HMTC

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CNAS TESTING CNAS L391

Type SHZV On-load Tap Changer

Type Test Report

Testing Commitment No.: Commitment 2016SY022-E

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

Tested Model: SHZVIII-600Y/170D-14273W

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

试验专用章

Tap Changer Testing Center of

Shanghai Huaming Power Equipment Co.,Ltd.

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

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Tap Changer Testing Center of Shanghai Huaming Power Equipment Co., Ltd	**Type Test Report**	**Type SHZVⅢ-600Y/170D-14273W** **On-load tap changer** **Commitment 2016SY022-E**

Test items and results

1 Tap changer performance test

1.1 Measurement of transmission torque

1.2 Contact moving sequence

1.3 Current carrying path resistance: Diverter switch≤165μΩ; tap selector≤70μΩ

2 Mechanical test

2.1 Pressure and vacuum test: No leakage under 8×10^4Pa for 24hours and -133Pa for 1hour.

2.2 Drying

2.3 Mechanical endurance test: 1,500,000 operations

2.4 Low temperature operating test (-25℃): 100 operations

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

2.6 Separate tightness test: Not required for vacuum on-load tap changer

3 Contact temperature rise test: under the current of 1200A，max. temperature rise value of diverter switch is 15.7K，max. temperature rise value of tap selector is 16.3K.

4 Switching test

4.1 Service duty test

Under first load point: $U_{st} = U_{im} = 3000V$ $I_n = I_{um} = 800A$ N=240,000 operations

Under second load point: $U_{st} = U_{im} = 4000V$，$I_n = 750A$ N=200,610 operations

4.2 Breaking capacity test

$U_{st} = U_{im} = 3000V$ $I_n = 2I_{um} = 800A$ N=40 operations

Contact electrical life＞600,000 operations

5 Short-circuit current test:

Thermal: I_{th} =12kA (r.m.s); t =3s; Dynamic: I_{1m}=30kA (peak value); N=3 applications

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6 Transition impedance test

7 Dielectric test:

7.1 Power frequency withstand voltage test

Diverter switch: to ground: 325kV;

(1min) between two adjacent taps: 20kV

Tap selector: between max. and min. taps: 105kV;

Between two adjacent taps: 30kV (1min)

7.2 Lightning impulse withstand voltage test

Diverter switch: to ground: 750kV

(1.2/50μs) between two adjacent taps: ≤90kV, no response

≥130kV, 100% response

Tap selector: between max. and min. taps: 490kV

(1.2/50μs) between two adjacent taps: 150kV

Test standard	**JB/T 8314-2008** ***Tap Changer Testing Guide*** **GB 10230.1-2007** ***Tap Changer Part 1: Performance requirement and test methods*** **IEC 60214-1-2014** ***Tap changers Part 1:Performance requirement and test methods*** ***Type SHZV On-load Tap Changer Testing Principles of Shanghai Huaming Power Equipment Co.,Ltd.***
Test conclusion	Test samples passed tests from item 1 to item 7, qualified.

Edited by: 单斌 Date: 2016.12.19	Revised by: 邵斌杰 Date: 2016.12.19	Approved by: Date: 2016.12.19

Tap Changer Testing Center of Shanghai Huaming Power Equipment Co., Ltd	Type test report	Type SHZVIII-600Y/170D-14273W On-load tap changer Commitment 2016SY022-E

Content

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		Commitment 2016SY022-E

0 General

0.1 Basic information of the test

0.1.1 Basic information of the testing sample

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

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

Model of the tap changer: SHZV-600Y/170D-14273W

Name and Model of the motor drive unit: CMA7

Sample No of motor drive unit.:E-SHZV16031

Series No. of tap changer: Sample E-SHZV16031

Manufacturer: Shanghai Huaming Power Equipment Co., Ltd.

0.1.2 Test category: Type Test

0.1.3 Test plan:

Sample E-SHZV16031: Tap changer performance test (including measurement of transmission torque, measurement of contact moving sequence, measurement of current carrying path resistance), mechanical test, dielectric test, contact temperature rise test, switching test, short circuit current test, transition impedance test and so on.

0.1.4 Test date:Apr.15.2016~ Nov.24.2016

0.1.5 Report date:Dec.15.2016

0.2 Testing sample Parameter

Tap Changer Model:	SHZVIII-600Y/170D-14273W
Insulating to ground:	170kV
Tap position:	25
Max. rated step voltage :	4000V
Max. rated through-current:	600A
Transition resistance:	R=5.0Ω
Phase:	3 phases
Frequency:	50Hz

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Mechanical performance lab

Test report

Tested by: 祁斌杰

Edited by: 单斌

Approved by: 朱志刚

Date: 2016.12.19

Tap Changer Testing Center of Shanghai Huaming Power Equipment Co., Ltd	Type test report	Type SHZVIII-600Y/170D-14273W On-load tap changer
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Test item and devices:

No.	Testing Item	Testing devices Code	Name of the testing devices
1	Performance test		
	Operating toque	A232-01	Torque measurement instrument
	Contact moving sequence	A209-02	On load tap changer testing system
	Current carrying circuit resistance	A204-04	Circuit resistance measurement instrument
2	Mechanical test		
	Pressure and vacuum test	A206-01	Pressure meter
		A206-05	Vacuum meter
	Mechanical endurance test	A111-01	Hot oil testing device
	-25℃ low temperature test	A112-01	16m^3 low temperature test chamber
	Separate tightness test	A113-01	Tightness test device
		A217-01	Gas chromatograph

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1 Tap changer performance test

1.1 Transmission operating toque

(Unit: N·m)

Measuring positions \ Measurement		Position of Max. torque	Measured value	Remark
Tap changer	Diverter switch	——	60	Diverter switch head
	Tap selector	12→13B 14→13B	165	Tap selector head
Motor drive unit	Hand crank	1→25	12	With whole set tap changer
	Transmission shaft	1→25	23	Locked by simulative load

Remark: Above mentioned tap selector includes the reversing changer-over selector.

1.2 Measurement of contact moving sequence

The test can be carried by acoustical and oscillographic method. During the test, connect the tap changer according to normal situation and immerse it in the transformer oil. Operate the tap changer through motor drive unit by hand crank and record contact moving sequence.

1.2.1 Measurement of tap selector contact moving sequence

Contact moving sequence is represented by the hand crank revolutions of the motor drive unit:

Movement of contacts		Revolution of hand crank	
		1→N	N→1
Start operation		0	0
Tap selector	Moving contact leaves fixed contact	9	$9\frac{1}{2}$
	Moving contact connects with the adjacent fixed contact	$21\frac{1}{2}$	22
Changer-over selector	Moving contact leaves fixed contact	13	$13\frac{1}{2}$
	Moving contact connects with the adjacent fixed contact	18	$18\frac{1}{2}$
Tap changer operates		$27\frac{1}{2}$	28
Finish one tap-change operation		33	33
The revolutions from first (last) tap position to the mechanical limitation		3	3

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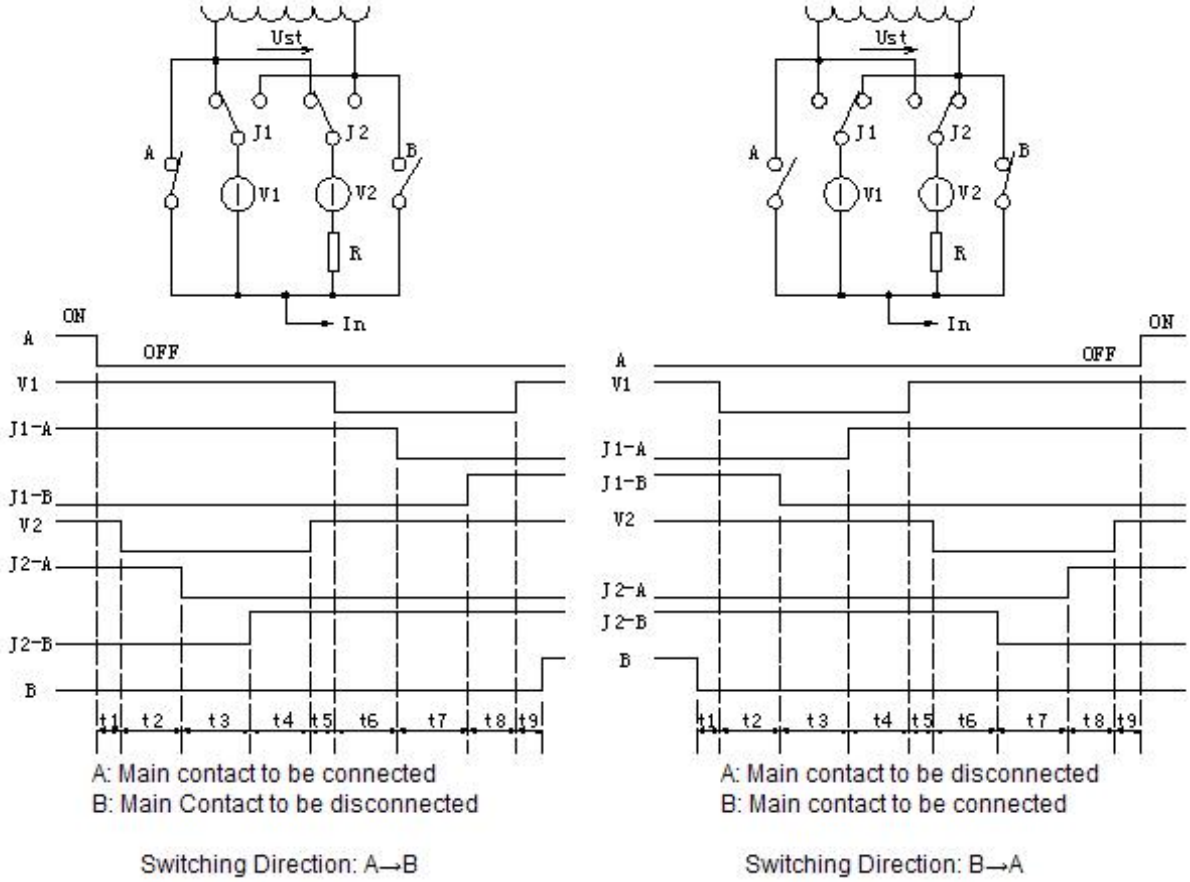
1.2.2 Measurement of diverter switch contact moving sequence

The moving speed of diverter switch is very fast, so oscillographic method is adopted to measure the sequence. Following are Circuit oscillogram and Oscillograms of contact:



R: Transition Resistor; V_1: Main Vacuum Interrupter; V_2: Transition vacuum interrupter;
J_1:Isolating contact with V_1; J_2: Isolating contact with V_2;

t_1:2~4ms Time interval between the opening of the main contact A (B) and opening time of the vacuum interrupter V_2 (V_1);

t_2:12~16ms Time for extinguishing the arc in the vacuum interrupter V_2 (V_1);

t_3:12~16ms Breaking time of isolating contact J_2 (J_1);

t_4:8~15ms The time interval between closing of isolating contact and the vacuum interrupter V_2 (V_1);

t_5:2~5ms Time interval of the middle position.

t_6:12~16ms Time for extinguishing the arc in the vacuum interrupter V_1 (V_2);

t_7:8~12ms Breaking time of isolating Contact J_1 (J_2)

t_8:4~10ms The time interval between closing of isolating contact and the vacuum interrupter V_1 (V_2);

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t_9:2~4ms The time interval between closing of the vacuum interrupter V_1 (V_2) and the main contact B (A)

Through the analysis on the recorded oscillograms, it indicated that the each phase of the tap changer was in normal switching sequence. The extracted oscillograms of switching sequence of phase U as below and the actual measured time for each stage is as following::

	A→B	B→A
t_1	2.8ms	3.4ms
t_2	12.6ms	13.5ms
t_3	13.5ms	14ms
t_4	13ms	11.5ms
t_5	4.1ms	3.3ms
t_6	13.5ms	12.8ms
t_7	11ms	10.4ms
t_8	6.1ms	4.8ms
t_9	2.9ms	2.6ms
	t6+t7+t8	t2+t3+t4
Switching time	30.6ms	39ms

Actual DC oscillograms

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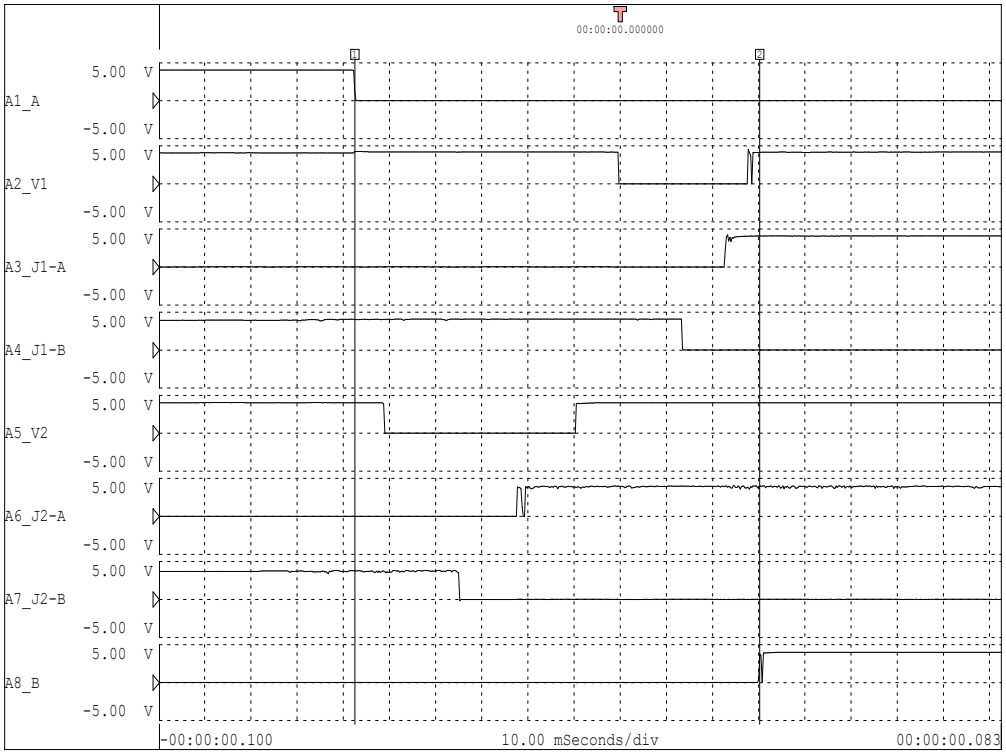
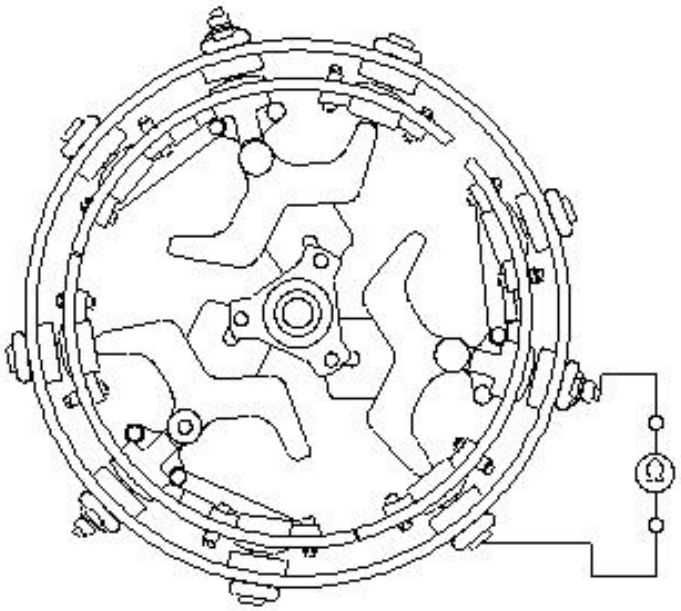
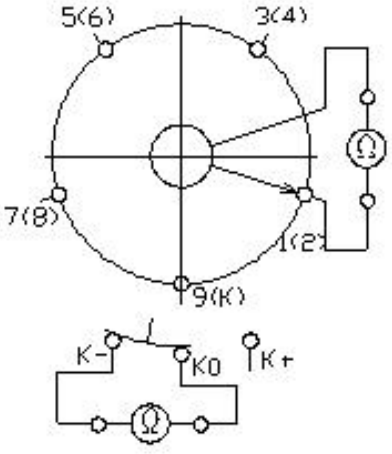


1.3 Measurement of current carrying path resistance

1.3.1 Circuit diagram of current carrying path resistance measurement



Diverter Switch



Tap Selector

1.3.2 Actual data measured as shown in the table:

Circuit of tap selector contacts: two contacts in each phase in series connection							
Odd	U	V	W	Even	U	V	W

1	39	41	40	2	42	37	40
3	42	40	39	4	41	36	41
5	49	39	47	6	46	44	44
7	39	39	41	8	37	39	38
9	44	38	39	10	42	39	47
11	42	40	40	12	40	36	40
				K	70	58	63
Circuit of diverter switch contacts: main contact, connection contact and neutral point contact in series connection.				Circuit of reversing changer-over selector contacts: two contacts in series connection.			
Position	A-U	A-V	A-W	K	U	V	W
Odd	140	165	130	K+	84	81	79
Even	120	150	140	K—	80	65	75

Remark: All the data are measured by each current carrying path according to diverter switch, tap selector and change-over selector.

1.3.3 Evaluation on contact resistance

According to the requirement of IEC60214-1:2014 and GB/T10230.2-2007 Tap Changer Part 2: Application Guide clause 9.2.2: As a guideline, if the contact loss (equals to the product of the contact resistance and square of the current) is higher than 100W (or when the rated current is very high, this value maybe smaller), it will cause overheat. For the tap changers with max. rated through-current 1000A, the permissible value of contact resistance should be less than 70μΩ. According to the circuit resistance shown in the table, we can get the contact resistance value:

Contact resistance of moving and fixed contacts=Rmax. / No. of contacts in series connection

Tap selector contact resistance R_{max} = 70/2 = 35μΩ

Changer-over selector contact resistance R_{max} = 84/2 = 42μΩ

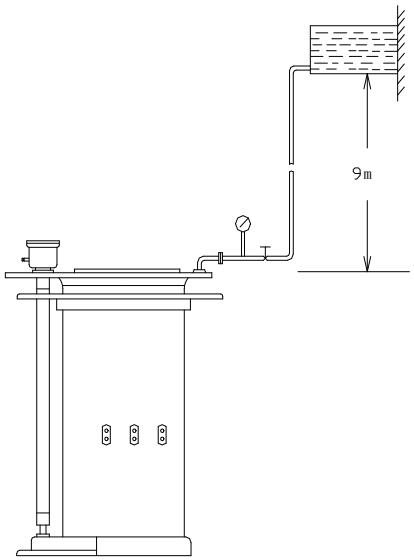
Diverter switch contact resistance R_{max}=165/3= 55μΩ

Through above calculation, we can get the contact resistance value which is smaller than 70μΩ and meets the requirement.

