TEST REPORT
Engineering Recommendation G99/1-8
Requirements for the connection of generation equipment in parallel with public distribution networks on or after 27 April 2019

Report	
Report Number. .... :	6138292.50V1.1
Date of issue.................................. :	2023-03-01
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Testing Laboratory .... :	DEKRA Testing and Certification (Suzhou) Co., Ltd.
Address .... :	No.99, Hongye Road, Suzhou Industrial Park, Suzhou, Jiangsu, P.R. China
Applicant's name .... :	Sungrow Power Supply Co., Ltd.
Address .... :	No.1699 Xiyou Rd., New & High Technology Industrial Development Zone, 230088, Hefei, P. R. China
Test specification:	
Standard.. :	Engineering Recommendation G99 Issue 1 – Amendment 8: 2021 (G99/1-8:2021)
Test procedure .... :	Type test
Non-standard test method…………..:	N/A
Test Report Form No. .... :	G99/1-8_V1.0
Test Report Form(s) Originator .... :	DEKRA Testing and Certification (Suzhou) Co., Ltd.
Master TRF .... :	Dated 2022-05
Test item description.................... :	Grid-connected PV inverter
Trade Mark .... :	SUNGROW
Manufacturer .... :	Sungrow Power Supply Co., Ltd. No.1699 Xiyou Rd., New & High Technology Industrial Development Zone, 230088, Hefei, P. R. China
Model/Type reference .... :	SG250HX
Ratings .... :	PV input: Max. 1500 Vdc, MPPT voltage range: 500-1500 Vdc, max 12*30 A, Isc PV: 12*50 A AC Output: 3/PE, 800Vac, 50/60 Hz, rated 225 kW, max 250 kVA, max 180.5 A

Responsible Testing Laboratory (as applicable), testing procedure and testing location(s):		
☒ **Testing Laboratory:**	DEKRA Testing and Certification (Suzhou) Co., Ltd.	
Testing location/ address .... :	No.99, Hongye Road, Suzhou Industrial Park, Suzhou, Jiangsu, P.R. China	
Tested by (name, function, signature) .... :	Sandy Qian (ENG)	Sandy Qian
Approved by (name, function, signature) .. :	Jason Guo (REW)	[redacted]
☐ ~~**Testing procedure: CTF Stage 1:**~~		
~~**Testing location/ address .... :**~~		
~~**Tested by (name, function, signature) .... :**~~		
~~**Approved by (name, function, signature) .. :**~~		
☐ ~~**Testing procedure: CTF Stage 2:**~~		
~~**Testing location/ address .... :**~~		
~~**Tested by (name + signature).................... :**~~		
~~**Witnessed by (name, function, signature) . :**~~		
~~**Approved by (name, function, signature) .. :**~~		
☐ ~~**Testing procedure: CTF Stage 3:**~~		
☐ ~~**Testing procedure: CTF Stage 4:**~~		
~~**Testing location/ address .... :**~~		
~~**Tested by (name, function, signature) .... :**~~		
~~**Witnessed by (name, function, signature) . :**~~		
~~**Approved by (name, function, signature) .. :**~~		
~~**Supervised by (name, function, signature) :**~~		

<table>
<tr><th colspan="4">G99/1-8</th></tr>
<tr><th>Clause</th><th>Requirement - Test</th><th>Result - Remark</th><th>Verdict</th></tr>
<tr><td>13.3.1.10</td><td>Table 13.6 Voltage against time parameters applicable to Type D Power Park Modules connected at or above 110 kV
<table>
<tr><th colspan="2">Voltage parameters (pu)</th><th colspan="2">Time parameters (s)</th></tr>
<tr><td>U_{ret}</td><td>0</td><td>t_{clear}</td><td>0.14</td></tr>
<tr><td>U_{clear}</td><td>0</td><td>t_{rec1}</td><td>0.14</td></tr>
<tr><td>U_{rec1}</td><td>0</td><td>t_{rec2}</td><td>0.14</td></tr>
<tr><td>U_{rec2}</td><td>0.85</td><td>t_{rec3}</td><td>2.2</td></tr>
</table></td><td></td><td>P</td></tr>
<tr><td>13.3.1.11</td><td>In addition to the requirements in 13.3.1.3 to 13.3.1.10:
(a) Each Power Generating Module shall be capable of satisfying the above requirements at the Connection Point when operating at Registered Capacity output and maximum leading Power Factor as specified in paragraph 13.5.1.</td><td></td><td>P</td></tr>
<tr><td></td><td>(b) The pre-fault voltage shall be taken to be 1.0 pu and the post fault voltage shall not be less than 0.9 pu.</td><td></td><td>P</td></tr>
<tr><td></td><td>(c) The DNO will publish fault level data under maximum demand conditions in the Long Term Development Statements. To allow a Generator to model the Fault Ride Through performance of its Power Generating Modules, the DNO will provide generic fault level values derived from typical cases. Where necessary, on reasonable request the DNO will specify the pre-fault and post fault short circuit capacity (in MVA) at the Connection Point and will provide additional network data as may reasonably be required for the Generator to undertake such study work.</td><td></td><td>P</td></tr>
<tr><td></td><td>(d) The protection schemes and settings for internal electrical faults shall not jeopardise Fault Ride Through performance as specified in paragraphs 13.3. For the avoidance of doubt where an internal fault on the Power Generating Module occurs during a Fault Ride Through condition, the Power Generating Module’s internal protection should trip the module to ensure safety and minimise damage.</td><td></td><td>P</td></tr>
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Clause	Requirement - Test	Result - Remark	Verdict
	(e) Each Power Generating Module shall be designed such within 0.5 s of restoration of the voltage at the Connection Point to 90% of nominal voltage or greater, Active Power output shall be restored to at least 90% of the level immediately before the fault. Once Active Power output has been restored to the required level, Active Power oscillations shall be acceptable provided that: ● The total active energy delivered during the period of the oscillations is at least that which would have been delivered if the Active Power was constant. ● The oscillations are adequately damped. ● In the event of power oscillations, Power Generating Modules shall retain steady state stability when operating at any point on the Generator Performance Chart.		P
13.3.2	In addition to paragraphs 13.3.1.1 – 13.3.1.11 where it has been specifically agreed between the DNO and the Generator that a Power Generating Facility will contribute to the DNO's Distribution Network security, (eg for compliance with EREC P2) the Power Generating Module(s) may be required to withstand, without tripping, the effects of a close up three phase fault and the Phase (Voltage) Unbalance imposed during the clearance of a close-up phase-to-phase fault, in both cases cleared by the DNO's main protection. The DNO will advise the Generator in each case of the likely tripping time of the DNO's protection, and for phase-phase faults, the likely value of Phase (Voltage) Unbalance during the fault clearance time.		P
13.3.3	In the case of phase to phase faults on the DNO's Distribution Network that are cleared by system back-up protection which will be within the plant short time rating on the DNO's Distribution Network the DNO, on request during the connection process, will advise the Generator of the expected Phase (Voltage) Unbalance.		P
13.3.4	Other Fault Ride Through Requirements (a) In the case of a Power Park Module, the requirements in paragraph 13.3 do not apply when the Power Park Module is operating at less than 5% of its Registered Capacity or during very high primary energy source conditions when more than 50% of the Generating Units in a Power Park Module have been shut down or disconnected under an emergency shutdown sequence to protect Generator's plant and apparatus. (b) For the avoidance of doubt the requirements specified in this Section 13.3 do not apply to Power Generating Modules connected to an unhealthy circuit and islanded from the Distribution Network even for delayed auto reclosure times.		P

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Clause	Requirement - Test	Result - Remark	Verdict
13.4	**Voltage Limits and Control**		P
13.4.1	Where a Power Generating Module is remote from a Network voltage control point it may be required to withstand voltages outside the normal statutory limits. In these circumstances, the DNO should agree with the Generator the declared voltage and voltage range at the Connection Point. Immunity of the Power Generating Module to voltage changes of ± 10% of the declared voltage is recommended, but is mandatory for Type D Power Generating Modules, subject to design appraisal of individual installations.		P
13.4.2	The connection of a Power Generating Module to the Distribution Network shall be designed in such a way that operation of the Power Generating Module does not adversely affect the voltage profile of and voltage control employed on the Distribution Network. ETR 126 provides DNOs with guidance on active management solutions to overcome voltage control limitations. Information on the voltage regulation and control arrangements will be made available by the DNO if requested by the Generator.		P
13.4.3	Synchronous Power Generating Modules Excitation Performance Requirements		N/A
13.4.4	Voltage Control Performance Requirements for Power Park Modules		P
13.4.4.1	Each Power Park Module shall be fitted with a continuously acting automatic control system to provide control of the voltage at the Connection Point without instability over the entire operating range of the Power Park Module. Any plant or apparatus used to provide such voltage control within a Power Park Module may be located at the Generating Unit terminals, an appropriate intermediate busbar or the Connection Point. When operating below 20% Registered Capacity the automatic control system may continue to provide voltage control using any available reactive capability. If voltage control is not being provided the automatic control system shall be designed to ensure a smooth transition between the shaded area below 20% of Active Power output and the non-shaded area above 20% of Active Power output in Figure 13.14.		P
13.4.4.2	The performance requirements for a continuously acting Automatic Voltage Control system that shall be complied with by the Generator in respect of Power Park Modules are defined in Annex C.5. The DNO will agree any site specific requirements with the Generator.		P

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Clause	Requirement - Test	Result - Remark	Verdict
13.4.5	As part of the connection application process the Generator shall agree with the DNO the set points of the control scheme for voltage control, Power Factor control or Reactive Power control as appropriate. These settings, and any changes to these settings, shall be agreed with the DNO and recorded in the Connection Agreement. The information to be provided is detailed in Schedule 5a and Schedule 5b of the Data Registration Code.		P
13.4.6	The final responsibility for control of Distribution Network voltage does however remain with the DNO.		P
13.4.7	Automatic Voltage Control (AVC) schemes employed by the DNO often assume that power flows from parts of the Distribution Network operating at a higher voltage to parts of the Distribution Network operating at lower voltages. Export from Power Generating Modules in excess of the local loads may result in power flows in the reverse direction. In this case AVC referenced to the Low Voltage side may not operate correctly without an import of Reactive power and relay settings appropriate to this operating condition. When load current compounding is used with the AVC and the penetration level of Power Generating Modules becomes significant compared to normal loads, it may be necessary to switch any compounding out of service.		P
13.4.8	Power Generating Modules can cause problems if connected to networks employing AVC schemes which use negative reactance compounding and line drop compensation due to changes in Active Power and Reactive Power flows. ETR 126 provides guidance on connecting generation to such networks using techniques such as removing the generation circuit from the AVC scheme using cancellation CTs.		P
13.5	**Reactive Capability**		P
13.5.1	All Synchronous Power Generating Modules shall be capable of satisfying the Reactive Power capability requirements at the Connection Point as defined in Figure 13.11 when operating at Registered Capacity. In some cases, for example, on large industrial sites etc where the Power Generating Module is embedded in the Generator's Installation, the DNO may specify a performance requirement for the Power Generating Module that fits within the rectangular boundary defined in Figure 13.11, ie an envelope agreed between the DNO and the Generator within the rectangle of Figure 13.11. In such cases the DNO and Generator might agree a different control point, such as the Power Generating Module's terminals. The performance requirements of the control system including Slope (where applicable) shall be agreed between the DNO and the Generator.		N/A

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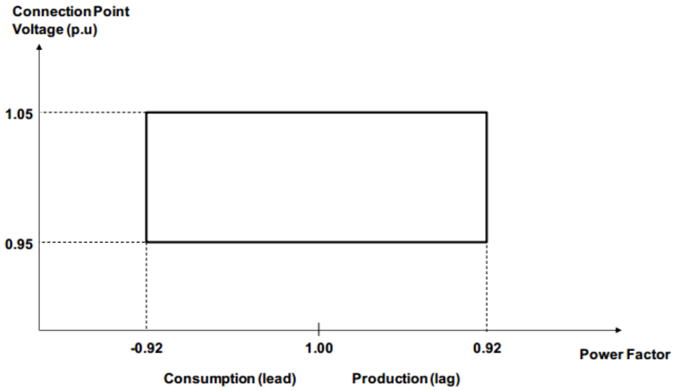
Clause	Requirement - Test	Result - Remark	Verdict
13.5.2	At Active Power output levels other than Registered Capacity all Generating Units within a Synchronous Power Generating Module shall be capable of continuous operation at any point between the Reactive Power capability limit identified on the Generator Performance Chart at least down to the Minimum Stable Operating Level. At reduced Active Power output, Reactive Power supplied at the Connection Point shall correspond to the Generator Performance Chart of the Synchronous Power Generating Module, taking the auxiliary supplies and the Active Power and Reactive Power losses of the Power Generating Module transformer or Station Transformer into account.		N/A
13.5.3	At voltages above 1.05 pu, or below 0.95 pu a Synchronous Power Generating Module shall maintain the Reactive Power output and Power Factor as far as possible recognizing that outside of the envelope of Figure 13.11 it will be necessary for the Reactive Power and/or Power Factor to be constrained by the capability as expressed on the Generator Performance Chart.		N/A
	 **Figure 13.11 Reactive Power capability requirements (Synchronous Power Generating Modules)**		N/A

