Type CV2
On-load Tap Changer
Type Test Report

Test Commitment No.:
2021-08-CV201E

Tested Model:
CV2III-600D/145-12233W

Name of Testing Sample:
Type CV2 On-load Tap Changer

Commitment Organization:
Shanghai Huaming Power Equipment Co.,Ltd

Tap Changer Testing Center of
Shanghai Huaming
Power Equipment Co.,Ltd.

Digitally signed by Casapu Valentin
Date: 2023.12.04 16:07:59 EET
Reason: MoldSign Signature
Location: Moldova

Declaration

1. Testing result is only valid to the testing samples;

2. Partial copies of type test report are invalid without written approval of testing centre

Address: No.977 Tongpu Road, Shanghai, China
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Tap Changer Test Center of Shanghai Huaming Power Equipment Co.,Ltd.	**Type Test Report**	CV2III-600D/145-12233W On-load Tap Changer 2021-08-CV201E

Testing Items and results

1. Performance test of tap changer

1.1 Measurement of operating torque

1.2 Measurement of contact moving sequence

1.3 Circuit Resistance Measurement: Tap selector ≤147μΩ; Reverse selector ≤90μΩ

2. Mechanical Test

2.1 Pressure and vacuum test: No leakage under 10×10^4Pa for 24hours, and under 133Pa for 1hour.

2.2 Mechanical endurance test: 1,500,000 operations

2.3 -25℃ Low temperature test: 100 operations

2.4 High temperature operating test (115℃): 100 operations

3. Contact Temperature Rise Test: The highest temperature rise of the contacts under the test current of It=720A should be 17.5 K.

4. Switching test

4.1 Service duty test

load point: Ust=Ui= 2000V, In=Ium= 600A; N=600,000 operations

4.2 Breaking capacity test

Us=Ui= 2000V, In=2Ium= 1200A, N=40 operations

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5 Short circuit current test:

Thermal: Ith=8kA (Sqm),t=3s

Dynamic: I1m=20kA (peak), N=3 times

6 Transition impedance test 295K

7 Insulation test

7.1 AC withstand voltage test

To ground and between phases: 275kV，1min

Between max. and min. taps: 50kV，1min

7.2 1.2/50μS Lightning impulse test

To ground and between phases: 650kV

Between max. and min. taps: 200kV

Test accordance	JB/T 8314-2008 < Tap Changer Test Guide> GB/T 10230.1-2019 <Tap Changer Part 1: Performance requirements and test methods> IEC 60214-1:2014 <Tap changers Part 1: Performance requirement and test methods> Shanghai Huaming Power Equipment Co.,Ltd <Type CV2 On-load Tap Changer Test Guide>
Test conclusions	Testing sample has passed tests from item 1 to item7.

Prepared by: 吴文华	Reviewed by: 卓斌	Approved by: 步杰斌
Date: 2021.6.10	Date: 2021.6.11	Date: 2021.6.12

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		2021-08-CV201E

0. General

0.1 Test Information

0.1.1 Testing sample

Commitment Organization: Shanghai Huaming Power Equipment Co., Ltd.

Name of the test sample: Type CV2 On-load Tap Changer

Model of the tap changer: CV2III-600 D /145-12233W

Motor drive unit: SHM-DL

No. of samples: 2

Serial No. of tap changer: 2021-08-CV201E-1# and 2021-08-CV201E -2#

Manufacturer: Shanghai Huaming Power Equipment Co., Ltd

0.1.2 Test category: Type Test

0.1.3 Test Plan

No. 2021-08-CV201E -1#: performance test (including transmission torque measurement, contact moving sequence measurement, circuit resistance measurement); mechanical test and dielectric test

No. 2021-08-CV201E -2#: contact temperature rise test, switching test, short-circuit current test and transition impedance test

0.1.4 Test date: Jan-23-2021～July-06-2021

0.1.5 Test report date: Jul-10-2021

0.2 Testing sample parameters

Sample model: CV2III-600 D /145-12233W

Insulation to ground: 145kV

No. of tap positions: 21

Max. rated step voltage: 2000V

Max. rated through current: 600A

Transition resistor: R=4.0Ω

No. of phase: three phases

Rated frequency: 50Hz

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Mechanical Performance Lab

Test Report

Tested by: 吴文华

Prepared by: 李对

Reviewed by: 马杰对

Date: 2021.6.12

Tap Changer Test Center of Shanghai Huaming Power Equipment Co.,Ltd.	**Type Test Report**	CV2III-600D/145-12233W On-load Tap Changer 2021-08-CV201E

Test items and test equipments

No.	Test items	No. of test equipment	Name of test equipment
1	Tap changer performance test		
	Operating toque	A232-01	Torque measurement instrument
	Contact moving sequence	A209-02	On-load tap changer testing system
	Circuit resistance	A204-04	Digital microhmmeter
2	Mechanical test		
	Pressure and vacuum test	A206-01	Voltmeter
		A206-05	Vacuum meter
	Mechanical endurance test	A111-01	Hot oil testing device
	Low temperature (-25℃) test	A112-01	$16m^3$ low temperature test chamber
	Tightness test	A113-01	Tightness testing device
		A217-01	Gas Chromatograph

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1. Performance test of tap changer

1.1 Measurement of operating torque

Position		Position of Max. torque	Observed value	Remarks
Tap selector		1→21	18 N·m	Head of tap selector
Motor drive unit	Hand crank	10→11，12→11	6.0 N·m	With tap changer
	Output shaft	10→11，12→11	46 N·m	With simulated load

1.2 Measurement of contact moving sequence

This test is conducted by acoustical and oscillographic methods. First, connect the tap changer according to normal service condition and immerse it in the transformer oil; then manually operate the tap changer by hand crank on motor drive unit and record contacts moving sequence.

1.2.1 Measurement of tap selector contacts moving sequence

Tap selector contacts moving sequence is indicated by hand crank revolutions of the motor drive unit, see below for the records:

(Unit: revolution)

Movement of contacts		Numbers of revolutions of hand crank	
		Tap position 1→N	Tap position N→1
Start		0	0
Change-over selector	Moving contact leave fixed contact	14	14.5
	Moving contact connects the adjacent fixed contact	17.5	18
	Movement finished	20	20.5
Tap changer operates		24	23.5
Finish one tap-change operation		33	33
The revolutions from first (last) tap position to the mechanical limitation		>3	>3

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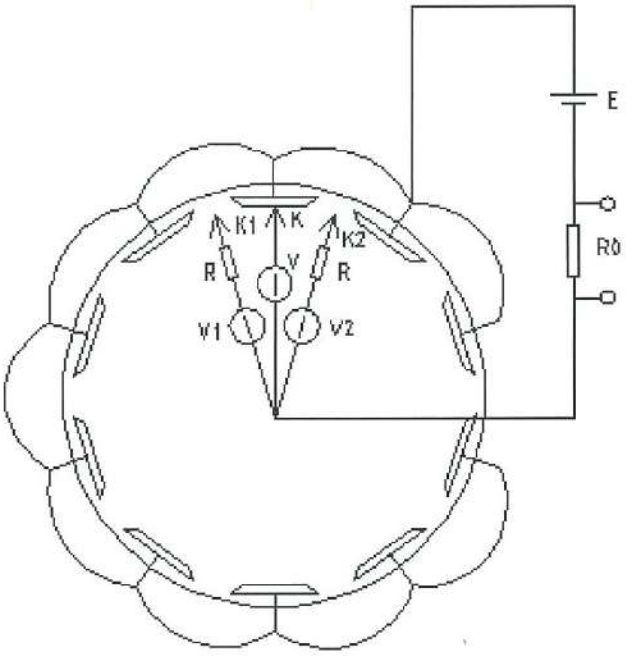
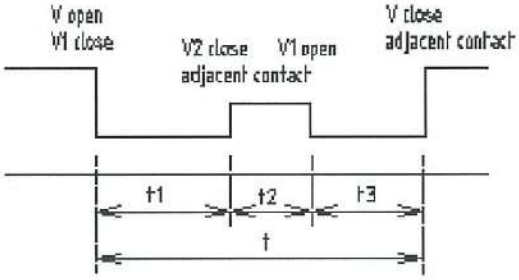
1.2.2 Measurement of tap selector switching sequence

It is measured by oscillographic method.



DC oscillographic measurement circuit

V—main vacuum interrupter
V1(V2) --transition vacuum interrupter
K1(K2) --contact that connect with transition vacuum interrupter V1(V2)
K--contact that connect with main vacuum interrupter V
R--transition resistor
R0--sampling resistance
E—DC power



DC oscillogram

t1--First half bridging time
t2—Bridging time
t3—Second half bridging time
t--Total switching time

The DC oscillogram shows that the switching sequence of all phases are normal, below are oscillograms of switching sequence for U phase, and the observed time are:

		1→N	N→1
t1	single resistor time:	18ms	20ms
t2	bridging time	13ms	15ms
t3	single resistor time	19ms	18ms
t	total switching time:	50ms	53ms