2 Mechanical test

2.1 Pressure and vacuum test

Test description: The oil compartment of the testing tap changer should sustain the pressure and vacuum test under 8×10^4Pa. As the figure below.



Fill the oil compartment fully with clean transformer oil firstly, then connect it with an oil tank of 9m height, with this oil-column height it forms a pressure about 8×10^4Pa and lasts for 24 hours, and then check its sealing parts as the head flange, top cover, cylinder bottom and contact., etc. No leakage was found.

Drain-off transformer oil which is in the oil compartment completely. Connect the oil compartment of tap changer with vacuum pump extracting the vacuum to 133Pa and lasts for 1 hour, the vacuum degree has no obvious change. No mechanical deformation was found in the top cover of tap changer.

2.2 Drying

The tap changer was put into the oven room with a temperature of about 60℃,and heated in the air under atmospheric pressure. The rate of temperature rise is 10 ℃/h and the max. heating temperature is 110℃. Drying procedure was finished after 20 hours.

2.3 Mechanical endurance test

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

2) Test arrangement:

Assembled the selector switch and CMA7 motor drive unit in normal situation and immersed them in a test tank equipped with a temperature control heating device. Cyclically change the transformer oil in the test tank under 80℃ and lower temperature everyday (heating 10 hours per day). Circulate the oil in the oil compartment and external test tank with the oil pump to make more than half operations of the test sample be carried in the hot oil.

Totally performed 1,500,532 operations including 1,100,000 operations on all tap positions. In order to operate the reversing changer-over selector at least 150,000 times (change the reversing changer-over selector every 18 operations), another 400,000 operations were performed during the tap position 7→8→9 (change the reversing changer-over selector every 4 operations). The operation frequency during the test is around 500 operations/hr.

Every 100,000 operations, lifted the insert to check, recorded the sequence oscillograms, checked every vacuum interrupter by 2500V megohmmeter and fastened the fasteners. After 1,500,500 operations, inspected the tap changer under disassembled condition and found there were no phenomena of break of mechanical parts or components and over-wear. And the tap changer still can be operated in normal situation.

3) DC oscillograms of mechanical life test:

At the beginning of mechanical life test: A→B

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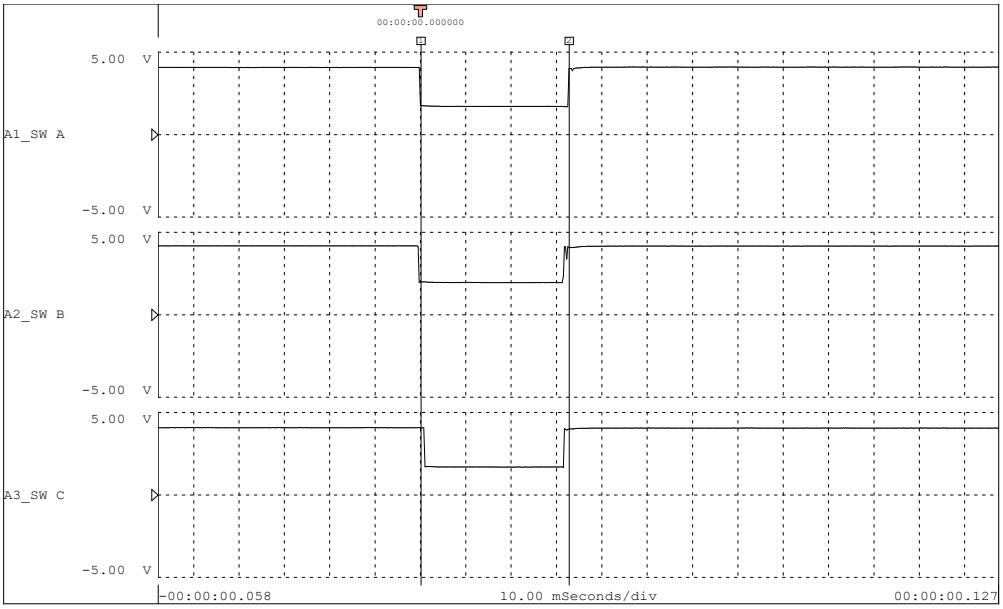
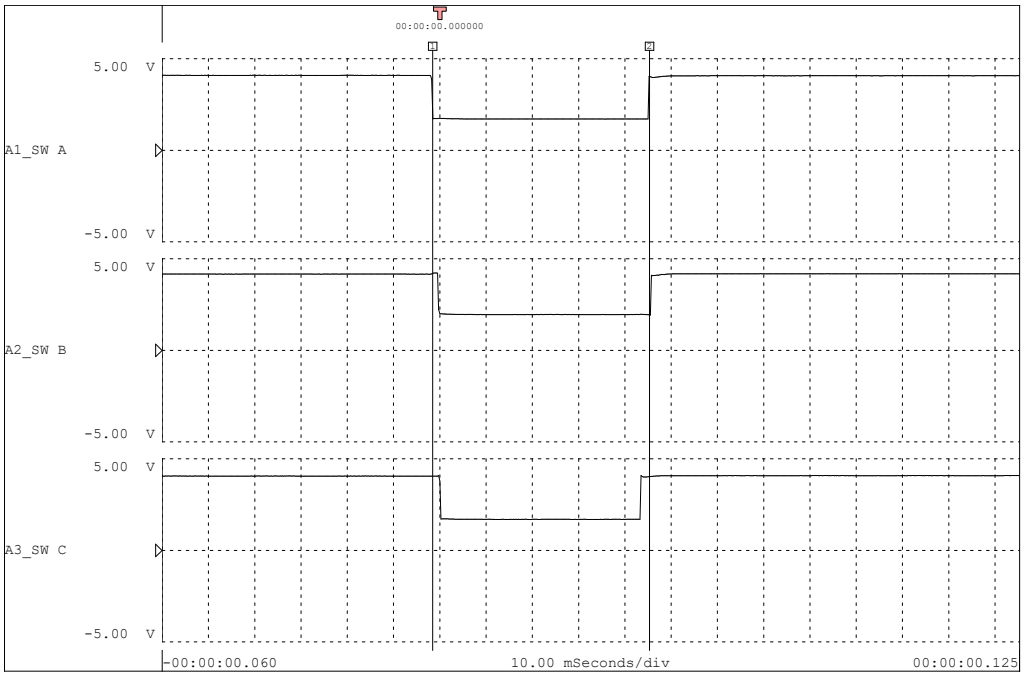


B→A



After mechanical life test: A→B

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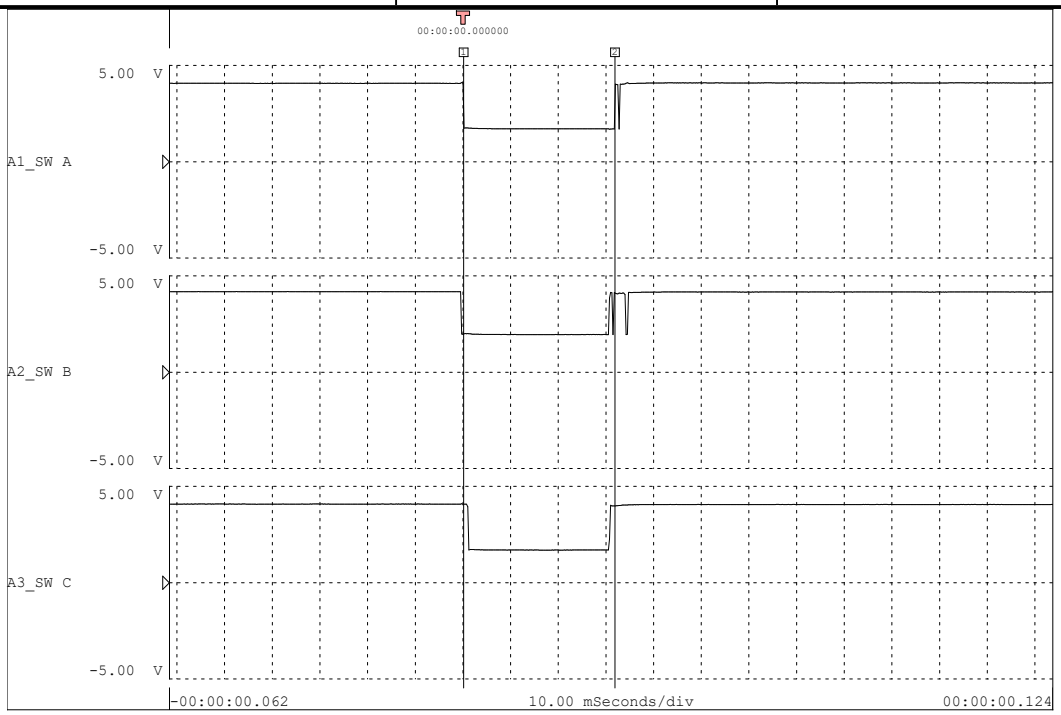
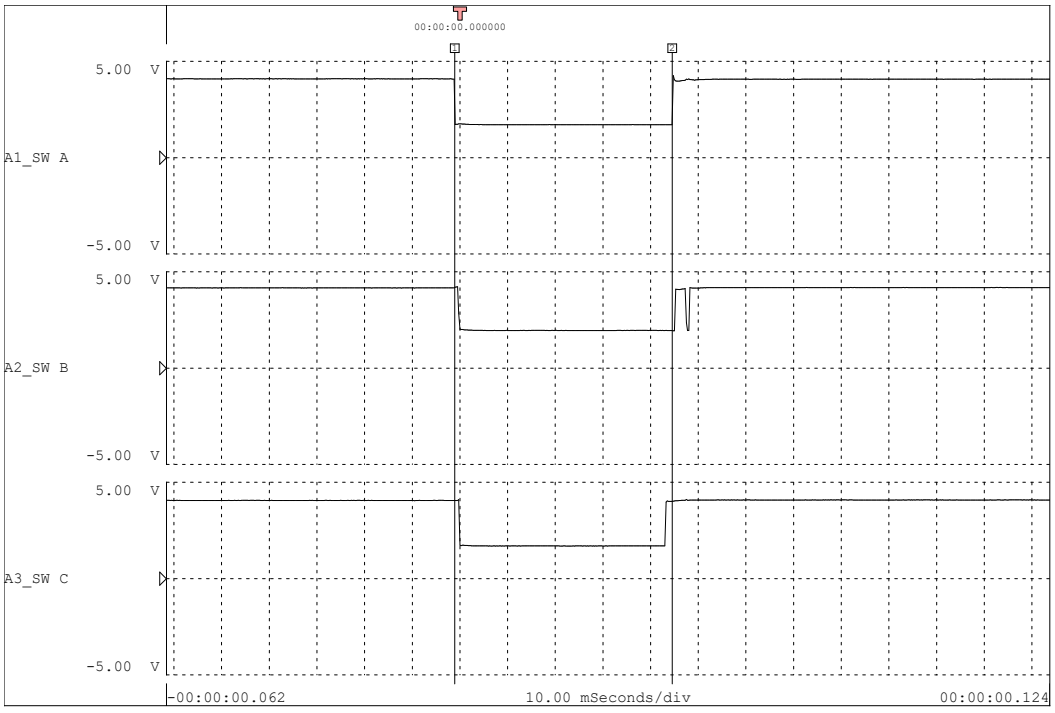


B→A



2.4 Low temperature operation test (-25℃)

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2.4.1Test requirements: 100 operations under the temperature of -25℃

2.4.1.1 Test procedure:

During mechanical endurance test, low temperature test must be carried out. Mounted the diverter switch on a movable test rack and immersed whole set in a low temperature test chamber with the volume of 16m^3. Located the thermocouples around the energy-accumulating mechanism, contact mechanism and transition resistor, etc to check the temperature of those parts. When the temperature of those parts reached -25℃±3℃, operated the tap changer with motor drive unit for 100 times and recorded the switching sequence oscillograms. Comparing these oscillograms with what's recorded in the normal temperature. Except the switching time is a litter longer, tap changer can finish operation reliably under low temperature

The procedure of low temperature operations test as following:

(1) Before test: performed 10 operations under ambient temperature and recorded oscillograms for every operation.

(2) During test: performed 100 operations under -25℃ and recorded oscillograms for every operation.

(3) After test: performed 10 operations after the temperature increased back and recorded oscillograms for every operation.

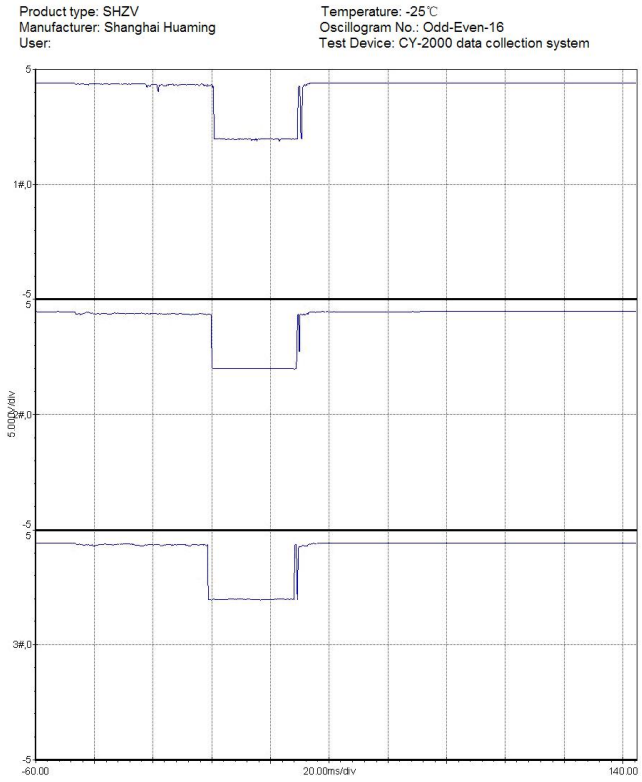
2.4.1.2 Tested data as following: (unit: ℃)

No.	Ambient temperature	Low temperature	Recover to ambient temperature
Temperature in the chamber (℃)	+21	-25	+19
Temperature of the diverter switch head	+21	-24.5	+19
Temperature of energy-accumulating mechanism	+21	-25.3	+19
Temperature of contact mechanism	+21	-25.3	+19
Temperature of transition resistor	+21	-25.1	+19
Switching time (ms)	30~35 37~45	30~40 45~55	30~36 39~45
Switching direction	A→B B→A	A→B B→A	A→B B→A

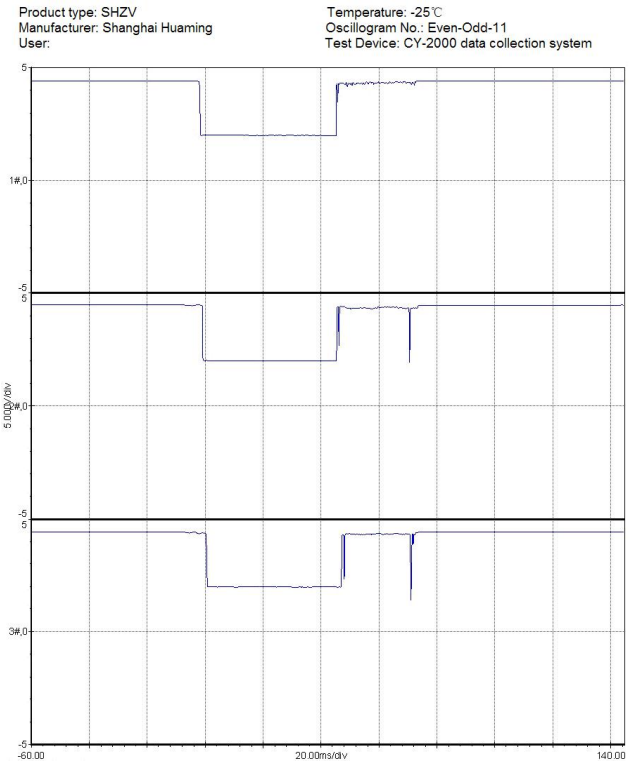
2.4.1.3 Oscillograms of low temperature operation test

Tap Changer Testing Center of Shanghai Huaming Power Equipment Co., Ltd	Type test report	Type SHZVIII-600Y/170D-14273W On-load tap changer Commitment 2016SY022-E

Under low temperature: A→B

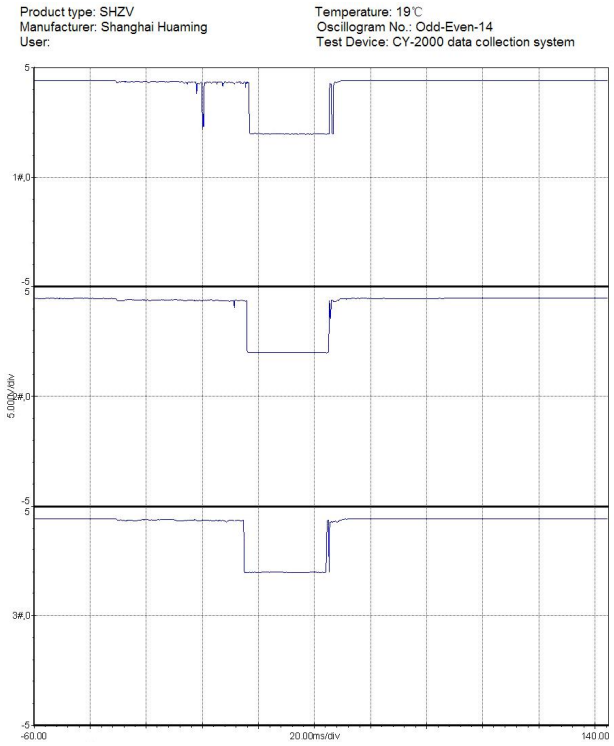


Under low temperature: B→A

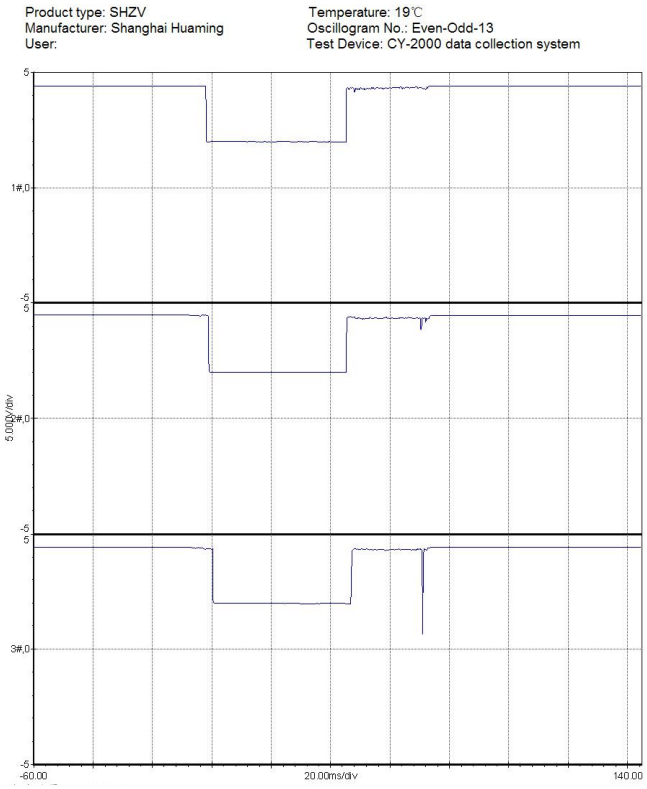


Return to ambient temperature: A→B

Tap Changer Testing Center of Shanghai Huaming Power Equipment Co., Ltd	Type test report	Type SHZVIII-600Y/170D-14273W On-load tap changer Commitment 2016SY022-E



Return to the ambient temperature: B→A



2.5 Operating test in 115℃ hot oil

2.5.1 Test requirement:

After 1,500,532 mechanical life test, immerse the tap changer in 115℃ hot oil and operate it 100 times.