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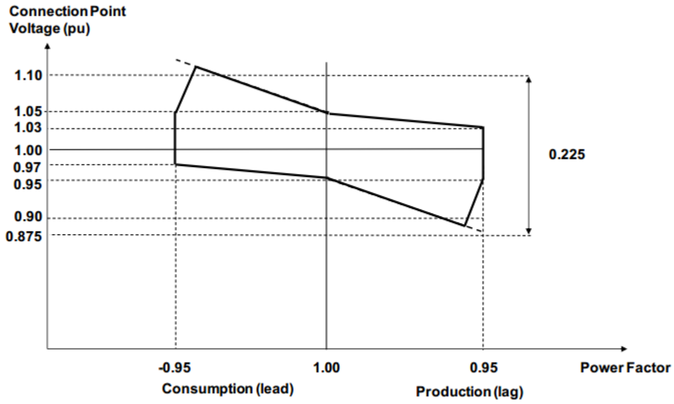
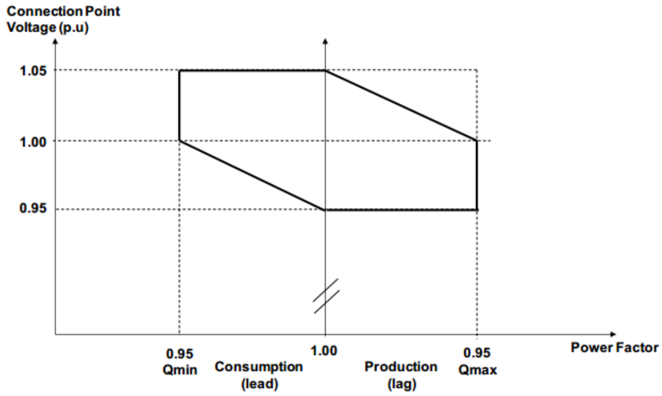
Clause	Requirement - Test	Result - Remark	Verdict
13.5.4	All Power Park Modules with a Connection Point voltage above 33 kV, shall be capable of satisfying the Reactive Power capability requirements at the Connection Point as defined in Figure 13.12 when operating at Registered Capacity.  **Figure 13.12 Reactive Power capability requirements (Power Park Modules operating at Registered Capacity, voltage above 33 kV)**		P
13.5.5	All Power Park Modules with a Connection Point voltage at or below 33 kV shall be capable of satisfying the Reactive Power capability requirements at the Connection Point as defined in Figure 13.13 when operating at Registered Capacity.  **Figure 13.13 Reactive Power capability requirements (Power Park Modules operating at Registered Capacity, voltage at or below 33 kV)**		P

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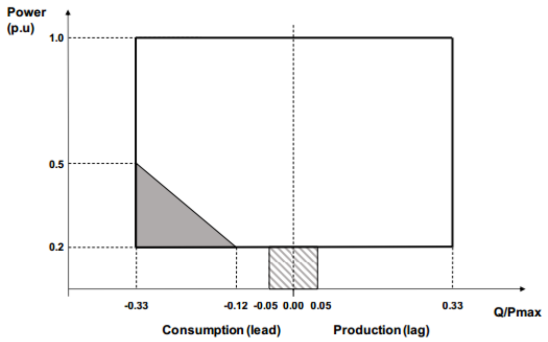
Clause	Requirement - Test	Result - Remark	Verdict
13.5.6	All Power Park Modules, shall be capable of satisfying the Reactive Power capability requirements at the Connection Point as defined in Figure 13.14 when operating below Registered Capacity. With all plant in service, the Reactive Power limits will reduce linearly below 50% Active Power output as shown in Figure 13.14 unless the requirement to maintain the Reactive Power limits defined at Registered Capacity under absorbing Reactive Power conditions down to 20% Active Power output has been specified by the DNO. These Reactive Power limits will be reduced pro rata to the amount of plant in service.  **Figure 13.14 Reactive Power capability requirements (Power Park Modules operating below Registered Capacity)**		P
13.6	**Fast Fault Current Injection**		P
13.6.1	Fast Fault Current injection is necessary to support the Total System during a fault on the Transmission System. The design of Fast Fault Current injection is tailored to this, and does not relate directly to faults on the Distribution Network, not least as these will tend to have longer clearing times than those of the Transmission System for which Fast Fault Current injection is designed. In this Section 13.6 the faults referred to are Transmission System faults which clear within 140 ms and which will be seen in the Distribution Network as a voltage depression. For this section 13.6 voltage and current quantities are assumed to be positive phase sequence values.		P
13.6.2	Each Power Park Module shall be required to satisfy the following requirements.		P

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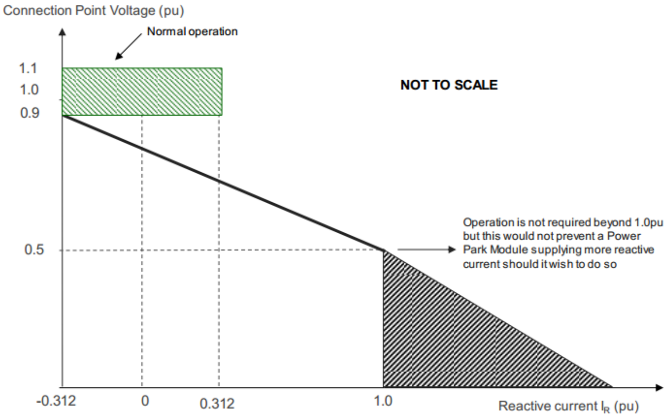
Clause	Requirement - Test	Result - Remark	Verdict
	(a) For any balanced fault on the Transmission System which results in the voltage at the Connection Point falling below 0.9 pu each Power Park Module shall unless otherwise agreed with the DNO, be required to inject reactive current IR that lies above the heavy black line shown in Figure 13.15.  **Figure 13.15 – locus of magnitude of injected reactive current**		P
	(b) Figure 13.15 defines the reactive current IR that is to be supplied during a fault on the Transmission System and which is dependent on the prefault operating conditions, and the voltage retained at the Connection Point. Each Power Park Module shall inject a reactive current I_R which shall not be less than its pre-fault reactive current and which shall as a minimum increase with the fall in retained voltage each time the retained voltage at the Connection Point falls below 0.9 pu, whilst ensuring that the overall rating of the Power Park Module is not exceeded		P
	(c) In addition each Power Park Module shall be required to satisfy the reactive current requirements shown in Figures 13.16 which shows how the reactive current should be injected over time from the fault inception. The injected current shall be above the shaded area shown in Figure 13.16 (a) or Figure 13.16 (b) with priority being given to reactive current injection with any residual capability being supplied as active current. Under any fault condition, where the voltage falls below 0.9 pu, there would be no requirement for any Power Park Module or constituent Generating Unit to exceed its transient or steady state rating.		

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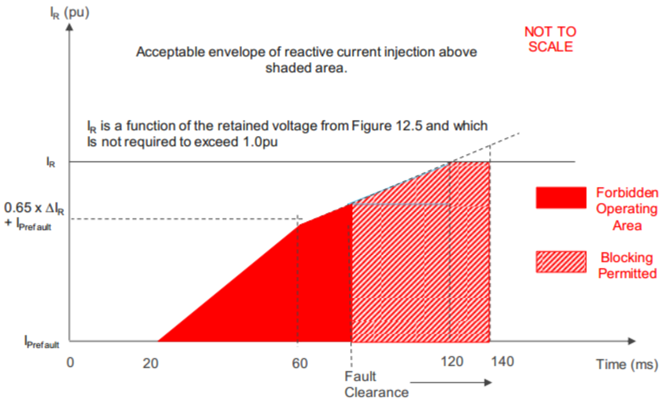
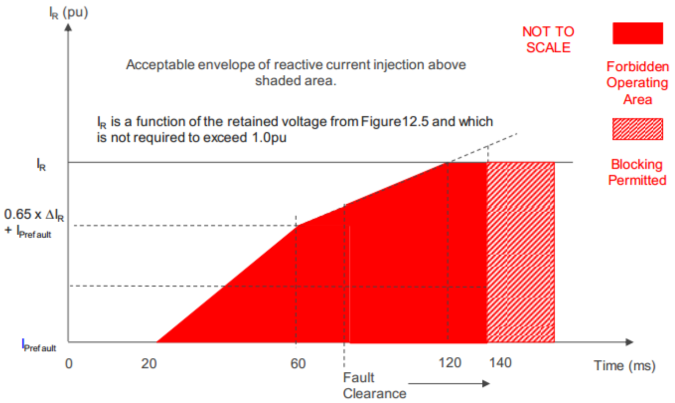
Clause	Requirement - Test	Result - Remark	Verdict
	 **Figure 13.16(a) Chart showing area of Reactive Current injections for voltage depressions of ≤ 140 ms duration**  **Figure 13.16(b) Chart showing area of Reactive Current injections for voltage depressions of > 140 ms duration**		P
	(d) For the purposes of this requirement, the maximum rated current is taken to be the maximum current each Generating Unit can supply when operating at Registered Capacity and 0.95 Power Factor at a nominal voltage of 1.0 pu.		P
	(e) All Power Park Module equipment shall be designed to ensure a smooth transition between any of its voltage, power factor, or reactive power control modes and fault ride through mode in order to prevent the risk of instability which could arise in the transition between the steady state voltage operating range and abnormal conditions where the retained voltage falls below 0.90 pu of nominal voltage. Such a requirement is necessary to ensure adequate performance between the pre-fault operating condition of the Power Park Module and its subsequent behaviour under fault conditions.		P

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Clause	Requirement - Test	Result - Remark	Verdict
	(f) Each Power Park Module shall be designed to reduce the risk of transient over voltage levels arising following clearance of the fault and in order to mitigate the risk of any form of instability which could result. Generators shall be permitted to block or employ other means where the anticipated transient over voltage would otherwise exceed the 1.05 pu of nominal. Figures 13.16 (a) and Figure 13.16 (b) show the impact of variations in fault clearance time which shall be no greater than 140 ms. The DNO may agree requirements for the maximum transient over voltage withstand capability and associated time duration. Such capability and parameters will be recorded in the Connection Agreement. Where the Generator is able to demonstrate to the DNO that blocking or other control strategies are required in order to prevent the risk of transient over voltage excursions Generators are required to both advise and agree with the DNO the control strategy, which must also include the approach taken to de-blocking.		P
	(g) To permit additional flexibility for example from Power Park Modules made up of full converter Generating Units, DFIG Generating Units or induction Generating Units, the DNO will permit transient deviations below the shaded area shown in Figure 13.16 (a) or Figure 13.16 (b) provided that the reactive current supplied is greater than the minimum requirement shown in Figures 13.16 (a) or Figure 13.16(b). This agreement will be formalised in the Connection Agreement.		P
	(h) In the case of an unbalanced fault, each Power Park Module or each Generating Unit within a Power Park Module shall be required to inject maximum reactive current without exceeding the transient rating of the Power Park Module.		P
13.7	**Black Start Capability and rapid re-synchronisation**		N/A
13.7.1	The National Electricity Transmission System will be equipped with Black Start Stations. It will be necessary for each Generator to notify the DNO if its Power Generating Module has a restart capability without connection to an external power supply, unless the Generator shall have previously notified the NETSO accordingly under the Grid Code. Such generation may be registered by the NETSO as a Black Start Station.		N/A

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Clause	Requirement - Test	Result - Remark	Verdict
13.7.2	In case of disconnection of the Power Generating Module from the Distribution Network, the Power Generating Module shall be capable of quick resynchronisation if required by the NETSO. Where rapid re-synchronisation is required: (a) A Power Generating Module with a minimum re-synchronisation time greater than 15 minutes after its disconnection from any external power supply must be capable of houseload operation from any operating point on its Power Generating Module Generator Performance Chart. And b) Power Generating Modules shall be capable of houseload operation, irrespective of any auxiliary connection to the Distribution Network. The minimum operation time shall be specified by the NETSO, taking into consideration the specific characteristics of prime mover technology.		N/A
13.8	**Technical Requirements for Embedded Medium Power Stations**		N/A
13.9	**Operational monitoring**		P
13.9.1	With regard to information exchange: (a) Power Generating Facilities shall be capable of exchanging information with the DNO in real time or periodically with time stamping; (b) the DNO, in coordination with the NETSO, shall specify the content of information exchanges including a precise list of data to be provided by the Power Generating Facility.		P
13.9.2	At each Power Generating Facility the DNO will install its own Telecontrol/SCADA outstation which will generally meet all the DNO's necessary and legal operational data requirements. The DNO will inform the Generator if additional specific data are required at the time of the connection offer.		P
13.9.3	Additionally each Power Generating Facility shall; (a) be fitted with fault recording and dynamic system monitoring facilities which shall be capable of recording System data including voltage, Active Power, Reactive Power and frequency in accordance with Annex C.6. (b) The settings of the fault recording equipment and dynamic system monitoring equipment (which is required to detect poorly damped power oscillations) including triggering criteria shall be agreed between the Generator and the DNO and recorded in the Connection Agreement. (c) The DNO may also specify that Generators shall install power quality monitoring equipment. Any such requirement including the parameters to be monitored would be specified by the DNO in the Connection Agreement. (d) Provisions for the submission of fault recording, dynamic system monitoring and power quality data to the DNO including the communications and protocols shall be specified by the DNO in the Connection Agreement.		P