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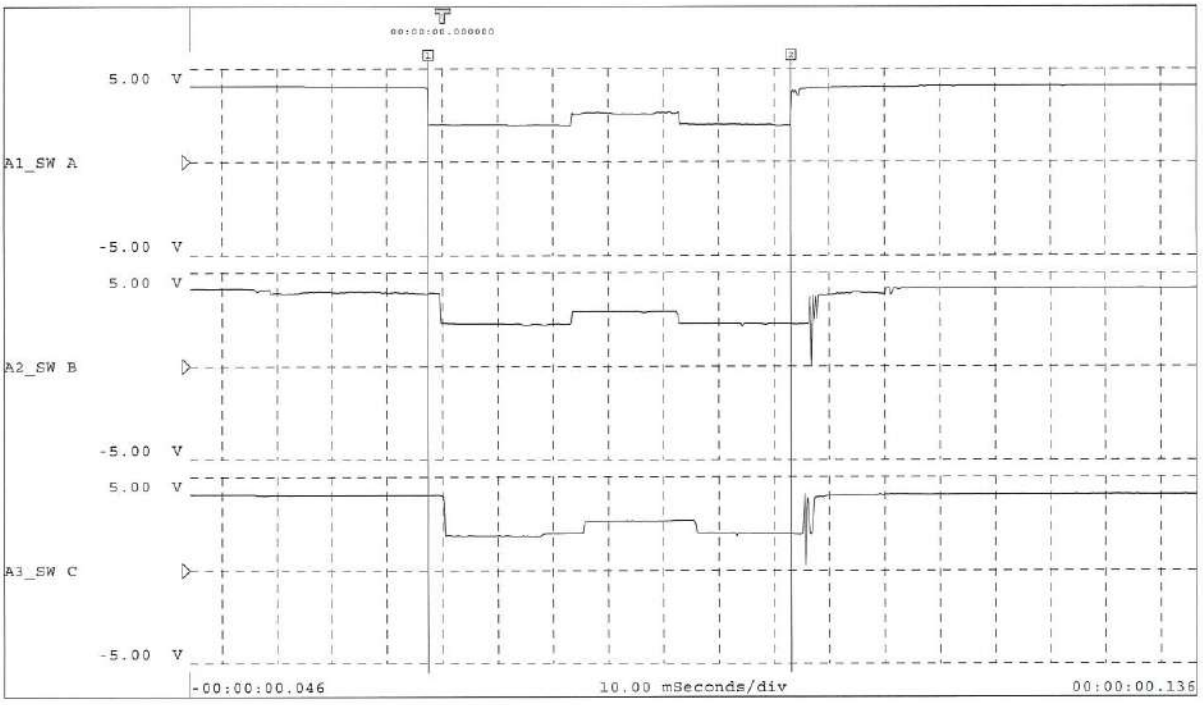
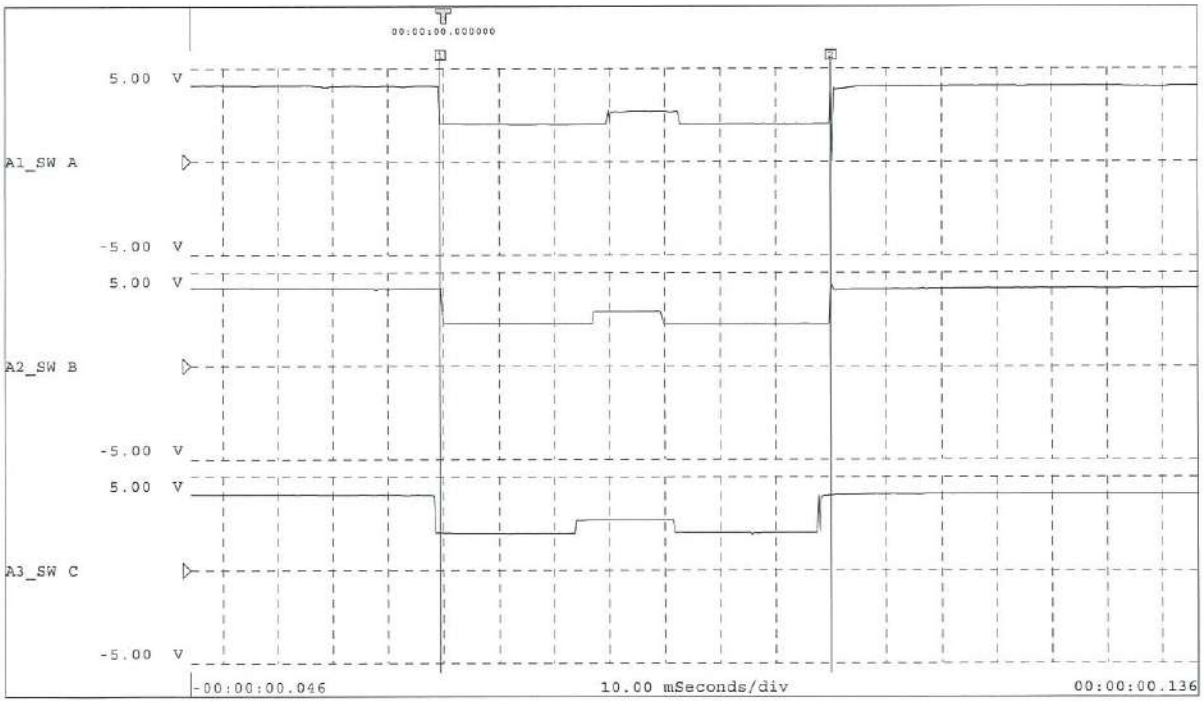
Recorded DC oscillograms as following:

Operate from 1 to N



Operate from N to 1



1.3 Circuit Resistance Measurement

The observed resistance is the series resistance of two fixed & moving contacts in the circuit, see below:

1.3.1 Observed resistance

Unit: μΩ

Measuring position		U	V	W	Measuring circuit
Change-over selector	K+	90	75	80	Two fixed & moving contacts in series
	K-	70	65	60	
Tap selector	1	120	115	125	Three fixed & moving contacts in series
	2	118	130	125	
	3	120	110	128	
	4	127	119	123	
	5	135	156	166	
	6	140	147	119	
	7	120	138	128	
	8	122	125	125	
	9	112	102	130	
	10	126	125	109	
	11	120	115	131	
	K	145	140	140	

1.3.2 Contact resistance assessment

According to in IEC60214-2: 2014 and GB/T 10230.2-2019 Tap changer, Part 2: Application guide, if contact loss (equals to the product of the contact resistance and square of the current) is more than 100W (which could be less when the rated current is very high), it might cause over-heat. The allowable contact resistance should be less than 250μΩ, when max. rated through current is 600A. The contact resistance can be calculated by the circuit resistance shown in the table.

Max. contact resistance = max. of observed resistance /No. of contacts in series connection

Change-over selector contact resistance Rmax = 90/2 =45μΩ

Tap selector contact resistance Rmax = 147/3 = 49μΩ

The contact resistance is calculated all less than 250μΩ and meets requirements.

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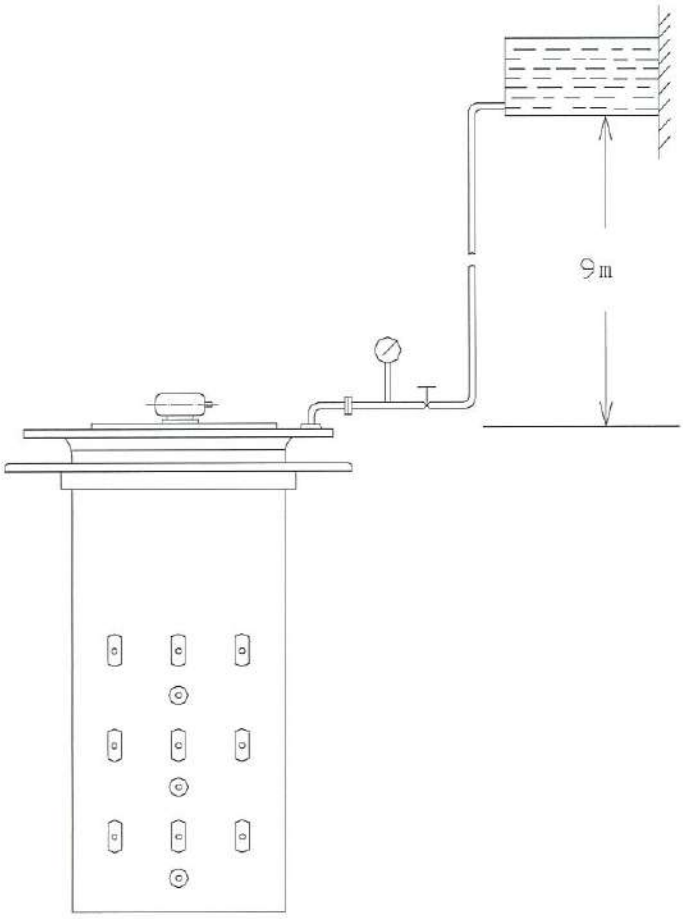
2. Mechanical test

2.1 Pressure and vacuum test

Test specification:

This test is only for tap selector oil-compartment.

The tap changer should suffer under the pressure of 10×10^4Pa,see below figure:



First fill the tap change oil-compartment full with clean transformer oil, and connect it with a 9 meter-high oil tank, which will cause the oil compartment under the pressure of 10×10^4Pa. keep in this condition for 24hours, then check if any leakage on the head flange of oil compartment, head cover, the bottom of compartment and contacts, no leakage and mechanical deformation was observed.

Drain the transformer oil in the compartment , and then connect the tap changer with a vacuum pump. When the pressure reduced to 133Pa, keep for 1hour, the vacuum meter shows no obvious change, and no mechanical deformation of tap changer head cover.

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2.2 Mechanical endurance test

(1)Test parameter: N=1,500,000 operations.

(2)Test arrangement:

Connect the tap changer with SHM-DL motor drive unit and place the tap changer in an oil tank a heater. The oil temperature is kept between 80℃ and ambient temperature by the heater controlled by a temperature controller (almost heating10hours each day). About half of the operations performed in the hot oil.

The tap changer runs 1,500,000 operations, of which change-over selector runs at least 150,000 operations, 1,150,000 operations are run within full tap position range (change-over selector operates once when tap changer runs 18 operations); another 350,000 operations are run among 10→11→12 (change-over selector operates once when tap changer runs 4 operations). The operating frequency is 500 operations/h.

Lift the insert every 100,000 operations for inspection, and then take oscillograms. Check vacuum interrupters by 2500V Megohmmeter and tighten all fastening parts. After 1,500,000 operations, disassemble the tap changer and check, no wearing or over loss of mechanical part & components was found, the tap changer still in good operating conditions.

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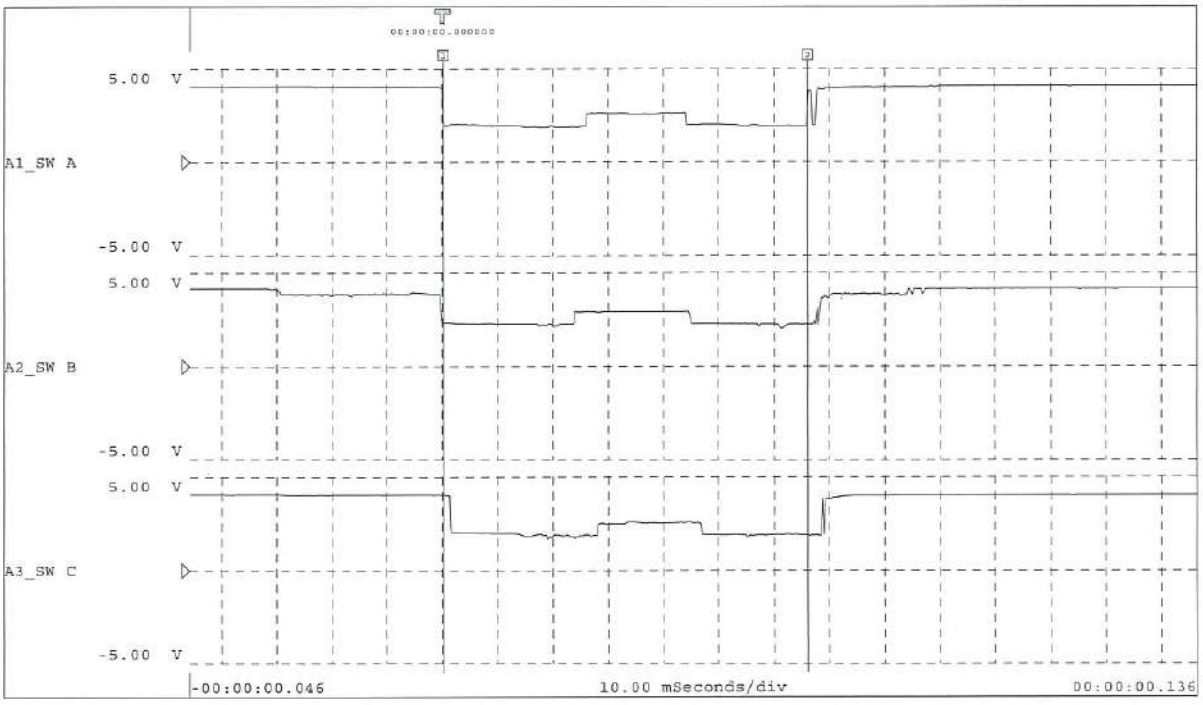
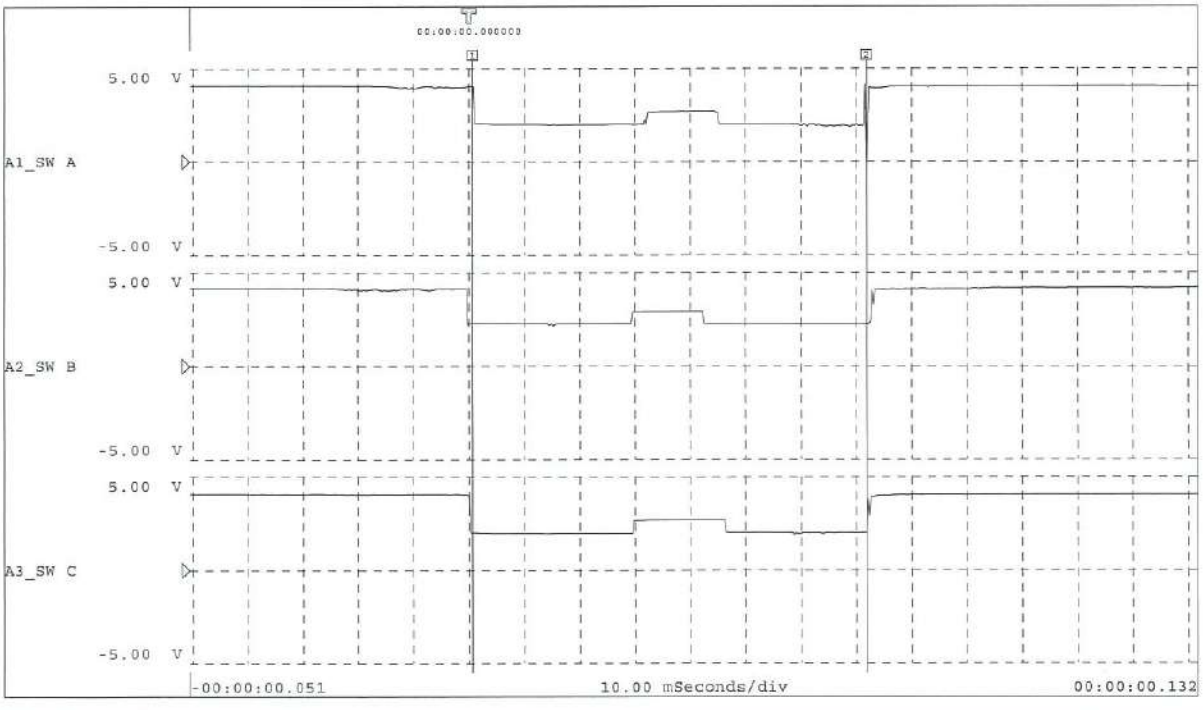
(3)DC oscillograms in mechanical endurance test

