause 4, 2012) when purchased as an option.
- GOOSE and secure Routable GOOSE (R-GOOSE) are supported with software options.
- Process Bus GOOSE is supported with a hardware module and software options for applicable relays

Settings and actual values can be accessed from the front panel or EnerVista software.

The Product uses flash memory technology that allows field upgrading of both firmware and software as new features are added.

The figures show typical two-terminal and three-terminal applications:

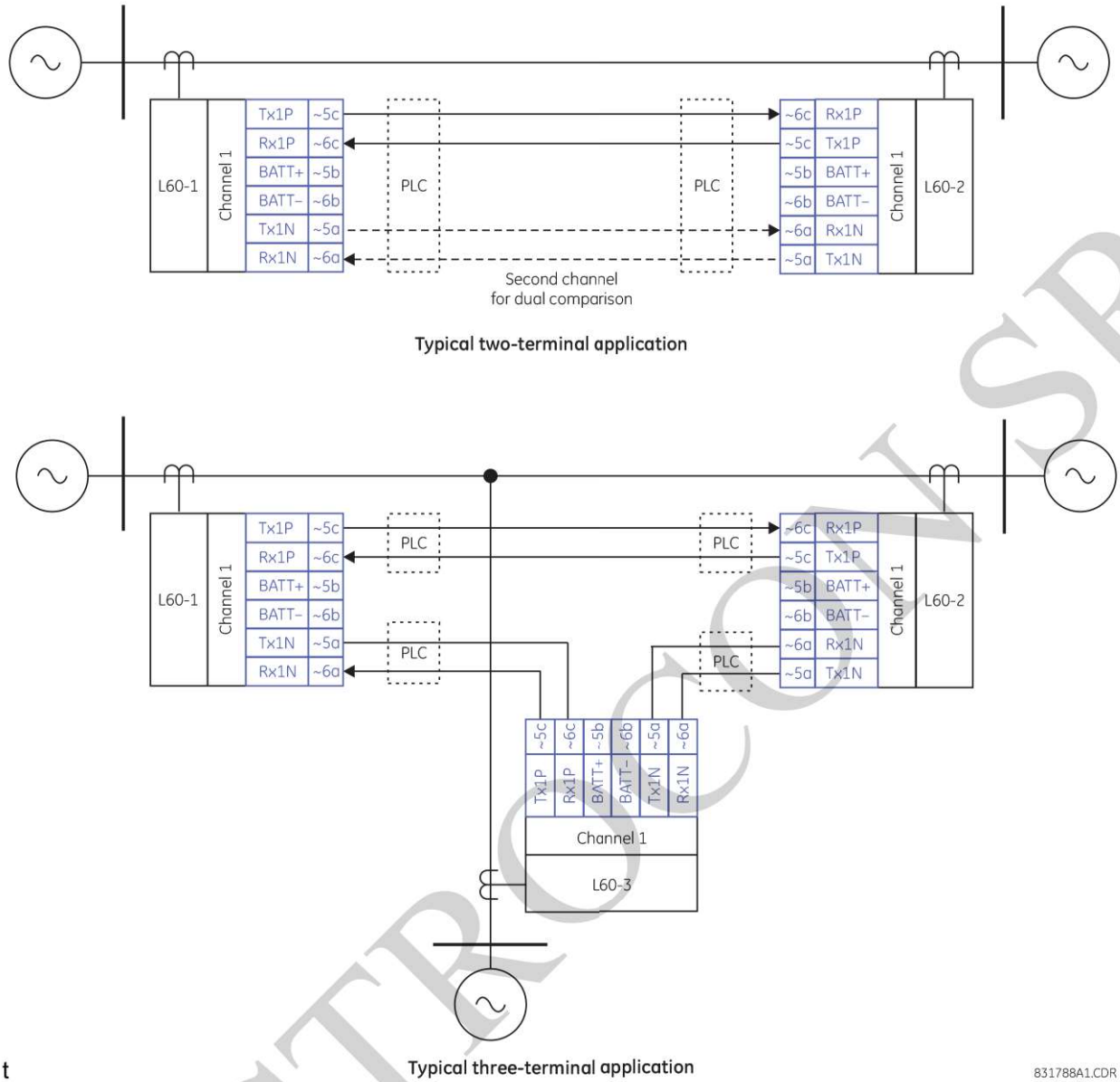

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Figure 1: 87PC communications

The relay supports the following ANSI functions (American National Standards Institue)

ANSI codes

ANSI code	Function	ANSI code	Function
21G	Ground distance	51P	Phase time overcurrent
21P	Phase distance	51_2	Negative-sequence time overcurrent
25	Synchrocheck	52	AC circuit breaker
27P	Phase undervoltage	59C	Compensated overvoltage
27X	Auxiliary undervoltage	59N	Neutral overvoltage
32N	Wattmetric zero-sequence directiona	59P	Phase overvoltage
49	Thermal overload protection	59X	Auxiliary overvoltage
50BF	Breaker failure	59_2	Negative-sequence overvoltage

ANSI code	Function
50DD	Adaptive fault detector (sensitive current disturbance detector)
50G	Ground instantaneous overcurrent
50N	Neutral instantaneous overcurrent
50P	Phase instantaneous overcurrent
50_2	Negative-sequence instantaneous overcurrent
51G	Ground time overcurrent
51N	Neutral time overcurrent

ANSI code	Function
67N	Neutral directional overcurrent
67P	Phase directional overcurrent
67_2	Negative-sequence directional overcurrent
68	Power swing blocking
78	Out-of-step tripping
79	Autoreclose
87PC	Phase comparison

The following single-line diagram illustrates the relay functionality using American National Standards Institute (ANSI) device numbers.

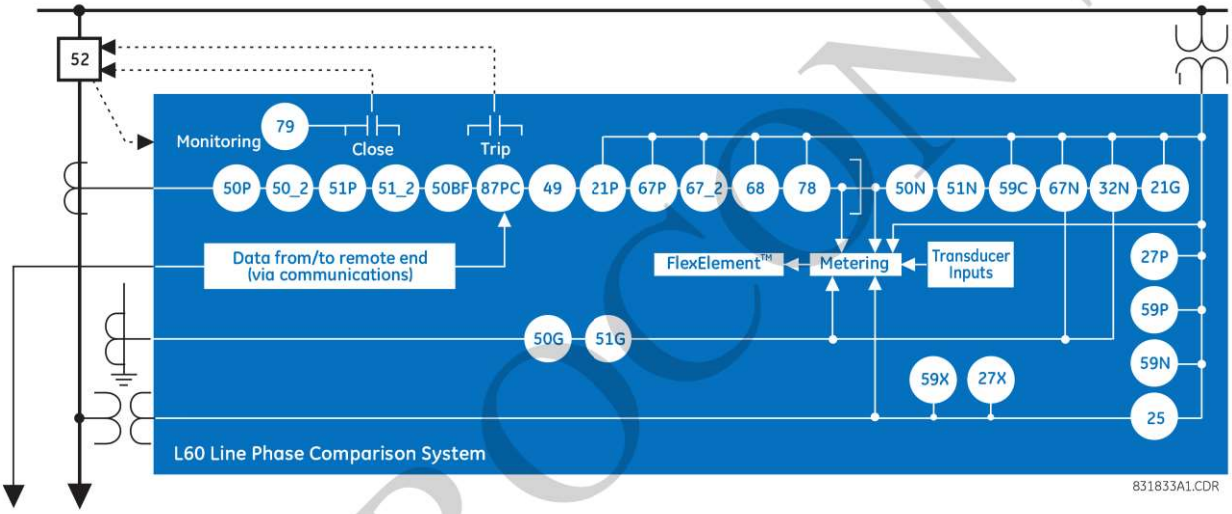

Figure 2: Single line diagram

Other device functions

Function	Function
Breaker Arcing Current (I^2t)	Line Pickup
Breaker Control	Load Encroachment
Breaker Flashover	Metering: Current, Voltage, Power, Energy, Frequency
Breaker Restrike	Modbus communications
Contact Inputs (up to 120)	Modbus user map
Contact Outputs (up to 72)	Non-Volatile Latches
Control Pushbuttons	Non-Volatile Selector Switch
CT failure detector	Open Breaker Echo
CyberSentry Security	Open pole detector

Function	Function
Data Logger	Oscillography
Demand	Pilot Scheme (POTT)
Digital Counters (8)	Setting Groups (6)
Digital Elements (96)	Time Synchronization over IRIG-B or IEEE 1588
Direct Inputs (8) (32 with direct fiber)	Time Synchronization over SNTP
Disconnect Switches	Transducer inputs and outputs
DNP 3.0 or IEC 60870-5-104 protocol	User-definable Displays
Event Recorder	User-programmable LEDs
Fault locator and fault reporting	User-definable pushbuttons
FlexElements (16)	User-programmable Self-Tests
FlexLogic Equations	Virtual Inputs (128)
IEC 60870-5-103 Communications	Virtual Outputs (256)
IEC 61850 Communications	VT Fuse Failure
IEC 62351-9 Data and Communications Security	

Number of elements per feature

Feature	No.	Feature	No.
CT Banks	2	Load Encroachment	1
VT Banks	1	Modbus Communications	1
# of DSPs	2	Modbus User Map	1
Autoreclose 1P 3P	1	Negative Sequence Directional OC	2
Auxiliary Overvoltage	3	Negative Sequence Instantaneous Overcurrent	2
Auxiliary Undervoltage	3	Negative Sequence Overvoltage	3
Basic UR relay features	1	Negative Sequence Time Overcurrent	2
Breaker Arcing Current (I2t)	2	Neutral Directional OC	2
Breaker Control	2	Neutral Overvoltage	3
Breaker switch	8	Neutral Instantaneous Overcurrent	12
Breaker Failure	2	Neutral Time Overcurrent	6
Breaker Flashover	2	Non Volatile Latches	16
Breaker Restrike	2	Oscillography	1
Broken Conductor Detection	2	Phase Comparison	1
Charging Current Compensation	1	Phase Directional	2
Compensated Overvoltage	1	Phase Distance	3
Contact Inputs	120	Phase Instantaneous Overcurrent	12
Contact Outputs	72	Phase Overvoltage	3

Feature	No.
CT Fail	4
Current CT settings	6
Current Unbalance	1
Demand	4
Digital Counters	8
Digital Elements	96
Platform Direct I/O	64
Disturbance Detection	4
Event Recorder	1
Fault Location	1
FlexElements	16
FlexLogic Equations	1
Ground Distance	3
Ground Instantaneous Overcurrent	12
Ground Time Overcurrent	6
IEC 61850 Communications	1
IEC 61850 Remote I/O (Fixed GOOSE/GSSE/GOOSE)	1
RxGOOSE	64
RxGOOSE BOOLEAN	256
RxGOOSE DPS	16
RxGOOSE I/O States	1
RxGOOSE Status	64
IEC103 Communications	1
L60 Channel Tests	1
Line Pickup	1

Feature	No.
Phase Time Overcurrent	6
Phase Undervoltage	3
Pilot POTT	1
Power Swing Detect	1
Precision Time Protocol(1588)	3
Security	1
Selector Switch	2
Setting Groups	6
Simple Network Time Protocol	1
Single Pole Tripping	1
Sources	4
Synchrocheck	4
Teleprotection I/O	1
Thermal Overload Protection	2
Transducer I/O	1
DCMA inputs	24
Trip Bus	6
User Programmable LEDs	48
User Programmable Pushbuttons	48
Control PBs	3
User-definable displays	16
Virtual Inputs	128
Virtual Outputs	256
VT Fuse Failure	4
Wattmetric Ground Fault	2

2.3 SIGNAL PROCESSING

The relays are microprocessor-based protection devices that are designed to measure power system conditions directly via CT and VT inputs and via other sources of information, such as analog inputs, communications inputs, and contact inputs. The following figure shows the overall signal processing in URs.