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Clause	Requirement - Test	Result - Remark	Verdict
13.9.4	The Generator will provide all relevant signals in a format to be agreed between the Generator and the DNO for onsite monitoring. All signals shall be suitably terminated in a single accessible location at the Generators site.		P
13.9.5	The Generator shall provide to the DNO a 230 V power supply adjacent to the signal terminal location.		P
13.9.6	Frequency Sensitive Mode (FSM) monitoring in real time		P
13.9.6.1	Power Generating Modules shall be fitted with facilities to record and monitor the operation of Active Power Frequency Response in real time if the Generator has chosen to enter into an appropriate ancillary services commercial contract with the NETSO.		P
13.9.6.2	Provisions for the submission of Frequency Sensitive Mode data to the DNO including the data to be monitored, communications and protocols shall be specified, if required, by the DNO in the Connection Agreement.		P
13.10	**Steady State Load Inaccuracies**		N/A
	The standard deviation of load error at steady state load over a 30 minute period shall not exceed 2.5% of a Power Generating Modules Registered Capacity. Where a Power Generating Module is instructed to operate in frequency sensitive operation, allowance will be made in determining whether there has been an error according to the governor Droop characteristic registered under the DDRC.		N/A
	For the avoidance of doubt in the case of a Power Park Module allowance will be made for the full variation of mechanical power output.		N/A
14	**INSTALLATION, OPERATION AND CONTROL INTERFACE**		P
14.1	**General**		P
14.2	**Isolation and Safety Labelling**		P
14.2.1	Every Generator’s Installation which includes Power Generating Modules operating in parallel with the Distribution Network must include a means of isolation capable of disconnecting the whole of the Power Generating Module7 infeed to the Distribution Network. This equipment will normally be owned by the Generator, but may by agreement be owned by the DNO.		P
14.2.2	The Generator must grant the DNO rights of access to the means of isolation without undue delay and the DNO must have the right to isolate the Power Generation Modules infeed at any time should such disconnection become necessary for safety reasons and in order to comply with statutory obligations. The isolating device should normally be installed at the Connection Point, but may be positioned elsewhere with the DNO’s agreement.		P

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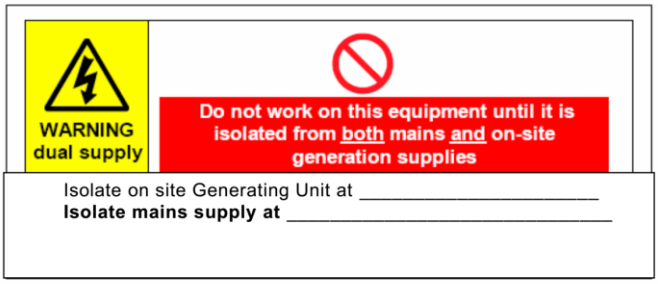
Clause	Requirement - Test	Result - Remark	Verdict
14.2.3	To ensure that DNO staff and that of the Generator and their contractors are aware of the presence of a Power Generating Module, appropriate warning labels should be used.		P
14.2.4	Where the installation is connected to the DNO LV Distribution Network the Generator should generally provide labelling at the Connection Point (Fused Cut-Out), meter position, consumer unit and at all points of isolation within the Generator's premises to indicate the presence of a Power Generating Module. The labelling should be sufficiently robust and if necessary fixed in place to ensure that it remains legible and secure for the lifetime of the installation. The Health and Safety (Safety Signs & Signals) Regulations 1996 stipulates that labels should display the prescribed triangular shape, and size, using black on yellow colouring. A typical label, for both size and content, is shown below in Figure 14.1.  **Figure 14.1 Warning label**		P
14.3	**Site Responsibility Schedule**		Info.
14.4	**Operational and Safety Aspects**		Info.
14.5	**Synchronizing and Operational Control**		P
15	**Common Compliance and Commissioning Requirements for all Power Generating Modules**		N/A
15.1	**Demonstration of Compliance**		N/A
15.2	**Wiring for Type Tested Power Generating Modules**		N/A
15.3	**Commissioning Tests / Checks required at all Power Generating Facilities**		N/A
15.4	**Additional Commissioning requirements for Non Type Tested Interface Protection**		N/A
15.5	**Compliance of Vehicle to Grid Electric Vehicles**		N/A
15.6	**Family approach to Type Testing**		N/A
15.7	**Compliance demonstration for Infrequent Short-Term Parallel Power Generating Modules**		N/A
16	**TYPE A COMPLIANCE TESTING, COMMISSIONING AND OPERATIONAL NOTIFICATION**		P
16.1	**Type Test Certification**		P

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Clause	Requirement - Test	Result - Remark	Verdict
16.1.1	The Power Generating Module can comprise Fully Type Tested equipment or be made up of some Type Tested equipment and require additional site testing prior to operation. The use of Fully Type Tested equipment simplifies the connection process, the protection arrangements and reduces the commissioning test requirements.		P
16.1.2	Type Tested certification is the responsibility of the Manufacturer. The Manufacturer shall submit the Type Test Verification Report confirming that the product has been Type Tested to satisfy the requirements of this EREC G99 to the Energy Networks Association (ENA) Type Test Verification Report Register. The report shall detail the type and model of product tested, the test conditions and results recorded. The report can include reference to Manufacturers' Information.		P
16.1.3	The required Type Test Verification Report and declarations including that for a Fully Type Tested Power Generating Module are shown in Annex A.2:		P
	• Form A2-1 - Compliance Verification Report for Synchronous Power Generating Modules up to and including 50 kW,	Inverter Connected Power Generating Modules.	N/A
	• Form A2-2 Compliance Verification Report for Synchronous Power Generating Modules greater than> 50 kW and also for Synchronous Power Generating Modules ≤ 50 kW where the approach of this form is preferred to that in Form A2-1, or	Inverter Connected Power Generating Modules.	N/A
	• Form A2-3 - Compliance Verification Report for Inverter Connected Power Generating Modules.		N/A

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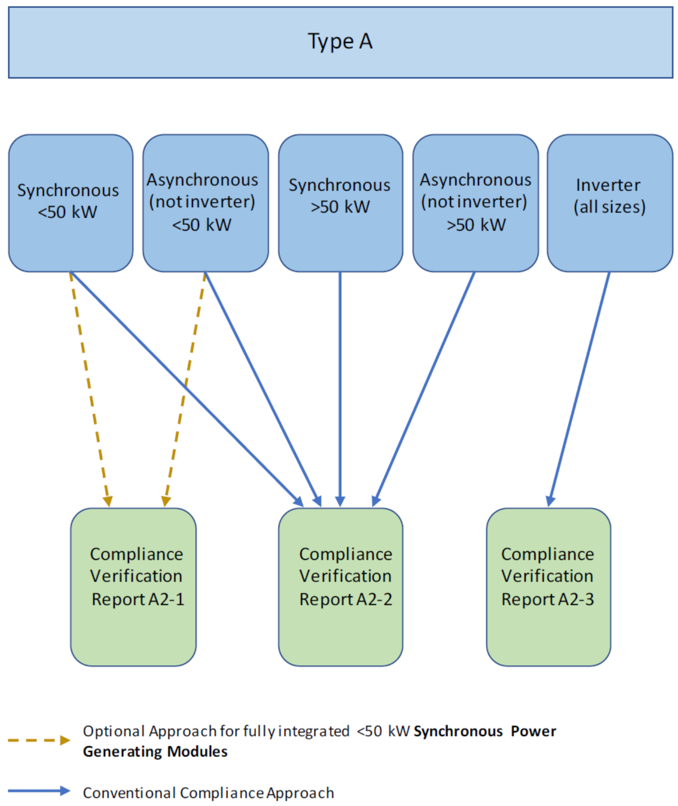
Clause	Requirement - Test	Result - Remark	Verdict
	The choice of compliance route available is shown in Figure 16-1 below.  **Figure 16-1 Illustration of the choice of compliance route**	Compliance Verification Report A2-3 used.	N/A
	It is intended that the Manufacturers will use the requirements of this EREC G99 to develop type verification certification (ie the Compliance Verification Report as shown in Annex A.2) for each of their Power Generating Module models.		N/A
	Form A2-3 caters for all asynchronous and inverter technologies of any size, with the exception of conventional induction Generating Units. Manufacturers of induction Generating Units may find it more appropriate to use forms A2-2 or A2-1 in preference to Form A2-3 (Annex A.2).		N/A
16.1.4	Guidance for Manufacturers on type testing for Power Generating Modules is included in Annex A.7 of this document.		N/A
16.1.5	Compliance with the requirements detailed in this EREC G99 will ensure that the Power Generating Module is considered to be approved for connection to the DNO's Distribution Network.		P
16.1.6	The Power Generating Module shall comply with all relevant UK and European Directives and should be labelled in accordance with those requirements.		P

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Clause	Requirement - Test	Result - Remark	Verdict
16.2	**Connection Process**		N/A
16.2.1	The Installer shall discuss the installation project with the local DNO at the earliest opportunity. The connection application will need to be in format as shown in Annex A.1 (Form A1) or for Power Generating Modules greater than 50 kW by using the Standard Application Form (generally available from the DNOs website). Where a Power Generating Module is Fully Type Tested and registered with the Energy Networks Association Type Test Verification Report Register, the application should include the Manufacturer's reference number (the Product ID), and the compliance test results do not need to be submitted as part of the application.	Relied on installer.	N/A
16.2.2	On receipt of the application, the DNO will assess: • whether any Distribution Network studies are required; • whether there is a need for work on the Distribution Network before the Tested Power Generating Module can be connected to the Distribution Network; and • whether there is a requirement to witness the commissioning tests and checks.	Fully Type Test.	N/A
16.2.3	Connection of the Power Generating Module is only allowed after the application for connection has been approved by the DNO and any DNO works facilitating the connection have been completed.	It's depended on installer and DNOs.	N/A
16.2.4	Where a Power Generating Module is not Fully Type Tested, the Generator or Installer shall provide the DNO with a Compliance Verification Report as per Annex A.2 (Forms A2-1, A2-2 or A2-3 as applicable) confirming that the Power Generating Module has or will be tested to satisfy the requirements of this EREC G99. This should be provided prior to commencing commissioning.	It's depended on installer and DNOs.	N/A
16.2.5	Where Power Generating Modules require connection to the DNO's Distribution Network in advance of the commissioning date, for the purposes of testing, the Power Generating Facility must comply with the requirements of the Connection Agreement. The Generator shall provide the DNO with a commissioning programme, which will be approved by the DNO if reasonable in the circumstances, to allow commissioning tests to be coordinated.	It's depended on installer and DNOs.	N/A

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Clause	Requirement - Test	Result - Remark	Verdict
16.2.6	Where commissioning tests are not witnessed, confirmation of the commissioning of each Power Generating Module will need to be made no later than 28 days after commissioning; the format and content shall be as shown in Annex A.3 (Form A3) Installation Document. The Installer or Generator, as appropriate, shall complete the declaration at the bottom of the Installation Document (Form A3) noting that this declaration also covers the Site Compliance and Commissioning Test Form (Form A2-4). Where the tests are witnessed a copy shall be provided to the DNO at the time of commissioning.	It's depended on installer and DNOs.	N/A
16.2.7	It is the responsibility of the Generator (which may be delegated to the Installer) to ensure that the relevant information is forwarded to the local DNO. The pro forma in Annex A are designed to: (a) simplify the connection procedure for both DNO and Installer; (b) provide the DNO with all the information required to assess the potential impact of the Power Generating Module connection on the operation of the Distribution Network; (c) inform the DNO that the Generator's Installation complies with the requirements of this EREC G99; (d) allow the DNO to accurately record the location of all Power Generating Modules connected to the Distribution Network.	It's depended on installer and DNOs.	N/A
16.3	**Witnessing and Commissioning**		N/A
16.4	**Operational Notification**		N/A
16.4.1	Notification that the Power Generating Module has been connected / commissioned is achieved by completing an Installation Document as per Annex A.3, which also includes the relevant details on the Generator's Installation required by the DNO.		N/A
16.4.2	The Installer, or an agent acting on behalf of the Installer, shall supply separate Installation Documents (Form A3-1 (Annex A.3) for Type A Power Generating Modules or Form A3-2 (Annex A.3) for Integrated Micro Generation and Storage installations) for each Power Generating Facility installed under EREC G99 to the DNO. Documentation shall be supplied either at the time of commissioning (where tests are witnessed) or within 28 days of the commissioning date (where the tests are not witnessed) and may be submitted electronically.	It's depended on installer and DNOs.	N/A
16.4.3	Generators who own Type A Power Generating Modules do not have permanent rights to operate their Power Generating Modules until the commissioning tests have been successfully completed (and witnessed by the DNO if required) and the Installation Document has been fully completed and sent to the DNO	It's depended on installer and DNOs.	N/A

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict
17	**TYPE B COMPLIANCE TESTING, COMMISSIONING AND OPERATIONAL NOTIFICATION**		P
17.1	**General**		P
17.1.1	Where Power Generating Modules require connection to the DNO’s Distribution Network in advance of the commissioning date, for the purposes of testing, the Power Generating Facility shall comply with the requirements of the Connection Agreement. The Generator shall provide the DNO with a commissioning programme, which will be approved by the DNO if reasonable in the circumstances, to allow commissioning tests to be co-ordinated. The tests shall take account of the requirements in Section 15.3 and Section 15.4 where applicable.		P
17.1.2	The Generator shall use Type Tested equipment and/or Manufacturers’ Information and/or site tests, as well as demonstrating commissioning tests performed on the Power Generating Module in order to discharge the requirements of this document. Examples of the combination of the use of type testing and the provision of Manufacturers’ Information are given in Section 22.1. Further information about Manufacturers’ Information for Inverter connected Power Park Modules is given in Section 21. Note that the DNO shall charge the Generator for attendance of staff for witness testing in accordance with its charging regime. The Generator shall make arrangements for the DNO to witness the commissioning tests unless otherwise agreed with the DNO.		P
17.1.3	It is the responsibility of the Generator to undertake commissioning tests / checks and to ensure the Power Generating Facility and Power Generating Modules meet all the relevant requirements.		P
17.1.4	In addition to the commissioning tests and checks required under EREC G99, in exceptional circumstances further tests may be required by the DNO from the Manufacturer, Supplier, Generator or Installer of the Power Generating Modules as may be required to satisfy legislation and other standards.		P
17.2	**Connection Process**		N/A
17.2.1	The Generator shall discuss the project with the local DNO at the earliest opportunity. The Generator will need to provide information using the Standard Application Form (generally available from the DNO’s website) to allow detailed system studies to be undertaken. Connection of the Power Generating Module is only allowed after the application for connection has been approved by the DNO and any DNO works facilitating the connection have been completed .	It’s depended on installer and DNOs.	N/A