At the beginning of mechanical endurance test:

1→N:



N→1:



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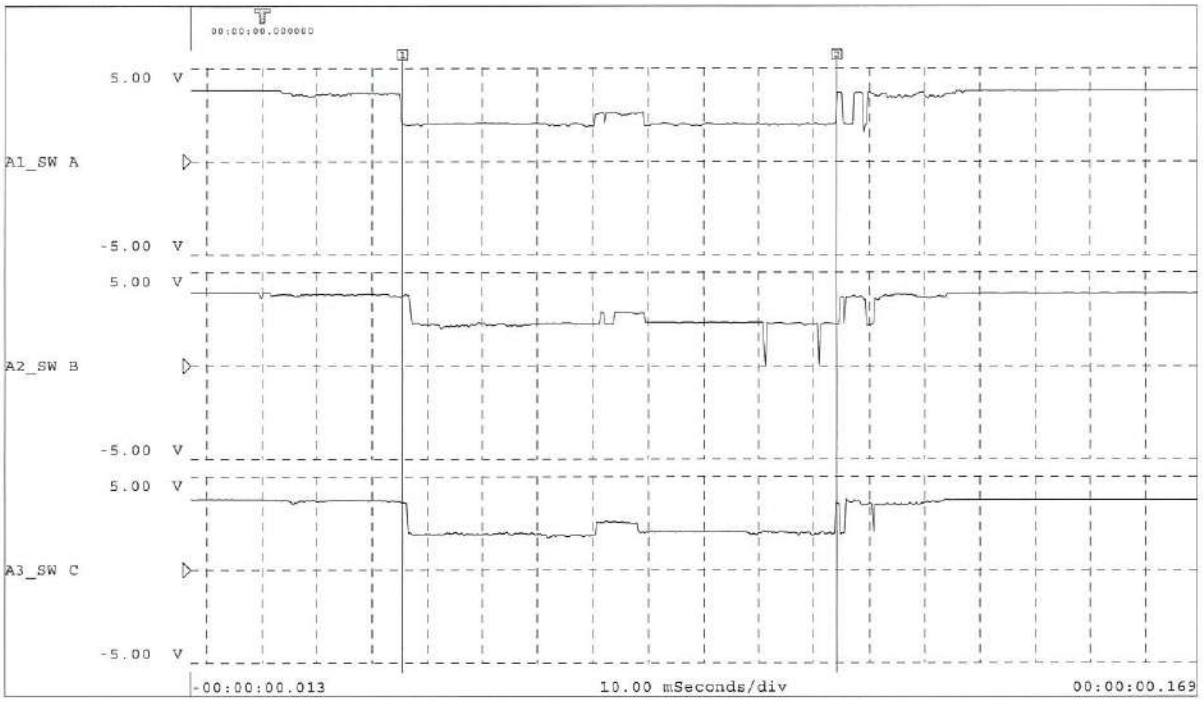
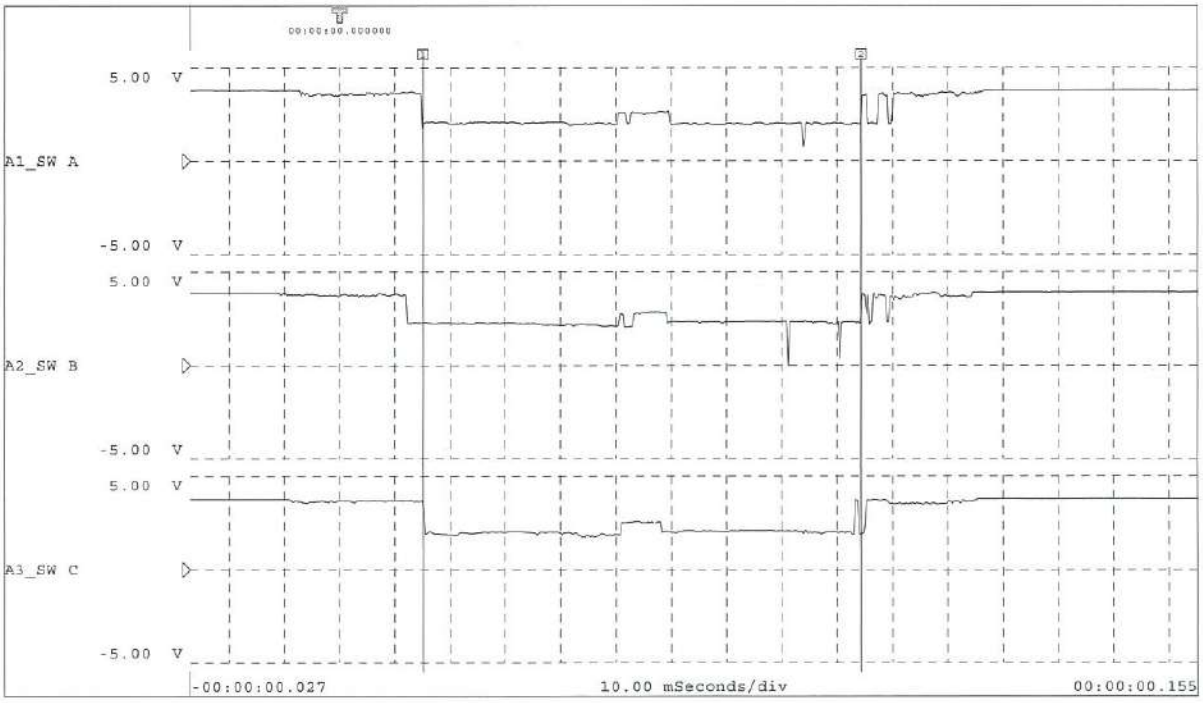
After mechanical endurance test:

1→N:



N→1:



As shown above, after 1,500,000 operations, the energy-accumulated spring has turned sluggish, which cause more switching time, but the switching process is still good.

2.3 -25℃ lower temperature test

2.3.1 Test specification

Run 100 operations under -25℃

2.3.1.1 Test process

Mount the tap changer on a movable testing rack, and then put into a 16m^3 low temperature testing chamber. Place thermocouples on the energy-accumulating mechanism, transition resistors and drive motor to monitor the temperature. When the temperature of above parts reaches to -25℃±3℃, run the tap changer by motor drive unit for 100 operations and record the switching oscillograms. Compare those oscillograms with what's recorded in room temperature, the switching time is a little longer, but it can still run reliably under low temperature.

The test procedure is as followings:

(1) Before test: Run 10 operations in room temperature, and record the oscillograms.

(2) During test: Run 100 operations under -25℃ low temperature, and record the oscillograms.

(3) After test: Run 10 operations after temperature rose to room temperature, and record the oscillograms.

2.3.1.2 Data comparisons

During test	Chamber temperature (℃)	Energy-accumulating mechanism temperature (℃)	Transition resistor temperature (℃)	Drive motor temperature (℃)	Switching time (ms)	Switching direction
Room temperature	+23.2	+23.2	+23.3	+23.1	52～55 48～52	1→N N→1
Lowe temperature	-25	-25.1	-24.8	25.5	60～64 67～70	1→N N→1
Room temperature	+23.2	+23.4	+23.5	24	55～58 52～54	1→N N→1