An analog low pass anti-aliasing filter with a 3 dB corner frequency is set at 2.4 kHz and is used for current and voltage analog filtering as well as signal conditioning. The same filtering is applied for phase, ground currents, phase-to-phase (when applicable), and auxiliary voltages. The 2.4 kHz cut-off frequency applies to both 50 and 60 Hz applications and fixed in the hardware, and thus is not dependent on the system nominal frequency setting.

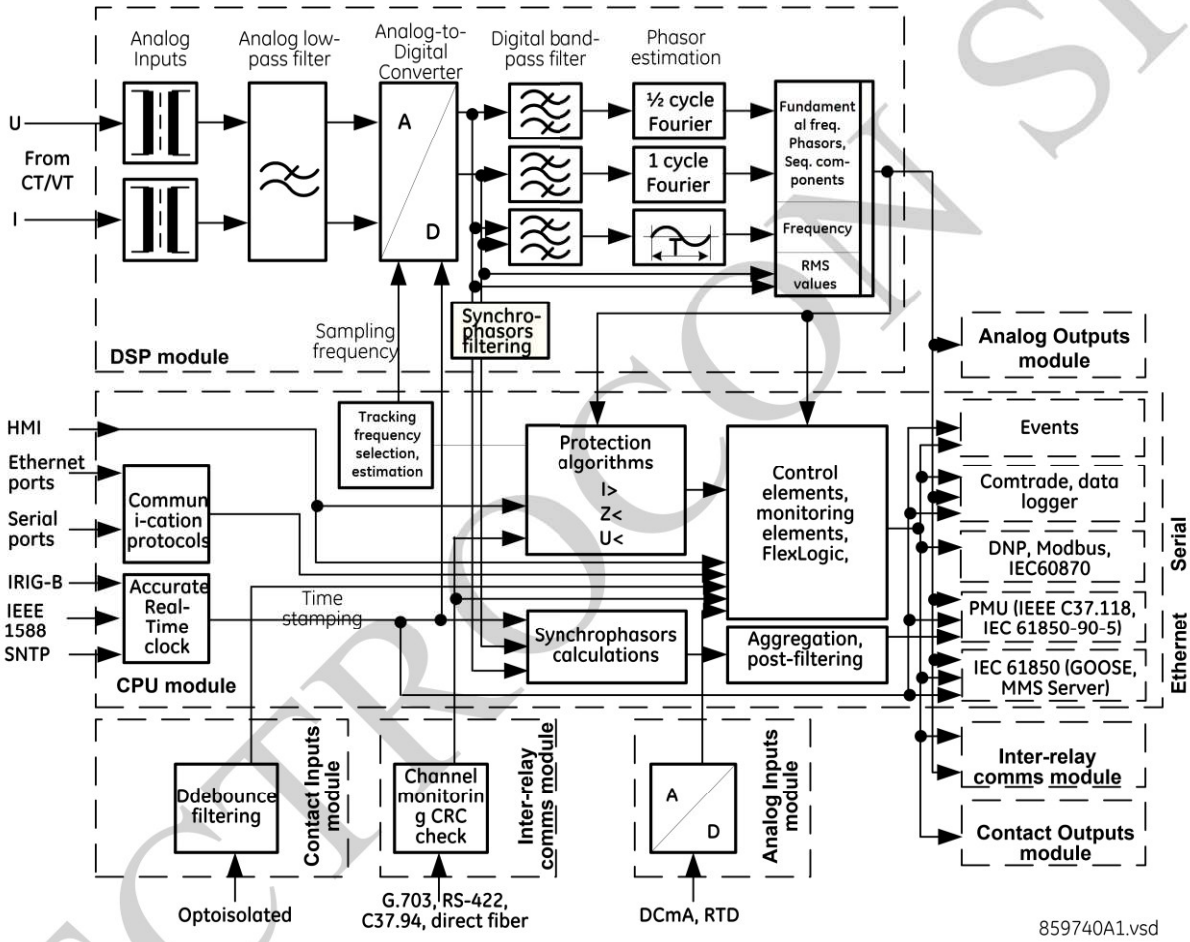

Figure 3: UR signal processing

The relay samples its AC signals at 64 samples per cycle, that is, at 3840 Hz in 60 Hz systems, and 3200 Hz in 50 Hz systems. The sampling rate is adjusted dynamically to the actual system frequency by an accurate and fast frequency tracking system.

The analog/digital converter has the following ranges of AC signals:

Voltages

$$\pm\sqrt{2}\cdot 260(\mathrm{V})$$

Currents

$$\pm\sqrt{2}\cdot 46\mathrm{rated}(\mathrm{A})$$

Current harmonics are estimated based on raw samples with the use of the full-cycle Fourier filter. Harmonics 2nd through 25th are estimated.

True RMS value for the current is calculated on a per-phase basis. The true RMS can be used for demand recording or as an input signal to Time Overcurrent function, if the latter is intended for thermal protection. The true RMS is calculated as per the widely accepted definition:

$$I_{RMS(t)} = \sqrt{\frac{1}{T}\int_{(t-T)}^{t} i^2(t)dt}$$

RMS values include harmonics, inter-harmonics, DC components, and so on, along with fundamental frequency values. The true RMS value reflects thermal effects of the current and is used for the thermal related monitoring and protection functions.

Protection and control functions respond to phasors of the fundamental and/or harmonic frequency components (magnitudes and angles), with an exception for some functions that have an option for RMS or fundamental measurements, or some function responding to RMS only. This type of response is explained typically in each element's section in this instruction manual.

Currents are pre-filtered using a Finite Impulse Response (FIR) digital filter. The filter is designed to reject DC components and low-frequency distortions, without amplifying high-frequency noise. This filter is referred to as a modified MIMIC filter, which provides excellent filtering and overall balance between speed and accuracy of filtering. The filter is cascaded with the full-cycle Fourier filter for the current phasor estimation.

Voltages are pre-filtered using a patented FIR digital filter. The filter has been optimized to reject voltage-transformer-specific distortions, such as Capacitive Voltage Transformer (CVT) noise and high-frequency oscillatory components. The filter is cascaded with the half-cycle Fourier filter for the voltage phasor estimation.

The URs measure power system frequency using the Clarke transformation by estimating the period of the waveform from two consecutive zero-crossings in the same direction (negative-to-positive). Voltage or current samples are pre-filtered using a Finite Impulse Response (FIR) digital filter to remove high frequency noise contained in the signal. The period is used after several security conditions are met, such as true RMS signal must be above 6% nominal for a certain time. If these security conditions are not met, the last valid measurement is used for a specific time after which the UR reverts to nominal system frequency.

Synchrophasors are calculated using a patented convolution integral algorithm. This algorithm allows use of the same time-stamped samples, which are used for protection and taken at the same sampling frequency. This allows URs to use one sampling clock for both protection algorithms and synchrophasors.

Synchrophasors on firmware versions 7.23 and up have been tested and certified to meet IEEE C37.118-2011 and C37.118.1a-2014 standards for both metering and protection classes with outputs available up to 60 synchrophasors per second for the metering class and 120 synchrophasors per second for the protection class. Synchrophasors measurement is also available via IEC 61850-90-5 protocol.

The contact inputs threshold is settable in the firmware with 17, 33, 84, and 166 V DC settings available. Inputs are scanned every 0.5 ms and can be conditioned for the critical applications, using debounce time timer, settable from 0.0 to 16.0 ms. Contact inputs with auto-burnishing are available as well, when external contacts are exposed to the contamination in a harsh industrial environment.

All measured values are available in the UR metering section on the front panel and via communications protocols. Measured analog values and binary signals can be captured in COMTRADE format with sampling rates from 8 to 64 samples per power cycle. Analog values can be captured with the Data Logger, allowing much slower rates extended over a long period of time.

Other advanced UR order code options are available to support IEC 61850 (including fast GOOSE, ICD/CID/IID files, and so on), IEEE 1588 (IEEE C37.238 power profile) based time synchronization, CyberSentry (advanced cyber security), the Parallel Redundancy Protocol (PRP), IEC 60870-5-103, and so on.

2.4 COMMUNICATION FUNCTIONS

The UR family supports an array of communication ports and protocols to allow connection to equipment such as personal computers, remote terminal units (RTUs), supervisory control and data acquisition (SCADA) masters, and programmable logic controllers. These communication features can be selected as options in the order codes.

Relay communication is a very extensive subject, requiring a significant amount of documentation. Because of this, we supply a separate Communications Guide, which is applicable to all models within the UR product family. The Communications Guide is a major part of the overall documentation of each product model.

Prior to this version, the product manuals themselves contained a large part of the communication documentation. With this version, much of the theoretical information has been moved from this product manual into the Communications Guide. Only communication information pertaining directly to front panel settings remains in this product manual. For further information, we refer you to the Communications Guide.

Due to the extensiveness of IEC61850 documentation, all IEC61850 information has been moved into the Communications Guide, including the settings.