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Clause	Requirement - Test	Result - Remark	Verdict
17.2.2	Not less than 28 days, or such shorter period as may be acceptable in the DNO's reasonable opinion, prior to the Generator wishing to synchronise its Power Generating Module for the first time the Generator will submit to the DNO a Power Generating Module Document containing at least but not limited to the items referred to in paragraph 17.2.3.	It's depended on installer and DNOs.	N/A
17.3	**Witnessing and Commissioning**		N/A
17.4	**Final Operational Notification**		N/A
18	**TYPE C COMPLIANCE TESTING, COMMISSIONING AND OPERATIONAL NOTIFICATION**		P
18.1	**General**		N/A
18.1.1	Where Power Generating Modules require connection to the DNO's Distribution Network in advance of the commissioning date, for the purposes of testing, the Power Generating Facility shall comply with the requirements of the Connection Agreement. The Generator shall provide the DNO with a commissioning programme, which will be approved by the DNO if reasonable in the circumstances, to allow commissioning tests to be co-ordinated. The tests shall take account of the requirements in Section 15.3 and Section 15.4 where applicable.		P
18.1.2	The Generator shall use Type Tested equipment and/or Manufacturers' Information and/or site tests as well demonstrating all the commissioning tests performed on the Power Generating Module in order to discharge the requirements of this document. Further information about Manufacturers' Information is given in Section 21. Examples of the combination of the use of type testing and the provision of Manufacturers' Information are given in Section 22.1. Note that the DNO shall charge the Generator for attendance of staff for witness testing in accordance with its charging regime. The Generator shall make arrangements for the DNO to witness the commissioning tests unless otherwise agreed with the DNO.		P
18.1.3	It is the responsibility of the Generator to undertake commissioning tests / checks and to ensure the Power Generating Facility and Power Generating Modules meet all the relevant requirements.		P
18.1.4	In addition to the commissioning tests and checks required under EREC G99, further tests may be required by the Manufacturer, Supplier, Generator or Installer of the Power Generating Modules as may be required to satisfy legislation and other standards.		P

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Clause	Requirement - Test	Result - Remark	Verdict
18.1.5	In the case of a Power Park Module the proportion of the Power Park Module which can be simultaneously synchronised to the Total System shall not exceed 20% of the Registered Capacity of the Power Park Module (or the output of a single Generating Unit where this exceeds 20% of the Power Park Module's Registered Capacity), until the Generator has completed the voltage control tests (detailed in Annex C.9.2) to the DNO's reasonable satisfaction. Following successful completion of this test each additional Generating Unit should be included in the voltage control scheme as soon as is technically possible (unless the DNO agrees otherwise).		P
18.2	**Connection Process**		N/A
18.3	**Witnessing and Commissioning**		N/A
18.4	**Final Operational Notification**		N/A
19	**TYPE D COMPLIANCE TESTING, COMMISSIONING AND OPERATIONAL NOTIFICATION**		P
19.1	**General**		P
19.1.1	A Type D Power Generating Module will be required to obtain an Energisation Operational Notification followed by an Interim Operational Notification and a Final Operational Notification as set out in this Section.		P
19.1.2	The Generator will use Type Tested equipment and or use Manufacturers' Information as well as demonstrating all the commissioning tests performed on the Power Generating Module in order to discharge the requirements of this document. Examples of the combination of the use of type testing and the provision of Manufacturers' Information are given in Section 22.1. Further information about Manufacturers' Information is given in Section 21. It is expected that the DNO will witness the commissioning tests for Power Generating Modules. Note that the DNO shall charge the Generator for attendance of staff for witness testing in accordance with its charging regime. The Generator shall make arrangements for the DNO to witness the commissioning tests unless otherwise agreed with the DNO.		P
19.1.3	It is the responsibility of the Generator to undertake these commissioning tests / checks and to ensure the Power Generating Facility and Power Generating Modules meet all the relevant requirements.		P
19.1.4	In addition to the commissioning tests and checks required under EREC G99, further tests may be required by the Manufacturer, Supplier, Generator or Installer of the Power Generating Modules as may be required to satisfy legislation and other standards.		P
19.2	**Connection Process**		N/A
19.3	**Interim Operational Notification**		N/A

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Clause	Requirement - Test	Result - Remark	Verdict
19.4	**Witnessing and Commissioning**		N/A
19.5	**Final Operational Notification**		N/A
19.6	**Limited Operational Notification**		N/A
19.7	**Processes Relating to Derogations**		N/A
20	**ONGOING OBLIGATIONS**		N/A
20.1	**Periodic Testing for Power Generating Modules**		N/A
20.2	**Operational Incidents affecting Compliance of any Power Generating Module**		N/A
20.3	**Changes to the Power Generating Facility or Power Generating Module**		N/A
20.4	**Notification of Decommissioning**		N/A
21	**MANUFACTURERS' INFORMATION APPLICABLE TO POWER PARK MODULES**		P
21.1	**General**		P
21.1.1	Manufacturers' Information covers such information as type testing details, parameters or data, simulation models and reports on studies run using those models. The guidance in this Section 21 Manufacturers' Information relates to simulation models.		P
21.1.2	In most cases Manufactures' Information is submitted by the Generator to the DNO. However, data and performance characteristics in respect of simulation models may be registered with the DNO by Generating Unit Manufacturers in the form of Manufacturers' Information.		P
21.1.3	A Generator planning to construct a new Power Generating Facility containing the appropriate version of Generating Units in respect of which Manufacturers' Information has been submitted to the DNO may reference the Manufacturers' Information in its submissions to the DNO. Any Generator considering referring to Manufacturers' Information for any aspect of its plant and apparatus may contact the DNO to discuss the suitability of the relevant Manufacturers' Information to its project to determine if, and to what extent, the data included in the Manufacturers' Information contributes towards demonstrating compliance with those aspects of this EREC G99 applicable to the Generator. The DNO will inform the Generator if the reference to the Manufacturers' Information is not appropriate or not sufficient for its project.		P
21.1.4	The process to be followed by Generating Unit Manufacturers submitting Manufacturers' Information must be agreed by the DNO. Paragraph 21.2 below indicates the specific requirement areas in respect of which Manufacturers' Information may be submitted.		P

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict
21.1.5	The DNO may maintain and publish a register of that Manufacturers' Information which the DNO has received and accepted as being an accurate representation of the performance of the relevant plant and / or apparatus. Such register will clearly identify the Manufacturer, the model(s) of Generating Unit(s) to which the report applies and the provisions of EREC G99 in respect of which the report contributes towards the demonstration of compliance in such a way that these models can easily be identified for appropriate use in other similar projects. The inclusion of any report in the register does not in any way confirm that any Power Park Modules which utilise any Generating Unit(s) covered by a report is or will be compliant with EREC G99.	It's depended on installer and DNOs.	N/A
21.2	Manufacturers' Information in respect of Generating Units may cover one (or part of one) or more of the following provisions: (a) Fault Ride Through capability; (b) Power Park Module mathematical model DDRC 5c.		P
21.3	Reference to a Manufacturer's Data & Performance Report in a Generator's submissions does not by itself constitute compliance with EREC G99.		P
21.4	A Generator referencing Manufacturers' Information should insert the relevant Manufacturers' Information reference in the appropriate place in the submission forms detailed in the Annexes. The DNO will consider the suitability of Manufacturers' Information in place of DDRC data submissions such as a mathematical model suitable for representation of the entire Power Park Module as per Annex B.4.4 or Annex C.7.4.5 as applicable. Site specific parameters will still need to be submitted by the Generator.		P
21.5	It is the responsibility of the Generator to ensure that the correct reference for the Manufacturers' Information is used and the Generator by using that reference accepts responsibility for the accuracy of the information. The Generator shall ensure that the Manufacturer has kept the DNO informed of any relevant variations in plant specification since the submission of the relevant Manufacturers' Information which could affect the validity of the information.		P

<table>
<tr><td colspan="4">G99/1-8</td></tr>
<tr><td>Clause</td><td>Requirement - Test</td><td>Result - Remark</td><td>Verdict</td></tr>
<tr><td>21.6</td><td>The DNO may contact the Generating Unit Manufacturer directly to verify the relevance of the use of such Manufacturers’ Information. If the DNO believes the use some or all of such Manufacturers’ Information is incorrect or the referenced data is inappropriate then the reference to the Manufacturers’ Information may be declared invalid by the DNO. Where, and to the extent possible, the data included in the Manufacturers’ Information is appropriate, the compliance assessment process will be continued using the data included in the Manufacturers’ Information.</td><td>It’s depended on installer and DNOs.</td><td>N/A</td></tr>
<tr><td>22</td><td colspan="2">TYPE TESTING AND ANNEX INFORMATION</td><td>P</td></tr>
<tr><td>22.1</td><td colspan="2">Fully Type Tested and Type Tested equipment</td><td>P</td></tr>
<tr><td></td><td>The following matrix demonstrates where Manufacturers’ Information and compliance and installation checks on site can be combined to demonstrate compliance for each Power Generating Module.
<table>
<tr><td></td><td>Manufacturers’ Information</td><td>Power Quality Assessment and Site Tests</td></tr>
<tr><td>Fully Type Tested (Type A only ≤ 50 kW)</td><td>Registered as Fully Type Tested information on ENA website via the Compliance Verification Report
(Form A2-1, A2-2 or A2-3 as appropriate)</td><td>An assessment of compliance with EREC G5 and EREC P28 is necessary. This will generally allow connection of a Fully Type Tested device with no need for mitigation. However, where the fault level is unusually low (eg in remote rural locations) mitigation measures might be needed

Only installation checks required – as on the Installation Document (Form A3-1 or A3-2)</td></tr>
</table></td><td>Fully Type Tested.</td><td>P</td></tr>
</table>

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Type Tested (**Type A**)	Registered as product or component Type Test information on ENA Website using applicable parts of Compliance Verification Report (Form A2-1, A2-2 or A2-3); and/or Supplied by the **Generator** using applicable parts of Compliance Verification Report (Form A2-1, A2-2 or A2-3)	Compliance of the installation with EREC G5 and EREC P28 Demonstration of technical requirements not covered by **Manufacturers' Information**. (Form A3-1 or A3-2) Standard installation checks (Form A3-1 or A3-2). Additional Site Compliance and Commissioning Checks (Form A2-4) may also be required	P
Type Tested (B, C, D)	Registered as product or component Type Test information on ENA Website; and/or Supplied by the **Generator**	Compliance of the installation with EREC G5 and EREC P28 Demonstration of technical requirements not covered by **Manufacturers' Information**. (Form B2-1 or Form C2-1) Standard installation checks (Form B3 or Form C3). Additional Site Compliance and Commissioning Checks (Form B2-2 or Form C2-2) may also be required	
One off installation (B, C, D)	To be provided by the **Generator** for those aspects that cannot be demonstrated on site (including simulations etc)	Compliance of the installation with EREC G5 and EREC P28 Demonstration of technical requirements not covered by **Manufacturers' Information**. (Form B2-1 or Form C2-1) Standard installation checks also required (Form B3 or Form C3). Additional Site Compliance and Commissioning Checks (Form B2-2 or Form C2-2) may also be required	

22.2	**Annex Contents and Form Guidance**	P

Annex	Application	Form Title
A.0	Cover Sheet for **Type A Power Generating Facility** Forms	
A.1	Connection Application for **Type A Fully Type Tested** (<50 kW) **Power Generating Modules** Connection Application for **Integrated Micro Generation and Storage** Note for all other **Power Generating Modules** the **DNO**'s Standard Application Form shall be used.	Form A1-1: Application for connection of **Power Generating Module**(s) with Total Aggregate Capacity <50 kW 3-phase or 17 kW single phase Form A1-2: Application for connection of an **Integrated Micro Generation and Storage** installation
A.2	Compliance report for **Type A Type Tested**	Form A2-1: Compliance Verification Report for **Synchronous Power Generating Modules** up to and including 50 kW Form A2-2: Compliance Verification Report for **Synchronous Power Generating Modules** > 50 kW and also for **Synchronous Power Generating Modules** ≤ 50 kW where the approach of this form is preferred to that in Form A2-1 Form A2-3 Compliance Verification Report for **Inverter** Connected **Power Generating Modules**
A.2	Additional Compliance and Commissioning test requirements for **Type A Power Generating Modules**	Form A2-4: Site Compliance and Commissioning test requirements for **Type A Power Generating Modules**