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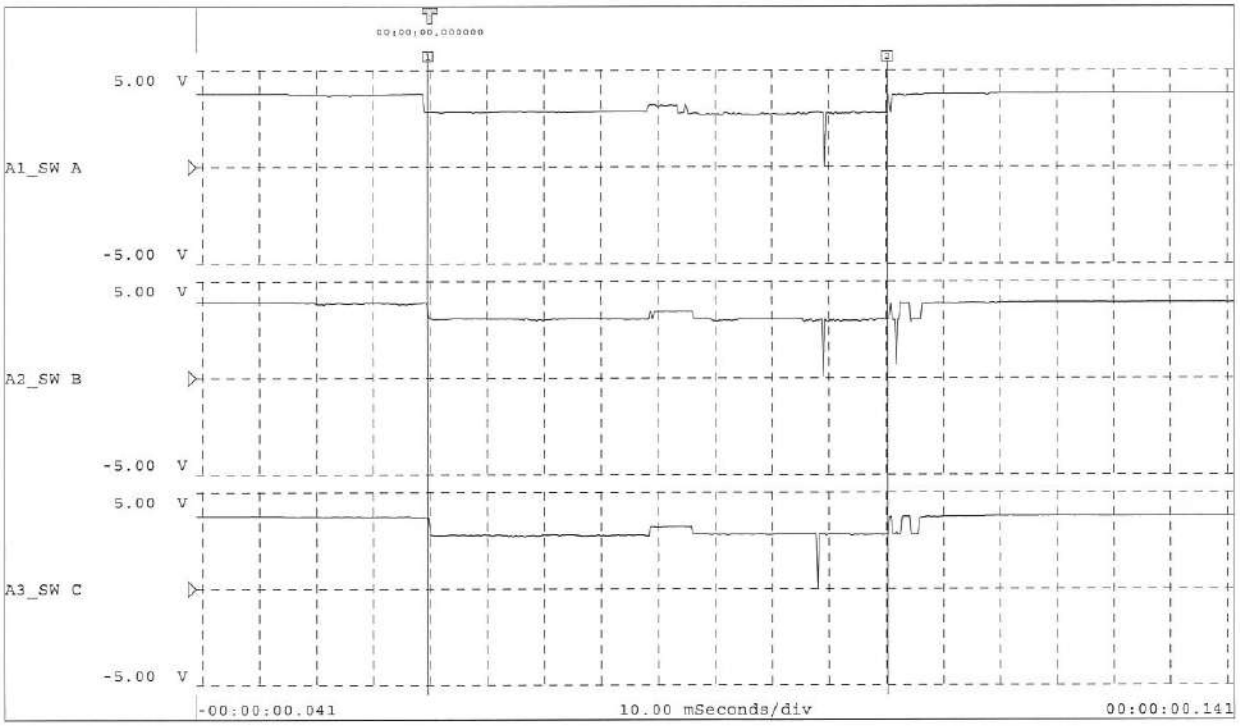
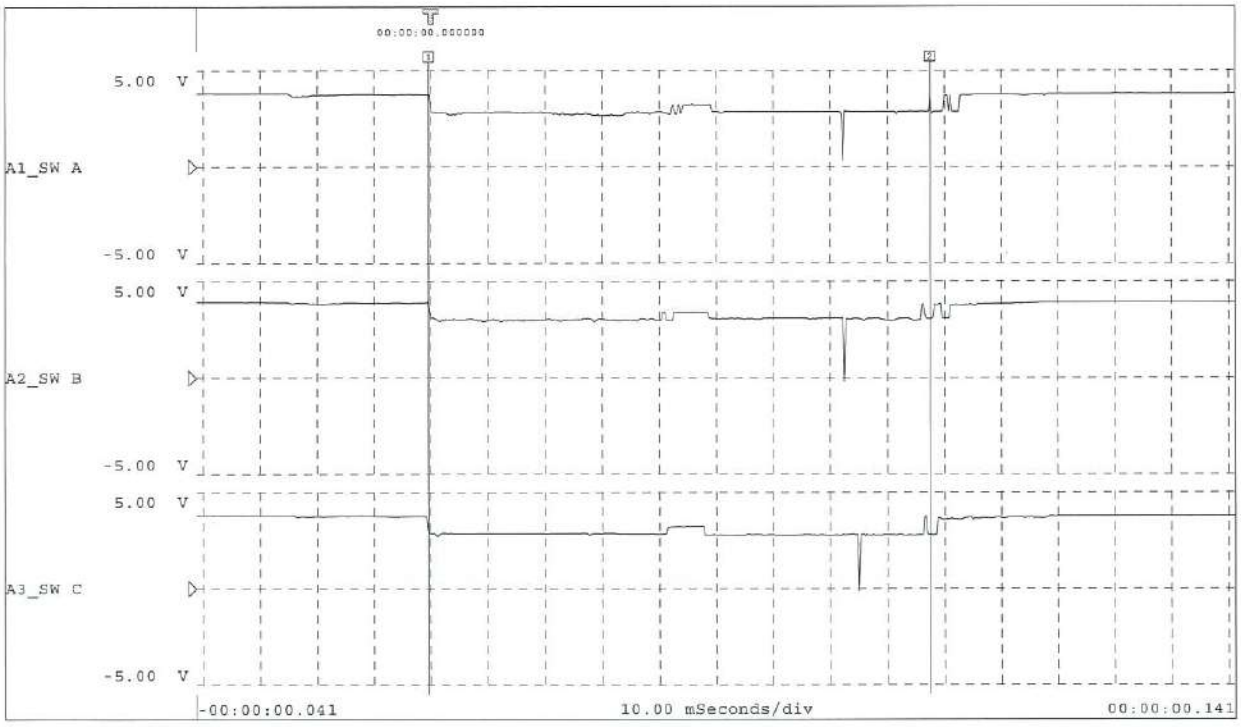
2.3.1.2 Testing oscillograms

Low temperature：1→N



Low temperature:N→1



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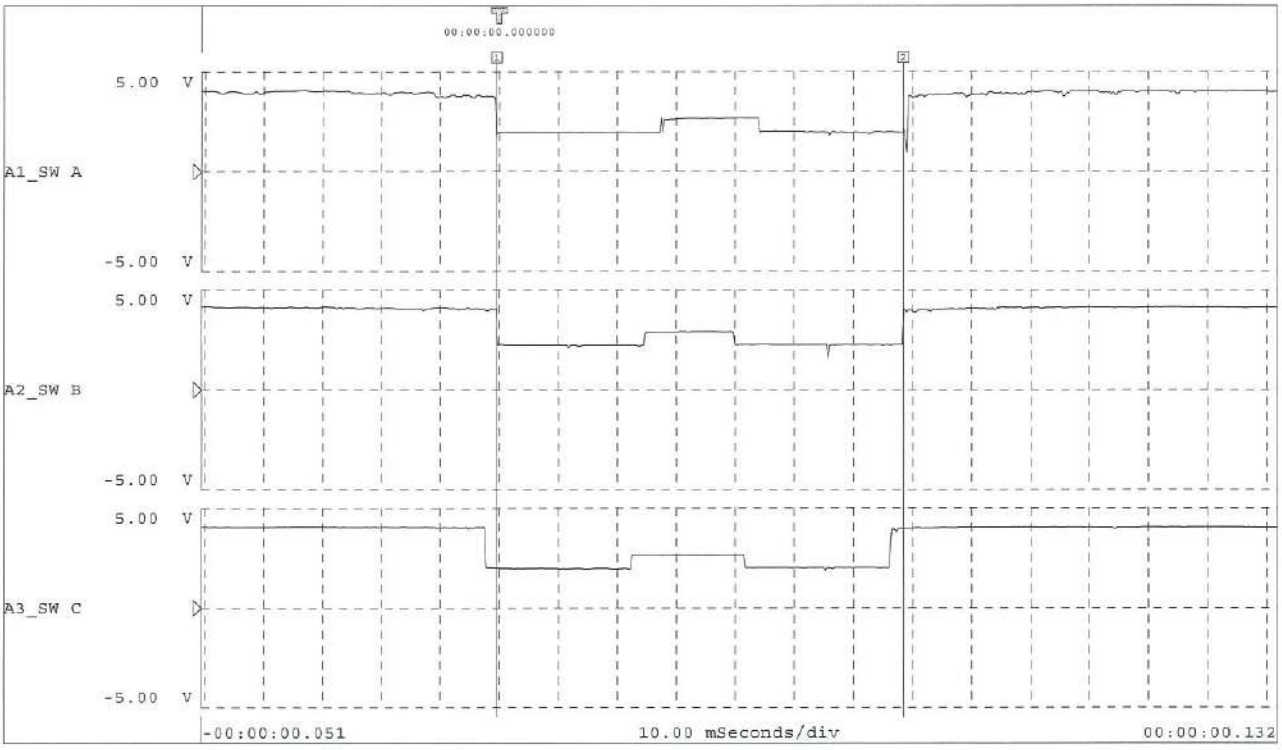
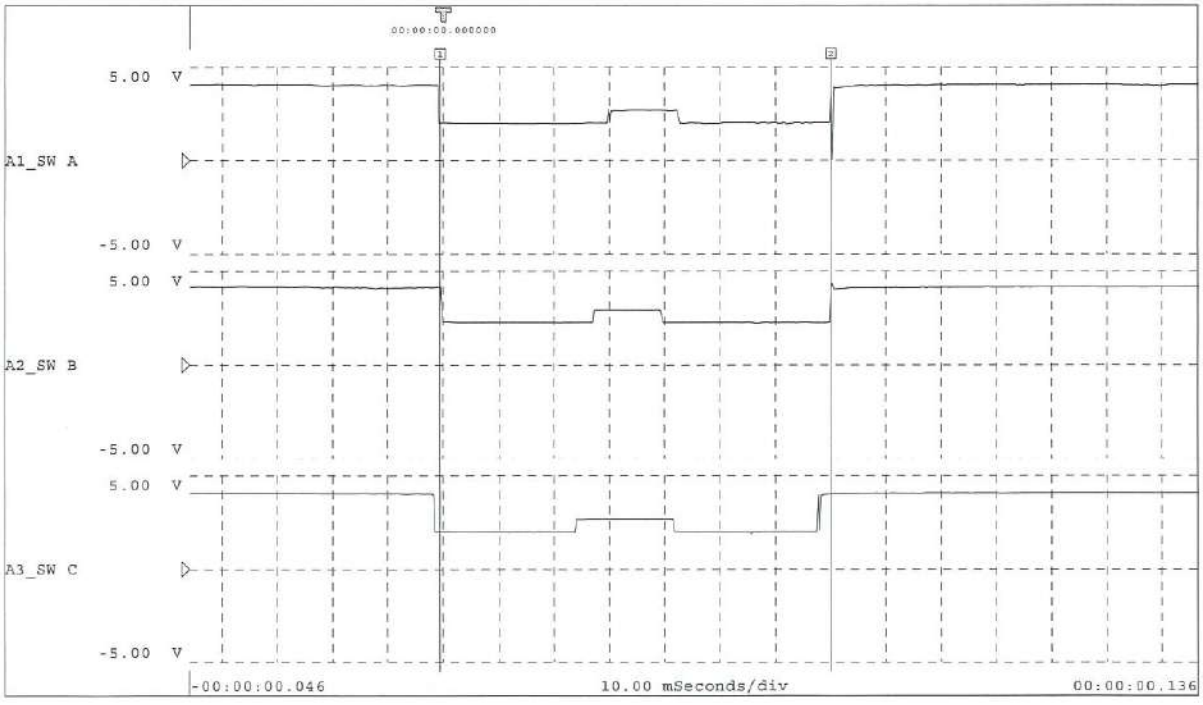
Room temperature: 1→N



Room temperature: N→1



2.4 Operating test in 115℃ hot oil

2.4.1 Test requirement:

After 1,500,000 mechanical life test, immerse the tap changer in 115℃ hot oil and operate it 100 times.

2.4.2 Test procedure:

Put the testing sample on the movable stand of hot oil testing facility. Immerse the tap changer in the oil tank. Head the oil inside the tank until 115℃. Drive the tap changer 100 operations with motor drive unit. After testing, lift out the tap changer and find tap changing right, no mechanical deformation and other malfunction.

2.4.3 Test result:

Testing tap changer can finish the tap operation successfully in 115℃±1℃ hot oil.

2.5 Disassemble the tap changer after mechanical test

Disassemble the tap changer after 1,500,000 operations, and the inspection records shown in below table.

2.5.1 Tap selector inspection results

No.	Inspection items	Inspection results
1	Vacuum interrupter	No leakage and no crack
2	Fasteners	No loose, well tightened.
3	Mechanical contact	Normal surface wearing
4	Contact pressure spring	No damage, no deformation and no crack
5	Mechanical operating parts	Operate flexibly, no stuck, well mated.
6	Energy-accumulating spring	No damage, no deformation and no crack
7	Transition resistor	No crack on insulation panel; no crack and falling off on resistance wire. Observed resistance is good
8	Insulation parts	No crack and damage on insulation parts
9	Wearing	Metal wearing debris at the bottom of oil compartment

2.5.3 Conclusions

After 1,500,000 operations, the diverter switch and tap selector was found still in good conditions.