2.5.2 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.

2.5.3 Test result:

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

2.6 Separate tightness test: Not required for vacuum On-load tap changer

2.7 Inspection result under disassembled condition after mechanical life test

After more than 1,500,6320 operations mechanical life test, check and measure the diverter switch and tap selector carefully. The result as following:

2.7.1 Inspection result of tap changer

No.	Inspection content	Result
1	Vacuum interrupter	No leakage, no damage
2	Fastener	No fracture, some bolts on the sectional contact shell are loosing
3	Braided wire	Scuff phenomena on the braided wire of output contacts
4	Mechanical isolation contact	Wearing on the surface is normal.
5	Contact pressure springs	No damage, no deformation, no break
6	Mechanical operating pieces	Operate flexibly, no stuck, mechanical parts act in concert with each other.
7	Energy accumulating mechanism	No damage, no deformation, no breaking on the energy accumulating springs and claw restoration springs. There is about 0.8mm wear on the claw restoration side.
8	Transition resistor	No fracture found on the insulating frame of the transition resistor

		and pottery clips, no fracture or loose weld found on the connection parts. The actual measured resistance value was qualified.
9	Insulating parts	Normal, no crack and damage.
10	Wearing debris	Found a little metallic wearing debris on the bottom of oil compartment

2.7.2 Inspection record of tap selector and changer-over selector

No	Inspection content of tap selector	Result
1	Fasteners	No loose, locked well, the insulating pole is tight, no loose.
2	Equipotential connection braided wire	No fracture and damage
3	Moving and fix arcing contacts	No strike trace, mechanical wearing on the surface is normal; fluctuation of moving contact bridge is normal
4	Contact pressure spring	No damage, no deformation and no fracture
5	Geneva mechanism	Operate flexibly, no stuck, mechanical parts act in concert with each other.
6	Wearing on moving parts	Surface hardening (such as nitridizing) on every moving part, wearing is normal or less.
7	Insulating parts	Normal, no crack and damage.
8	Wearing debris	Found a little metallic wearing debris on the bottom of tap selector

2.7.3 Test conclusion:

After 1,500,632 operations of mechanical test, we found the diverter switch and tap selector were in good conditions and had much more margin.

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Electrical performance Lab

Test report

Tested by: 邵斌杰

Edited by: 章斌

Approved by:

Date: 2016.12.1

Tap Changer Testing Center of Shanghai Huaming Power Equipment Co., Ltd	Type test report	Type SHZVIII-600Y/170D-14273W On-load tap changer
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Test items and devices:

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

3 Contact temperature rise test

Tap Changer Testing Center of Shanghai Huaming Power Equipment Co., Ltd	Type test report	Type SHZVIII-600Y/170D-14273W On-load tap changer Commitment 2016SY022-E

3.1 Test description

The test was carried in the transformer oil. Applied It=1.2In=1200A to the tap changer and measured the temperature rise of the contacts by thermocouples. Chose the test circuit according to the measured value of the circuit resistance and located the thermocouples on the contacts in series connection in the circuit. The location of the thermocouples should be near the contacting point of the contact and the ambient temperature was measured not less than 25mm under the contacting point. When the variance temperature of the contact and the ambient was not over 1K per hour within 2 hours, the temperature was thought to be stabilized. The required test value should be less than 20K

All leads carried the load were with the suitable section for 1200A

3.2 Measurement of circuit resistance

See the table as below:

unit: μΩ

Circuit of tap selector contacts: two contacts in each phase in series connection							
Odd	U	V	W	Even	U	V	W
1	39	41	40	2	42	37	40
3	42	40	39	4	41	36	41
5	49	39	47	6	46	44	44
7	39	39	41	8	37	39	38
9	44	38	39	10	42	39	47
11	42	40	40	12	40	36	40
				K	70	58	63
Circuit of diverter switch contacts: main contact, connection contact and neutral point contact in series connection.				Circuit of reversing changer-over selector contacts: two contacts in series connection			
Position	A-U	A-V	A-W	Position	U	V	W
Odd	140	165	130	K+	84	81	79

Even	120	150	140	K—	80	65	75

Remark: Tested diverter switch and tap selector separately. According to the above test result, for diverter switch, chose neutral point → odd side of phase V as the test path, chose K+ of tap selector→ double deck conduct ring of phase V → K of phase V as the test path, and located the thermocouples on the contacts in series connection to measure the temperature rise.

3.3 Circuit diagram of contact temperature rise test

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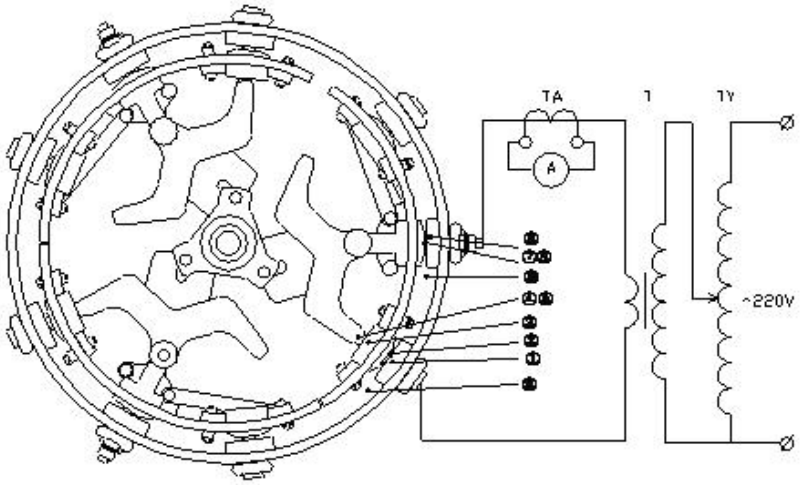
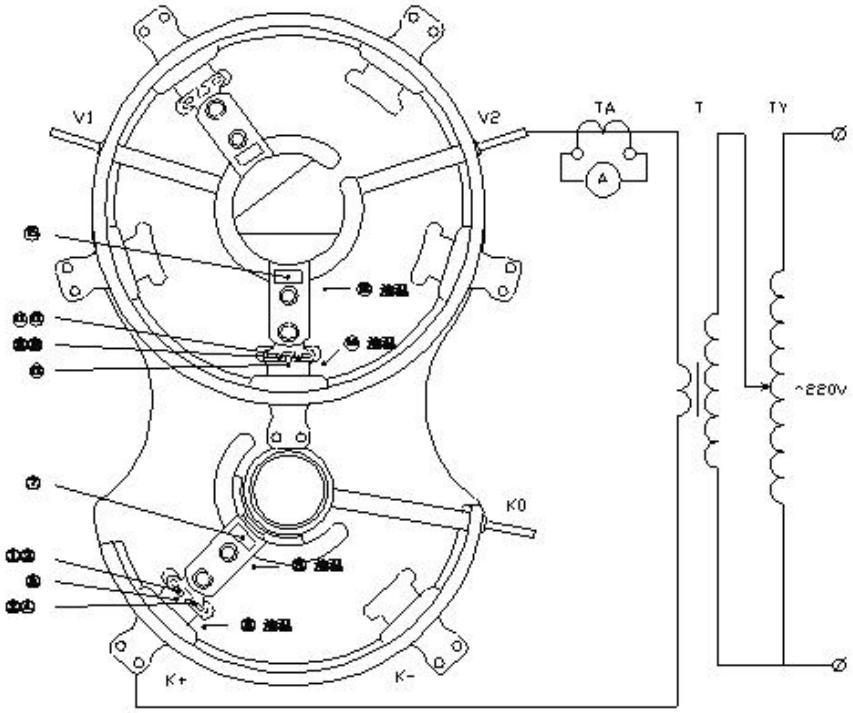


Diverter Switch



Tap Selector

3.4 Result of contact temperature rise test

s.n	Measuring point		The stable temperature-rise (K)
1	ер s	On fixed contact of neutral point	15.7

2		Under fixed contact of neutral point	14.5
3		On fixed contact of phase U2	14.2
4		Under fixed contact of phase U2	12.7
5		Moving contact of phase U2	12.2
13	Change-over selector	Left side of change-over selector moving contact	9.7
14		Right side of change-over selector moving contact	9.9
15		Grading ring of change-over selector	6.3
16		Joint of grading ring	8.1
23	Tap selector	Left upper of moving contact of tap selector	9.2
24		Lower left of moving contact of tap selector	7.7
25		Right side of moving contact of tap selector	8.6
26		Grading ring of tap selector	8.6

4 Switching test

Switching test consists of service duty switching test and breaking capacity test.

4.1 Test description

Testing OLTC sample and accompany testing OLTC are 2 different phases of the same diverter switch operated by SHM-1 motor drive unit. In order to avoid over heating of the test oil by

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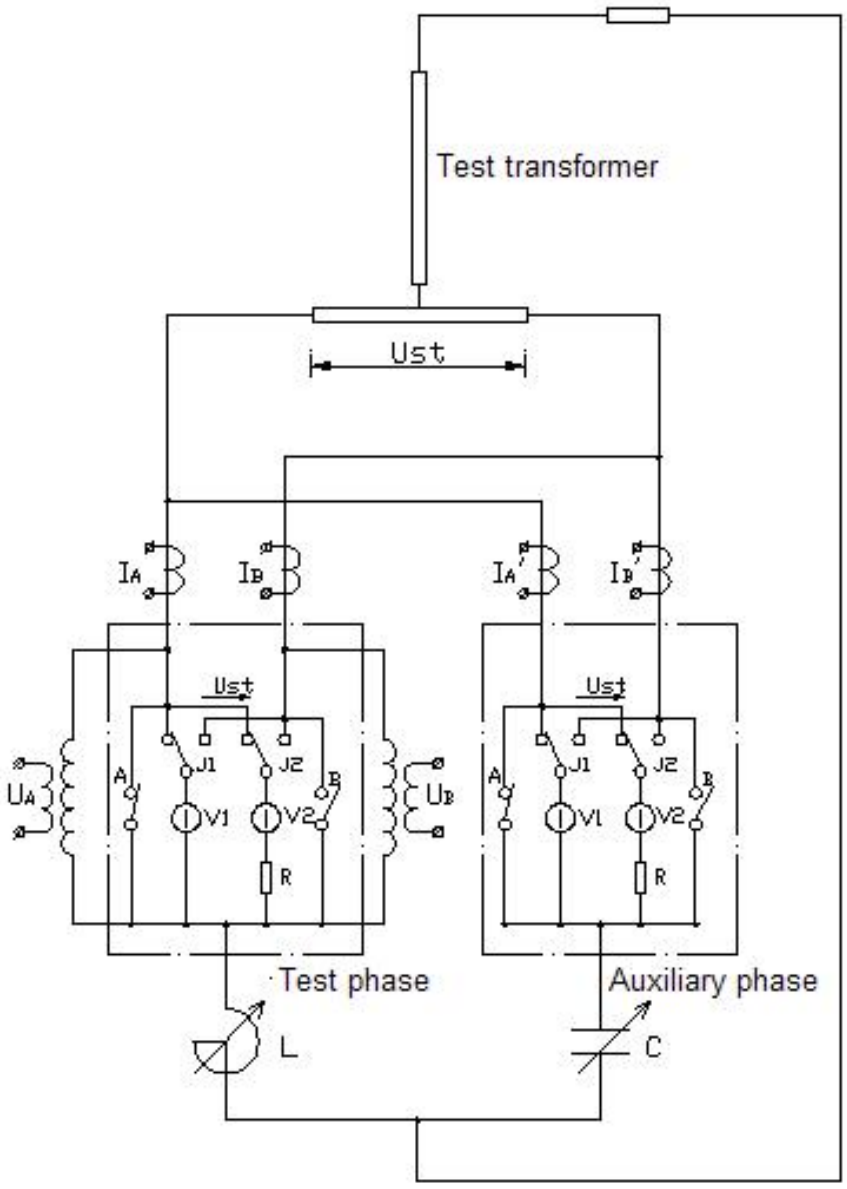
continuously operation of the transition resistors, a set of external resistors are used for the test. The resistance value of the external resistor is kept the same but with higher thermal capacity.



Circuit diagram of switching test for SHZV OLTC

The explanation of the time in the switching oscillogram as following:

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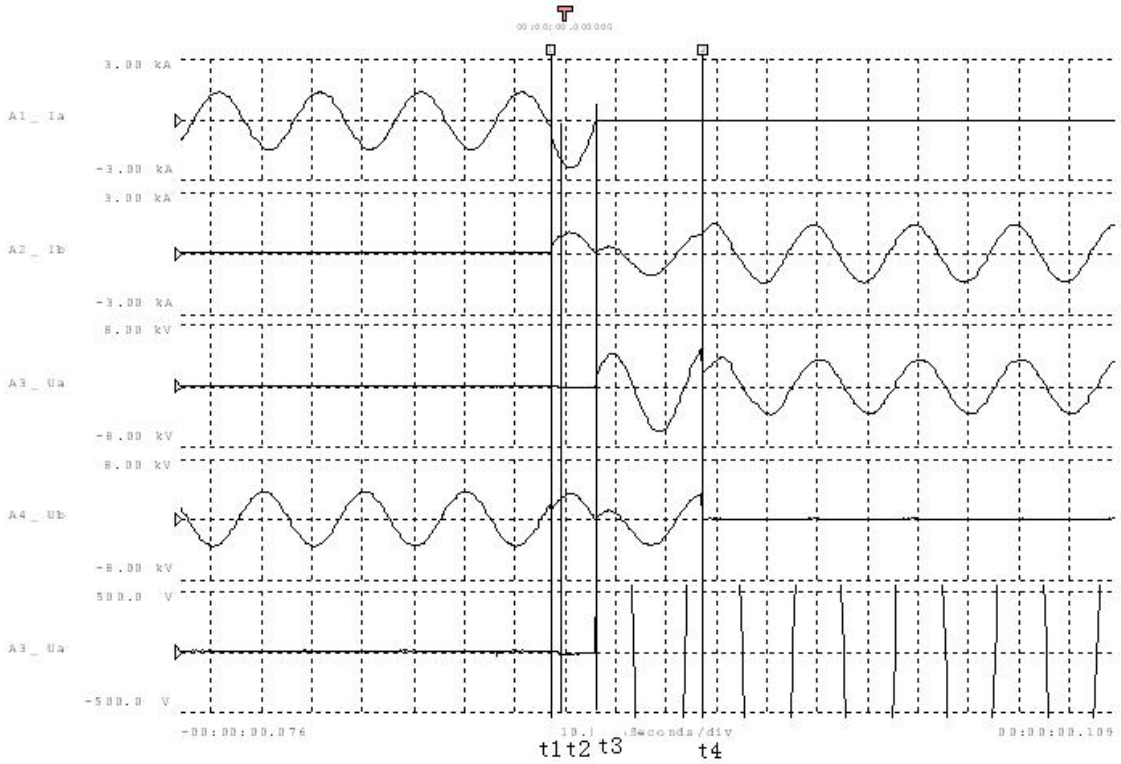

Side A → Side B:

t1 Switching operation starts. The transition vacuum interrupter V2 connects Side B and circulating current appears;

t2 Main Vacuum Interrupter V1 disconnects side A;

t3 Arc in the main vacuum interrupter V1 has extinguished;

t2-t3 Time of arcing in the main vacuum interrupter V1;

t4 The main interrupter V1 connects side B. The switching operation ends.

Side B →Side A:

t1 Switching operation starts. The main interrupter V1 opens;

t2 Arc in the main vacuum interrupter V1 has extinguished;

t1-t2 Time of arcing in the main vacuum interrupter V1;

t3 The main interrupter V1 connects side A, and circulating current appears;

t4 Arc in the transition vacuum interrupter V2 has extinguished;

t3-t4 Time of Arcing in the transition vacuum interrupter V2 and bridging connection time.

4.2 Service duty test

First load point: Ust=Ui= 3000V, In=Ium= 800A, R=3.750Ω.

Second load point: Ust=Uim= 4000V, In = 750A, R1=5.0Ω.