Verdict: P

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict
			P

A.3	Installation and Commissioning a **Power Generating Facility** comprising one or more **Type A Generating Modules**	Form A3-1: Installation Document for **Type A Power Generating Modules** Form A3-2: Installation Document for **Integrated Micro Generation and Storage** installations
A.4	Emerging Technologies and other Exceptions	
A.5	Example calculations to determine if unequal generation across different phases is acceptable or not	
A.6	Scenario examples in respect of the application of EREC G59 and EREC G99 to new or modified sites after 27/04/19	
A.7	Requirements for Type Testing **Type A Power Generating Modules**	
B.1	Application	Refer to Standard Application Form
B.2-1	Compliance documentation for **Type B Power Generating Modules**	Form B2-1: **Power Generating Module Document** for **Type B Power Generating Modules**
B.2-2	Additional Compliance and Commissioning test requirements for **Type B Power Generating Modules**	Form B2-2 Site Compliance and Commissioning test requirements for **Type B Power Generating Modules**
B.3	Installation and Commissioning Confirmation Form	Form B2: Installation and Commissioning Confirmation Form for **Type B Power Generating Modules**
B.4	Simulation Studies for **Type B Power Generating Modules**	
B.5	Compliance Testing of **Type B Synchronous Power Generating Modules**	
B.6	Compliance testing of **Type B Power Park Modules**	
C.1	Application	Refer to Standard Application Form
C.2-1	Compliance documentation for **Type C** and **Type D Power Generating Modules**	Form C2-1: **Power Generating Module Document** for **Type C and Type D Power Generating Modules**
C.2-2	Additional Compliance and Commissioning test requirements for **Type C** and **Type D Power Generating Modules**	Form C2-2 Site Compliance and Commissioning test requirements for **Type C** and **Type D Power Generating Modules**
C.3	Installation and Commissioning Confirmation Form	Form C3: Installation and Commissioning Confirmation Form for **Type C** and **Type D Power Generating Modules**
C.4	Performance Requirements For Continuously Acting Automatic Excitation Control Systems For **Type C** and **Type D Synchronous Power Generating Modules**	
C.5	Performance Requirements For Continuously Acting Automatic Excitation Control Systems For **Type C** and **Type D Power Park Modules**	
C.6	Functional Specification for Fault Recording and Power Quality Monitoring Equipment Studies for **Type C** and **Type D Power Generating Modules**	
C.7	Simulation Studies for **Type C** and **Type D Power Generating Modules**	

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Clause	Requirement - Test	Result - Remark	Verdict

C.8	Compliance Testing of **Type C** and **Type D Synchronous Power Generating Module**s		
C.9	Compliance Testing of **Type C** and **Type D Power Park Module**s		
C.10	Minimum Frequency Response Capabilities for **Type C** and **Type D Power Generating Module**s		
D.0	Decommissioning of any **Power Generating Module**	Form D1**: Decommissioning Confirmation**	
D.1	Additional Information Relating to **System Stability** Studies		
D.2	Loss of Mains Protection Analysis		
D.3	Main Statutory and other Obligations		
D.4	Summary of **Reactive Power** and voltage control requirements		

Verdict: P

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Appendix 1: Compliance Verification Report – Tests for Type B, C and D Inverter Connected Power Generating Modules

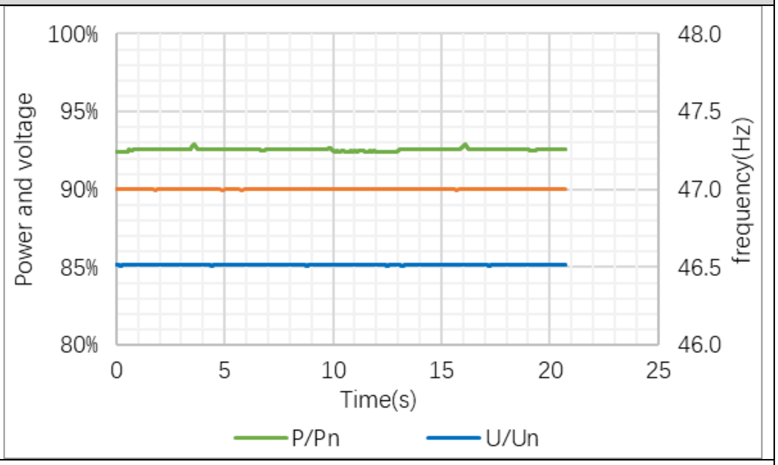
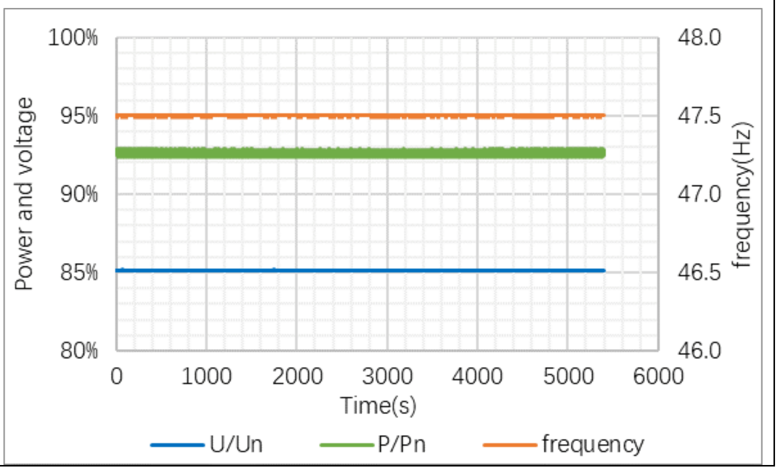
12.2.1/12.2.2 13.2.1/13.2.2	**Operating Range:**	**P**

Two tests should be carried with the **Power Generating Module** operating at **Registered Capacity** and connected to a suitable test supply or grid simulation set. The power supplied by the primary source shall be kept stable within ± 5 % of the apparent power value set for the entire duration of each test sequence.

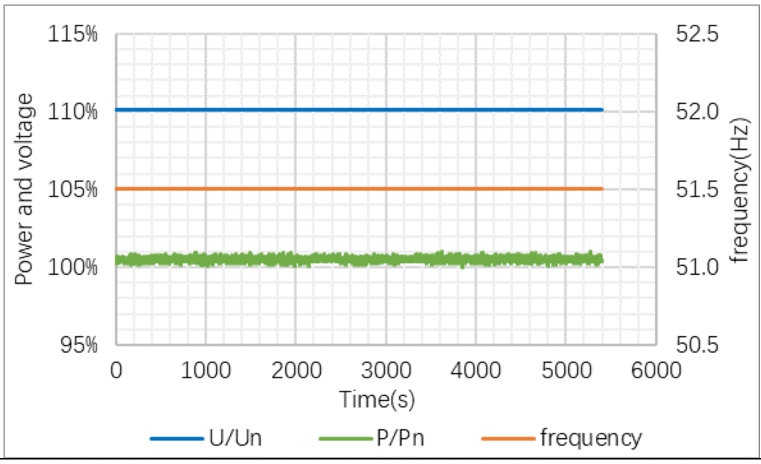
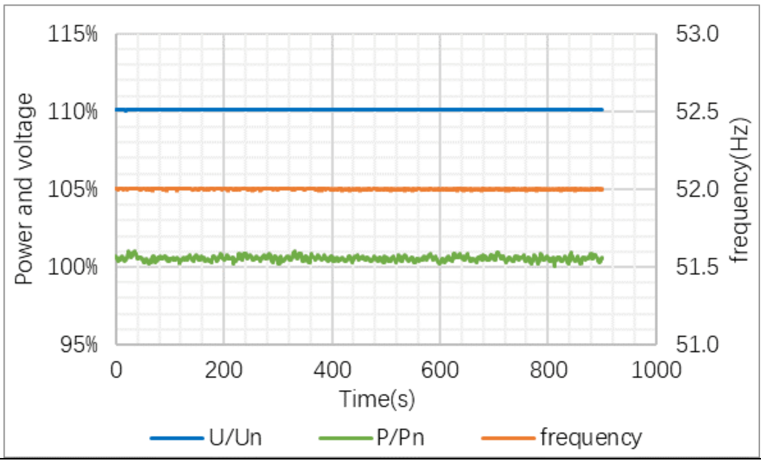
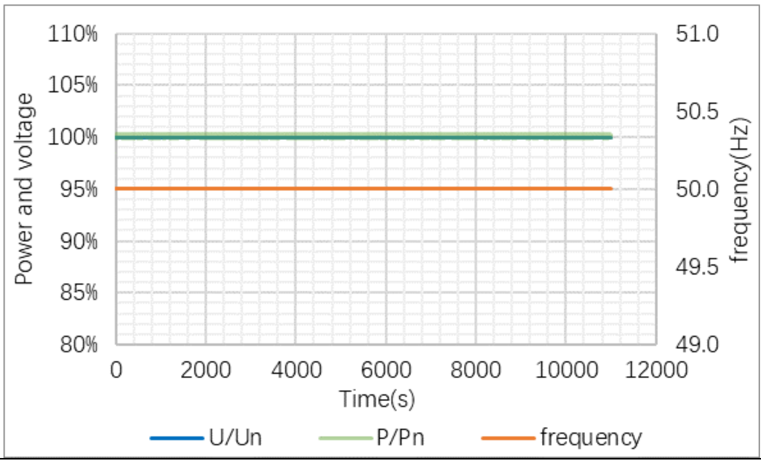
Frequency, voltage and **Active Power** measurements at the output terminals of the **Power Generating Module** shall be recorded every second. The tests will verify that the **Power Generating Module** can operate within the required ranges for the specified period of time.

The **Interface Protection** shall be disabled during the tests.
In case of a PV **Power Park Module** the PV primary source may be replaced by a DC source.
In case of a full converter **Power Park Module** (eg wind) the primary source and the prime mover **Inverter**/rectifier may be replaced by a DC source.

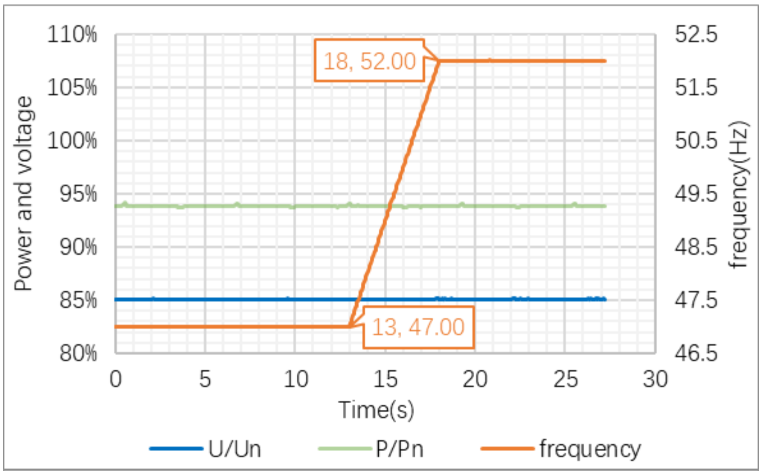
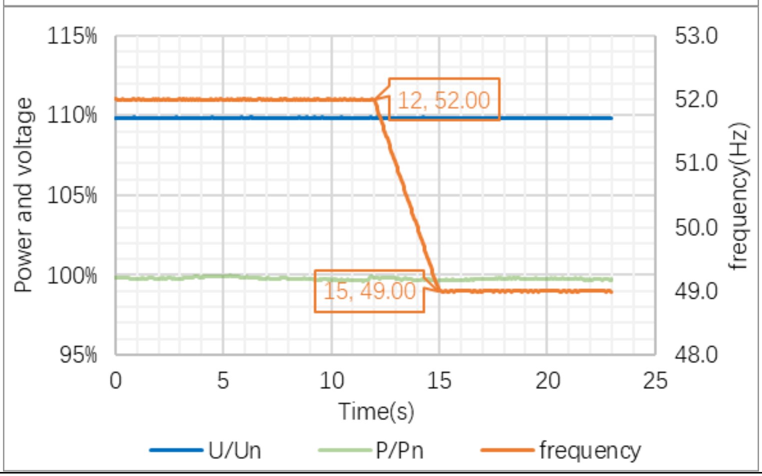
Pass or failure of the test should be indicated in the fields below (right hand side), for example with the statement "Pass", "No disconnection occurs", etc. Graphical evidence is preferred.
Note that the value of voltage stated in brackets assumes a **LV** connection. This should be adjusted for **HV** as required.

Test 1 Voltage = 85% of nominal (195.5 V), Frequency = 47 Hz, **Power Factor** = 1, Period of test 20 s	
Test 2 Voltage = 85% of nominal (195.5 V), Frequency = 47.5 Hz, **Power Factor** = 1, Period of test 90 minutes	

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 3 Voltage = 110% of nominal (253 V), Frequency = 51.5 Hz, **Power Factor** = 1, Period of test 90 minutes	
Test 4 Voltage = 110% of nominal (253 V), Frequency = 52.0 Hz, **Power Factor** = 1, Period of test 15 minutes	
Test 5 Voltage = 100% of nominal (230 V), Frequency = 50.0 Hz, **Power Factor** = 1, Period of test = 90 minutes	

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 6 RoCoF withstand Confirm that the **Power Generating Module** is capable of staying connected to the **Distribution Network** and operate at rates of change of frequency up to 1 Hzs^{-1} as measured over a period of 500 ms. Note that this is not expected to be demonstrated on site.	

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Model: SG250HX				P
Test 1:				
Measured Voltage (V)	Measured Frequency (Hz)	Measured Power (kW)	Measured Power factor	Test Time (seconds)
681.03	47.00	208.275	1.000	20
Test 2:				
Measured Voltage (V)	Measured Frequency (Hz)	Measured Power (kW)	Measured Power factor	Test Time (Minutes)
681.03	47.50	208.222	1.000	90
Test 3:				
Measured Voltage (V)	Measured Frequency (Hz)	Measured Power (W)	Measured Power factor	Test Time (Minutes)
880.56	51.50	226.172	1.000	90
Test 4:				
Measured Voltage (V)	Measured Frequency (Hz)	Measured Power (kW)	Measured Power factor	Test Time (Minutes)
880.58	52.00	226.238	1.000	15
Test 5:				
Measured Voltage (V)	Measured Frequency (Hz)	Measured Power (kW)	Measured Power factor	Test Time (Minutes)
799.63	50.00	225.308	1.000	90
Test 6:				
Measured Voltage (V)	Ramp range	Test frequency ramp	Test Duration	Confirm no trip
680.0	47.0 Hz to 52.0 Hz	+1 Hzs^{-1}	5.0 s	No trip
880.0	52.0 Hz to 49.0 Hz	-1 Hzs^{-1}	5.0 s	No trip

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

9.4.3 Power Quality – Harmonics:	P

For **Power Generating Modules** of **Registered Capacity** of less than 75 A per phase (ie 50 kW) the test requirements are specified in Annex A.7.1.5**.** These tests should be carried out as specified in BS EN 61000-3-12, and measurements for the 2nd – 13th harmonics should be provided. The results need to comply with the limits of Table 2 of BS EN 61000-3-12 for single phase equipment and Table 3 of BS EN 610000-3-12 for three phase equipment. For three phase **Power Generating Modules**, measurements for all phases should be provided.