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Electrical performance test lab

Test Report

Tested by: 吴文华

Prepared by: 陈效

Reviewed by: 李志斌

Date: 2021.6.12

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Testing items and devices:

No.	Testing items	Testing device No.	Testing device name
1	Contact temperature rise test	A117-01	Voltage regulator
		A110-01	Big current transformer
		A211-09	current transformer
		A209-06	Ammeter
		A208-01	Thermocouple
		A202-06	Potentiometer
		A204-08	Circuit resistance tester
2	Switching test (including service duty test and breaking capacity test)	A102-01	Testing transformer (switching)
		A115	Reactor set
		A116	Capacitor set
		A211-11	Current transformer
		A212	Voltage transformer
		A209-01	8-channel digital recorder
3	Short-circuit current test	A103-01	Testing transformer (short-circuit)
		A115-12	Current-limiting reactor
		A209-01	8-channel digital recorder
		A211-11	Current transformer
		A204-08	Circuit resistance tester
4	Transition impedance test	Same as switching test	
		A208-01	Thermocouple
		A202-06	Potentiometer

3. Contact temperature rise test

3.1 Test description

The test is conducted in room temperature transformer oil. Energized the tap changer with It=1.2In =600A current, the contact temperature will rise due to thermocouple. Determine the test circuit according to the resistance, then place thermocouples on contacts in series connection. Thermocouples are planted on contacts near to the contacting points, measure the ambient temperature at the place where not less than 25mm below thermocouples. When the temperature difference between contact and ambient does not exceed 1K per hour in continuous 2 hours, the temperature rise is considered to be stable. The test requirement for temperature rise is ≤20K.

Cross-section of all wires meet requirements of 600A.

3.2 Circuit resistance measurement

See below table

Unit: μΩ

Measuring position		U	V	W	Measuring circuit
Change-over selector	K+	75	90	80	Two fixed & moving contacts in series
	K-	70	65	60	
Tap selector	1	120	115	125	Three fixed & moving contacts in series
	2	118	130	125	
	3	120	110	128	
	4	127	119	123	
	5	135	156	166	
	6*	140	147/150	119	
	7	120	138	128	
	8	122	125	125	
	9	112	102	130	
	10	126	125	109	
	11	120	115	131	
	K	145	140	140	

Note: 147/150 indicates measurement before/after test.

As we can see from above, we can choose change-over selector V phase K+ →K0 → V6 phase to be a series connection current circuit, then place thermocouples on all contacts to measure temperature rise.

3.3 Contact temperature rise test results

No.	Measuring points		Stable temperature rise (K)
1	Change-over selector	K0 side fixed contact	16.3
2		K0 side moving contact (inner side)	16.6
3		K0 side moving contact (outer side)	16.1
4		K+ side moving contact (inner side)	14.9
5		K+ side moving contact (outer side)	15.3
6*		K+ side fixed contact	16.2
7	Tap selector	Position 6, fixed contact (near the roller contact)	16.5
8*		Position 6,cage fixed contact (near take-off terminal)	17.5*
9		6 tap change take-off terminal	16.2
10		Moving contact (upper roller contact on collect ring side)	15.3
11		Moving contact (lower roller contact on collect ring side)	16.3
12		Moving contact (upper roller contact on cage fixed contact side)	16.5
13		Moving contact (lower roller contact on cage fixed contact side)	15.6
14		V phase take-off terminal	15.7
15		V phase cage fixed contact (near take-off terminal)	15.1
16		Collect-ring terminal	15.3

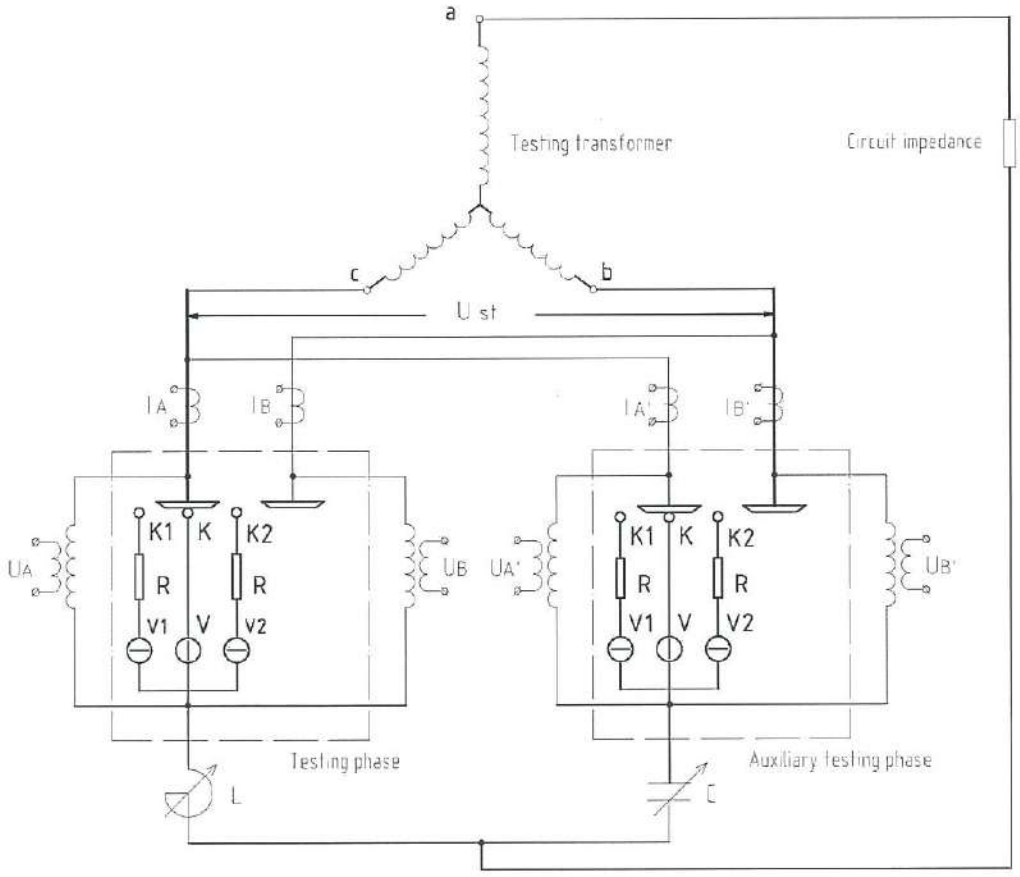
Note: * indicates observed highest temperature rise

4. Switching test

Switching test include service duty test and breaking capacity test

4.1 Test description

Test diagram as below figure. Connect U phase and V phase in the testing circuit, and run the tap changer by SHM-DL motor drive unit.



CV2 type On-load Tap Changer Switching Test Circuit Diagram

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4.2 Service duty test

load point:: Ust=Ui= 2000V，In=Ium= 600A，R1=4.0Ω；

Test conducted as below:

1)、600,000 operations to be performed as service duty test;

2)、40 operations at 2 times of max. rated through current as the breaking capacity test

4.2.1 Service duty test

Duty condition: Ust=Ui= 2000V，In=Ium= 600A，R1=4.0Ω

Under above duty condition, the main vacuum interrupter and transition vacuum interrupter will have below breaking current and recovery voltage, which can be calculated and compared with corresponding values shown on the oscillogram (only analyze heavy switching direction, when cosΦ=1).

Main vacuum interrupter V：

$I1 = In = 600\ A$ $\qquad$ $Uw1 = InR = 2400\ V$

Transition vacuum interrupter V1、V2：

$I2 = \frac{1}{2}\ (In + \frac{Ust}{R}) = 550A$ $\qquad$ $Uw2 = Ust + InR = 4400\ V$

The test wad conducted under below conditions:

Contact duty	observed value	calculated value
Ust	2020～2130V	2000V
In	605～650A	600A
Main vacuum interrupter		
I1	605～650A	600A
Uw1	2410V～2490V	2400V
Transition vacuum interrupter		
I2	555～570A	550A
Uw2	4420～4510V	4400

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Arcing time statistic:

Contact		oscillogram	Arcing time (ms)			
			0～10	10.1～20	20.1～30	Max.
Main vacuum interrupter	N	200	200	---	---	9.8
	Percentage (100%)		100	---	---	
Transition vacuum interrupter	N	100*	100	---	---	9.6
	Percentage (100%)		100	---	---	

* only evaluate switching oscillogram in the heavy duty direction

The tap changer runs for 600,000 operations under this duty with a frequency of 350 operations per hour. The oscillogram should be monitored during the whole test. Lift out the tap changer every 50,000 operations for inspection, and change the circulating current direction to simulate the real breaking capacity of main vacuum interrupter. From the oscillogram, we can see the tap changer has good arc-extinguishing performance, and no arc-restriking. The tap changer runs normally after test.

4.3 Breaking capacity test

This test was conducted AFTER Service duty test. The test was conducted for 40 times, each 20 times for positive and negative polarity, record the oscillograms. As we can see from the oscillogram, all operations are good.

The test was done under below duty condition:

Ust= Ui=2000V, In=2Ium=1200A, R=2.0Ω

According to formula in Section 4.2.1, the test was actually performed udder below condition:

Contact duty	observed value	calculated value
Ust	2010~2110V	2000V
In	1215～1260A	1200A
Main vacuum interrupter		
I1	1210～1250A	1200A
Uw1	2450V～2480V	2400V
Transition vacuum interrupter		
I2	1110～1130A	1100A
Uw2	4480～4550V	4400V

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Arcing time:

Contact		oscillogram	Arcing time (ms)			
			0～10.1	10.1～20	20.1～30	Max
Main vacuum interrupter	N	40	38	2	---	10.9
	Percentage (100%)		95	5	---	
Transition vacuum interrupter	N	20*	19	1	---	10.6
	Percentage (100%)		95	5	---	

* Only evaluate switching oscillograms under heavy duty condition.