The test is performed according to the following sequence:

1. 200,042 operations are performed at the first load point;

2. 200,611 operations are performed at the second load point.

3. Another 200,017 operations are performed at first load point until total 600,000 operations are performed.

4. 40 operations of breaking capacity test under 2 times of maximum rated through current.

4.2.1 Service duty test at the first load point

Load point: Ust=Ui= 3000V， In=Ium= 800A，R=3.75Ω

Testing OLTC sample uses switching method of asymmetrical pennant cycle. So under the above-mentioned points, the main vacuum interrupter and transition vacuum interrupter of testing OLTC sample will show the following breaking current and recovery voltage during the test. Those values are calculated and compared with the testing value in the oscillogram. (cosΦ=1)

Side A → Side B:

Main vacuum interrupter V1(the interrupting current is related with the direction of circulate current):

Heavy load: I1 = In + IC = In+ UstR = 2000A

Uw1 = Ust+ InR = 6000V

Light load: I1 = In - IC = In- UstR = 0

Uw1 = Ust- InR = 0

Transition vacuum Interrupter V2 (the interrupting current is not related with the direction of circulating current): I2 =0

Uw2 =0

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Side B→ Side A:

Main Vacuum Interrupter V1 (the interrupting current is not related with the direction of circulating current): I1 = In= 1000A

Uw1 = InR = 3000V

Transition Interrupter V2 (the interrupting current is not related with the direction of circulating current): I2 = Ic = UstR = 1000A

Uw2 = Ust = 3000V

The actual values measured are as following:

Load	Measured Values	Calculated Value
Ust	3010～3030V	3000V
In	1005～1025A	1000A
Main vacuum Interrupter		
I1	1005～1025A /2010～2030A	1000A/2000A
Uw1	3010V～3030V/6010～6030V	3000V/6000V
Transition Vacuum Interrupter		
I2	990～1010A/0	1000A/0
Uw2	3010～3030V/0	3000V/0

Statistics of arcing time:

Contact		Oscillogram	Arcing time (ms)			
			0～10	10.1～20	20.1～30	Max. value
Main Vacuum Interrupter	N	352	335	17	---	10.8
	Percentage (100%)		95	5	---	
Transition Vacuum Interrupter	N	176*	172	4	---	10.1
	Percentage (100%)		98	2	---	

*only evaluate the oscillograms on heavy switching direction.

Test was completed after 400,059 operations. The operating frequency is 350operations/hr during the test. And supervised the switching oscillograms in the whole course. Every 100,000 operations lifted and checked the insert and changed the direction of circulating current in order to match the

same situation of breaking capacity for main vacuum interrupter in the real application. Through the analysis of the oscillograms recorded in the test, the test tap changer has good property of arc extinguishment and no restrike arc found. And after switching test, the test tap changer still has normal operation sequence.

4.2.2 Service duty test at the second load point

Load point: Ust=Uim=4000V,In=Ii=750A，R=5Ω

Under this load point, the main arcing contact and transition contact of testing OLTC sample will have the following breaking current and recovery voltage:

Side A → Side B:

Main vacuum interrupter V1(the interrupting current is related with the direction of circulate current):

Heavy Load: $I1 = In + IC = In + \frac{Ust}{R} = 1550A$

$Uw1 = Ust + InR = 7750V$

Light Load: $I1 = In - IC = In - \frac{Ust}{R} = 50A$

$Uw1 = Ust - InR = 250V$

Transition vacuum Interrupter (the interrupting current is not related with the direction of circulating current): I2 =0 Uw2 =0

Side B → Side A:

Main Vacuum Interrupter V1 (the interrupting current is not related to the direction of circulating current): I1 = In= 750A

Uw1 = InR = 3750V

Transition Interrupter V2 (the interrupting current is not related to the direction of circulating current):

$I2 = \frac{Ust}{R} = 800A$

Uw2 = Ust = 4000V

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The test is carried out in the following actual load conditions:

Load	Measure Value	Calculated Value
Ust	4050～4130V	4000V
In	760～790A	750A
Main Vacuum Interrupter		
I1	760～790A/1480～1505A	750A/1550A
Uw1	4050～4130V/7780～7860V	3750V/7750V
Transition Vacuum Interrupter		
I2	750～780A/0	800A/0
Uw2	4050～4130V/0	4000V/0

Statistics of arcing time:

Contact		Oscillogram	Arcing time (ms)			
			0～10	10.1～20	20.1～30	Max. value
Main Vacuum Interrupter	N	136	132	4	---	12.1
	Percentage (100%)		97	3	---	
Transition Vacuum Interrupter	N	68*	64	4	---	10.4
	Percentage (100%)		94	6	---	

*only evaluate the oscillograms on heavy switching direction.

The test tap changer takes total 200,611 operations. According to the record of oscillogram during the test, arc extinguishing function of OLTC test sample is good.

4.3 Breaking capacity test

Breaking capacity test is performed after the tap changer runs for more than 600,000 operations of service duty test. The transition resistor installed inside the tap changer is used for the test. 40 operations were carried out during the test. In order to have stricter test, all tests are performed under heavy-loaded condition of the main vacuum interrupter. The oscillogram of each switching is recorded, and every switching operation is normal according to the record.

Test was carried under the load point as following:

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Ust= Ui=3000V, In=2Ium=2000A, R=3.0Ω

According to the formula in 4.2.1, the test was carried under the load condition as following:

Contact load	Measured value	Calculated value
Ust	3020～3050V	3000V
In	2015～2030A	2000A
Main vacuum interrupter		
I1	2015～2030A/2860～2920A	2000A/3000A
Uw1	3020～3050V/8260～8420V	3000V/9000V
Transition vacuum interrupter		
I2	1010～1015A/0	1000A/0
Uw2	3010～3020V/0	3000V/0

Statistics of arcing time:

Contact		Oscillograms	Arcing time (ms)			
			0～10.1	10.1～20	20.1～30	Max. value
Main Vacuum Interrupter	N	40	36	4	---	13.6
	Percentage (100%)		90	10	---	
Transition Vacuum Interrupter	N	20*	19	1	---	10.8
	Percentage (100%)		95	5	---	

*only evaluate the oscillograms on heavy switching direction.

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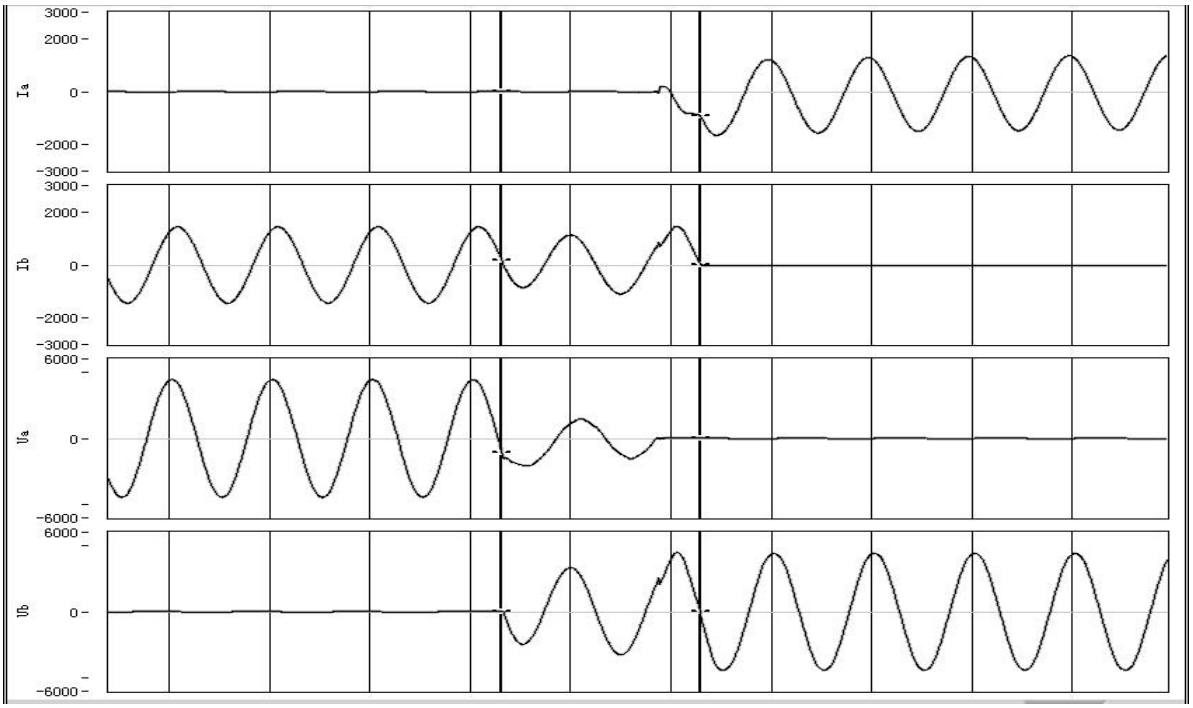
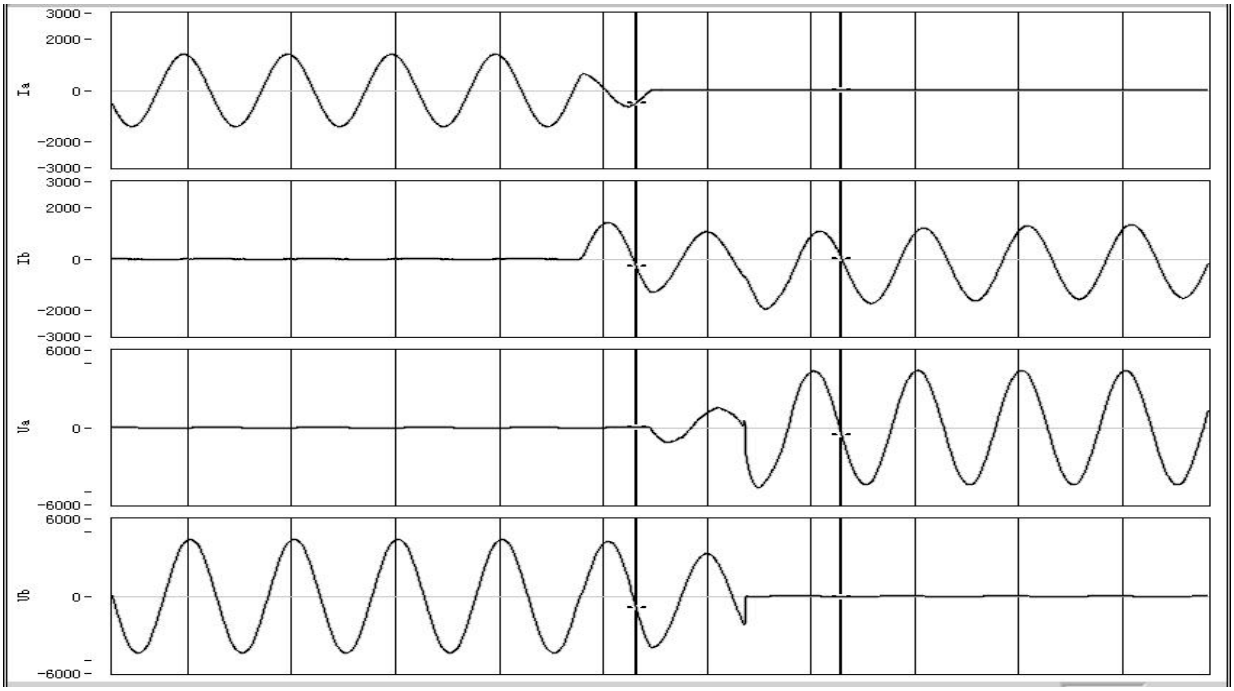
4.4 Oscillograms of switching test

Service duty test First load point B→A

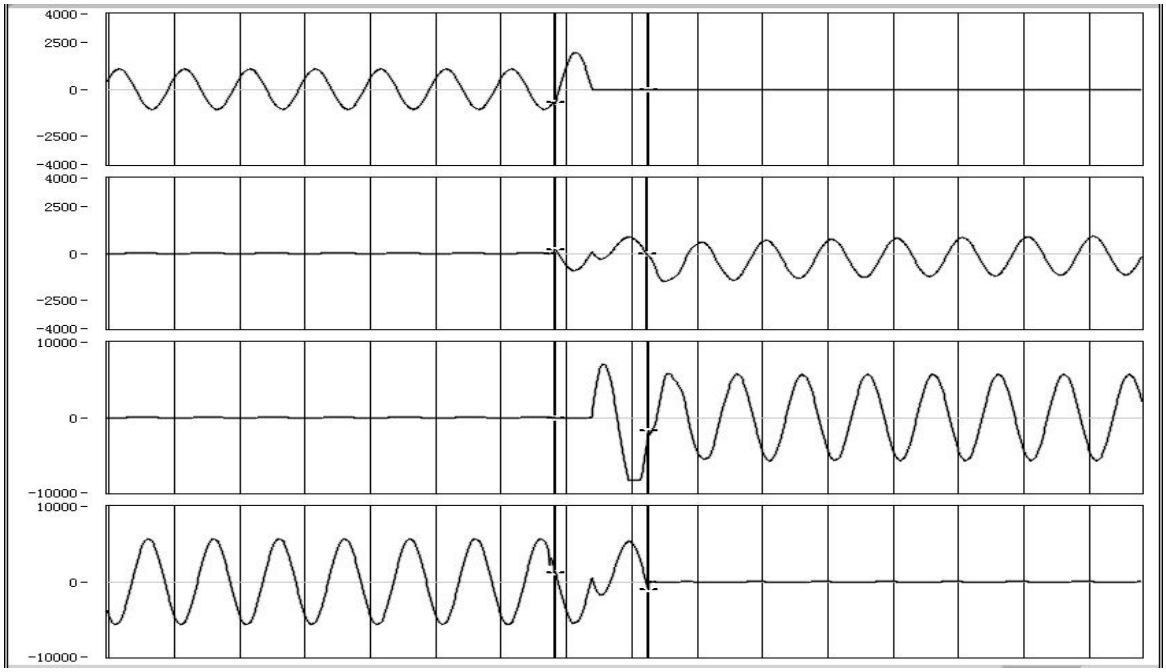


Service duty test First load point A→B

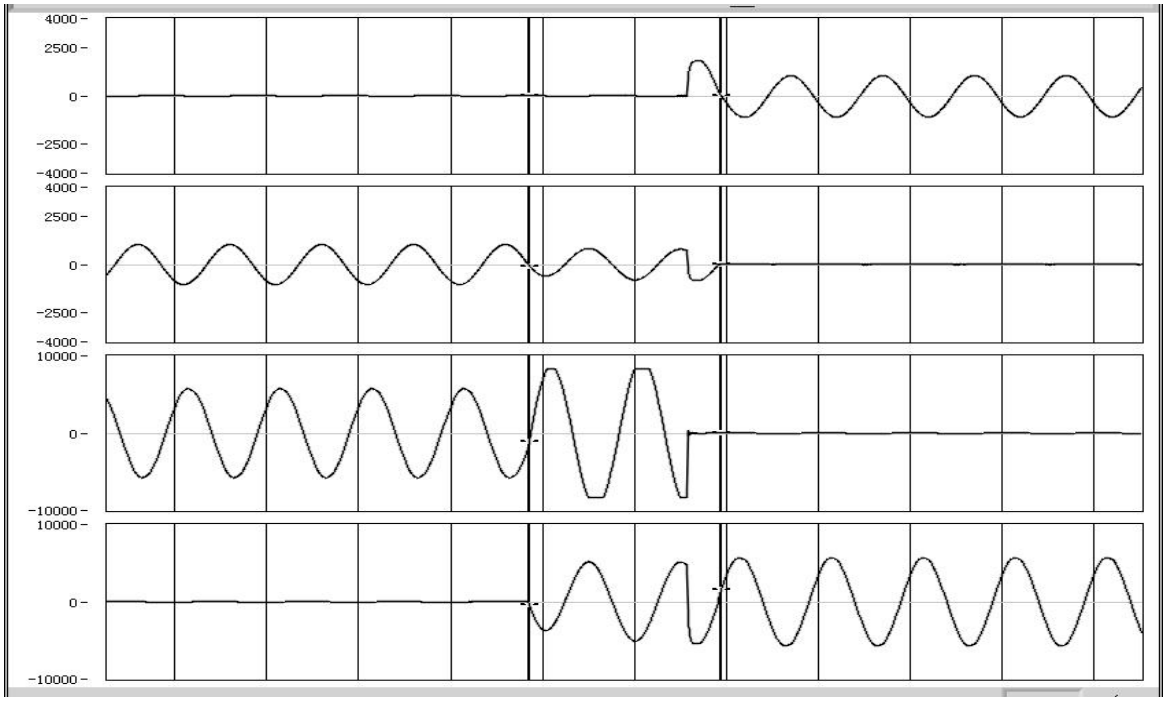


Service duty test Second load point A→B

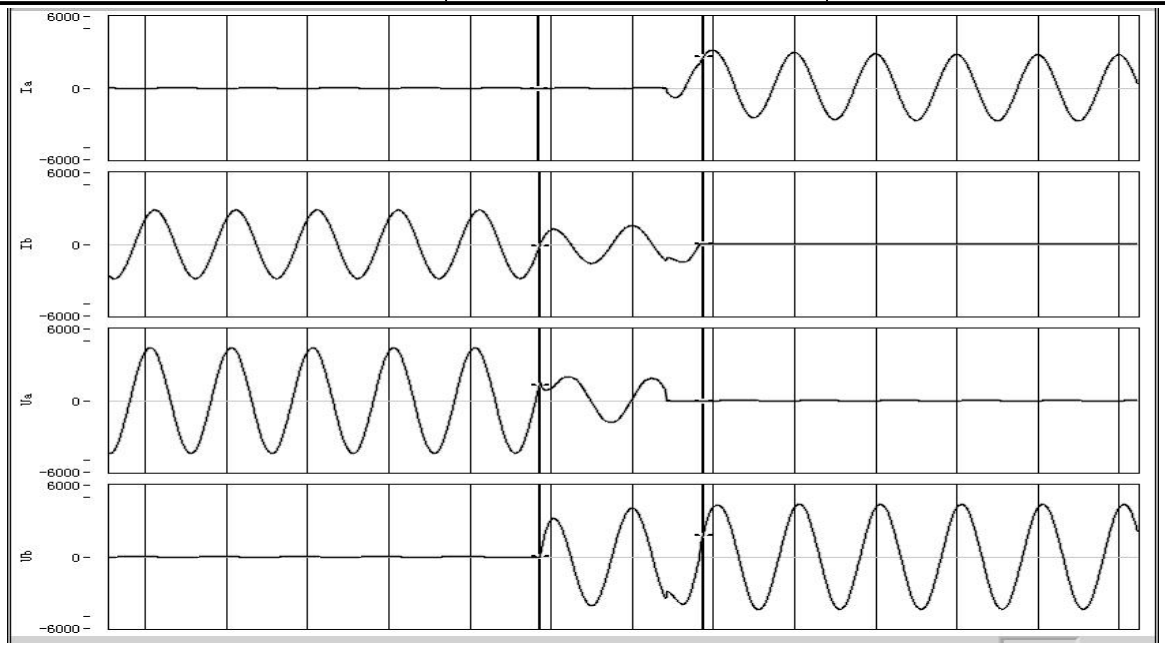
Tap Changer Testing Center of Shanghai Huaming Power Equipment Co., Ltd	Type test report	Type SHZVIII-600Y/170D-14273W On-load tap changer Commitment 2016SY022-E