For **Power Generating Modules** of **Registered Capacity** of greater than 75 A per phase (ie 50 kW) the installation must be designed in accordance with EREC G5.

The rating of the **Power Generating Module** (per phase) should be provided below, and the Total Harmonic Distortion (THD) and Partial Weighted Harmonic Distortion (PWHD) should be provided at the bottom of this section.

Model: SG250HX

Power Generating Module tested to BS EN 61000-3-12

Power Generating Module rating per phase (rpp)	75	kVA	Harmonic % = Measured Value (A) x 46/rating per phase (kVA)
Single or three phase measurements (for single phase measurements, only complete L1 columns below)	three phase PV inverter		

Harmonic	At 45-55% of **Registered Capacity**						Limit in BS EN 61000-3-12	
	Measured Value (MV) in Amps			Measured Value (MV) in %				
	L1	L2	L3	L1	L2	L3	1 phase	3 phase
2	0.044	0.077	0.077	0.03	0.05	0.05	8%	8%
3	0.183	0.093	0.089	0.11	0.06	0.05	21.6%	Not stated
4	0.041	0.025	0.040	0.03	0.02	0.02	4%	4%
5	1.966	1.903	2.020	1.21	1.17	1.24	10.7%	10.7%
6	0.025	0.025	0.026	0.02	0.02	0.02	2.67%	2.67%
7	3.408	3.368	3.336	2.09	2.07	2.05	7.2%	7.2%
8	0.025	0.028	0.023	0.02	0.02	0.01	2%	2%
9	0.150	0.084	0.101	0.09	0.05	0.06	3.8%	Not stated
10	0.025	0.024	0.025	0.02	0.01	0.02	1.6%	1.6%
11	0.884	0.767	0.808	0.54	0.47	0.50	3.1%	3.1%
12	0.026	0.033	0.035	0.02	0.02	0.02	1.33%	1.33%
13	0.122	0.140	0.152	0.07	0.09	0.09	2%	2%
THD	-	-	-	2.58	2.53	2.55	23%	13%
PWHD	-	-	-	3.10	3.21	3.11	23%	22%

THD = Total Harmonic Distortion
PWHD = Partial Weighted Harmonic Distortion

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Harmonic	At 100% of **Registered Capacity**						Limit in BS EN 61000-3-12	
	Measured Value (MV) in Amps			Measured Value (MV) in %				
	L1	L2	L3	L1	L2	L3	1 phase	3 phase
2	0.061	0.099	0.105	0.04	0.06	0.06	8%	8%
3	0.160	0.056	0.117	0.10	0.03	0.07	21.6%	Not stated
4	0.040	0.026	0.026	0.02	0.02	0.02	4%	4%
5	0.822	0.733	0.707	0.50	0.45	0.43	10.7%	10.7%
6	0.042	0.051	0.023	0.03	0.03	0.01	2.67%	2.67%
7	2.054	2.065	2.009	1.26	1.27	1.23	7.2%	7.2%
8	0.025	0.056	0.048	0.02	0.03	0.03	2%	2%
9	0.124	0.115	0.077	0.08	0.07	0.05	3.8%	Not stated
10	0.033	0.053	0.034	0.02	0.03	0.02	1.6%	1.6%
11	0.949	0.883	0.923	0.58	0.54	0.57	3.1%	3.1%
12	0.036	0.052	0.028	0.02	0.03	0.02	1.33%	1.33%
13	0.682	0.610	0.649	0.42	0.37	0.40	2%	2%
THD				1.62	1.59	1.58	23%	13%
PWHD				2.25	2.29	2.33	23%	22%

THD = Total Harmonic Distortion
PWHD = Partial Weighted Harmonic Distortion

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

9.4.3 Power Quality – Voltage fluctuations and Flicker:									**P**
These tests should be undertaken in accordance with Annex A.7.2.5.3. Results should be normalised to a standard source impedance, or if this results in figures above the limits set in BS EN 61000-3-11 to a suitable maximum impedance.									
Model:		SG250HX							
		Starting			Stopping			Running	
		d(max) [%]	d(c) [%]	d(t) [%]	d(max) [%]	d(c) [%]	d(t) [%]	P_{st} [%]	P_{lt} 2 hours [%]
Measured Values at test impedance	L1	0.61	0.07	0	0.76	0.14	0	0.07	0.07
	L2	0.69	0.12	0	0.88	0.07	0	0.07	0.07
	L3	0.95	0.16	0	0.70	0.14	0	0.07	0.07
Normalised to standard impedance	L1	0.61	0.07	0	0.76	0.14	0	0.07	0.07
	L2	0.69	0.12	0	0.88	0.07	0	0.07	0.07
	L3	0.95	0.16	0	0.70	0.14	0	0.07	0.07
Normalised to required maximum impedance	L1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	L2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	L3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Limits set under BS EN 61000-3-11		4%	3.3%	3.3%	4%	3.3%	3.3%	1.0	0.65

Test Impedance	R	0.4	Ω	Xl	0.25	Ω
Standard Impedance	R	0.24 * 0.4 ^	Ω	Xl	0.15 * 0.25 ^	Ω
Maximum Impedance	R	N/A #	Ω	Xl	N/A #	Ω

* Applies to three phase and split single phase **Power Generating Modules.**

^ Applies to single phase **Power Generating Module** and **Power Generating Modules** using two phases on a three phase system. Delete as appropriate.

All the test value and calculated value normalised to standard impedance of dmax test, dc test, d(t) test, Pst test and Plt test were complies with the requirements of IEC 61000-3-11 and therefore is not subject to conditional connection, so the manufacturer no need to declare maximum Impedance.

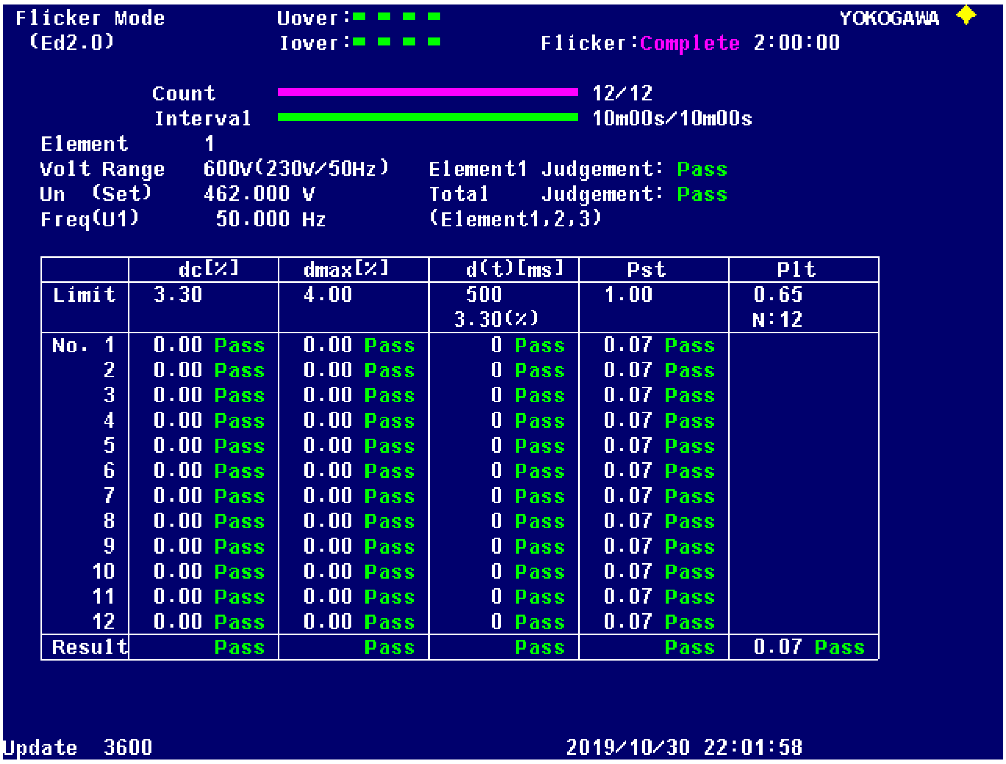
For voltage change and flicker measurements the following formula is to be used to convert the measured values to the normalised values where the Power Factor of the generation output is 0.98 or above.

Normalised value = Measured value x reference source resistance/measured source resistance at test point.

Single phase units reference source resistance is 0.4 Ω

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Continuous operating L1 phase



Flicker Mode (Ed2.0) Uover: Iover: YOKOGAWA
Flicker:Complete 2:00:00
Count 12/12
Interval 10m00s/10m00s
Element 1
Volt Range 600V(230V/50Hz) Element1 Judgement: Pass
Un (Set) 462.000 V Total Judgement: Pass
Freq(U1) 50.000 Hz (Element1,2,3)

	dc[%]	dmax[%]	d(t)[ms]	Pst	Plt
Limit	3.30	4.00	500 3.30(%)	1.00	0.65 N:12
No. 1	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
2	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
3	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
4	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
5	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
6	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
7	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
8	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
9	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
10	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
11	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
12	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
Result	Pass	Pass	Pass	Pass	0.07 Pass

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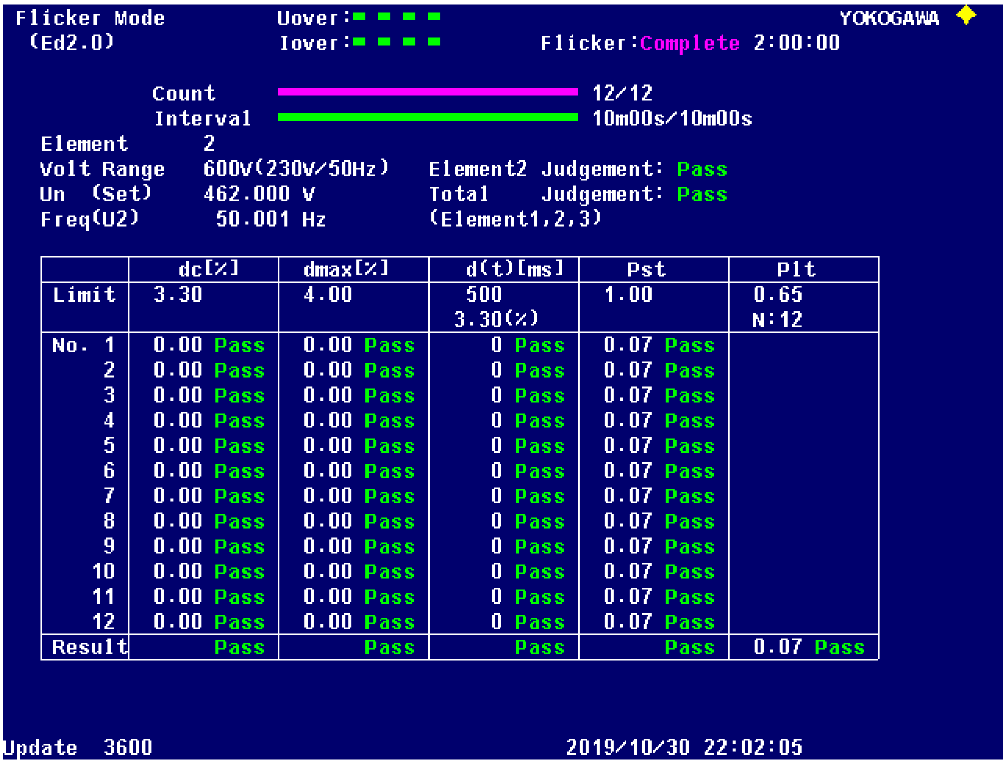
Continuous operating L2 phase



Flicker Mode (Ed2.0) Uover: Iover: YOKOGAWA
Flicker:Complete 2:00:00
Count 12/12
Interval 10m00s/10m00s
Element 2
Volt Range 600V(230V/50Hz) Element2 Judgement: Pass
Un (Set) 462.000 V Total Judgement: Pass
Freq(U2) 50.001 Hz (Element1,2,3)

	dc[%]	dmax[%]	d(t)[ms]	Pst	Plt
Limit	3.30	4.00	500 3.30(%)	1.00	0.65 N:12
No. 1	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
2	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
3	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
4	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
5	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
6	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
7	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
8	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
9	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
10	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
11	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
12	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
Result	Pass	Pass	Pass	Pass	0.07 Pass

Update 3600 2019/10/30 22:02:05

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Continuous operating L3 phase

Flicker Mode (Ed2.0) Uover:■ ■ ■ ■ Iover:■ ■ ■ ■ YOKOGAWA ◆
Flicker:Complete 2:00:00

Count 12/12
Interval 10m00s/10m00s
Element 3
Volt Range 600V(230V/50Hz) Element3 Judgement: Pass
Un (Set) 462.000 V Total Judgement: Pass
Freq(U3) --------- (Element1,2,3)

	dc[%]	dmax[%]	d(t)[ms]	Pst	Plt
Limit	3.30	4.00	500 3.30(%)	1.00	0.65 N:12
No. 1	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
2	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
3	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
4	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
5	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
6	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
7	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
8	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
9	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
10	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
11	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
12	0.00 Pass	0.00 Pass	0 Pass	0.07 Pass	
Result	Pass	Pass	Pass	Pass	0.07 Pass

Update 3600 2019/10/30 22:02:10

Switch on and switch off operating L1 phase

Flicker Mode IEC61000-4-15 Ed2.0 Uover:■ ■ ■ ■ Iover:■ ■ ■ ■ I1-3 :200mV YOKOGAWA ◆
Flicker:Complete 0:20:00