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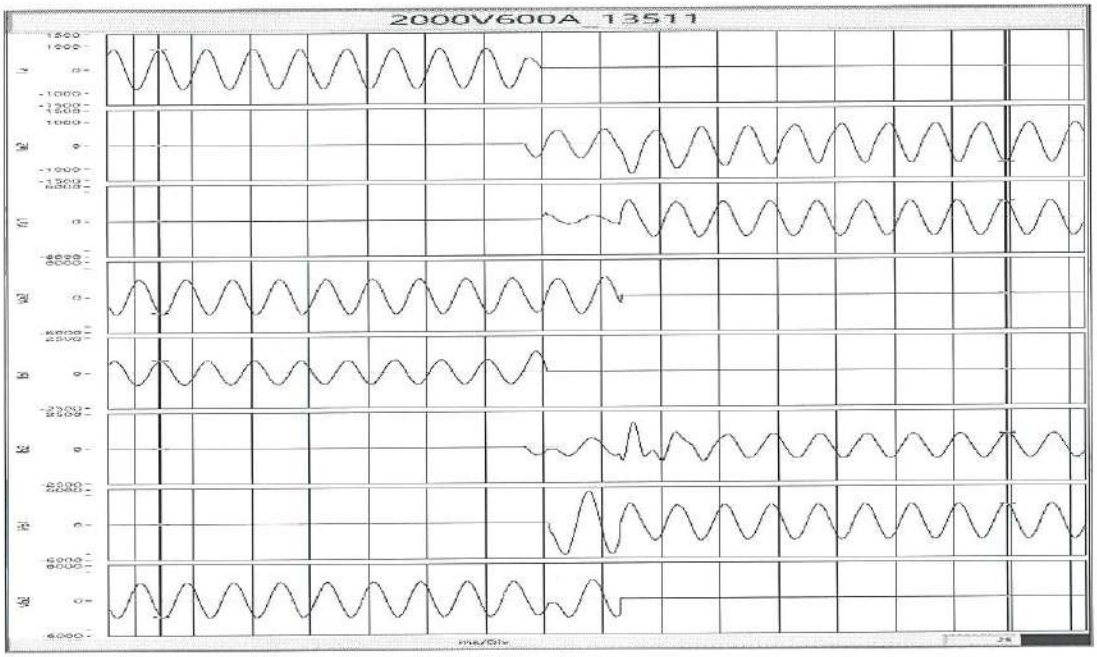
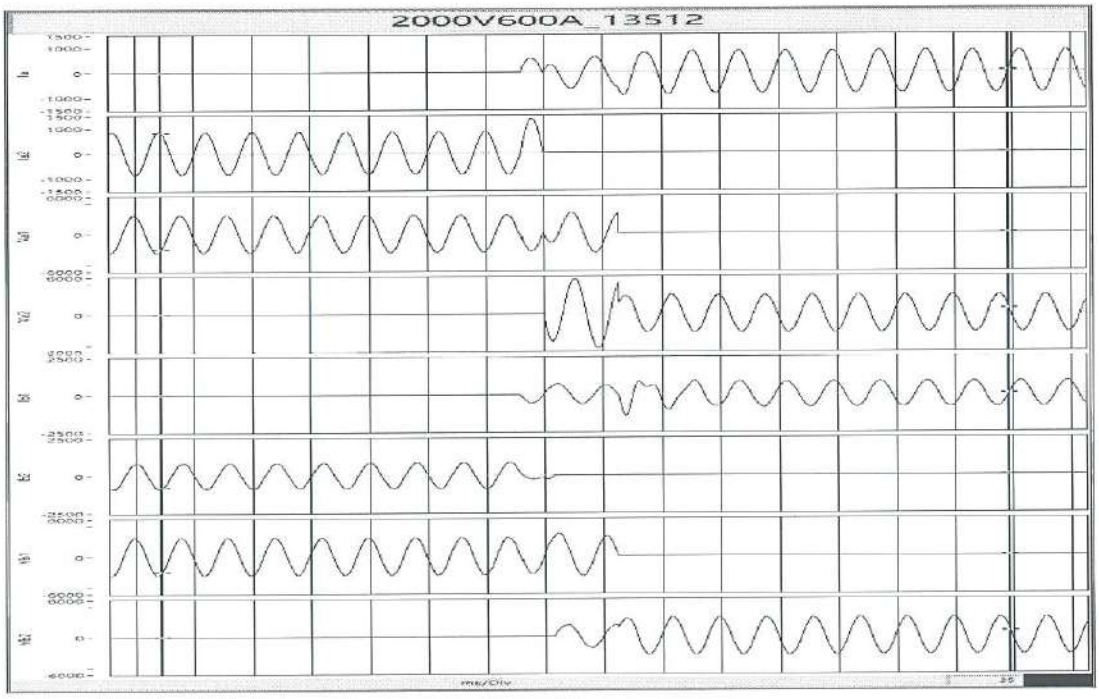
4.4 Switching test oscillograms

Service duty test A→B (heavy duty)



Service duty test B→A (normal duty)



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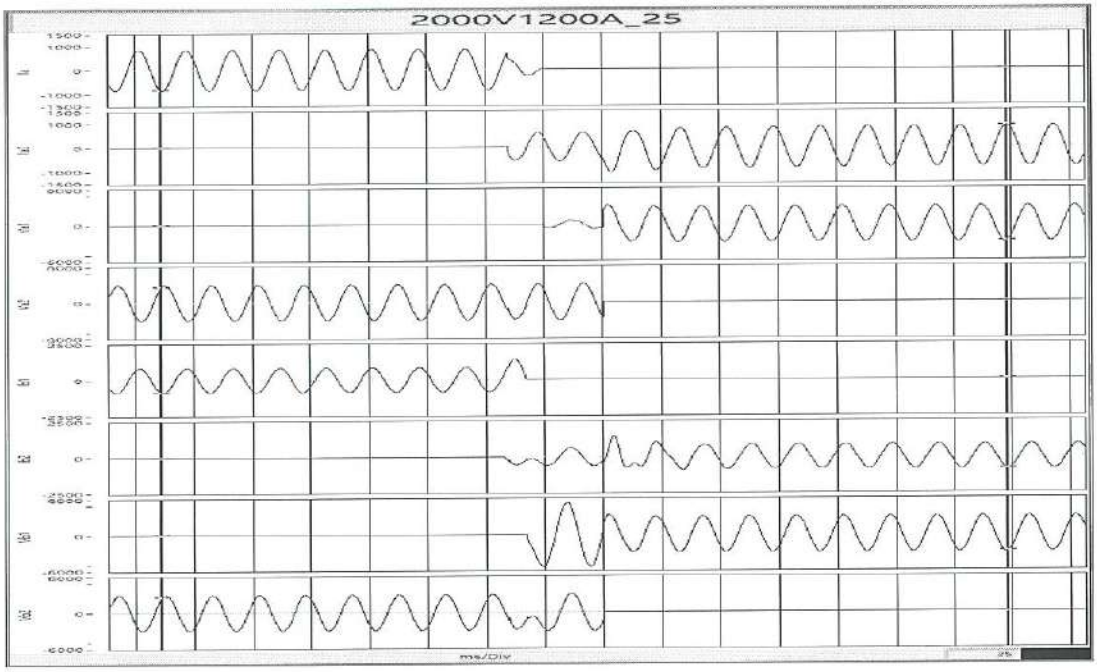
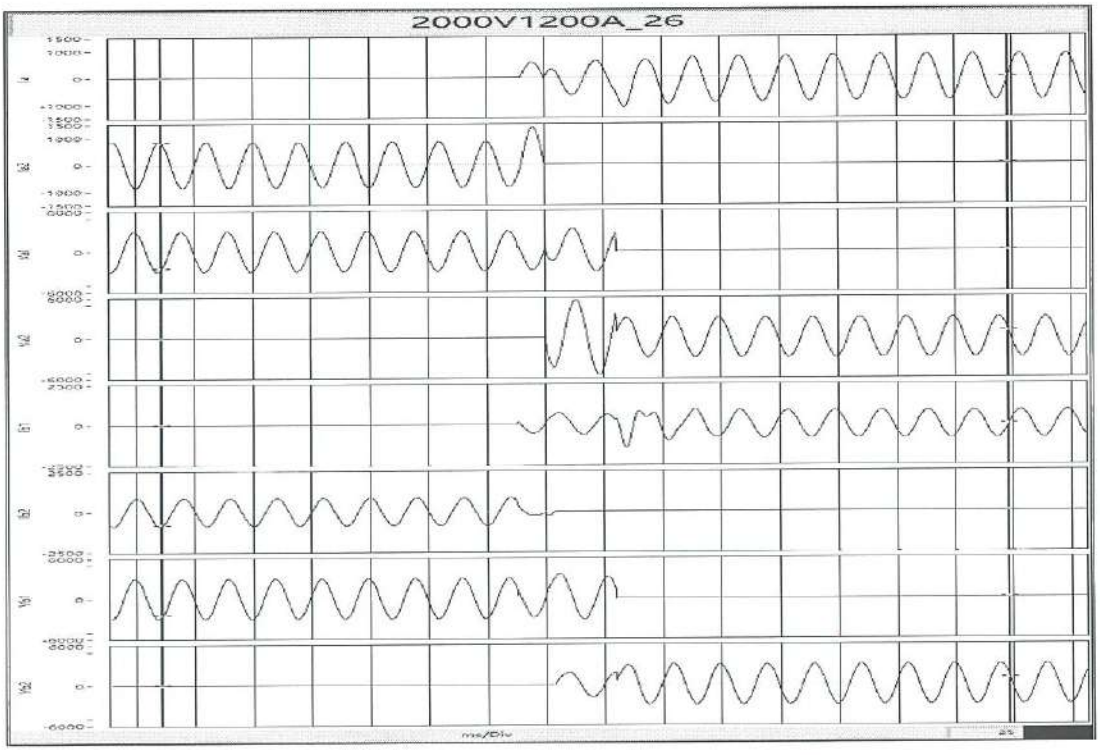
Breaking capacity test A→B (heavy duty)



Breaking capacity test B→A (light duty)



No arc-restrike happened during 360,040 operations. The tap changer still in good conditions and runs well after test.

5. Short circuit current test

5.1 Test parameters

Dynamic current: I1m: 20kA (peak value)

Thermal stable current: Ith: 8kA (Rms),t=3s

3 applications with the interval of 5min

5.2 Test description

This test was performed in transformer oil.

Before test, run the tap changer with no load for several t operations, and choose the current path for short-circuit current test, for tap selector, choose the path of V phase K+ →K0 → V phase tap selector terminal 6.

Since there is no point-on-wave close equipment, the dynamic current and thermal current can not be satisfied in one time, we have to do the test as following: increase the short-circuit current Rms value to make sure it will reach to peak value during three times, and calculate the hold-on time according to below formula:

$$t \geq \frac{3}{n^2} s$$

n: Multiple of increased current

5.3 Short-circuit current test data

No.	Dynamic stable current	Thermal stable current	Hold-on time	Thermal current in 3s	Remarks
1	20.1kA	8.1kA	3.05s	8.1kA	The first time, good
2	20.2kA	8.2kA	3.1s	8.2kA	The second time, good
3	20.5kA	8.2kA	3.1s	8.2kA	The third time, good

After three times of short-circuit current test, the tap changer shows no contact welding and deformation, and no damage or color change on insulation parts. The circuit is in good condition.

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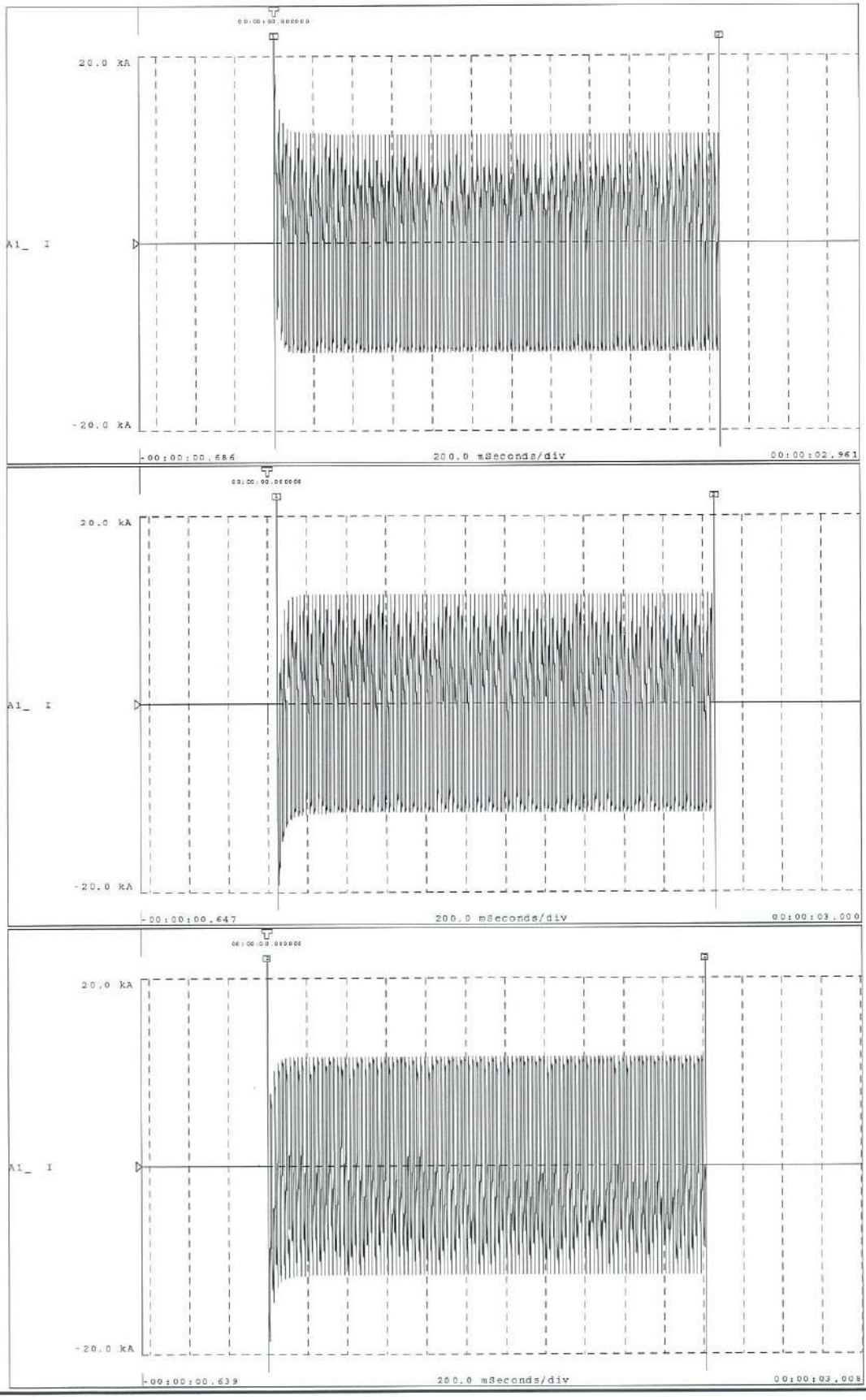
5.4 Short-circuit current test oscillogram