2.5 ORDER CODES

The order code is on the product label and indicates the product options applicable.

The L60 is available as a 19-inch rack horizontal mount or reduced-size (¾) vertical unit and consists of the following modules:

- Power supply
- CPU
- CTs and VTs
- Contact inputs and outputs
- Inter-relay communications.

Module options are specified at the time of ordering.

The L60 is specified with either one CT/VT module (8P) or two CT/VT modules (8F and 8P). When the L60 is applied in two-breaker configurations (such as breaker-and-a-half or ring configurations), the currents from the two CTs are summed internally within the relay or externally. If the 8F CT/VT module is not included in the relay order-code, some functions (such as distance, undervoltage, and synchrocheck) are not available.

Order codes are subject to change without notice. See the web page for the product for the latest options.

The letters in the top row of the table correspond to slots in the UR chassis, for example slot F, H, or U.

Note:
The R-GOOSE protocol described in IEC 61850-8-1 is available through the IEC 61850 software option. R-GOOSE security requires the CyberSentry software option.

Note:
For Japanese, the settings display in Japanese on the graphical front panel, while the keys printed on the panel are in English.

Order code

Please note that this manual must be opened with Adobe Acrobat Reader to allow access to the attached spreadsheet. This program is freely available on the Adobe website. The spreadsheets may be opened using free web-based software such as Google Sheets.

An Open File dialogue box may open with a warning message about potential harm from programs, macros or viruses. The files supplied do not contain any harmful content, and may be safely opened.

Click on the button below to open the spreadsheet.

Order Code L60 87x

2.5.1 ORDER CODES FOR REPLACEMENT MODULES

Replacement modules can be ordered separately. When ordering a replacement CPU module or front panel, provide the serial number of your existing unit.

Not all replacement modules apply to the relay described in this manual.

The order codes shown here are subject to change without notice. See the web page for the product for the latest options.

Please note that this manual must be opened with Adobe Acrobat Reader to allow access to the attached spreadsheet. This program is freely available on the Adobe website. The spreadsheets may be opened using free web-based software such as Google Sheets.

An Open File dialogue box may open with a warning message about potential harm from programs, macros or viruses. The files supplied do not contain any harmful content, and may be safely opened.

Note:
Note: The SL and TL power supply options are only available as a special option. Please contact GE Vernova for more information

CHAPTER 3

SPECIFICATIONS

3.1 CHAPTER OVERVIEW

This chapter contains the following sections:

3.2 PROTECTION ELEMENTS

The operating times include the activation time of a trip rated form-A output contact unless otherwise indicated. FlexLogic operands of a given element are 4 ms faster. Take this into account when using FlexLogic to interconnect with other protection or control elements of the relay, building FlexLogic equations, or interfacing with other intelligent electronic devices (IEDs) or power system devices via communications or different output contacts. If not specified, the operate times given here are for a 60 Hz system at nominal system frequency. Operate times for a 50 Hz system are 1.2 times longer. Timer Accuracy is specified as a percentage of the total operating time that is the sum of the Operate Time and settable Pickup Delay.

3.2.1 87PC SCHEME

87 PC SCHEME	
Signal selection:	mixed I_2 – K × I_1 (K = 0.00 to 0.25 in steps of 0.01), or 3I_0
Angle reference:	0 to 360° leading in steps of 1
Fault detector low	
Mixed signal overcurrent:	0.02 to 15.00 pu in steps of 0.01
I2 × Z – V2:	0.005 to 15.000 pu in steps of 0.001
dI2 / dt:	0.01 to 5.00 pu in steps of 0.01
dI1 / dt:	0.01 to 5.00 pu in steps of 0.01
I1 overcurrent:	0.20 to 5.00 pu in steps of 0.01
I2 overcurrent:	0.02 to 5.00 pu in steps of 0.01
Fault detector high	
Mixed signal overcurrent:	0.10 to 15.00 pu in steps of 0.01
I2 × Z – V2:	0.005 to 15.000 pu in steps of 0.001
dI2 / dt:	0.01 to 5.00 pu in steps of 0.01
dI1 / dt:	0.01 to 5.00 pu in steps of 0.01
I1 overcurrent:	0.50 to 5.00 pu in steps of 0.01
I2 overcurrent:	0.05 to 5.00 pu in steps of 0.01
Signal symmetry adjustment:	–5.0 to 5.0 ms in steps of 0.1
Channel delay adjustment:	0.000 to 30.00 ms in steps of 0.001
Channel adjustments:	channel delay and signal symmetry compensation
Operate time (typical):	¾ cycle for single phase comparison ½ cycle for dual phase comparison
Trip security:	first coincidence or enhanced
Second coincidence timer:	10 to 200 ms in steps of 1
Enhanced stability angle:	40 to 180° in steps of 1
Charging current compensation:	0.100 to 65.535 kW in steps of 0.001

3.2.2 PHASE DISTANCE

PHASE DISTANCE	
Characteristic	mho (memory polarized or offset) or quad (memory polarized or non-directional), selectable individually per zone
Number of zones	3
Directionality	forward, reverse, or non-directional
Reach (secondary Ω)	0.02 to 500.00 Ω in steps of 0.01

PHASE DISTANCE	
Reach accuracy zone 1	±5% including the effect of CVT transients up to an SIR of 30 and ±7% for 30<SIR<60 at RCA angle
Reach accuracy zones 2 or higher	±5% for steady fault conditions
Distance comparator limit angle	30 to 90° in steps of 1
Directional supervision characteristic angle	30 to 90° in steps of 1
Directional supervision limit angle	30 to 90° in steps of 1
Right blinder (Quad only) reach	0.02 to 500 Ω in steps of 0.01
Right blinder (Quad only) characteristic angle	60 to 90° in steps of 1
left blinder (Quad only) reach	0.02 to 500 Ω in steps of 0.01
Left blinder (Quad only) characteristic angle	60 to 90° in steps of 1
Time delay	0.000 s to 65.535 s in steps of 0.001
Timer accuracy	±3% of operate time or ±1/4 cycle (whichever is greater)
Current supervision level	line-to-line current
Current supervision pickup	0.050 to 30.000 pu in steps of 0.001
Current supervision level droput	97 to 98%
Memory duration	5 to 25 cycles in steps of 1
VT location	all delta-wye and wye-delta transformers
CT location	all delta-wye and wye-delta transformers
Voltage supervision pickup (series compensation applications	0 to 5.000 pu in steps of 0.001
Operation time:	1 to 1.5 cycles (typical) (see NOTE 1)
Reset time:	1 power cycle (typical)

Protection and control elements have additional operating time delay of up to 3 ms if the product is ordered with an IEC 61850-9-2LE / IEC 61869 Process Bus Module (order code 85, 86, 87).

3.2.3 GROUND DISTANCE

GROUND DISTANCE	
Characteristic	mho (memory polarized or offset) or quad (memory polarized or non-directional)
Number of zones	3
Directionality	forward, reverse, or non-directional
Reach (secondary Ω)	0.02 to 500.00 Ω in steps of 0.01
Reach accuracy zone 1	±5% including the effect of CVT transients up to an SIR of 30 and ±7% for 30<SIR<60 at RCA angle
Reach accuracy zones 2 or more	±5% for steady fault conditions
Distance characteristic angle	30 to 90° in steps of 1
Distance comparator limit angle	30 to 90° in steps of 1
Directional supervision characteristic angle	30 to 90° in steps of 1
Directional supervision limit angle	30 to 90° in steps of 1
Right blinder (Quad only) reach	0.02 to 500 Ω in steps of 0.01
Right blinder (Quad only) characteristic angle	60 to 90° in steps of 1
left blinder (Quad only) reach	0.02 to 500 Ω in steps of 0.01

GROUND DISTANCE	
Left blinder (Quad only) characteristic angle	60 to 90° in steps of 1
Time delay	0.000 s to 65.535 s in steps of 0.001
Timer accuracy	±3% of operate time or ±1/4 cycle (whichever is greater)
Current supervision level	neutral current (3I_0)
Current supervision pickup	0.050 to 30.000 pu in steps of 0.001
Current supervision level dropout	97 to 98%
Memory duration	5 to 25 cycles in steps of 1
Voltage supervision pickup (series compensation applications	0 to 5.000 pu in steps of 0.001
Reactance polarization	negative-sequence or zero-sequence current
Non-homogeneity angle	–40 to 40° in steps of 1
Zero-sequence compensation Z0/Z1 magnitude	0.00 to 10.00 in steps of 0.01
Zero-sequence compensation Z0/Z1 angle	–90 to 90° in steps of 1
Zero-sequence mutual compensation Z0M/Z1 magnitude	0.00 to 7.00 in steps of 0.01
Zero-sequence mutual compensation Z0M/Z1 angle	–90 to 90° in steps of 1
Operation time:	1 to 1.5 cycles (typical) (see NOTE 1)
Reset time:	1 power cycle (typical)

Protection and control elements have additional operating time delay of up to 3 ms if the product is ordered with an IEC 61850-9-2LE / IEC 61869 Process Bus Module (order code 85, 86, 87).

3.2.4 LINE PICKUP

LINE PICKUP	
Phase instantaneous overcurrent	0.020 to 30.000 pu
Undervoltage pickup:	0.004 to 3.000 pu
Overvoltage delay	0.000 to 65.535 s

3.2.5 PHASE/NEUTRAL/GROUND TIME OVERCURRENT

PHASE/NEUTRAL/GROUND TOC	
Current	Phasor or RMS
Pickup level (Phase and Neutral)	0.020 to 30.000 pu in steps of 0.001
Pickup level (Ground and Sensitive Ground)	0.0020 to 30.000 pu in steps of 0.001. Note: A module with sensitive ground can only measure current up to 4.6 pu.
Pickup level (Process Bus Module, ground)	0.005 to 30.000 pu in steps of 0.001
Dropout level	97% of pickup
Level accuracy	
0.1 to 2.0 x CT rating	±0.5% of reading or ±0.4% of rated (whichever is greater)
>2.0 x CT rating	±1.5% of reading

PHASE/NEUTRAL/GROUND TOC	
Timing characteristics	IEEE Moderately/Very/Extremely Inverse; IEC (and BS) A/B/C and Short Inverse; GE IAC Inverse, Short/Very/ Extremely Inverse; I2t; FlexCurves™ (programmable); (Curve multiplier 0.00 to 600.00 in steps of 0.01 s) Definite Time (Time delay = 0.00 to 600.00 in steps of 0.01 s)
Reset type:	Instantaneous/Timed (per IEEE)
Curve timing accuracy at 1.03 to 20 x pickup	±3.5% of operate time or ±½ cycle (whichever is greater) from pickup to operate (see NOTE 1)
Voltage restraint	Modifies pickup current for voltage in the range of 0.1 < V < 0.9 VT Nominal in a fixed linear relationship

Note:
Protection and control elements have additional operating time delay of up to 3 ms if the product is ordered with an IEC 61850-9-2LE / IEC 61869 Process Bus Module (order code 85, 86, 87).