Count 2/2
Interval 10m00s/10m00s
Element 1
Volt Range A1000V(230V/50Hz) Element1 Judgement: Pass
Un (U1) 0.80035kV Total Judgement: Pass
Freq(U1) 50.000 Hz (Element1,2,3)

	dc[%]	dmax[%]	Tmax[ms]	Pst	Plt
Limit	3.30	4.00	500 3.30(%)	1.00	0.65 N:12
No. 1	0.07 Pass	0.61 Pass	0 Pass	0.13 Pass	
2	0.14 Pass	0.76 Pass	0 Pass	0.13 Pass	
Result	Pass	Pass	Pass	Pass	0.07 Pass

Update 600

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Switch on and switch off operating L2 phase

Flicker Mode Uover:■ ■ ■ ■ I1-3 :200mV YOKOGAWA ◆
IEC61000-4-15 Ed2.0 Iover:■ ■ ■ ■ Flicker:Complete 0:20:00

Count 2/2
Interval 10m00s/10m00s
Element 2
Volt Range A1000V(230V/50Hz) Element2 Judgement: Pass
Un (U2) 0.79940kV Total Judgement: Pass
Freq(U2) 50.000 Hz (Element1,2,3)

	dc[%]	dmax[%]	Tmax[ms]	Pst	Plt
Limit	3.30	4.00	500 3.30(%)	1.00	0.65 N:12
No. 1	0.12 Pass	0.69 Pass	0 Pass	0.13 Pass	
2	0.07 Pass	0.88 Pass	0 Pass	0.14 Pass	
Result	Pass	Pass	Pass	Pass	0.08 Pass

Update 600

Switch on and switch off operating L3 phase

Flicker Mode Uover:■ ■ ■ ■ I1-3 :200mV YOKOGAWA ◆
IEC61000-4-15 Ed2.0 Iover:■ ■ ■ ■ Flicker:Complete 0:20:00

Count 2/2
Interval 10m00s/10m00s
Element 3
Volt Range A1000V(230V/50Hz) Element3 Judgement: Pass
Un (U3) 0.80197kV Total Judgement: Pass
Freq(U3) 50.000 Hz (Element1,2,3)

	dc[%]	dmax[%]	Tmax[ms]	Pst	Plt
Limit	3.30	4.00	500 3.30(%)	1.00	0.65 N:12
No. 1	0.16 Pass	0.95 Pass	0 Pass	0.14 Pass	
2	0.14 Pass	0.70 Pass	0 Pass	0.14 Pass	
Result	Pass	Pass	Pass	Pass	0.08 Pass

Update 600

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

9.4.6 Power quality – DC injection:	**P**

The tests should be carried out on a single **Generating Unit**. Tests are to be carried out at three defined power levels ±5%. At 230 V a 50 kW three phase **Inverter** has a current output of 217 A so DC limit is 543 mA. These tests should be undertaken in accordance with Annex A.7.1.4.4.

The % DC injection ("as % of rated AC current" below) is calculated as follows:

% DC injection = Recorded DC value in Amps / Base current

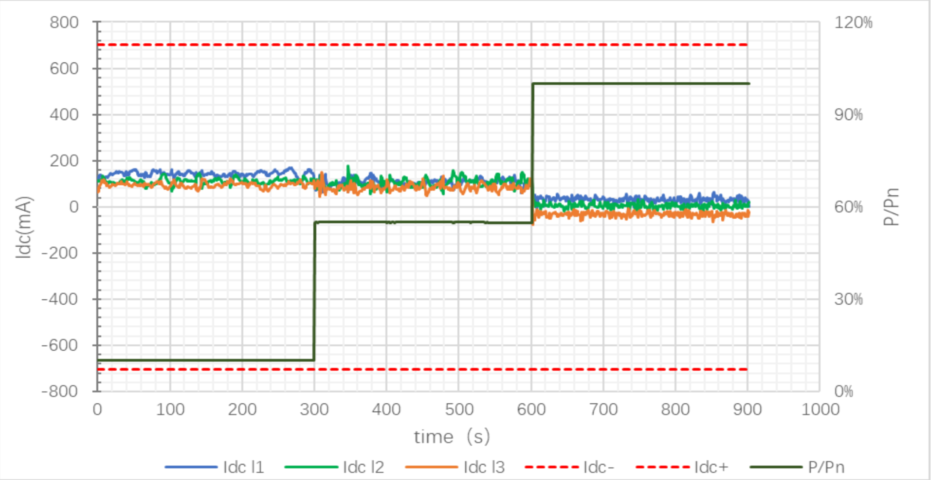
where the base current is the **Registered Capacity** (W) / Vphase. The % DC injection should not be greater than 0.25%.

Model: SG250HX

L1			
Test power level	10%	55%	100%
Recorded DC injection value in mA	168.0	145.0	62.0
as % of rated AC current	0.10	0.09	0.04
Limit	0.25%	0.25%	0.25%

L2			
Test power level	10%	55%	100%
Recorded DC injection value in mA	143.9	178.0	55.0
as % of rated AC current	0.09	0.11	0.04
Limit	0.25%	0.25%	0.25%

L3			
Test power level	10%	55%	100%
Recorded DC injection value in mA	122.3	148.0	79.0
as % of rated AC current	0.08	0.09	0.05
Limit	0.25%	0.25%	0.25%



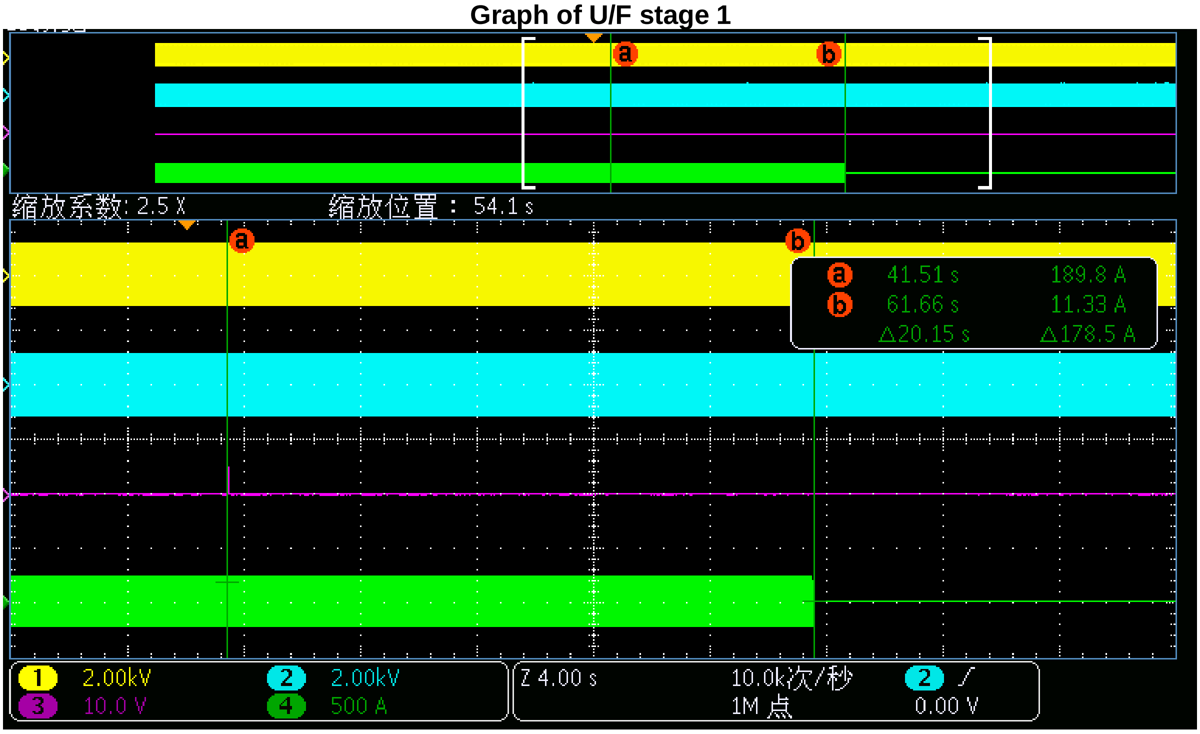
G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

9.4.5 Power Factor:			**P**
The tests should be carried out on a single **Power Generating Module**. Tests are to be carried out at three voltage levels and at **Registered Capacity** and the measured **Power Factor** must be greater than 0.95 to pass. Voltage to be maintained within ±1.5% of the stated level during the test. These tests should be undertaken in accordance with Annex A.7.1.4.2 Note that the value of voltage stated in brackets assumes a **LV** connection. This should be adjusted for **HV** as required.			
Model: SG250HX			
Voltage	0.94 p.u. (752 V)	1 p.u. (800 V)	1.1 p.u. (880 V)
Measured value	0.9999	0.9999	0.9999
Power Factor Limit	>0.95	>0.95	>0.95

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

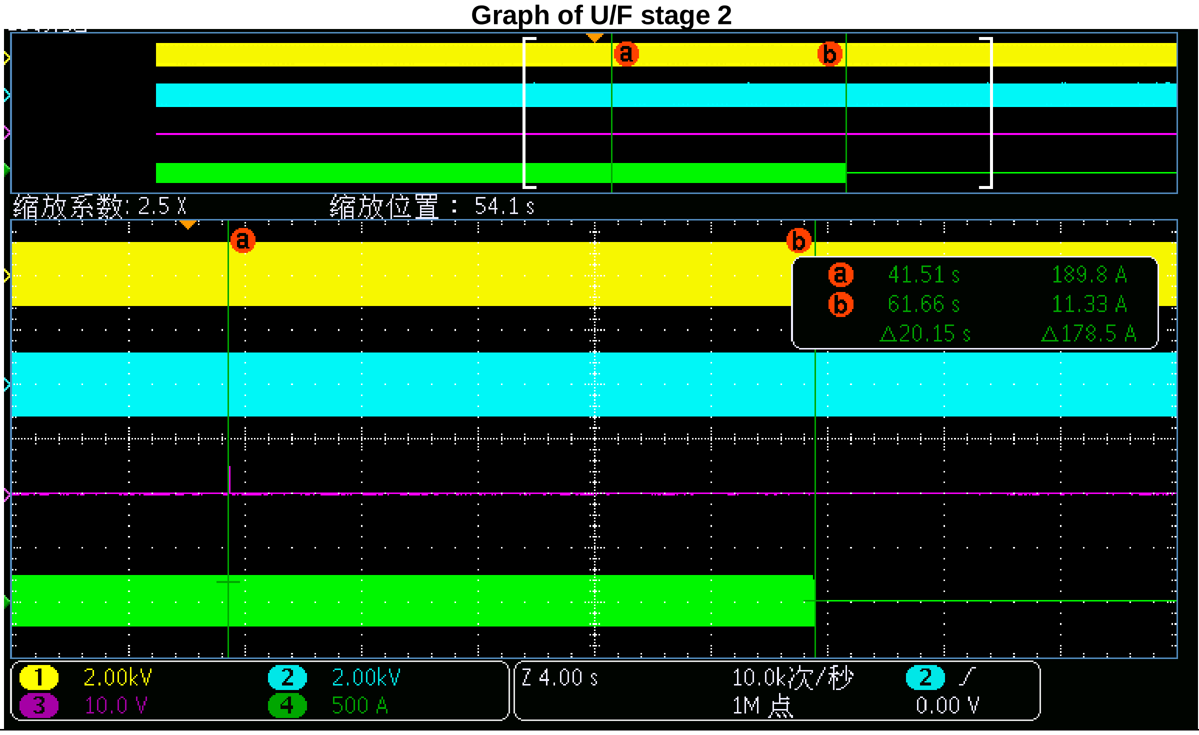
10.6.7.1 Protection – Frequency tests:						**P**
These tests should be carried out in accordance with the Annex A.7.1.2.3. For trip tests, frequency and time delay should be stated. For “no trip tests”, “no trip” can be stated.						
Model: SG250HX						
Function	Setting		Trip test		“No trip tests”	
	Frequency	Time delay	Frequency	Time delay	Frequency / time	Confirm no trip
U/F stage 1	47.5 Hz	20 s	47.4Hz	20.15s	47.7 Hz 30 s	No trip
U/F stage 2	47 Hz	0.5 s	46.9Hz	0.551s	47.2 Hz 19.5 s	No trip
					46.8 Hz 0.45 s	No trip
O/F	52.0Hz	0.5s	52.1Hz	0.542s	51.8 Hz 120.0 s	No trip
					52.2 Hz 0.45 s	No trip
Note: For frequency trip tests the frequency required to trip is the setting ± 0.1 Hz. In order to measure the time delay a larger deviation than the minimum required to operate the projection can be used. The “No trip tests” need to be carried out at the setting ± 0.2 Hz and for the relevant times as shown in the table above to ensure that the protection will not trip in error.						