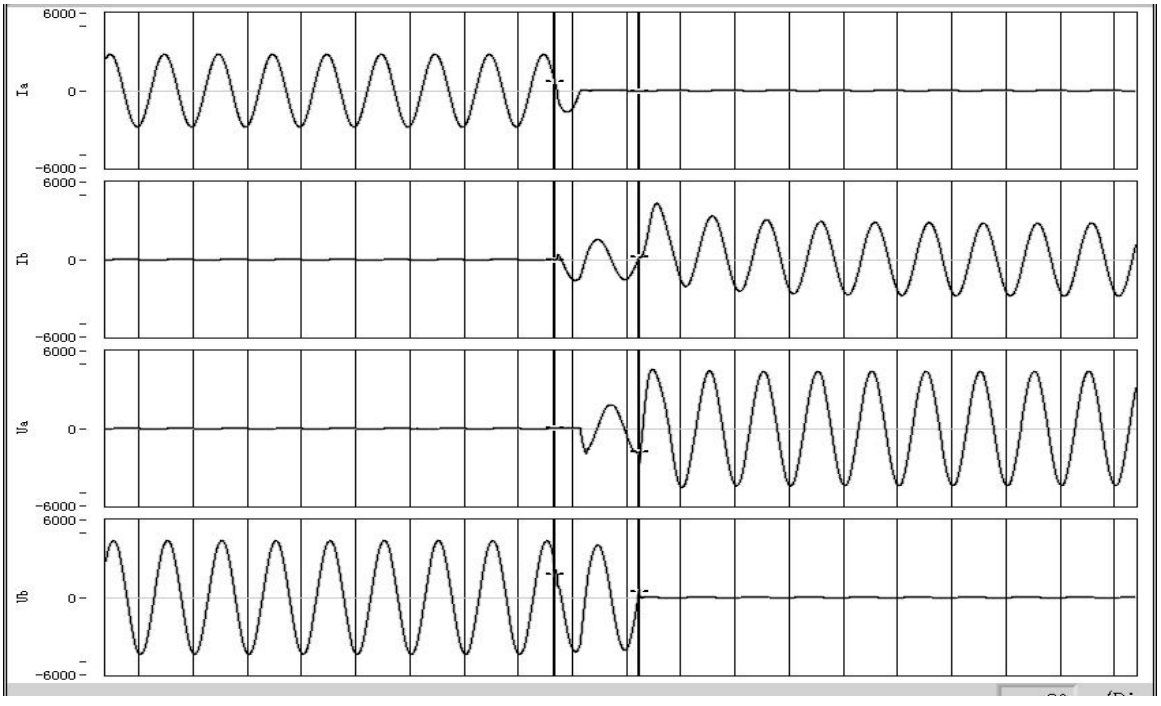
Service duty test Second load point B→A (Light load)



Breaking capacity test B→A



Breaking capacity test A→B



The test tap changer takes totally 600,650 operations and no re-strike arc is found. And after switching test, the test tap changer still has normal operation sequence.

5 Short-circuit current test

5.1 Test parameter

Dynamic I1m: 30kA (peak)

Thermal Ith: 12kA (r.m.s), t=3s

Applied 3 times, 5 minutes interval between each time.

5.2 Test description

The test was carried in the transformer oil.

As the temperature rise test of contact, tested diverter switch and tap selector separately. Chose odd side of phase V of diverter switch which was qualified by contact rise test, chose K+ of phase V of tap selector→ double current ring of phase V → K of phase V as the test path.

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:

$$t \geq \frac{3}{n^2} \quad S$$

n: incremental multiple of the test current.

5.3 Test circuit diagram of short-circuit current test

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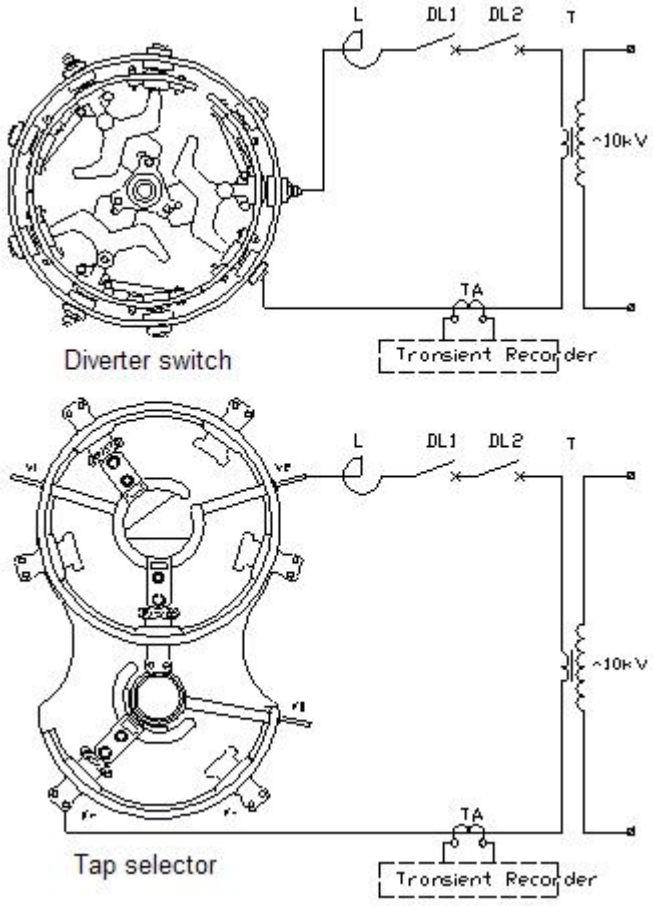

5.4 Datasheet of short-circuit current test

Sample	No.	Dynamic	Thermal	Duration	Remark
Diverter switch	1	33.3kA	14.4kA	2.30s	First application: OK
	2	29.5kA	14.4kA	2.30s	Second application: OK
	3	31.5kA	14.3kA	2.20s	Third application: OK
Tap selector	4	29.6kA	13.9kA	2.27s	First application: OK
	5	28.9kA	14.0kA	2.33s	Second application: OK
	6	31.0 kA	14.0kA	2.35s	Third application: OK

The test tap changer was applied by the short-circuit current for 3 times. There is no fusion and erosion phenomenon found on all contacts in the test circuit and no damage, color changer, etc. on insulating material because of over heating. Short-circuit current test passed.

5.5 Oscillograms of short-circuit current test

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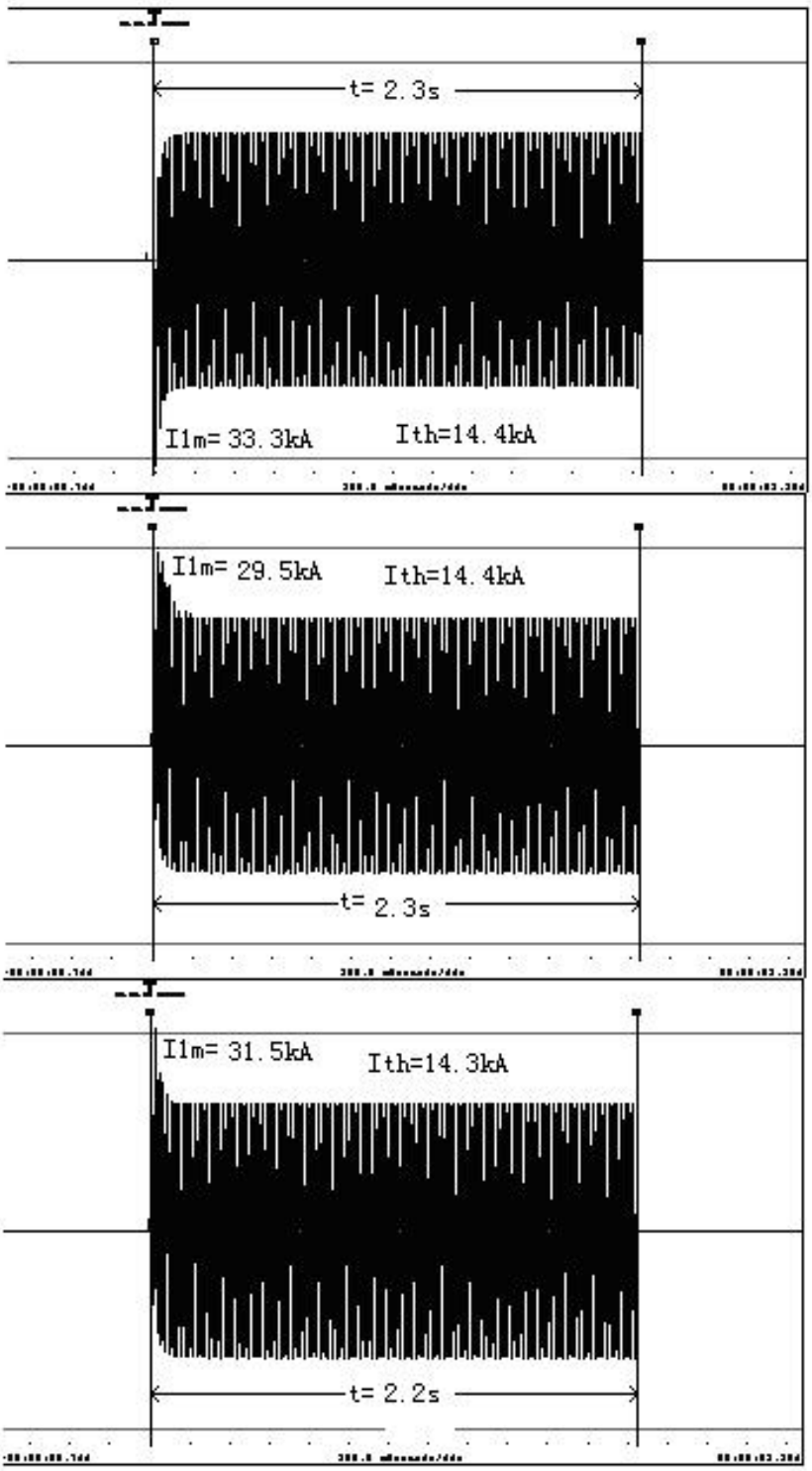
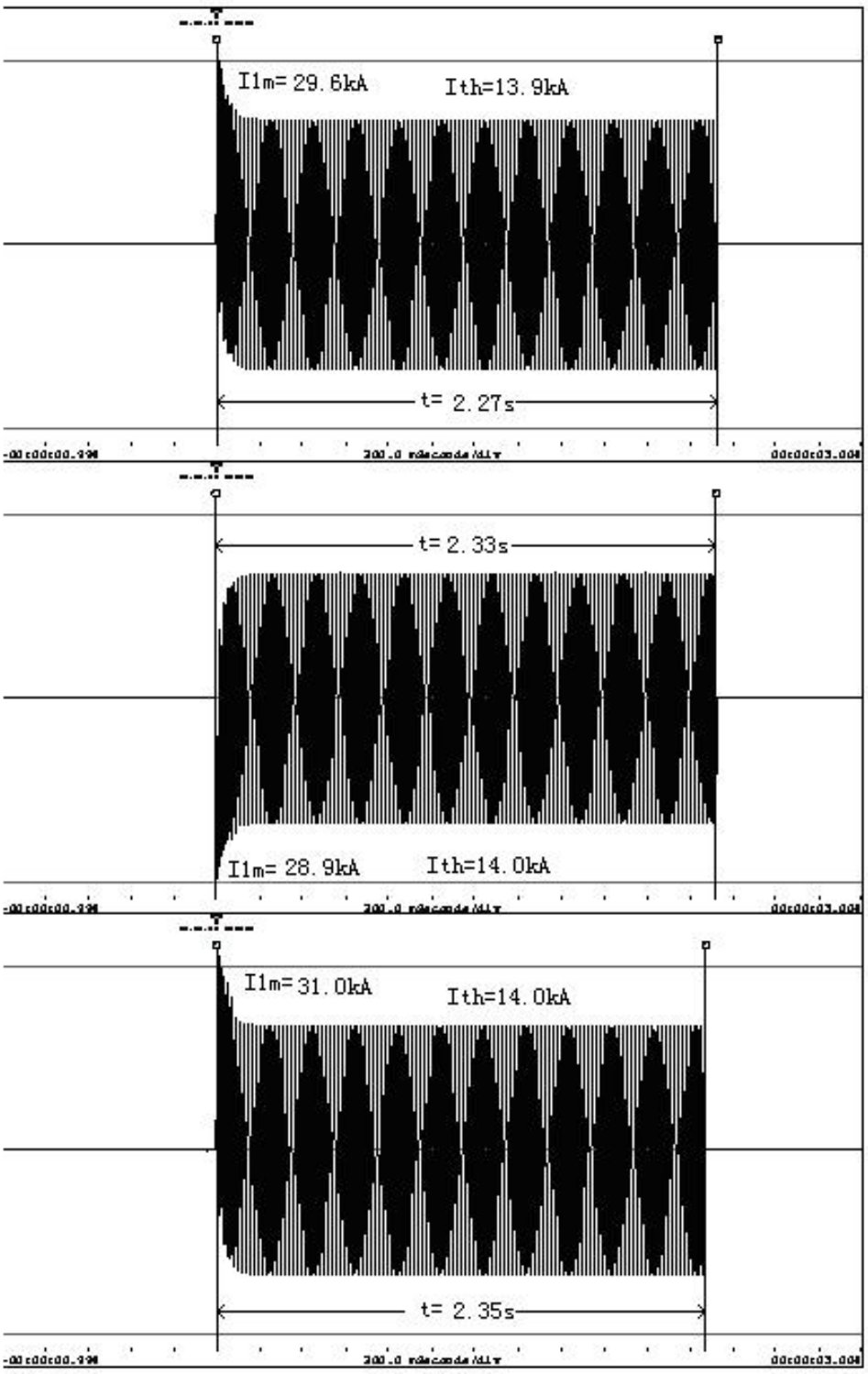
Short-circuit of diverter switch



Short-circuit of tap selector

Tap Changer Testing Center of Shanghai Huaming Power Equipment Co., Ltd	Type test report	Type SHZVIII-600Y/170D-14273W On-load tap changer Commitment 2016SY022-E



6 Transition impedance test

6.1 Test requirement

Under the condition of Ust=3000V, In=1.5×1000A=1500A, operated the test sample for half the operation cycle. Recorded the transition resistor temperature in the last switching operation and its temperature rise against ambient ≤350K.

6.2 Test description

The test was carried out in the transformer oil under room temperature.. In the test, adopted the transition resistor and installation method of the test tap changer. The test circuit was as same as switching test circuit. A nickel-chromium & nickel-silicone thermocouple (K scale division) was positioned on the transition resistor and below more less 25mm of the measuring point to measure the ambient temperature. Operated 10 operations (half cycle) continuously by the motor drive unit and measured the max. temperature rise of the transition resistor immediately after last operation.

6.3 Test result

Operation time	Point 1			Point 2		
	mV	Temp (℃)	Temp rise (K)	mV	Temp (℃)	Temp rise (K)
1	2.448		293.7	1.463		
2	2.876		303.8	1.463		
3	3.285		313.8	1.463		
4	3.156		313.4	1.463		
5	3.428		314.1	1.463		
6	3.048		313.2	1.463		
7	3.285		313.8	1.463		
8	2.984		303.9	1.463		
9	3.356		313.9	1.463		
10	3.158		313.4	1.463		
11	3.094		313.3	1.463		
12						
13						
14						
15						
16						
17						
18						
Oil temperature was measured after 10 operations						

After actual test, the max.temperature rise of the transition resistor is 314.1K, less than 350K.