3.2.6 PHASE/NEUTRAL/GROUND INSTANTANEOUS OVERCURRENT

PHASE/NEUTRAL/GROUND IOC	
Pickup level Pickup level (Phase and Neutral)	0.020 to 30.000 pu in steps of 0.001
Pickup level (Ground and Sensitive Ground)	0.0020 to 30.000 pu in steps of 0.001. Note: A module with sensitive ground can only measure current up to 4.6 pu.
Pickup level (Process Bus Module, ground)	0.005 to 30.000 pu in steps of 0.001
Dropout level	97% of pickup
Level accuracy	
0.1 to 2.0 x CT rating	±0.5% of reading or ±0.4% of rated (whichever is greater)
>2.0 x CT rating	±1.5% of reading
Overreach	<2%
Pickup delay	0.00 to 600.00 s in steps of 0.01
Reset delay	0.00 to 600.00 s in steps of 0.01
Operate time	<16 ms at 3 × pickup at 60 Hz (Phase IOC) (see NOTE 1) <20 ms at 3 × pickup at 60 Hz (Neutral IOC) (see NOTE 1) <25 ms at 3 x pickup at 60 Hz (Ground IOC) (see NOTE 1)
Timer accuracy	±3.5% of operate time or ±1/4 cycle (whichever is greater)

3.2.7 NEGATIVE SEQUENCE TIME OVERCURRENT

NEGATIVE SEQUENCE TOC	
Current	Phasor
Pickup level	0.020 to 30.000 pu in steps of 0.001
Dropout level	97% of pickup
Level accuracy	
0.1 to 2.0 x CT rating	±0.5% of reading or ±0.4% of rated (whichever is greater)
>2.0 x CT rating	±1.5% of reading
Timing characteristics	IEEE Moderately/Very/Extremely Inverse; IEC (and BS) A/B/C and Short Inverse; GE IAC Inverse, Short/Very/ Extremely Inverse; I2t; FlexCurves™ (programmable); (Curve multiplier 0.00 to 600.00 in steps of 0.01 s) Definite Time (Time delay = 0.00 to 600.00 in steps of 0.01 s)

NEGATIVE SEQUENCE TOC	
Reset type:	Instantaneous/Timed (per IEEE) and linear
Curve timing accuracy at 1.03 to 20 x pickup	±3.5% of operate time or ±½ cycle (whichever is greater) from pickup to operate (see NOTE 1).

Note:
Protection and control elements have additional operating time delay of up to 3 ms if the product is ordered with an IEC 61850-9-2LE / IEC 61869 Process Bus Module (order code 85, 86, 87).

3.2.8 NEGATIVE SEQUENCE INSTANTANEOUS OVERCURRENT

NEGATIVE SEQUENCE OVERCURRENT	
Current	Phasor
Pickup level	0.020 to 30.000 pu in steps of 0.001
Dropout level	97% of pickup
Level accuracy	
0.1 to 2.0 x CT rating	±0.5% of reading or ±0.4% of rated (whichever is greater)
>2.0 x CT rating	±1.5% of reading
Overreach:	<2%
Pickup delay	0.00 to 600.00 s in steps of 0.01
Reset delay	0.00 to 600.00 s in steps of 0.01
Reset type:	Instantaneous/Timed (per IEEE) and linear
Operate time	<20 ms at 3 × pickup at 60 Hz (see NOTE 1)
Timer accuracy	±3% of operate time or ±1/4 cycle (whichever is greater)

3.2.9 PHASE DIRECTIONAL OVERCURRENT

PHASE DIRECTIONAL OVERCURRENT	
Relay connection	90° (quadrature)
Quadrature voltage	ABC phase seq.: phase A (VBC), phase B (VCA), phase C (VAB); ACB phase seq.: phase A (VCB), phase B (VAC), phase C (VBA)
Polarizing voltage threshold	0.004 to 3.000 pu in steps of 0.001
Current sensitivity threshold	0.05 pu
Characteristic angle	0 to 359° in steps of 1
Angle accuracy	±2°
Operation time (FlexLogic operands)	
Tripping (reverse load, forward fault)	<12 ms, typically (see NOTE 1)
Blocking (forward load, reverse fault)	<8 ms, typically (see NOTE 1)

Note:
Protection and control elements have additional operating time delay of up to 3 ms if the product is ordered with an IEC 61850-9-2LE / IEC 61869 Process Bus Module (order code 85, 86, 87).

3.2.10 NEUTRAL DIRECTIONAL OVERCURRENT

NEUTRAL DIRECTIONAL OVERCURRENT	
Directionality:	Co-existing forward and reverse
Polarizing:	Voltage, Current, Dual, Dual-V, Dual-I
Polarizing voltage	V_0 or VX
Polarizing current	IG
Operating current	I_0
Level sensing	3 × (|I_0| – K × |I_1|), IG Independent for forward and reverse
Restraint, K	0.000 to 0.500 in steps of 0.001
Characteristic angle	–90 to 90° in steps of 1
Limit angle	40 to 90° in steps of 1, independent for forward and reverse
Angle accuracy	±2°
Offset impedance	0.00 to 250.00 Ω in steps of 0.01
Pickup level	0.002 to 30.000 pu in steps of 0.01
Dropout level	97 to 98%
Operation time	<16 ms at 3 × pickup at 60 Hz (see NOTE 1)

Note:
Protection and control elements have additional operating time delay of up to 3 ms if the product is ordered with an IEC 61850-9-2LE / IEC 61869 Process Bus Module (order code 85, 86, 87).

3.2.11 NEGATIVE SEQUENCE DIRECTIONAL OVERCURRENT

NEGATIVE SEQUENCE DIRECTIONAL OVERCURRENT	
Directionality:	Co-existing forward and reverse
Polarizing:	Voltage
Polarizing voltage	V_2
Operating current	I_2
Level sensing zero-sequence	|I_0| – K × |I_1|
Level sensing negative-sequence	|I_2| – K × |I_1|
Restraint, K	0.000 to 0.500 in steps of 0.001
Characteristic angle	0 to 90° in steps of 1
Limit angle	40 to 90° in steps of 1, independent for forward and reverse
Angle accuracy	±2°
Offset impedance	0.00 to 250.00 Ω in steps of 0.01
Pickup level	0.002 to 30.000 pu in steps of 0.01
Dropout level	97%
Operation time	<16 ms at 3 × pickup at 60 Hz (see NOTE 1)

3.2.12 WATTMETRIC ZERO-SEQUENCE DIRECTIONAL

WATTMETRIC ZERO-SEQUENCE DIRECTIONAL	
Measured power	Zero-sequence

WATTMETRIC ZERO-SEQUENCE DIRECTIONAL	
Number of elements	2
Characteristic angle	0 to 360° in steps of 1
Minimum power	0.001 to 1.200 pu in steps of 0.001
Pickup level accuracy	±1% or ±0.0025 pu, whichever is greater
Hysteresis	3% or 0.001 pu, whichever is greater
Timing characteristics	Inverse time, or FlexCurve (Curve multiplier= 0.01 to 2.00 in steps of 0.01 s); Definite Time (Time delay = 0.00 to 600.00 in steps of 0.01 s)
Curve timing accuracy	±3.5% of operate time or ±1 cycle (whichever is greater) from pickup to operate
Operate time	<30 ms at 60 Hz

3.2.13 PHASE UNDERVOLTAGE

PHASE UNDERVOLTAGE	
Voltage	Phasor only
Pickup level	0.004 to 3.000 pu in steps of 0.001
Dropout level	102% of pickup
Level accuracy	±0.5% of reading from 10 to 208 V
Timing characteristics	GE IAV Inverse (Curve multiplier 0.00 to 600.00 in steps of 0.01 s) Definite Time (Time delay = 0.00 to 600.00 in steps of 0.01 s) FlexCurves (programmable, Curve multiplier = 0.00 to 600.00 in steps of 0.01 s)
Reset delay	0 to 600.00 s in steps of 0.01 s
Curve timing accuracy at <0.90 x pickup	±3.5% of operate time or ±1/2 cycle (whichever is greater) from pickup to operate
Operate time	<30 ms at 0.9 pickup at 60 Hz for Definite Time mode

3.2.14 AUXILIARY UNDERVOLTAGE

AUXILIARY UNDERVOLTAGE	
Pickup level	0.004 to 3.000 pu in steps of 0.001
Dropout level	103% of pickup
Level accuracy	±0.5% of reading from 10 to 208 V
Timing characteristics	GE IAV Inverse (Curve multiplier 0.00 to 600.00 in steps of 0.01 s) Definite Time (Time delay = 0.00 to 600.00 in steps of 0.01 s) FlexCurves (programmable, Curve multiplier = 0.00 to 600.00 in steps of 0.01 s)
Reset delay	0 to 600.00 s in steps of 0.01 s
Curve timing accuracy at <0.90 x pickup	±3.5% of operate time or ±1/2 cycle (whichever is greater) from pickup to operate
Operate time	<30 ms at 0.9 pickup at 60 Hz for Definite Time mode

3.2.15 PHASE OVERVOLTAGE

PHASE OVERVOLTAGE	
Voltage	Phasor only

PHASE OVERVOLTAGE	
Pickup level	0.004 to 3.000 pu in steps of 0.001
Dropout level	98% of pickup
Level accuracy	±0.5% of reading from 10 to 208 V
Timing characteristics	GE IAV Inverse (Curve multiplier 0.00 to 600.00 in steps of 0.01 s) Definite Time (Time delay = 0.00 to 600.00 in steps of 0.01 s) FlexCurves (programmable, Curve multiplier = 0.00 to 600.00 in steps of 0.01 s)
Reset delay	0 to 600.00 s in steps of 0.01 s
Curve timing accuracy at >1.1 x pickup	±3.5% of operate time or ±1 cycle (whichever is greater) from pickup to operate
Operate time	<30 ms at 1.1 x pickup at 60 Hz for Definite Time mode