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6. Transition impedance test

6.1 Test description

Under duty condition of Ust=1000V,In=1.5×600A=900A, continuously run the tap changer for half cycle, record the temperature of transition resistor after the last tap changing, the temperature rise ≤350K.

6.2 Test process

The test was performed in transformer oil under room temperature. The test circuit is the same as switching test circuit. Place thermocouple on the transition resistors and the location not less than 25mm below the transition resistors to measure the temperature. Continuously run the tap changer with motor drive unit for half a cycle, immediately measure the max. Temperature rise after the last operation.

6.3 Test result

Tap position / Measuring position	1	2	3	4	5	6	7	8	9	10
Resistor temperature (℃)	23	56	72	95	106	129	147	162	186	203
Oil temperature (℃)	23									

Tap position / Measuring position	11	12	13	14	15	16	17	18	19	20
Resistor temperature (℃)	218	231	243	255	265	276	284	298	310	317
Oil temperature (℃)	23									

Tap position / Measuring position	21	Temperature rise (K)
Resistor temperature (℃)	323	295
Oil temperature (℃)	28	

The max. temperature rise of transition resistor is 295K.

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High-voltage Performance Test Lab

Test Report

Tested by: 吴文华

Prepared by: 章斌

Reviewed by: 方杰斌

Date: 2021.6.12

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Test items and equipments

No.	Test items	Test equipment code	Test equipment name
1	AC withstand voltage test	A105-01	500kV AC withstand voltage test equipment
2	Lightning impulse test	A108-01	1350kV impulse voltage test equipment
3	Partial discharge test	A105-02	600kV corona free AC withstand test equipment
		A210-01	Partial discharge tester
		A210-02	Calibrated impulse signal generator

7. Insulation test

7.1 Test description

Voltage applied	AC withstand voltage (kV/min)	Lightning impulse voltage (1.2/50μs)
To ground	275kV	650kV
Between phases	275kV	650kV
Between max. and min tap	50kV	200kV

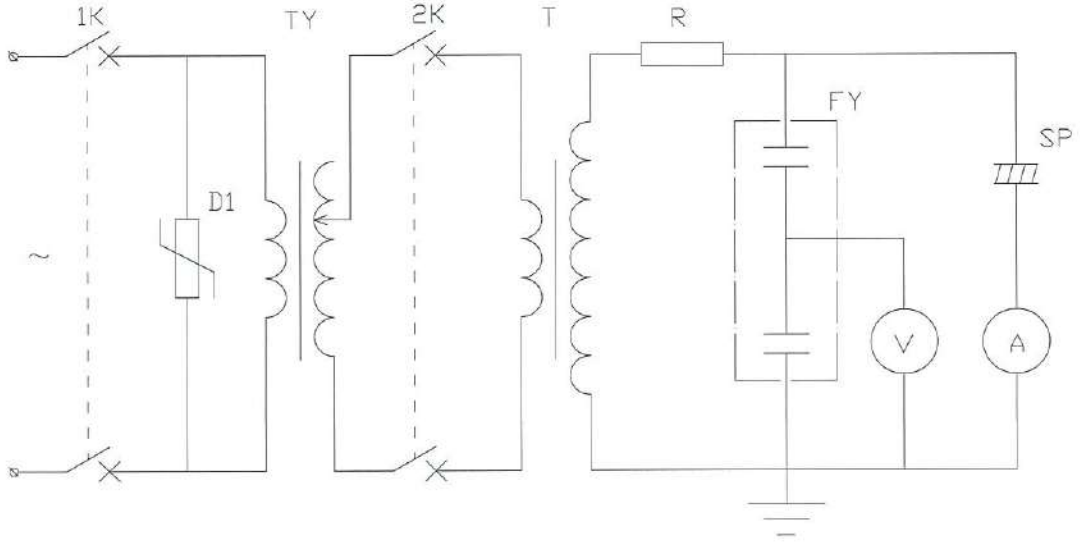
Dry process before insulation test, then immerse the tap changer in the transformer oil with an insulation strength

Not less than 40kV. The tap changer should not have flashover and breakdown.

7.2 Test results

7.2.1 AC withstand voltage test

See below for the test diagram



1K: switch No.1 2K: Switch No.2 TY: Voltage regulator T: Testing transformer R: Protective resistor FY: Capacitive voltage divider SP: Tested sample D1: ZnO Resistor

Apply prescribed voltage on tap changer by power frequency transformer under room temperature, keep for 1minutes. No flashover or breakdown was noticed, test passed.

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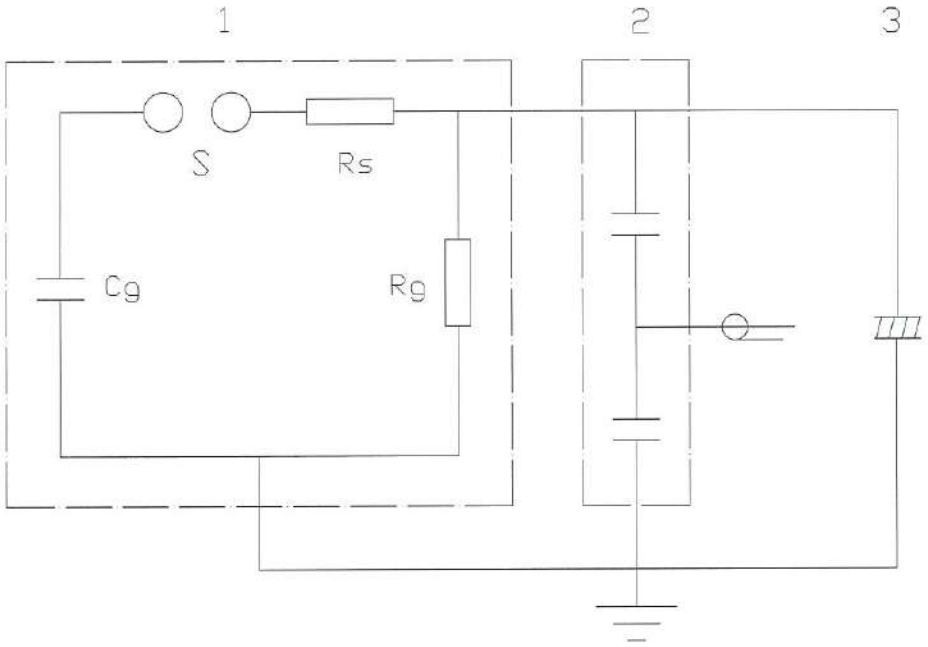
7.2.2 Lightning impulse test

See below for the test diagram



1: impulse voltage generator

2: weak damper voltage divider

3: tested sample

Apply prescribed voltage on the tap changer by impulse voltage generator CDY-1350. Apply three times on each testing position, both positive and negative polarity, no flashover or breakdown was noticed, the test passed.

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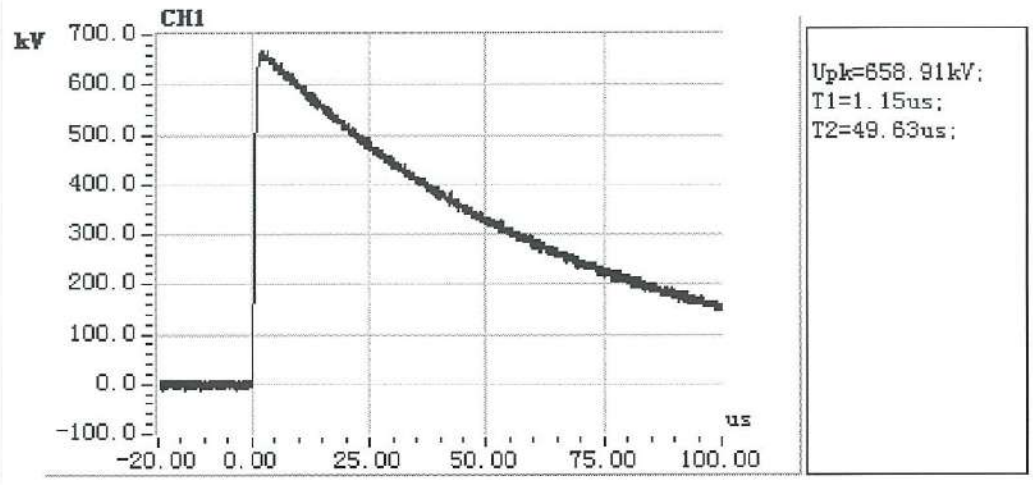
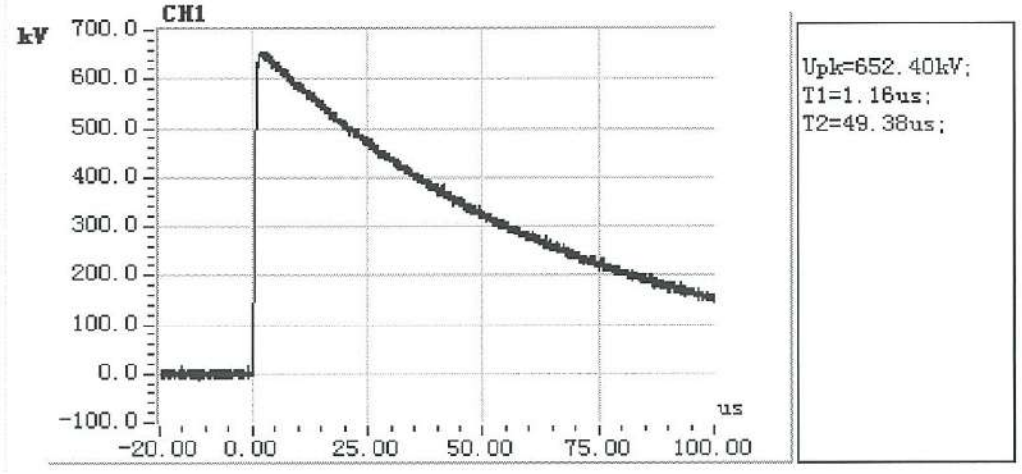
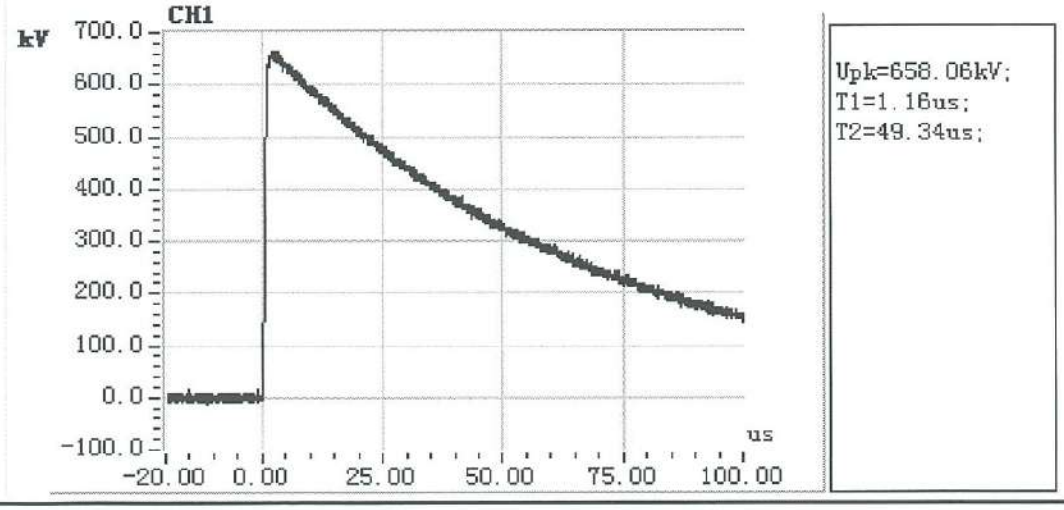
7.2.3 Lightning impulse test waveshapes