Tap Changer Testing Center of Shanghai Huaming Power Equipment Co., Ltd	Type test report	Type SHZVIII-600Y/170D-14273W On-load tap changer Commitment 2016SY022-E

High Voltage Performance Lab

Test report

Tested by: 祁斌杰

Edited by: 黄斌

Approved by: 朱志刚

Date: 2016.12.29

Test items and devices:

No.	Testing item	Testing device code	Name of testing device
1	Power frequency withstand voltage test	A105-01	500kV Power frequency withstand voltage testing device
2	Lightning impulse test	A108-01	1350kV Impulse voltage testing device
3	Partial discharge measurement	A105-02	600kV no corona power frequency withstand voltage testing device
		A210-01	Partial discharge instrument
		A210-02	Calibrated impulse signal generator

7 Dielectric test

Tap Changer Testing Center of Shanghai Huaming Power Equipment Co., Ltd	Type test report	Type SHZVIII-600Y/170D-14273W On-load tap changer
		Commitment 2016SY022-E

7.1 Test requirement

Test position		Power frequency withstand voltage (kV/min)	Impulse withstand voltage (kV) 1.2/50μs
Diverter switch	To ground	325kV	750kV
	Between two adjacent taps	20kV	≤90kV, no response ≥130kV, response
Tap selector	Between max. and min. taps of same phase (with spark protection)	105kV	490kV
	Between two adjacent taps	30kV	150kV

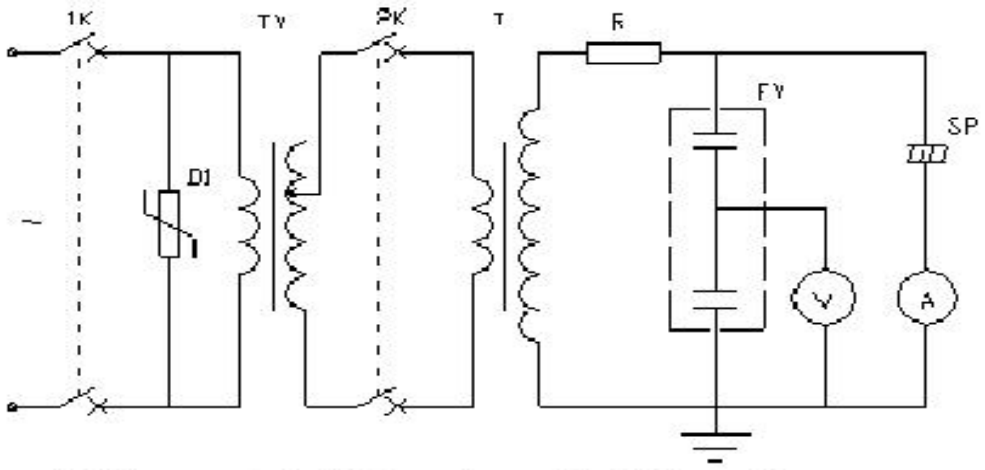
The test tap changer is dried before dielectric test. Immersed the tap changer in the transformer oil with insulating strength not less than 40kV. During the test, there should be no break-down and flash-over phenomena.

7.2 Test result

Diverter switch and tap selector are tested separately.

7.2.1 Power frequency withstand voltage test

Test circuit as following:



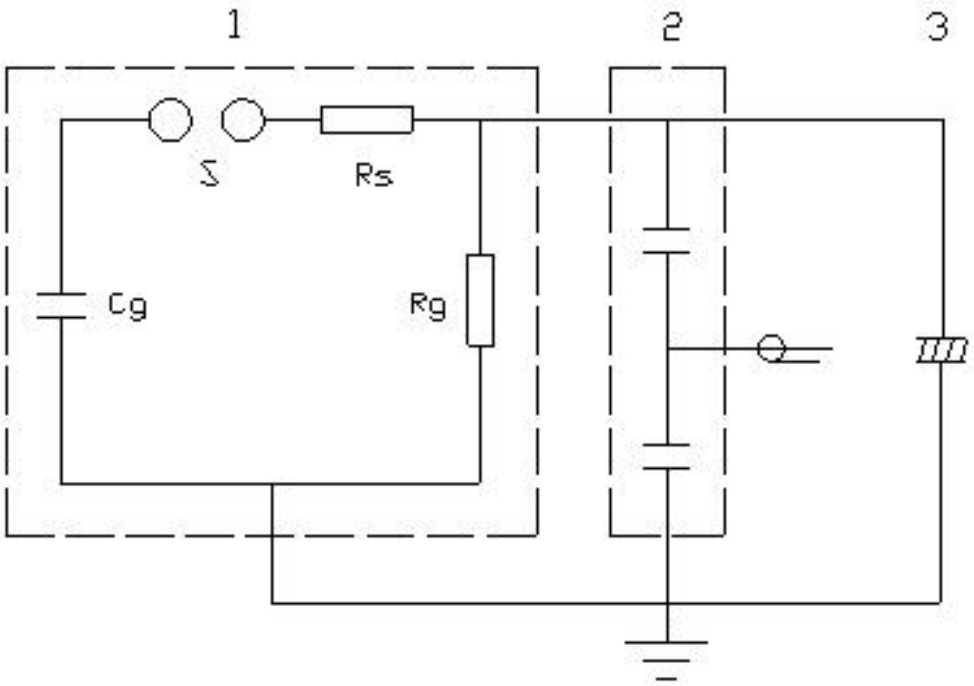
1K: Primary switch 2K: Secondary switch TY: Regulator
T: Test transformer R: Protective resistor FY: Condenser divider
SP: Test tap changer D1: Zinc oxide resitor

In the transformer oil with normal temperature, applied set test voltage to all the test positions of the

test tap changer with power frequency withstand voltage test transformer. Lasted 1min for every application and there were no break-down or flash-over phenomena, qualified.

7.2.2 Lightning impulse test

Test circuit as following:



1: Impulse voltage generator 2: Light damping voltage divider
3: Test tap changer

In the transformer oil with normal temperature, applied lightning impulse voltage to all the test positions of the test tap changer with Model CDY-1350 impulse voltage generator. Each test position was applied for 3 times on positive and negative respectively and there were no break-down and flash-over phenomena, qualified.

7.2.3 Oscillograms of lightning impulse voltage test

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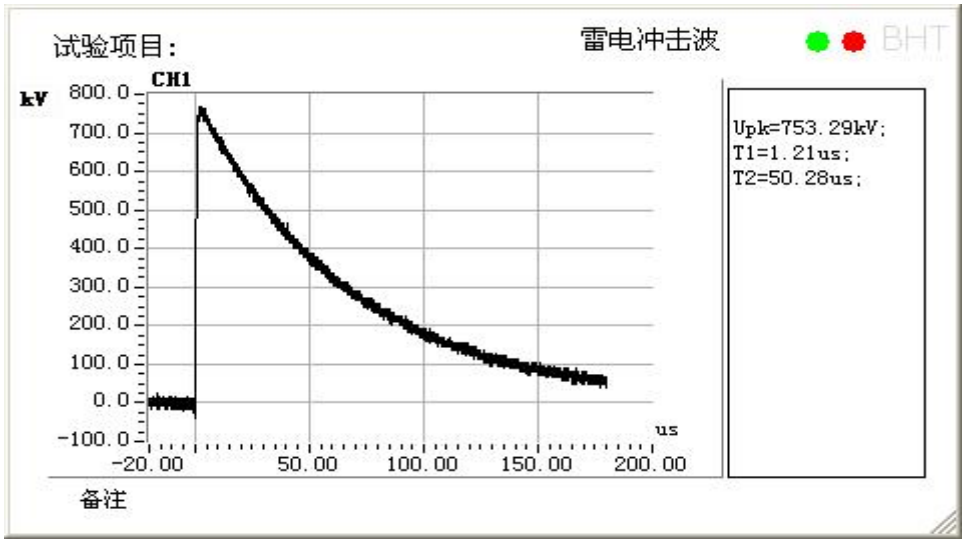
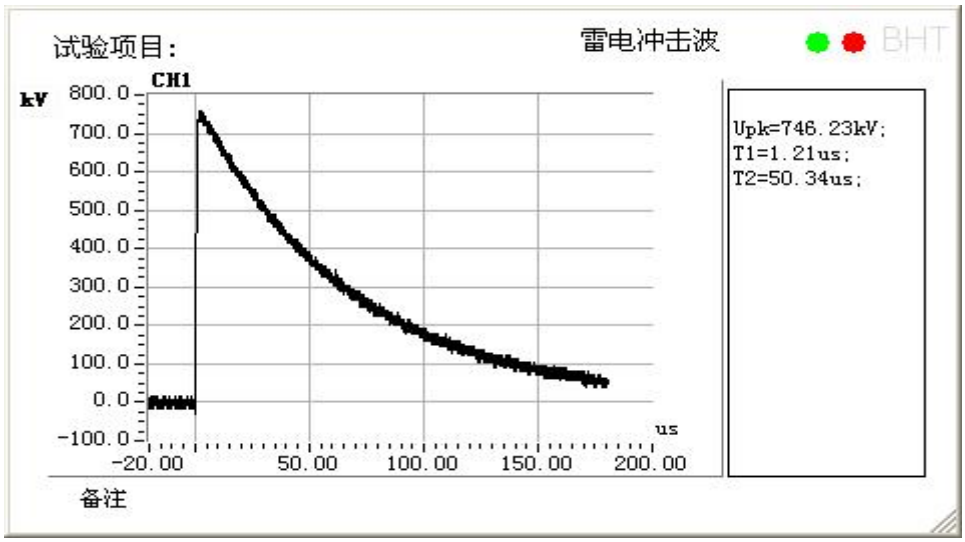
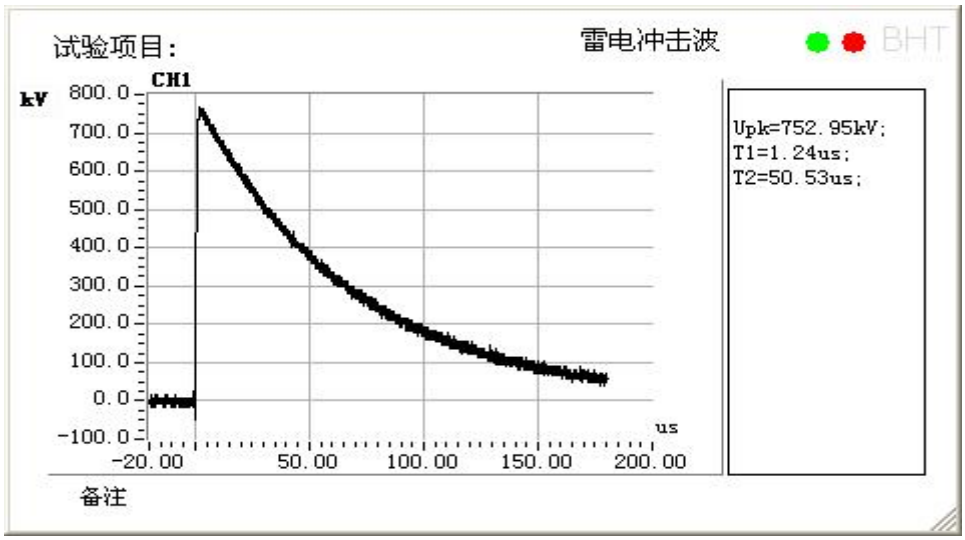
Diverter switch to ground 750kV (Positive)

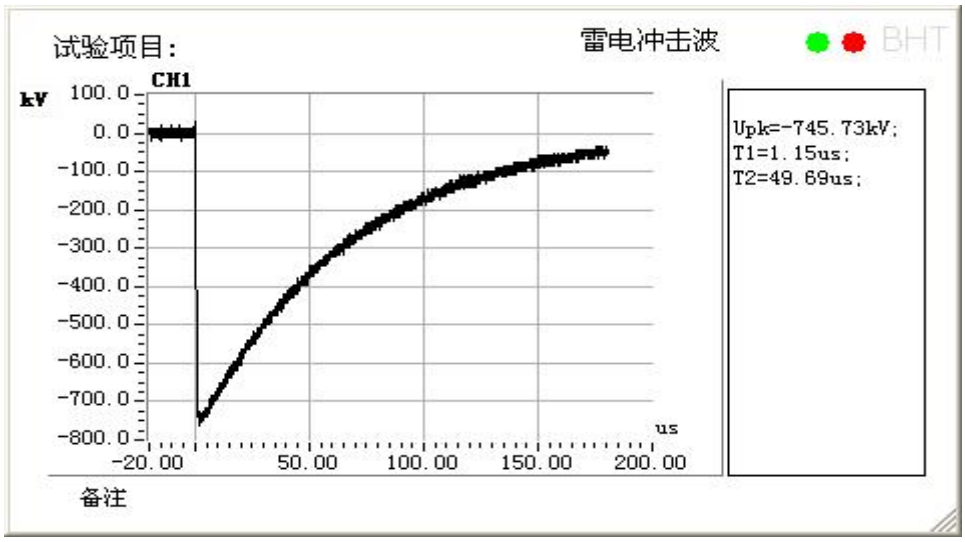


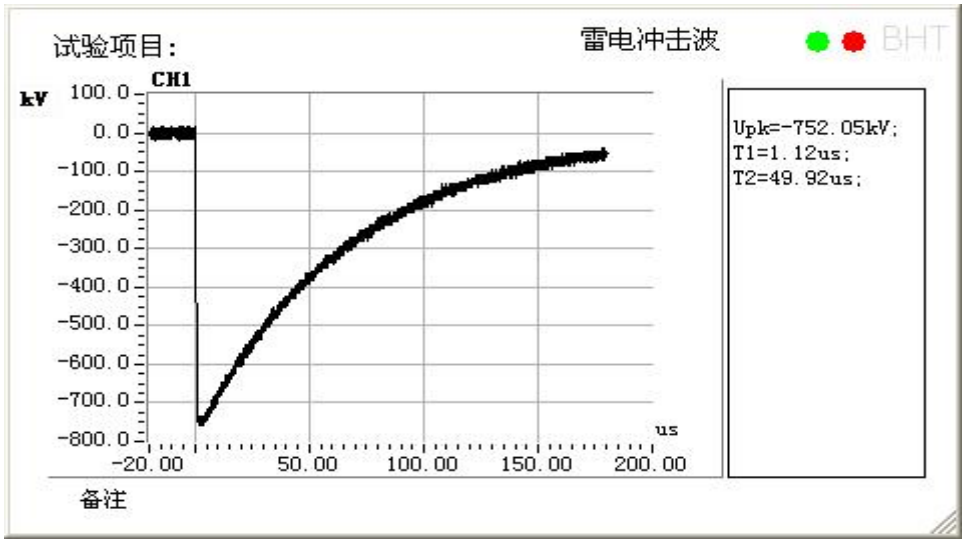


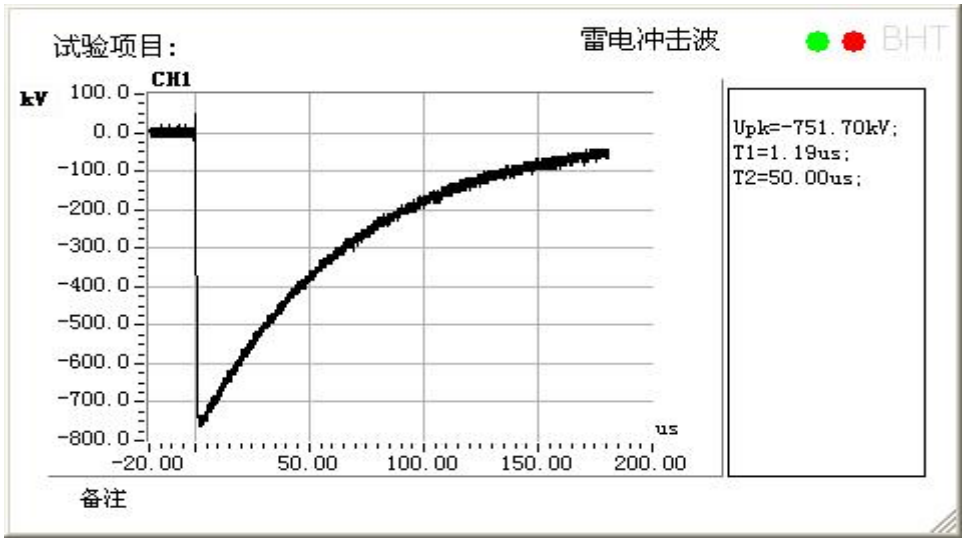


Tap Changer Testing Center of Shanghai Huaming Power Equipment Co., Ltd	Type test report	Type SHZVIII-600Y/170D-14273W On-load tap changer Commitment 2016SY022-E

Diverter switch to ground 750kV (Negative)

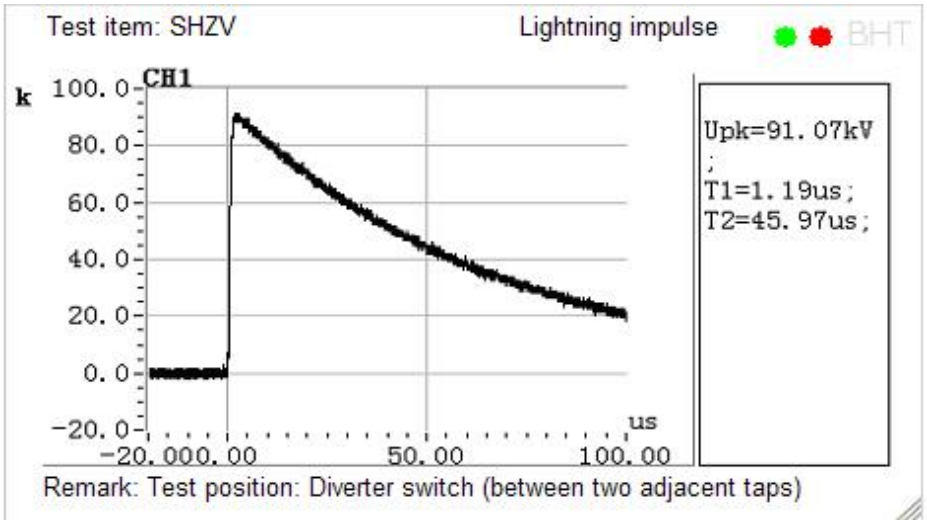


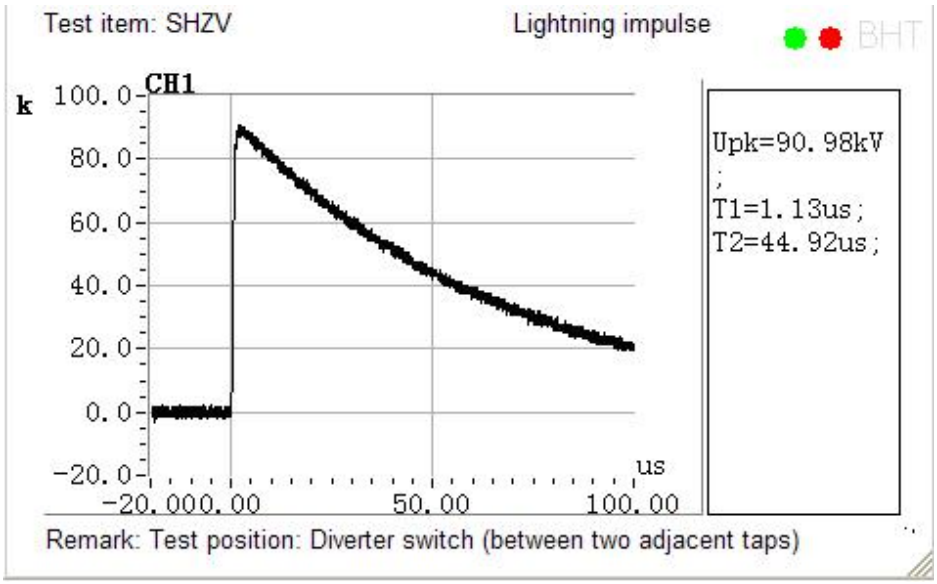


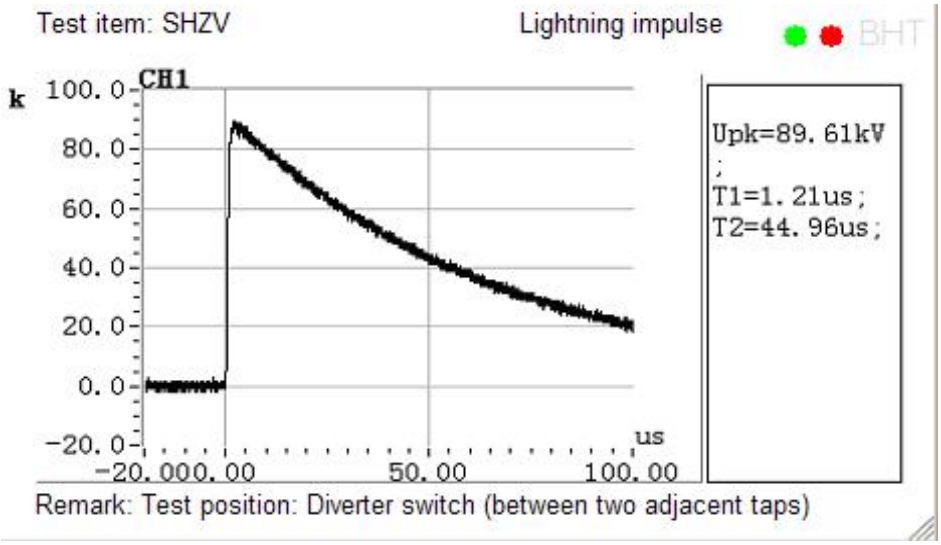


Tap Changer Testing Center of Shanghai Huaming Power Equipment Co., Ltd	Type test report	Type SHZVIII-600Y/170D-14273W On-load tap changer Commitment 2016SY022-E