3.2.16 COMPENSATED OVERVOLTAGE

COMPENSATED OVERVOLTAGE	
Elements	1
Stages	3
Pickup level	0.25 to 3 pu in steps of 0.001
Level accuracy	±0.5% of reading from 10 to 208 V
Hysteresis:	97 to 98% of pickup
Pickup delay	0.00 to 600.00 s in steps of 0.01
Timer accuracy	±3% of operate time or ±20 ms (whichever is greater)
Operate time	< 2 cycles at 1.1 x pickup

3.2.17 NEUTRAL OVERVOLTAGE

NEUTRAL OVERVOLTAGE	
Pickup level	0.004 to 3.000 pu in steps of 0.001
Dropout level	97% of pickup
Level accuracy	±0.5% of reading from 10 to 208 V
Pickup delay	0.00 to 600.00 s in steps of 0.01 (definite time) or user-defined curve
Reset delay	0.00 to 600.00 s in steps of 0.01
Curve timing accuracy at >1.1 × pickup	±3.5% of operate time or ±1 cycle (whichever is greater) from pickup to operate
Operate time	<30 ms at 1.10 × pickup at 60 Hz

3.2.18 AUXILIARY OVERVOLTAGE

AUXILIARY OVERVOLTAGE	
Pickup level	0.004 to 3.000 pu in steps of 0.001
Dropout level	97% of pickup
Level accuracy	±0.5% of reading from 10 to 208 V

AUXILIARY OVERVOLTAGE	
Timing characteristics	Definite Time (Time delay = 0.00 to 600.00 in steps of 0.01 s); GE IAV Inverse (Curve multiplier= 0.00 to 600.00 in steps of 0.01 s); FlexCurves (programmable, Curve multiplier= 0.00 to 600.00 in steps of 0.01 s)
Reset delay	0.00 to 600.00 s in steps of 0.01
Curve timing accuracy at >1.1 × pickup	±3.5% of operate time or ±1 cycle (whichever is greater) from pickup to operate
Operate time	<30 ms at 1.10 × pickup at 60 Hz for Definite Time mode
Operate time when 20 Hz injection is performed (G60 only):	8 power system cycles

3.2.19 NEGATIVE SEQUENCE OVERVOLTAGE

NEGATIVE SEQUENCE OVERVOLTAGE	
Pickup level:	0.004 to 1.250 pu in steps of 0.001
Dropout level:	97% of pickup
Level accuracy:	±0.5% of reading from 10 to 208 V
Pickup delay:	0 to 600.00 s in steps of 0.01
Reset delay:	0 to 600.00 s in steps of 0.01
Timer accuracy:	±3% of operate time or ±20 ms, whichever is greater
Operate time:	<30 ms at 1.10 x pickup at 60 Hz

3.2.20 BREAKER FAILURE

BREAKER FAILURE	
Mode:	1-pole, 3-pole
Current supervision	phase, neutral current
Current supervision pickup	0.020 to 30.000 pu in steps of 0.001
Current supervision dropout	97% of pickup
Current supervision accuracy	
0.1 to 2.0 × CT rating	±0.75% of reading or ±2% of rated (whichever is greater)
above 2 × CT rating	±2.5% of reading

3.2.21 BREAKER ARCING CURRENT

BREAKER ARCING CURRENT	
Principle	accumulates breaker duty (I^2t) and measures fault duration
Initiation:	programmable per phase from any FlexLogic operand
Compensation for auxiliary relays	0 to 65.535 s in steps of 0.001
Alarm threshold	0 to 50000 kA^2-cycle in steps of 1
Fault duration accuracy	0.25 of a power cycle
Availability:	1 per CT bank with a minimum of 2

3.2.22 BREAKER FLASHOVER

BREAKER FLASHOVER	
Operating quantity	phase current, voltage, and voltage difference
Pickup level voltage	0.004 to 1.500 pu in steps of 0.001
Dropout level voltage	97% of pickup
Pickup level current	0.020 to 1.500 pu in steps of 0.001
Dropout level current	97% of pickup
Level accuracy	±0.5% or ±0.1% of rated, whichever is greater
Pickup delay	0 to 65.535 s in steps of 0.001
Timer accuracy	±3% of operate time or ±42 ms, whichever is greater
Operate time	<42 ms at 1.10 × pickup at 60 Hz (see NOTE 1)

Note:
Protection and control elements have additional operating time delay of up to 3 ms if the product is ordered with an IEC 61850-9-2LE / IEC 61869 Process Bus Module (order code 85, 86, 87).

3.2.23 BREAKER RESTRIKE

BREAKER RESTRIKE	
Principle	detection of high-frequency overcurrent condition ¼ cycle after breaker opens
Availability	one per digital signal processor (DSP)
Pickup level	0.1 to 2.00 pu in steps of 0.01
Reset delay	0.000 to 65.535 s in steps of 0.001

3.2.24 OPEN BREAKER ECHO

OPEN BREAKER ECHO	
Operation:	Keying of the transmitter in case one end of the line is open or weak-infeed at the terminal.

3.2.25 SYNCHROCHECK

SYNCHROCHECK	
Max voltage difference	0 to 400000 V in steps of 1
Max angle difference	0 to 100° in steps of 1
Max frequency difference	0.005 to 2.000 Hz in steps of 0.001
Hysteresis for max frequency difference	0.000 to 0.100 Hz in steps of 0.001
Dead source function	None, LV1 & DV2, DV1 & LV2, DV1 or DV2, DV1 xor DV2, DV1 & DV2 (L = Live, D = Dead)
S-CLS MAX dF	0.100 to 10.000 Hz in steps of 0.001
S-CLS MIN dF	0.005 to 1.000 Hz in steps of 0.001
V2 MAG CORR FACTOR	0.10 to 10.00 in steps of 0.01

SYNCHROCHECK	
V2 ANGLE SHIFT	-180° to +180° in steps of 1°
PHASE SELECT	Auto, VAG, VBG, VCG, VAB, VBC, VCA

3.2.26 AUTORECLOSE

AUTORECLOSE
Two breakers applications
Single- and three-pole tripping schemes
Up to four reclose attempts before lockout
Selectable reclosing mode and breaker sequence

3.2.27 PILOT-AIDED SCHEMES

PILOT-AIDED SCHEMES
Direct Underreaching Transfer Trip (DUTT)
Permissive Underreaching Transfer Trip (PUTT)
Permissive Overreaching Transfer Trip (POTT)
Hybrid POTT Scheme
Directional Comparison Blocking Scheme
Directional Comparison Unblocking Scheme (DCUB)

3.2.28 TRIP OUTPUT

TRIP OUTPUT	
Collects trip and reclose input requests and issues outputs to control tripping and reclosing.	
Communications timer delay	0 to 65535 s in steps of 0.001
Evolving fault timer	0.000 to 65.535 s in steps of 0.001
Timer accuracy	±3% of operate time or ±1/4 cycle (whichever is greater)

3.2.29 POWER SWING DETECT

POWER SWING DETECT	
Functions	Power swing block, out-of-step trip
Characteristic	Mho or Quad
Measured impedance	Positive-sequence
Blocking / tripping modes	2-step or 3-step
Tripping mode	Early or Delayed
Current supervision Pickup level	0.050 to 30.000 pu in steps of 0.001
Current supervision Dropout level	97 to 98% of pickup
Fwd / reverse reach (sec. Ω)	0.10 to 500.00 Ω in steps of 0.01
Left and right blinders (sec. Ω):	0.10 to 500.00 Ω in steps of 0.01
Impedance accuracy	±5%

POWER SWING DETECT	
Fwd / reverse angle impedances	40 to 90° in steps of 1
Angle accuracy	±2°
Characteristic limit angles	40 to 140° in steps of 1
Timers	0.000 to 65.535 s in steps of 0.001
Timer accuracy	±3% of operate time or ±1/4 cycle (whichever is greater)

3.2.30 LOAD ENCROACHMENT

LOAD ENCROACHMENT	
Responds to	Positive-sequence quantities
Minimum voltage	0.004 to 3.000 pu in steps of 0.001
Reach (sec. Ω)	0.02 to 250.00 Ω in steps of 0.01
Impedance accuracy	±5%
Angle	5 to 80° in steps of 1
Angle accuracy	±2°
Pickup delay	0 to 65.535 s in steps of 0.001
Reset delay	0 to 65.535 s in steps of 0.001
Timer accuracy:	±3% of operate time or ±1/4 cycle (whichever is greater)
Operate time:	<30 ms at 60 Hz (see NOTE 1)

Note:
Protection and control elements have additional operating time delay of up to 3 ms if the product is ordered with an IEC 61850-9-2LE / IEC 61869 Process Bus Module (order code 85, 86, 87).