Testing Position: To Ground & Between phases 650kV (positive polarity)







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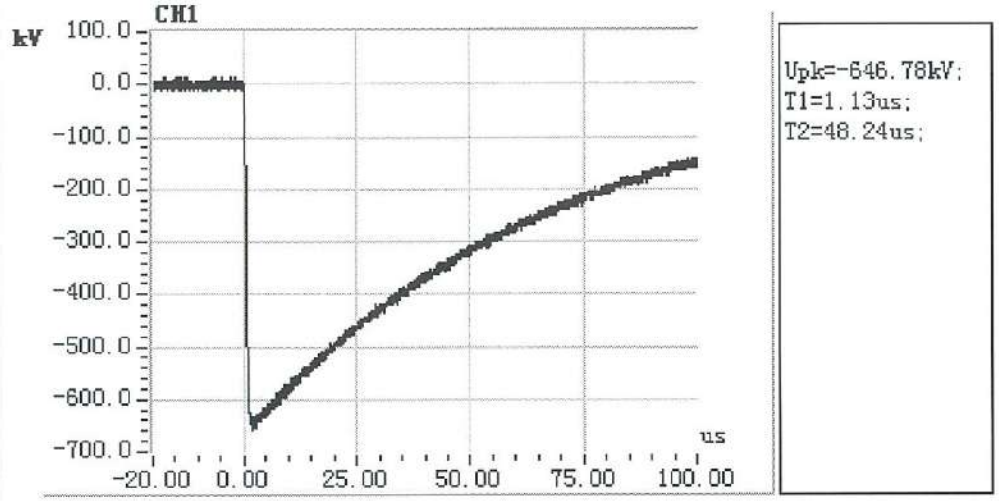
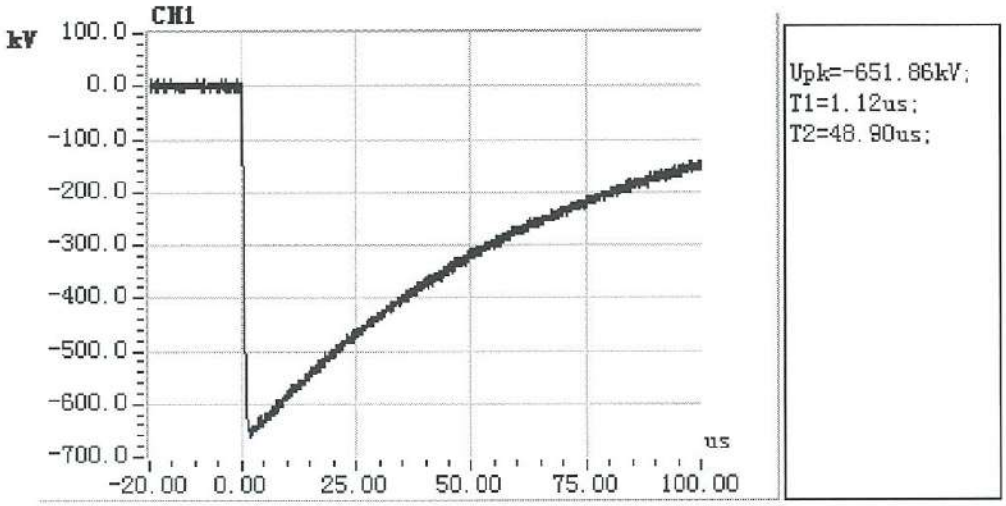
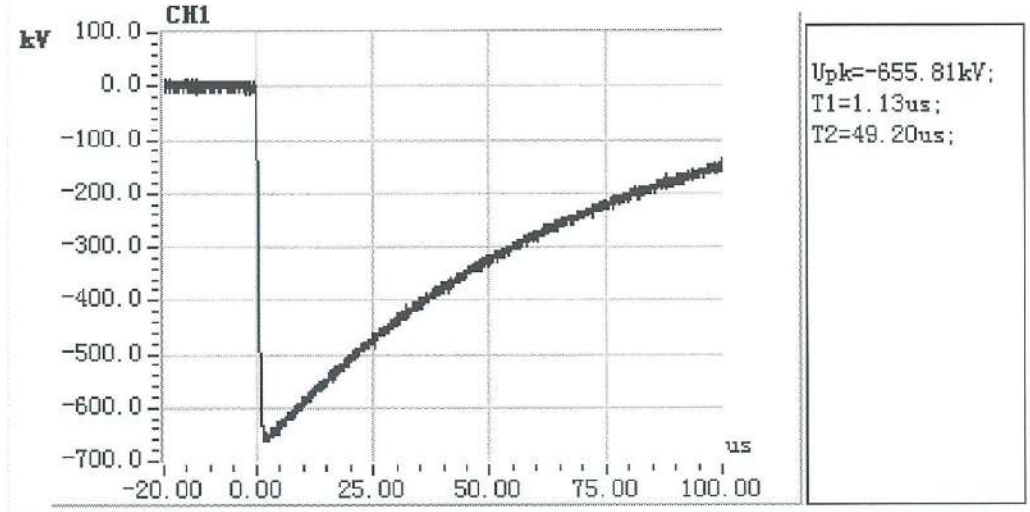
Testing Position: To Ground & Between phases 650kV (negative polarity)







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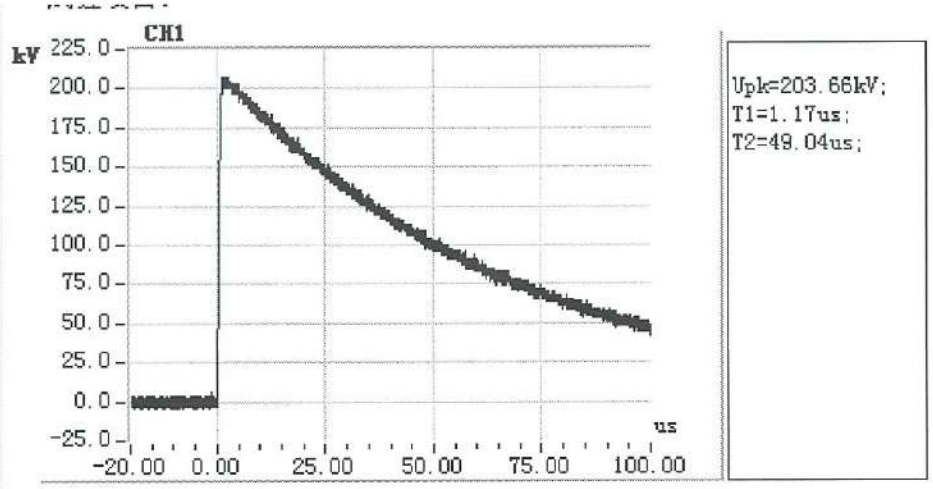
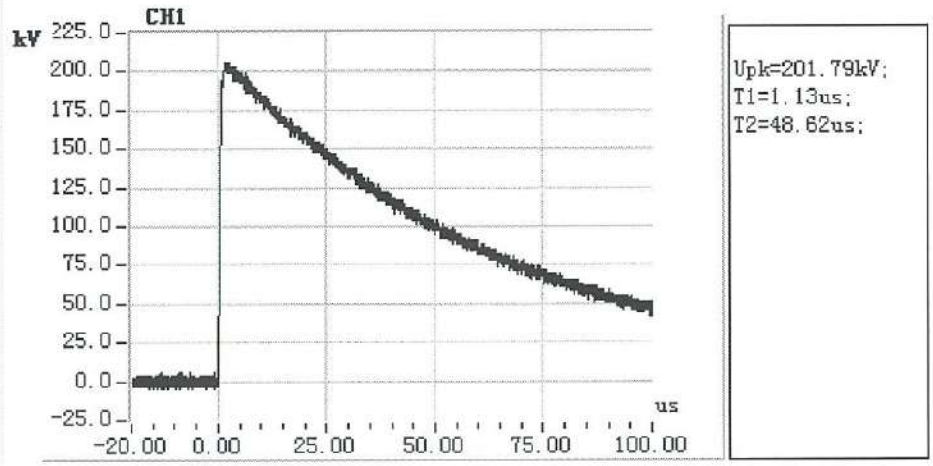
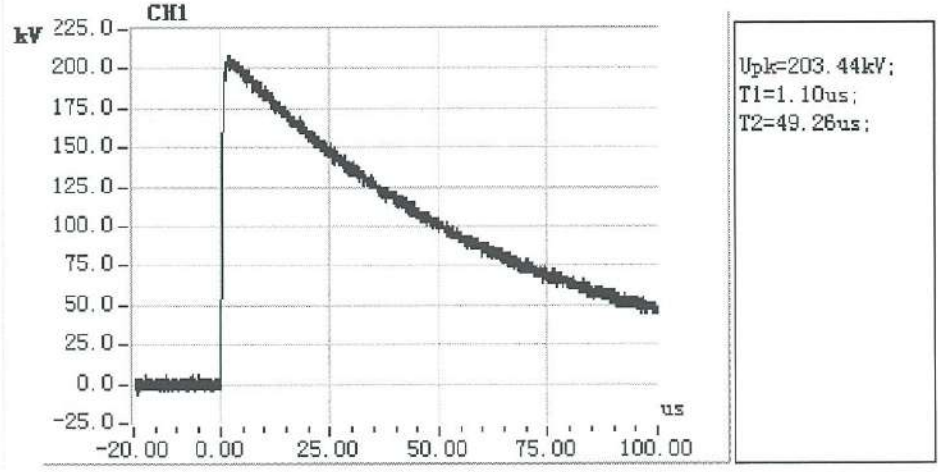
Test position: Between Max. & Min tap 200kV (Positive polarity)







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Test position: Between Max. & Min. tap 200kV (Negative polarity)