Between two adjacent taps of diverter switch (with spark gap):no response at 90kV (Positive)

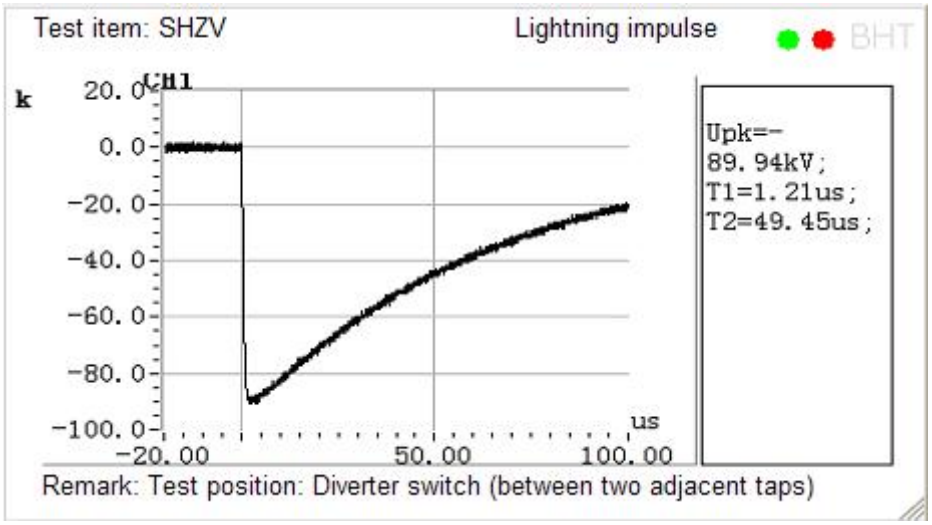


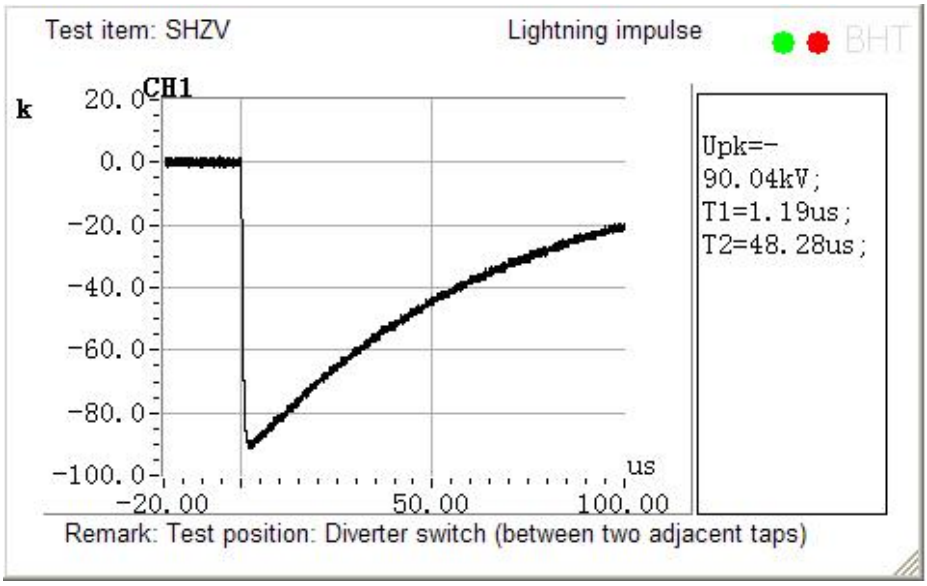


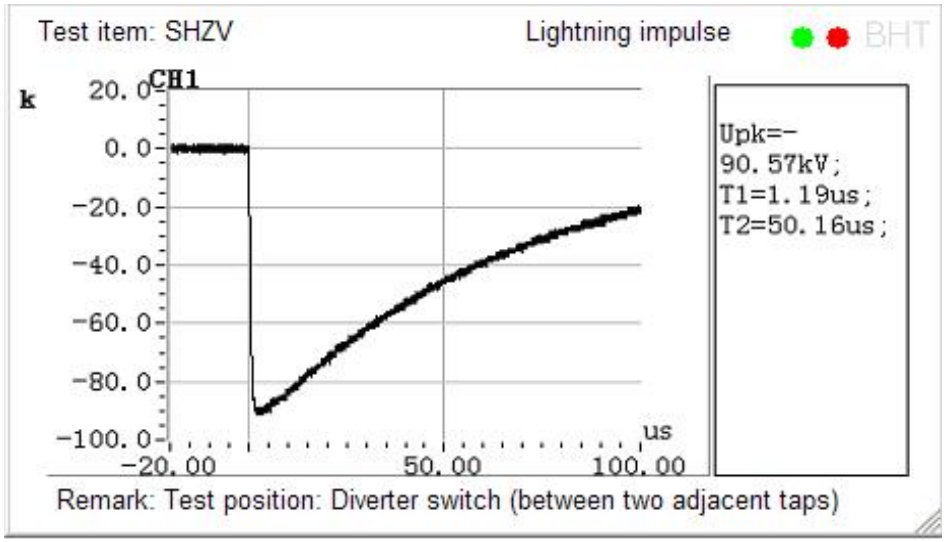


Tap Changer Testing Center of Shanghai Huaming Power Equipment Co., Ltd	Type test report	Type SHZVIII-600Y/170D-14273W On-load tap changer Commitment 2016SY022-E

Between two adjacent taps of diverter switch (with spark gap):no response at 90kV (Negative)

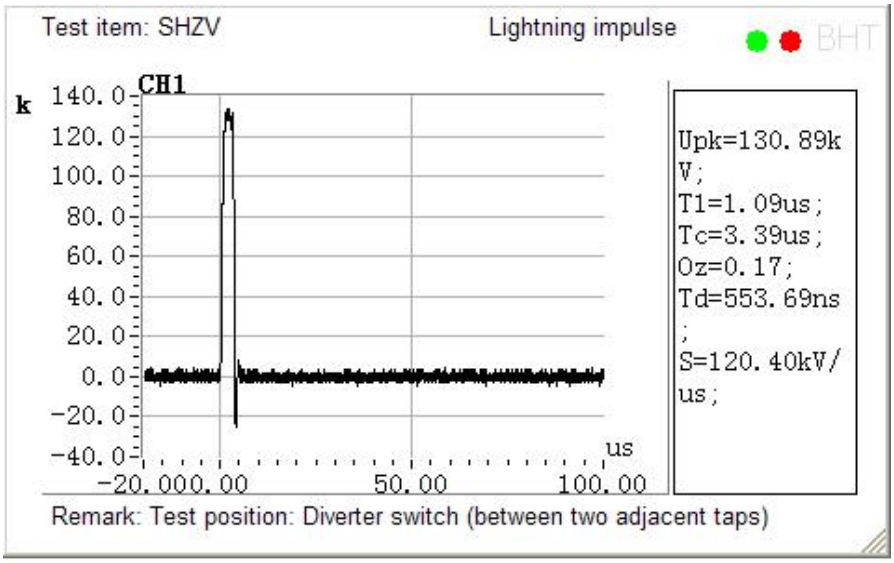


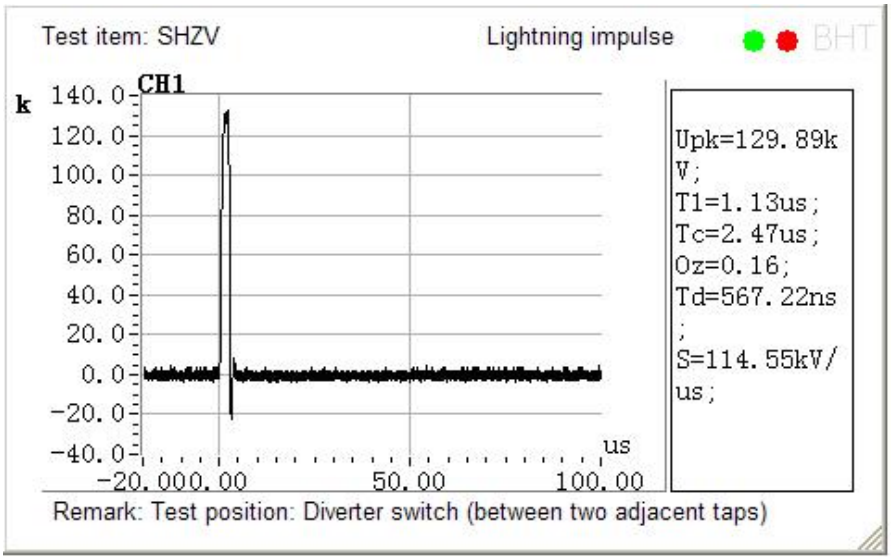


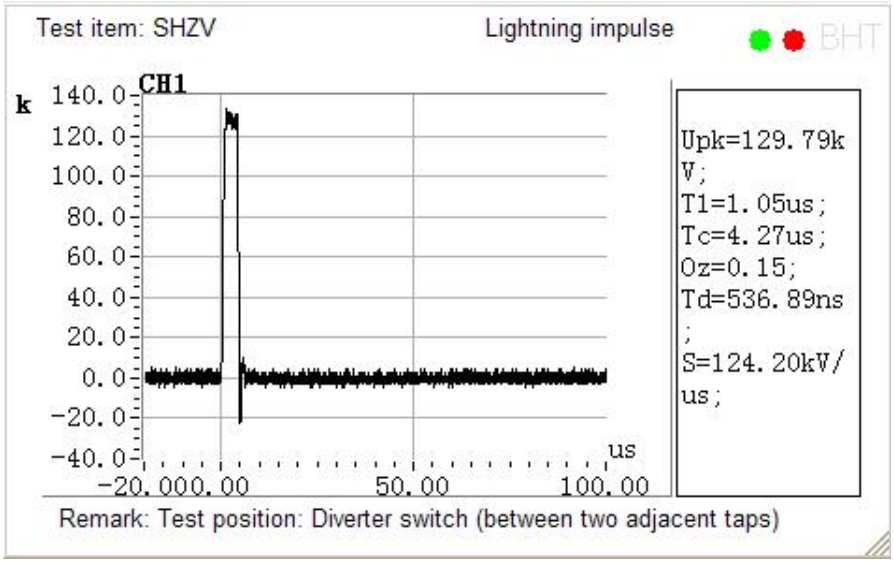


Tap Changer Testing Center of Shanghai Huaming Power Equipment Co., Ltd	Type test report	Type SHZVIII-600Y/170D-14273W On-load tap changer Commitment 2016SY022-E

Between two adjacent taps of diverter switch (with spark gap):100% response at 130kV (Positive)

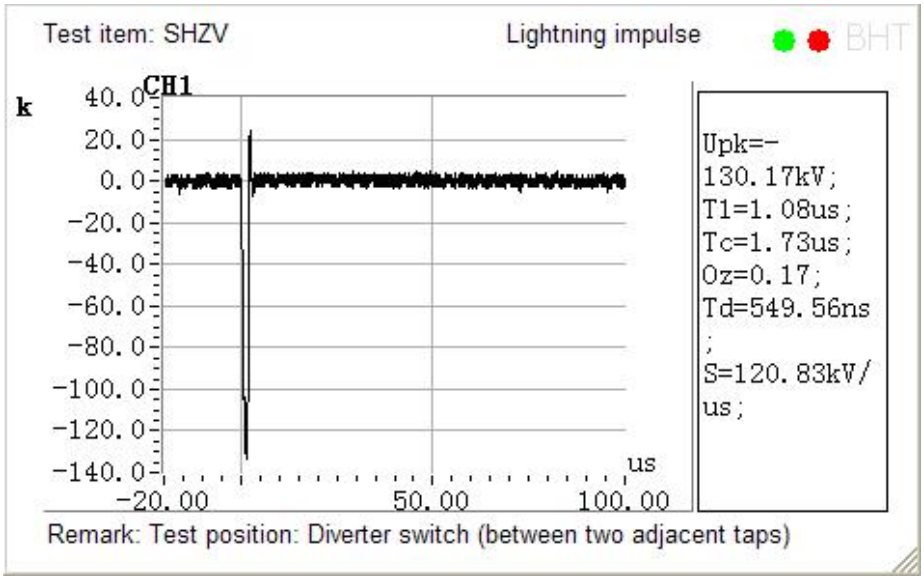


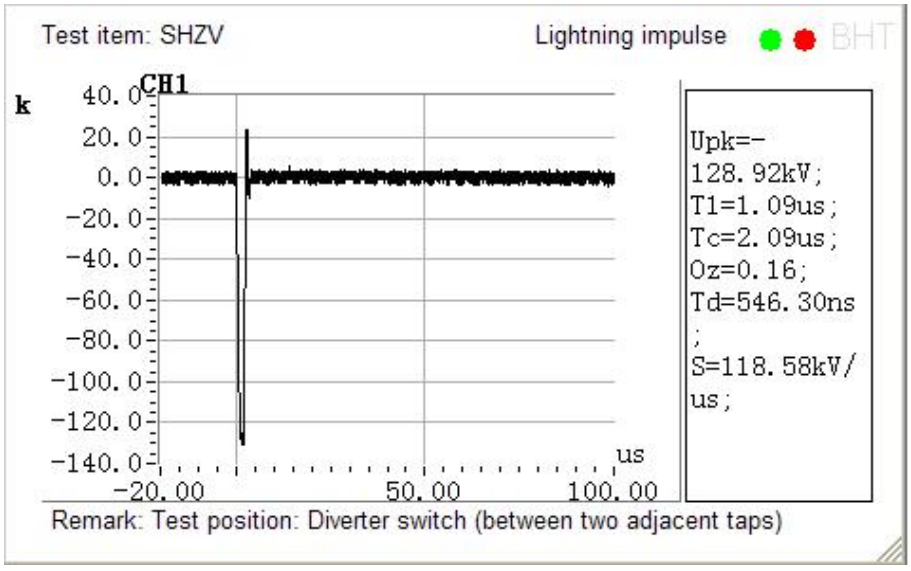




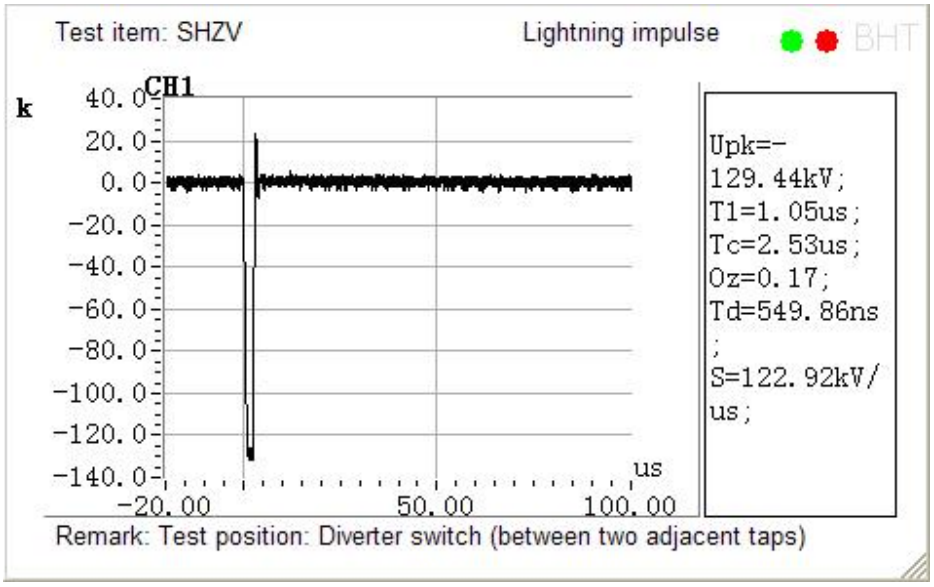
Tap Changer Testing Center of Shanghai Huaming Power Equipment Co., Ltd	Type test report	Type SHZVIII-600Y/170D-14273W On-load tap changer Commitment 2016SY022-E

Between two adjacent taps of diverter switch (with spark gap):100% response at 130kV (Negative)