3.2.31 OPEN POLE DETECTOR

OPEN POLE DETECTOR	
Detects an open pole condition, monitoring breaker auxiliary contacts, the current in each phase, and optional voltages on the line.	
Current pickup level	0.020 to 30.000 pu in steps of 0.001
Line capacitive reactances (X_{C1}, X_{C0})	300.0 to 9999.9 sec. Ω in steps of 0.1
Remote current pickup level	0.000 to 30.000 pu in steps of 0.001
Current dropout level	pickup + 3%, not less than 0.05 pu

3.2.32 THERMAL OVERLOAD

THERMAL OVERLOAD	
Thermal overload curves	IEC 255-8 curve
Base current	0.20 to 3.00 pu in steps of 0.01
Overload (k) factor	0.2 to 4 pu in steps of 0.05
Alarm level	0.2 to 1.0 pu in steps of 0.1
Trip time constant	0 to 999 min. in steps of 0.1

THERMAL OVERLOAD	
Reset time constant	0 to 999 min. in steps of 0.1
Minimum reset time	0 to 999 min. in steps of 0.1
Timer accuracy (cold curve)	±100 ms or 2%, whichever is greater
Timer accuracy (hot curve)	±500 ms or 2%, whichever is greater for Ip < 0.9 × k × Ib and I / (k × Ib) > 1.1

3.2.33 TRIP BUS (TRIP WITHOUT FLEXLOGIC)

TRIP BUS (TRIP WITHOUT FLEXLOGIC)	
Number of elements	6
Number of inputs	16
Operate time	<2 ms at 60 Hz
Timer accuracy	±3% or 10 ms, whichever is greater

3.3 USER-PROGRAMMABLE ELEMENTS

3.3.1 FLEXLOGIC

FLEXLOGIC	
Programming language	Reverse Polish Notation with graphical visualization (keypad programmable)
Lines of code	1024
Internal variables	64
Supported operations	NOT, XOR, OR (2 to 16 inputs), AND (2 to 16 inputs), NOR (2 to 16 inputs), NAND (2 to 16 inputs), latch (reset-dominant), edge detectors, timers
Inputs:	any logical variable, contact, or virtual input
Number of timers	64
Pickup delay	0 to 60000 (ms, sec., min.) in steps of 1
Dropout delay	0 to 60000 (ms, sec., min.) in steps of 1
Timer accuracy	±0.1% of operate time or ±1/8 cycle, whichever is greater

3.3.2 FLEXCURVES

FLEXCURVES	
Number	4 (A through D)
Reset points	40 (0 through 1 of pickup)
Operate points	80 (1 through 20 of pickup)
Time delay	0 to 65535 ms in steps of 1

3.3.3 FLEXSTATES

FLEXSTATES	
Number	up to 256 logical variables grouped under 16 Modbus addresses
Programmability	any logical variable, contact, or virtual input

3.3.4 FLEXELEMENTS

FLEXELEMENTS	
Number of elements:	16
Operating signal	any analog actual value, or two values in differential mode
Operating signal mode	signed or absolute value
Operating mode	level, delta
Comparator direction	over, under
Pickup level	–90.000 to 90.000 pu in steps of 0.001
Hysteresis	0.1 to 50.0% in steps of 0.1
Delta dt	20 ms to 60 days
Pickup and dropout delay	0.000 to 65.535 s in steps of 0.001

3.3.5 NON-VOLATILE LATCHES

NON-VOLATILE LATCHES	
Type	set-dominant or reset-dominant
Number	16 (individually programmed)
Output	stored in non-volatile memory
Execution sequence	as input prior to protection, control, and FlexLogic

3.3.6 USER-PROGRAMMABLE LEDS

USER-PROGRAMMABLE LEDs (Enhanced and basic front panels)	
Number:	48 plus trip and alarm
Programmability	from any logical variable, contact, or virtual input
Reset mode	self-reset or latched

3.3.7 LED TEST

LED TEST	
Initiation	from any contact input or user-programmable condition
Number of tests	3, interruptible at any time
Duration of full test	approximately 3 minutes
Test sequence 1	all LEDs on
Test sequence 2	all LEDs off, one LED at a time on for 1 s
Test sequence 3	all LEDs on, one LED at a time off for 1 s

3.3.8 USER-DEFINABLE DISPLAYS

USER-DEFINABLE DISPLAYS (Enhanced and basic front panels)	
Number of displays	16
Lines of display	2 × 20 alphanumeric characters
Parameters	up to 5, any Modbus register addresses
Invoking and scrolling	keypad, or any user-programmable condition, including pushbuttons

3.3.9 CONTROL PUSHBUTTONS

CONTROL PUSHBUTTONS (Enhanced and basic front panels)	
Number of pushbuttons	7
Operation	drive FlexLogic operands

3.3.10 USER-PROGRAMMABLE PUSHBUTTONS

CONTROL PUSHBUTTONS (Enhanced and basic front panels)	
Number of pushbuttons	12 on basic front panel 16 on enhanced horizontal front panel 6 on enhanced vertical front panel 48 on graphical front panel (8 physical pushbuttons, 40 graphical interface pushbuttons)
Mode	self-reset, latched

CONTROL PUSHBUTTONS (Enhanced and basic front panels)	
Display message	2 lines of 20 characters each
Drop-out timer	0.00 to 60.00 s in steps of 0.05
Autoreset timer	0.2 to 600.0 s in steps of 0.1
Hold timer	0.0 to 10.0 s in steps of 0.1

3.3.11 SELECTOR SWITCH

SELECTOR SWITCH	
Number of elements	2
Upper position limit	1 to 7 in steps of 1
Selecting mode	time-out or acknowledge
Time-out timer	3.0 to 60.0 s in steps of 0.1
Control inputs	step-up and 3-bit
Power-up mode	restore from non-volatile memory or synchronize to a 3-bit control input or synch/restore mode

3.3.12 DIGITAL ELEMENTS

DIGITAL ELEMENTS	
Number of elements:	96
Operating signal	any FlexLogic operand
Pickup delay	0.000 to 999999.999 s in steps of 0.001
Dropout delay	0.000 to 999999.999 s in steps of 0.001
Timing accuracy	±3% or ±4 ms, whichever is greater

3.4 MONITORING

3.4.1 OSCILLOGRAPHY

OSCILLOGRAPHY	
Number of records	3 to 64, configurable
Sampling rate	8, 16, 32, or 64 samples per power cycle, configurable
Triggers	any FlexLogic operand, configurable
Trigger position	0 to 100%, configurable
Recorded data	raw AC input channels up to 127 configured digital channels (+ 1 trigger operand), representing any FlexLogic operand up to 32 configured analog channels, representing any measured analog value
Data storage	in non-volatile memory
Format:	COMTRADE IEEE C37.111 (1999 or 2013)

3.4.2 EVENT RECORDER

EVENT RECORDER	
Capacity	1024 events
Time-tag	to 1 microsecond
Triggers	any FlexLogic operand, configurable
Data storage	in non-volatile memory

3.4.3 DATA LOGGER

DATA LOGGER	
Number of channels	1 to 16
Parameters	any available analog actual value
Sampling rate	15 to 3600000 ms in steps of 1
Trigger	any FlexLogic operand
Mode	continuous or triggered
Storage capacity: 1-second rate: (NN is dependent on memory)	01 channel for NN days 16 channels for NN days
Storage capacity: 60-minute rate: (NN is dependent on memory)	01 channel for NN days 16 channels for NN days

3.4.4 FAULT LOCATOR

FAULT LOCATOR	
Number of independent fault locators:	1
Method	single-ended

FAULT LOCATOR	
Voltage source	wye-connected VTs, delta-connected VTs and neutral voltage, delta-connected VTs and zerosequence current (approximation)
Maximum accuracy if	fault resistance is zero and fault currents from all line terminals are approximately in phase (single-ended method)
Relay accuracy	±1.5% (V > 10 V, I > 0.2 pu), single-ended method ±0.5% (V > 10 V, I > 0.2 pu), multi-ended method
Worst-case accuracy	
$VT_{\%error}$ +	user data
$CT_{\%error}$ +	user data
$ZLine_{\%error}$ +	user data
$METHOD_{error}$ +	1.5% single-ended method
$METHOD_{error}$ +	0.5% multi-ended method
See Theory of Operation chapter, Fault Locator section	

3.5 METERING

3.5.1 RMS CURRENT: PHASE, NEUTRAL AND GROUND

RMS CURRENT: PHASE, NEUTRAL, AND GROUND	
Accuracy at 0.1 to 2.0 × CT rating	±0.25% of reading or ±0.1% of rated (whichever is greater)
Accuracy at > 2.0 × CT rating	±1.0% of reading

3.5.2 RMS VOLTAGE

VOLTAGE	
Accuracy:	±0.5% of reading from 10 to 208 V

3.5.3 REAL POWER (WATTS)

REAL POWER (WATTS)	
Accuracy at 0.1 to 1.5 x CT rating and 0.8 to 1.2 x VT rating:	±1.0% of reading at $-1.0 \le PF < -0.8$ and $0.8 < PF \le 1.0$

3.5.4 REACTIVE POWER (VARS)

REACTIVE POWER (VARS)	
Accuracy at 0.1 to 1.5 x CT rating and 0.8 to 1.2 x VT rating:	±1.0% of reading at $-0.2 \le PF \le 0.2$

3.5.5 APPARENT POWER (VA)

APPARENT POWER (VA)	
Accuracy at 0.1 to 1.5 x CT rating and 0.8 to 1.2 x VT rating:	±1.0% of reading

3.5.6 WATT-HOURS (POSITIVE AND NEGATIVE)

WATT-HOURS (POSITIVE AND NEGATIVE)	
Accuracy	±2.0% of reading
Range	±0 to 1×10^6 MWh
Parameters	three-phase only
Update rate	50 ms

3.5.7 VAR-HOURS (POSITIVE AND NEGATIVE)

VAR-HOURS (POSITIVE AND NEGATIVE)	
Accuracy	±2.0% of reading
Range	±0 to 1×10^6 Mvarh
Parameters	three-phase only
Update rate	50 ms

3.5.8 FREQUENCY

FREQUENCY	
Accuracy for input at V = 0.8 to 1.2 pu	±0.001 Hz (when voltage signal is used for frequency measurement)
Accuracy for input at I = 0.1 to 0.25 pu	±0.02 Hz (when current signal is used for frequency measurement)
Accuracy for input at I > 0.25 pu	±0.005 Hz (when current signal is used for frequency measurement)

3.5.9 DEMAND

DEMAND	
Measurements	Phases A, B, and C present and maximum measured currents 3-Phase Power (P, Q, and S) present and maximum measured currents
Accuracy	±2.0%

3.6 POWER SUPPLY

3.6.1 LOW RANGE

LOW RANGE	
Nominal DC voltage	24 to 48 V
Minimum DC voltage	20 V
Maximum DC voltage	75 V for SL power supply module
Voltage loss hold-up	200 ms duration at maximum load

Note:
Low range is DC only

3.6.2 HIGH RANGE

HIGH RANGE	
Nominal DC voltage	125 to 250 V
Minimum DC voltage	88 V
Maximum DC voltage	300 V
Nominal AC voltage	100 to 240 V at 50/60 Hz
Minimum AC voltage	88 V at 25 to 100 Hz
Maximum AC voltage	265 V at 25 to 100 Hz
Voltage loss hold-up	200 ms duration at maximum load

3.6.3 ALL RANGES

ALL RANGES	
Volt withstand	2 × Highest Nominal Voltage for 10 ms
Power consumption typical	15 to 20 W/VA
Power consumption maximum	45 W/VA

Note:
Contact factory for exact order code consumption

3.6.4 INTERNAL FUSE

INTERNAL FUSE	
Rating (low range)	8 A / 250 V
Rating (high range)	4 A / 250 V
Interrupting capacity (AC)	100 000 A RMS symmetrical
Interrupting capacity (DC)	10 000 A

3.7 INPUTS

3.7.1 AC CURRENT

AC CURRENT	
CT rated primary	1 to 50000 A
CT rated secondary	1 or 5 A by connection
Relay burden	< 0.2 VA at rated secondary
Conversion range (Standard CT):	0.02 to 46 × CT rating RMS symmetrical
Conversion range (Sensitive Ground CT module):	0.002 to 4.6 × CT rating RMS symmetrical
Current withstand:	20 ms at 250 times rated 1 sec at 100 times rated continuous 4x Inom URs equipped with 24 CT inputs have a maximum operating temperature of 50°C
Short circuit rating	150000 RMS symmetrical amperes, 250 V maximum (primary current to external CT)

3.7.2 AC VOLTAGE

AC VOLTAGE	
VT rated secondary	25.0 to 240.0 V
VT ratio	1.00 to 24000.00
Relay burden	< 0.25 VA at 120 V
Conversion range	1 to 275 V
Voltage withstand	continuous at 260 V to neutral 1 min/hr at 420 V to neutral

3.7.3 FREQUENCY

FREQUENCY	
Nominal frequency setting	25 to 60 Hz
Sampling frequency	64 samples per power cycle
Tracking frequency range with DSP	20 to 65 Hz

3.7.4 CONTACT INPUTS

CONTACT INPUTS	
Dry contacts	1000 Ω maximum
Wet contacts	300 V DC maximum
Selectable thresholds	17 V, 33 V, 84 V, 166 V
Tolerance	±10%
Contacts per common return (standard module)	4
Contacts per common return (6Y I/O module)	2

CONTACT INPUTS	
Recognition time	< 1 ms
Debounce time	0.0 to 16.0 ms in steps of 0.5
Continuous current draw (standard module)	4 mA (when energized)
Continuous current draw (6Y I/O module)	2 mA (when energized)

3.7.5 CONTACT INPUTS WITH AUTO-BURNISHING

CONTACT INPUTS WITH AUTO-BURNISHING	
Dry contacts	1000 Ω maximum
Wet contacts	300 V DC maximum
Selectable thresholds	17 V, 33 V, 84 V, 166 V
Tolerance	±10%
Contacts per common return	2
Recognition time	< 1 ms
Debounce time	0.0 to 16.0 ms in steps of 0.5
Continuous current draw	4 mA (when energized)
Auto-burnish impulse current	50 to 70 mA
Duration of auto-burnish impulse	25 to 50 mS

3.7.6 DCMA INPUTS

DCMA INPUTS	
Current input (mA DC)	0 to –1, 0 to +1, –1 to +1, 0 to 5, 0 to 10, 0 to 20, 4 to 20 (programmable)
Input impedance	379 Ω ±10%
Conversion range	–1 to + 20 mA DC
Accuracy	±0.2% of full scale
Type	Passive

3.7.7 RTD INPUTS

RTD INPUTS	
Types (3-wire)	100 Ω Platinum, 100 and 120 Ω Nickel, 10 Ω Copper
Sensing current	5 mA
Range	–50 to +250°C
Accuracy	±2°C
Isolation	36 V pk-pk

3.7.8 IRIG-B INPUT

IRIG-B INPUT	
IRIG formats accepted:	B000…B007, B120…B127
IRIG control bits	IEEE Std C37.118.1-2011

IRIG-B INPUT	
Amplitude modulation	1 to 10 V pk-pk
DC shift operating range:	0 to 10 V DC
TTL logic low	0.0 to 0.8 V DC
TTL logic high	2.0 to 5.0 V DC
Input impedance	50 kΩ
Isolation	2 kV

3.7.9 DIRECT INPUTS

DIRECT INPUTS	
Input points:	3264256
Remote devices:	16
Default states on loss of comms:	On, Off, Latest/Off, Latest/On
Ring configuration:	Yes, No
Data rate:	64 or 128 kbps
CRC:	32-bit
CRC alarm responding to:	Rate of messages failing the CRC
CRC alarm monitoring message count:	10 to 10000 in steps of 1
CRC alarm threshold:	1 to 1000 in steps of 1
Unreturned message alarm responding to:	Rate of unreturned messages in the ring configuration
Unreturned message alarm monitoring message count:	10 to 10000 in steps of 1
Unreturned message alarm alarm threshold:	1 to 1000 in steps of 1

3.7.10 TELEPROTECTION

TELEPROTECTION	
Input points:	16
Remote devices:	3
Default states on loss of comms:	On, Off, Latest/Off, Latest/On
Ring configuration:	No
Data rate:	64 or 128 kbps
CRC:	32-bit

3.8 OUTPUTS

3.8.1 FORM-A RELAY

FORM-A RELAY	
Make and carry for 0.2 s	30 A as per ANSI C37.90
Carry continuous	6 A
Break (DC inductive, L/R = 40 ms)	1 A at 24V 0.5 A at 48 V 0.3 A at 125 V 0.2 A at 250 V
Operate time	< 4 ms
Contact material	silver alloy
Contacts per common return (6Y I/O module)	2
Contacts with voltage monitoring (6Y I/O module)	2

6Y FORM-A VOLTAGE MONITOR	
Applicable voltage	approx. 15 to 250 V DC
Carry continuous	approx. 2mA

3.8.2 LATCHING RELAY

LATCHING RELAY	
Make and carry for 0.2 s	30 A as per ANSI C37.90
Carry continuous	6 A as per IEEE C37.90
Break (DC resistive as per IEC 61810-1)	6 A at 24V 1.6 A at 48 V 0.4 A at 125 V 0.2 A at 250 V
Operate time	6ms (Typical) <10ms (maximum)
Contact material	Silver alloy
Control	Separate operate and reset inputs
Control mode	Operate-dominant or reset-dominant

3.8.3 FORM-A MONITORS

FORM-A MONITORS	
FORM-A VOLTAGE MONITOR	
Applicable voltage	approx. 15 to 250 V DC
Trickle current	approx. 1 to 2.5 mA
FORM-A CURRENT MONITOR	
Threshold current	approx. 80 to 100 mA

3.8.4 FORM-C AND CRITICAL FAILURE RELAY

FORM-A RELAY	
Make and carry for 0.2 s	30 A as per ANSI C37.90

FORM-A RELAY	
Carry continuous	8 A
Break (DC inductive, L/R = 40 ms)	1 A at 24V 0.5 A at 48 V 0.3 A at 125 V 0.2 A at 250 V
Operate time	< 8 ms
Contact material	silver alloy

3.8.5 FAST FORM-C RELAY

FORM-A RELAY	
Make and carry	0.1A max (resistive load)
Minimum load impedance (2 W resistor)	20 KΩ at 250 V DC 5 KΩ at 120 V DC 2 KΩ at 48 V DC 2 KΩ at 24 V DC
Minimum load impedance (1 W resistor)	50 KΩ at 250 V DC 2 KΩ at 120 V DC 2 KΩ at 48 V DC 2 KΩ at 24 V DC
Note: *Values for 24 V and 48 V are the same due to a required 95% voltage drop across the load impedance.*	
Operate time	< 0.6 ms
Internal Limiting Resistor	100 Ω, 2 W

3.8.6 SOLID-STATE OUTPUT RELAY

SOLID-STATE OUTPUT RELAY	
Operate and release time	<100 µs
Maximum voltage	265 V DC
Maximum leakage current in off state (excluding voltage monitor circuit current)	100 µA
Maximum continuous current	5 A at 45°C; 4 A at 65°C
Make and carry (for 0.2 s)	30 A as per ANSI C37.90
Make and carry (for 0.03 s)	300 A

Breaking Capacity

Specification	UL 508	Utility application (autoreclose scheme)	Industrial application
Operations per interval	5000 operations, 1 second on, 9 seconds off	5 operations, 0.2 seconds on, 0.2 seconds off, within 1 minute	10000 operations, 0.2 seconds on, 30 seconds off
	1000 operations, 0.5 seconds on, 0.5 seconds off		

Specification	UL 508	Utility application (autoreclose scheme)	Industrial application
Break capability (0 to 250 V DC)	3.2 A at L/R = 10 ms	10 A at L/R = 40 ms	10 A at L/R = 40 ms
	1.6 A at L/R = 20 ms		
	0.8 A L/R = 40 ms		

3.8.7 CONTROL POWER EXTERNAL OUTPUT

CONTROL POWER EXTERNAL OUTPUT (For dry contact input)	
Capacity	100 mA DC at 48 V DC
Isolation	±300 Vpk

3.8.8 DCMA OUTPUTS

DCMA OUTPUTS	
Range	–1 to 1 mA, 0 to 1 mA, 4 to 20 mA
Max. load resistance	12 kΩ for –1 to 1 mA range 12 kΩ for 0 to 1 mA range 600 Ω for 4 to 20 mA range
Accuracy:	±0.75% of full-scale for 0 to 1 mA range ±0.5% of full-scale for –1 to 1 mA range ±0.75% of full-scale for 0 to 20 mA range
99% Settling time to a step change	100 ms
Isolation	1.5 kV
Driving signal	any FlexAnalog quantity
Upper and lower limit for the driving signal	–90 to 90 pu in steps of 0.001

3.9 COMMUNICATION PROTOCOLS

IEC 61850	
IEC 61850	Supports IEC 61850 Editions 1.0 and 2.0. See the UR Family Communications Guide and its conformance statements.