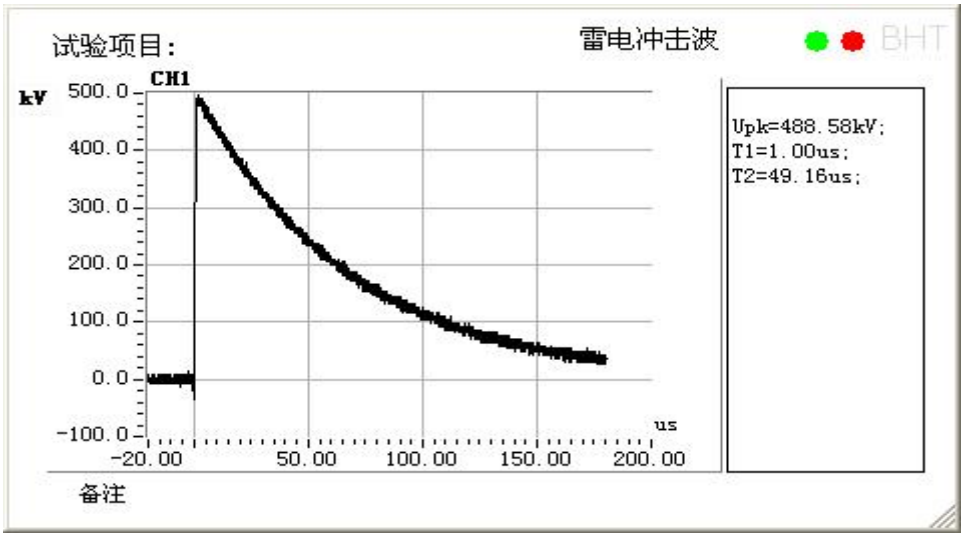




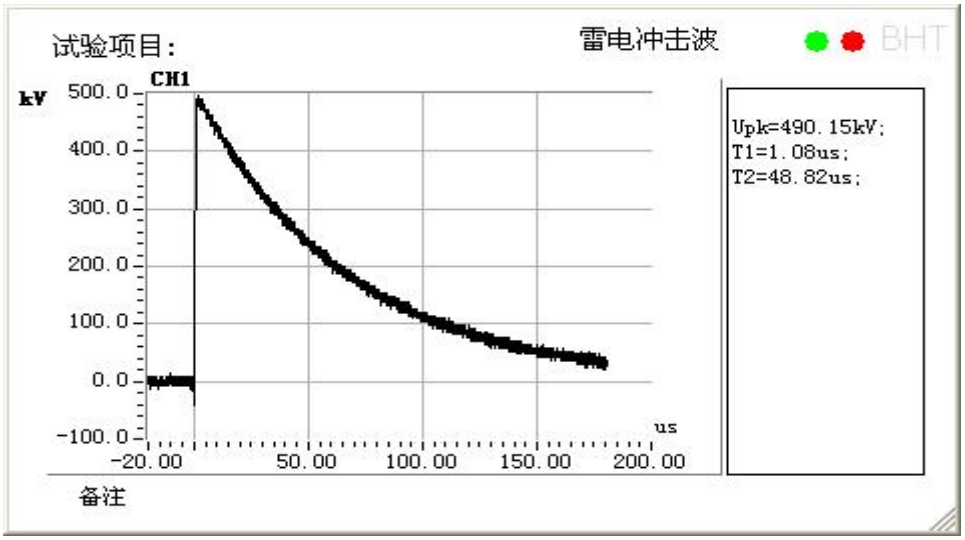
Tap Changer Testing Center of Shanghai Huaming Power Equipment Co., Ltd	Type test report	Type SHZVIII-600Y/170D-14273W On-load tap changer Commitment 2016SY022-E

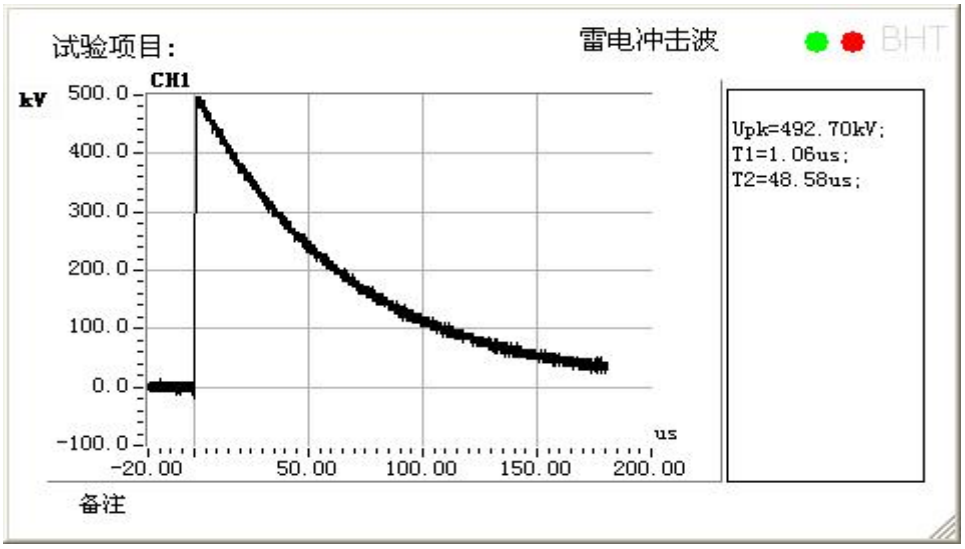


Tap selector test: between the min. tap and max. tap: 490kV (Positive)

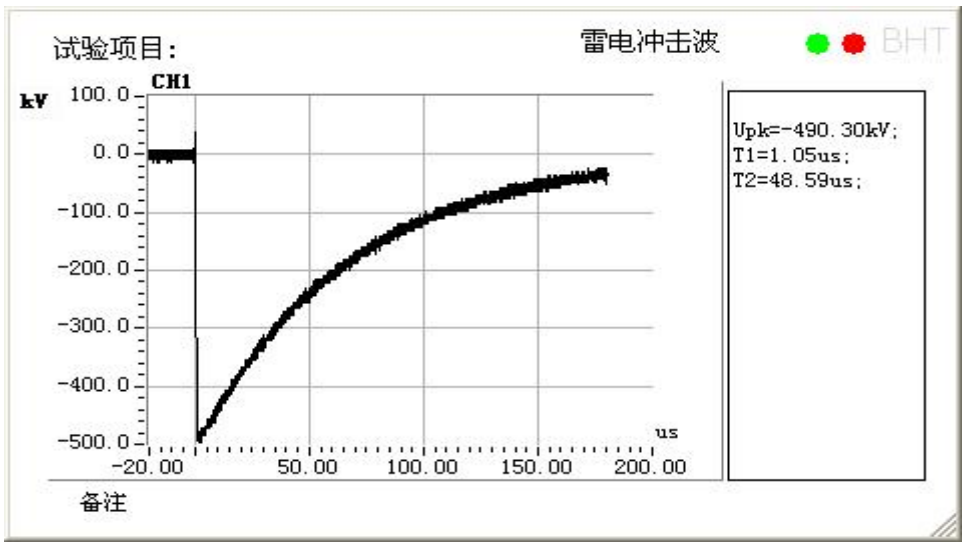


Tap Changer Testing Center of Shanghai Huaming Power Equipment Co., Ltd	Type test report	Type SHZVIII-600Y/170D-14273W On-load tap changer Commitment 2016SY022-E

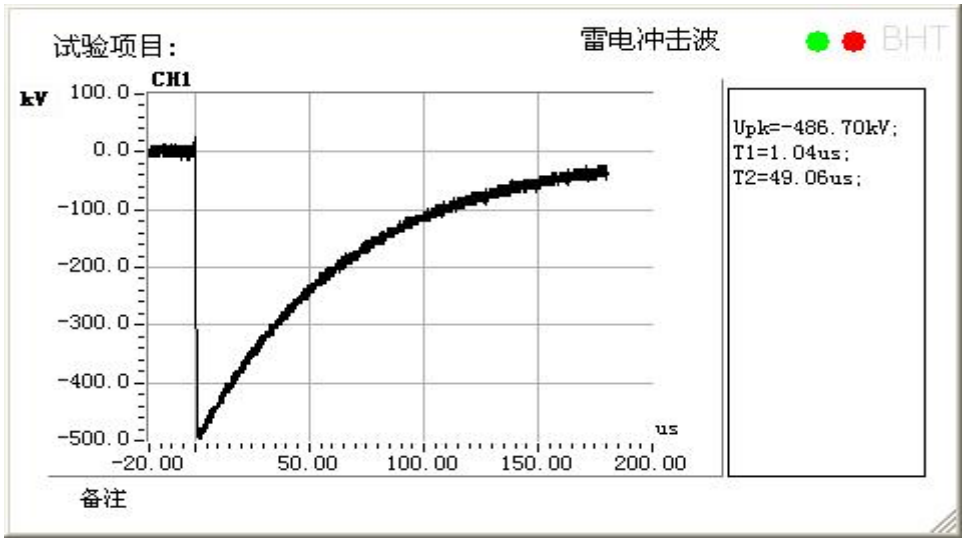


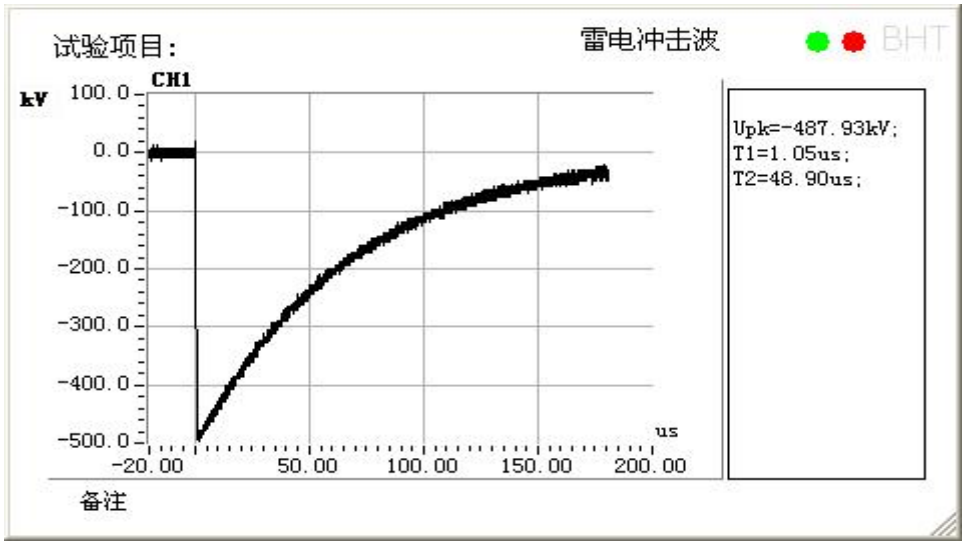


Tap selector test: between the min. tap and max. tap: 490kV (Negative)

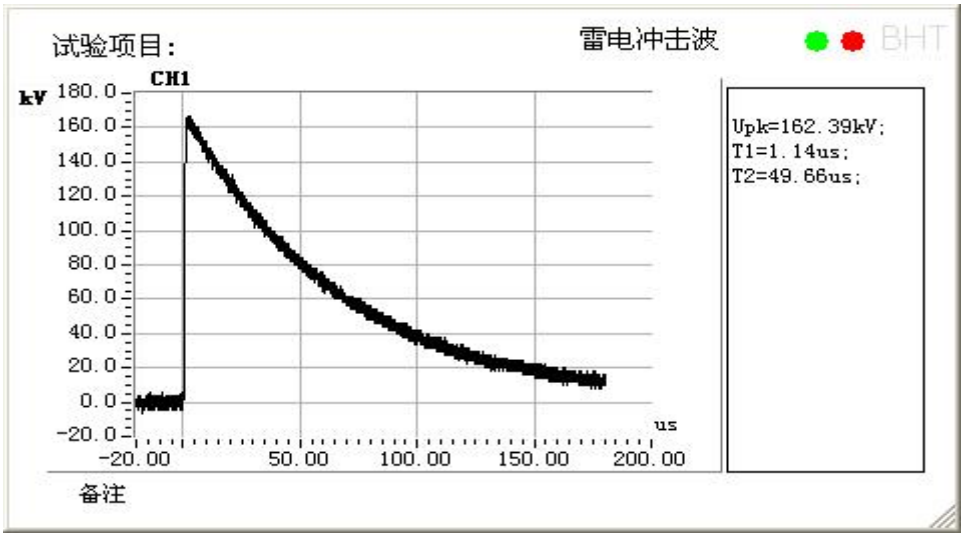


Tap Changer Testing Center of Shanghai Huaming Power Equipment Co., Ltd	Type test report	Type SHZVIII-600Y/170D-14273W On-load tap changer Commitment 2016SY022-E

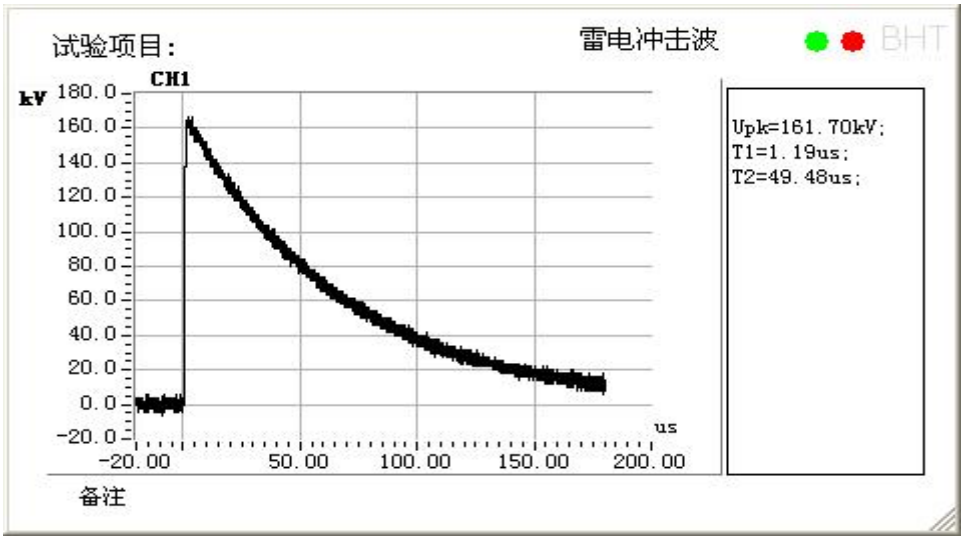


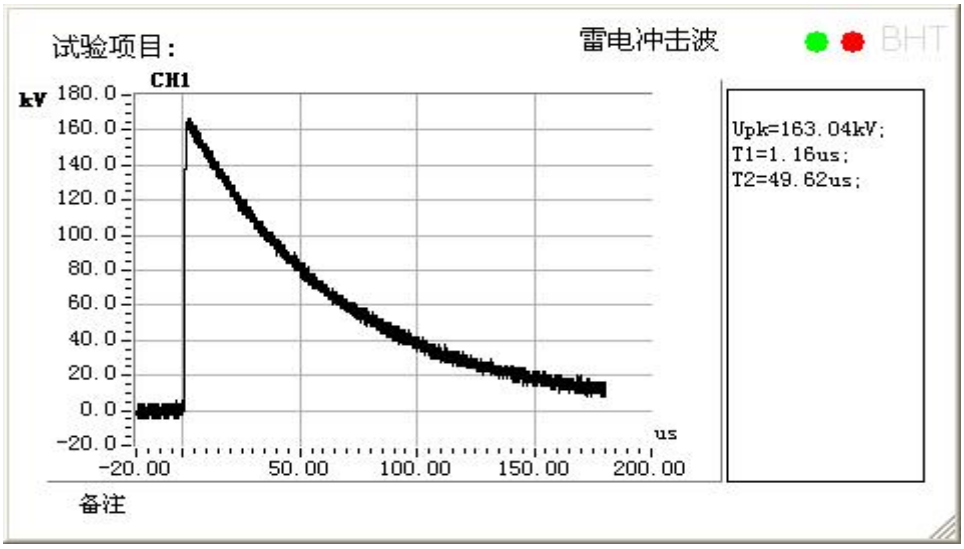


Tap selector test: between two adjacent taps:150kV (Positive)

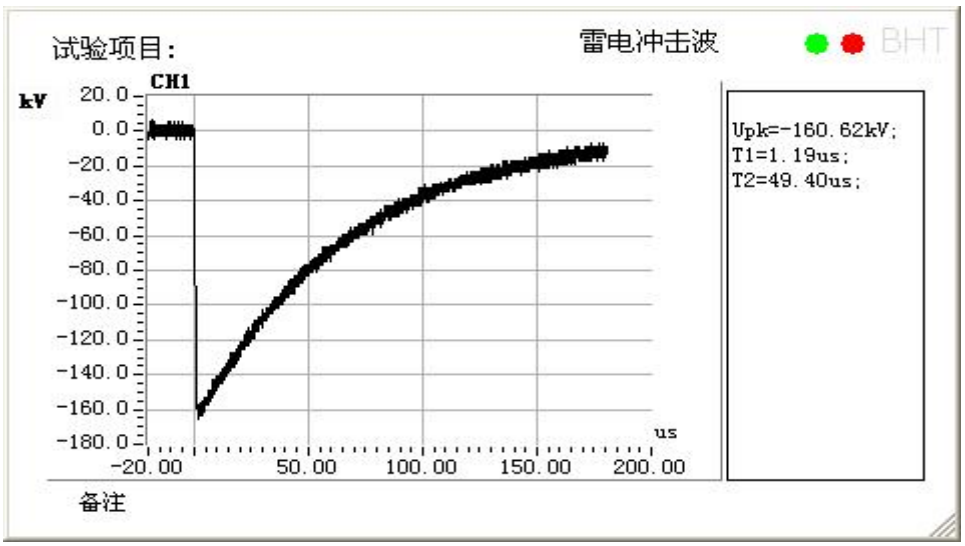


Tap Changer Testing Center of Shanghai Huaming Power Equipment Co., Ltd	Type test report	Type SHZVIII-600Y/170D-14273W On-load tap changer Commitment 2016SY022-E





Tap selector test: between two adjacent taps:150kV (Negative)



Tap Changer Testing Center of Shanghai Huaming Power Equipment Co., Ltd	Type test report	Type SHZVIII-600Y/170D-14273W On-load tap changer Commitment 2016SY022-E