RS232 (Enhanced and basic front panels)	
Front port	19.2 kbps, Modbus RTU

USB (Graphical front panel)	
Front port	USB 2.0 type B

RS485	
1 rear port	up to 115 kbps, Modbus RTU, DNP 3, IEC 60870-5-103
Typical distance	1200 m
Isolation	2 kV, isolated together at 36 Vpk

FIBER ETHERNET PORT	
Operates with 50/125 µm and 62.5/125 µm multimode fiber	
Parameters (100 Mb multimode)	
Wavelength	1310 nm
Connector	LC
Transmit power	–20 dBm
Receiver sensitivity	–30 dBm
Power budget	10 dB
Maximum input power	–14 dBm
Typical distance	2 km
Full duplex	yes
Redundancy	yes

ETHERNET	
Modes	10 Mb, 10/100 Mb (auto-detect)
Connector	RJ45
Cable type	CAT 5 or CAT 6 Shielded twisted Pair (STP)

SIMPLE NETWORK TIME PROTOCOL (SNTP)	
Clock synchronization error	<10 ms (typical)

PRECISION TIME PROTOCOL (PTP) PTP IEEE Std 1588-2008 (version 2)	
Power Profile (PP)	as per IEEE StandardPC37.238-2017

PRECISION TIME PROTOCOL (PTP) PTP IEEE Std 1588-2008 (version 2)	
Clock	Slave-only ordinary clock when using station bus Ethernet interface. Boundary clock when using process bus Ethernet interface

PARALLEL REDUNDANCY PROTOCOL (PRP) (IEC 62439-3 CLAUSE 4, 2012)	
Ethernet ports used	2 and 3
Networks supported	10/100 Mb Ethernet

OTHER	
Other protocols	TFTP, SFTP, HTTP, IEC 60870-5-104, Ethernet Global Data (EGD), IEEE C37.118

3.10 INTER-RELAY COMMUNICATIONS

3.10.1 STP INTERFACE OPTIONS

SHIELDED TWISTED-PAIR INTERFACE OPTIONS	
Interface type	**Typical distance**
RS422	1200 m
Note: *RS422 distance is based on transmitter power and does not take into consideration the clock source provided by the user*	
G.703	100 m

3.10.2 LINK POWER BUDGET AND MAXIMUM OPTICAL INPUT POWER

LINK POWER BUDGET AND MAXIMUM OPTICAL INPUT POWER

Emitter, fiber type	Cable type	Transmit power	Received sensitivity	Power budget	Maximum optical input power
820 nm, multimode	62.5/125 µm	-16 dBm	-32 dBm	16 dBm	-8 dBm
	50/125 µm	-20 dBm		12 dBm	
1300 nm, multimode	62.5/125 µm	-16 dBm	-32 dBm	16 dBm	-8 dBm
	50/125 µm	-20 dBm		12 dBm	
1300 nm, single mode	9/125 µm	-15 dBm	-32 dBm	17 dBm	-8 dBm
1300 nm, laser, single mode	9/125 µm	0 dBm	-34 dBm	34 dBm	-8 dBm
1550 nm, laser single mode	9/125 µm	5 dBm	-34 dBm	39 dBm	-10 dBm

The following specifications apply to filter interface modules implemented before January 2012:

Emitter, fiber type	Transmit power	Received sensitivity	Power budget	Maximum optical input power
820 nm LED, multimode	–20 dBm	–30 dBm	10 dB	–7.6 dBm
1300 nm LED, multimode	–21 dBm	–30 dBm	9 dB	–11 dBm
1300 nm ELED, single mode	–23 dBm	–32 dBm	9 dB	–14 dBm
1300 nm Laser, single mode	–1 dBm	–30 dBm	29 dB	–14 dBm
1550 nm Laser, single mode	+5 dBm	–30 dBm	35 dB	–14 dBm

Note:
The power budgets are calculated from the manufacturer's worst-case transmitter power and worst case receiver sensitivity.

Note:
The power budgets for the 1300 nm ELED are calculated from the manufacturer's transmitter power and receiver sensitivity at ambient temperature. At extreme temperatures these values deviate based on component tolerance. On average, the output power decreases as the temperature is increased by a factor of 1 dB / 5 °C.

3.10.3 TYPICAL LINK DISTANCE

Emitter, fiber type	Cable type	Connector type	Typical distance	
			Before Jan 2012	From Jan 2012
820 nm LED, multimode	62.5/125 µm	ST	1.65 km	2 km
	50/125 µm	ST	1.65 km	2 km
1300 nm LED, multimode	62.5/125 µm	ST	4 km	5 km
	50/125 µm	ST	4 km	5 km
1300 nm ELED, single mode	9/125 µm	ST	11.4 km	20 km
1300 nm laser, single mode	9/125 µm	ST	64 km	65 km
1550 nm laser, single mode	9/125 µm	ST	105 km	125 km

Note:
Typical distances listed are based on the following assumptions for system loss. As actual losses vary from one installation to another, the distance covered by your system can vary.

3.10.4 LOSSES AND MARGIN

CONNECTOR LOSSES (Total at both ends)	
ST connector	0.7 dB (each)

FIBER LOSSES	
820 nm multimode	3 dB/km
1300 nm multimode	1 dB/km
1300 nm single mode	0.35 dB/km
1550 nm single mode	0.25 dB/km
Splice losses	one splice every 2 km at 0.05 dB loss per splice

SYSTEM MARGIN	
Additional loss added to calculations to compensate for all other losses	3 dB
Compensated difference in transmitting and receiving (channel asymmetry) channel delays using GPS satellite clock:	10 ms

3.11 CYBERSENTRY SECURITY

OPTIONS	
Software options	Level 1, Level 2

3.12 GRAPHICAL FRONT PANEL

DISPLAY	
Type	Color graphical back-lit LCD display
Size	7 inches (17.8 cm)
Resolution	800 by 480 pixels
Pages	5 single-line diagram pages with controls, status, and metering values Up to 8 annunciator pages with total of 96 annunciator windows 1 phasor metering page for each AC Source 5 tabular metering pages with dynamic metering and status Event records page with dynamic update Product information page Settings, actual values, error messages (targets)

LED INDICATORS	
Functions	5 device status indicators 9 event cause indicators 8 user-programmable pushbutton indicators

PUSHBUTTONS	
Type	membrane
Functions	5 bottom Tab pushbuttons and 1 Home pushbutton for page recall 4 directional, 1 ENTER, and 1 ESCAPE pushbutton element selection 10 side pushbuttons for power system element control RESET pushbutton

INGRESS PROTECTION	
IP code	IP40 front (IP54 front with IP54 mounting collar accessory) IP10 back (IP20 back with IP20 cover accessory)

3.13 ENVIRONMENTAL

AMBIENT TEMPERATURES	
Maximum operating range	–40 to 85°C
Continuous operating range	–40 to 60°C*

Note:
**Based on IEC 60068-2-1 and IEC 60068-2-2, Variant Bd and Ad for 16 hrs. The UR can operate up to a surrounding ambient of 85°C, however operating outside the recommended continuous temperature range for extended periods can result in MTBF degradation.*

Note:
LCD contrast and performance will degrade below -20C. Contrast and performance will return to normal once temperature returns above -20C.

Ideal Storage Temperature Range	15ºC to 27ºC

HUMIDITY	
Humidity	Operating up to 95% (non-condensing) at 55°C (as per IEC 60068-2-30 variant 1, 6 days)
Ideal Storage Humidity Range	30% to 60%
Relative Humidity (RH) Air Quality	Proper ventilation is recommended

OTHER	
Altitude	2000 m (maximum)
Pollution degree	II
Overvoltage category	II
Ingress protection	IP20 front, IP10 back (basic front panel and Rev. 1 enhanced front panel) IP40 front, IP10 back (Rev. 2 enhanced front panel) IP54 front with IP54 mounting collar accessory (Rev. 2 enhanced front panel)
Ingress protection with IP20 cover accessory	IP20 back
Noise	0 dB

3.14 TYPE TESTS

Test	Reference standard	Test level
Dielectric voltage withstand	EN 60255-5*	2.2 kV
Impulse voltage withstand	EN 60255-51*	5 kV
Damped oscillatory	IEC 61000-4-18 / IEC 60255-26-1	2.5 kV CM, 1 kV DM
Electrostatic discharge	EN 61000-4-2 / IEC 60255-26-2	Level 3
RF immunity	EN 61000-4-3 / IEC 60255-26-3	Level 3
Fast transient disturbance	EN 61000-4-4 / IEC 60255-26-4	Class A and B
Surge immunity	EN 61000-4-5 / IEC 60255-26-5	Level 3 and 4
Conducted RF immunity	EN 61000-4-6 / IEC 60255-26-6	Level 3
Power frequency immunity	EN 61000-4-7* / IEC 60255-26-7	Class A and B
Voltage interruption and ripple DC	IEC 60255-11	12% ripple, 200 ms interrupts
Radiated and conducted emissions	CISPR11 / CISPR22 / IEC 60255-25	Class A
Sinusoidal vibration	IEC 60255-21-1	Class 1
Shock and bump	IEC 60255-21-2	Class 1
Seismic	IEC 60255-21-3	Class 1
Power magnetic immunity	IEC 61000-4-8	Level 5
Pulse magnetic immunity	IEC 61000-4-9	Level 4
Damped magnetic immunity	IEC 61000-4-10	Level 4
Voltage dip and interruption	IEC 61000-4-11	0, 40, 70, 80% dips; 250 / 300 cycle interrupts
Damped oscillatory	IEC 61000-4-12*	2.5 kV CM, 1 kV DM
Conducted RF immunity, 0 to 150 kHz	IEC 61000-4-16	Level 4
Voltage ripple	IEC 61000-4-17	15% ripple
Ingress protection	IEC 60529*	IP20 front, IP10 back
Cold	IEC 60068-2-1	–40°C for 16 hours
Hot	IEC 60068-2-2	85°C for 16 hours
Humidity	IEC 60068-2-30	6 days, variant 1
Damped oscillatory	IEEE/ANSI C37.90.1	2.5 kV, 1 MHz
RF immunity	IEEE/ANSI C37.90.2	20 V/m, 80 MHz to 1 GHz
Safety	UL 508	e83849 NKCR Section 43 - Temperature test Energization of Contact Inputs and/or Contact Outputs for continuous duty is not to exceed a total of 31 W of power
Safety	UL C22.2-14	e83849 NKCR7
Safety	UL 1053	e83849 NKCR
Safety	IEC 60255-27	Insulation: class 1, Pollution degree: 2, Over voltage cat II

*Not tested by third party

3.15 PRODUCTION TESTS

OPTIONS	
Thermal	Products go through an environmental test based upon an Accepted Quality Level (AQL) sampling process.

3.16 APPROVALS

Compliance	Applicable council directive	According to
CE	Low voltage directive	EN 60255-5
	EMC directive	EN 60255-26 / EN 50263
		EN 61000-6-5
C-UL-US	---	UL 508
		UL 1053
		C22.2 No. 14

3.17 MAINTENANCE

MOUNTING

Attach mounting brackets using 20 inch-pounds (±2 inch-pounds) of torque.

CLEANING

Normally, cleaning is not required. When dust has accumulated on the front panel display, wipe with a dry cloth.

Note:
To avoid deterioration of electrolytic capacitors, power up units that are stored in a de-energized state once per year, for one hour continuously