Graph of U/F stage 1

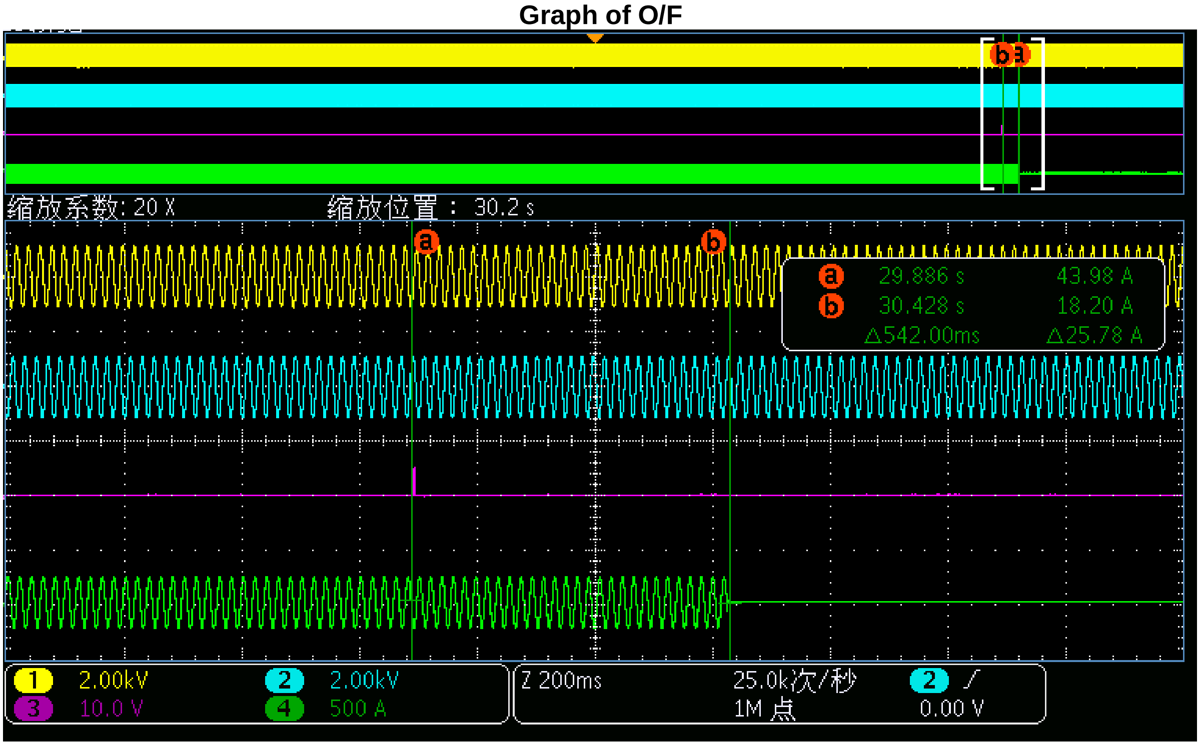


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Graph of U/F stage 2



Graph of O/F



Channel 1 represents output voltage of EUT
Channel 3 represents trip signal
Channel 4 represents output current of EUT

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

10.6.7.1 Protection – Voltage tests Type B, C – LV Protection	**P**

These tests should be carried out in accordance with Annex A.7.1.2.2. For trip tests, voltage and time delay should be stated. For "no trip tests", "no trip" can be stated.

Note that the value of voltage stated below assumes a **LV** connection This should be adjusted for **HV** taking account of the VT ratio as required.

Model: SG250HX

L1-L2 Phase

Function	Setting		Trip test		"No trip tests"	
	Voltage	Time delay	Voltage	Time delay	Voltage /time	Confirm no trip
U/V	0.8 pu (640 V)	2.5 s	637 V	2.545 s	654.3 V 5.0 s	No trip
					626.1 V 2.45 s	No trip
O/V stage 1	1.14 pu (912 V)	1.0 s	915 V	1.045 s	898.4 V 5.0 s	No trip
O/V stage 2	1.19 pu (952 V)	0.5 s	955 V	0.565 s	938.4 V 0.95 s	No trip
					965.6 V 0.45 s	No trip

L2-L3 Phase

Function	Setting		Trip test		"No trip tests"	
	Voltage	Time delay	Voltage	Time delay	Voltage/time	Confirm no trip
U/V	0.8 pu (640 V)	2.5 s	637 V	2.537 s	654.3 V 5.0 s	No trip
					626.1 V 2.45 s	No trip
O/V stage 1	1.14 pu (912 V)	1.0 s	915 V	1.033 s	898.4 V 5.0 s	No trip
O/V stage 2	1.19 pu (952 V)	0.5 s	955 V	0.561 s	938.4 V 0.95 s	No trip
					965.6 V 0.45 s	No trip

L3-L1 Phase

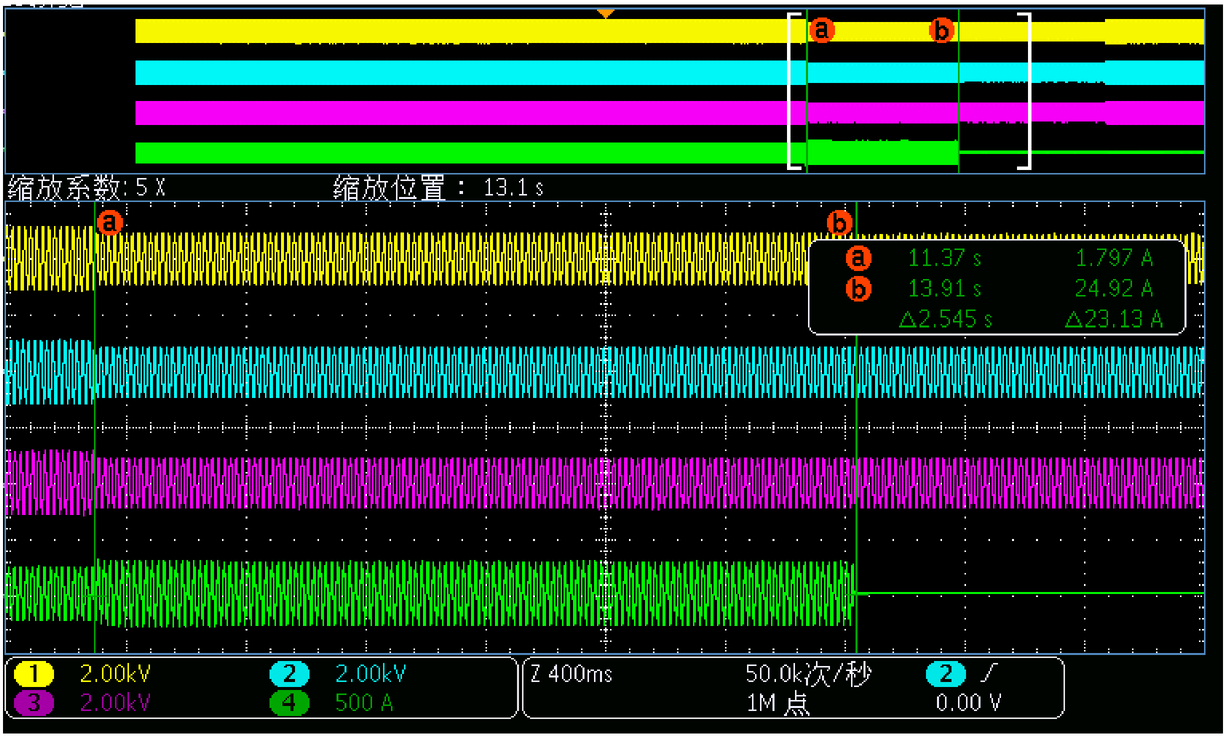
Function	Setting		Trip test		"No trip tests"	
	Voltage	Time delay	Voltage	Time delay	Voltage/time	Confirm no trip
U/V	0.8 pu (640 V)	2.5 s	637 V	2.553 s	654.3 V 5.0 s	No trip
					626.1 V	No trip

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

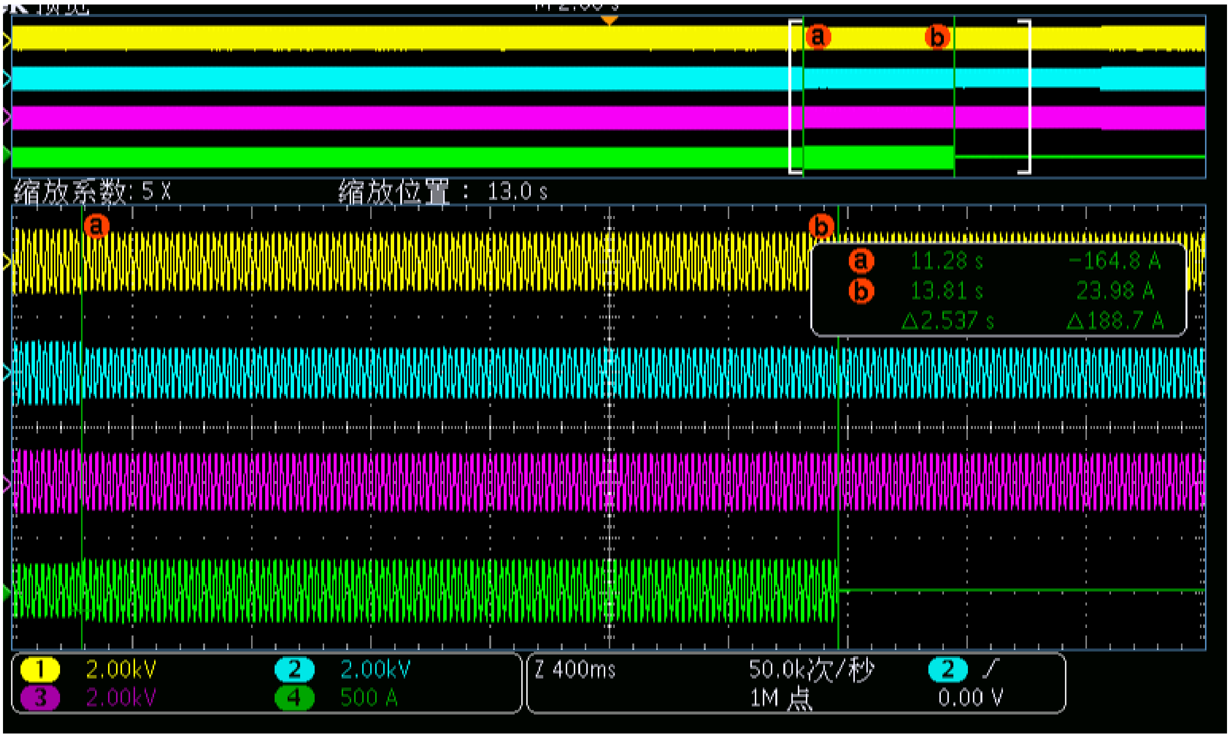
					2.45 s	
O/V stage 1	1.14 pu (912 V)	1.0 s	915 V	1.041 s	898.4 V 5.0 s	No trip
O/V stage 2	1.19 pu (952 V)	0.5 s	955 V	0.533 s	938.4 V 0.95 s	No trip
					965.6 V 0.45 s	No trip
Note: For Voltage tests the Voltage required to trip is the setting ±3.45 V. The time delay can be measured at a larger deviation than the minimum required to operate the protection. The No trip tests need to be carried out at the setting ±4 V and for the relevant times as shown in the table above to ensure that the protection will not trip in error.						

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Graph of U/V L1-L2 Phase

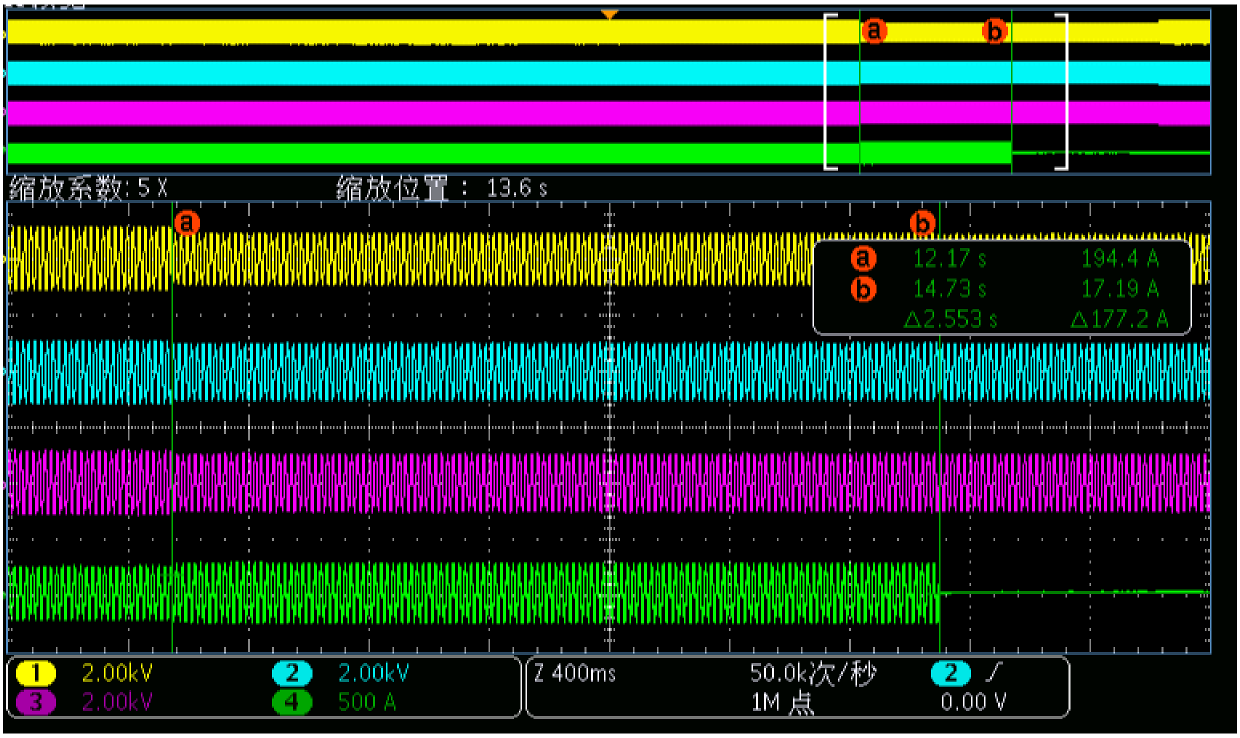


Graph of U/V L2-L3 Phase

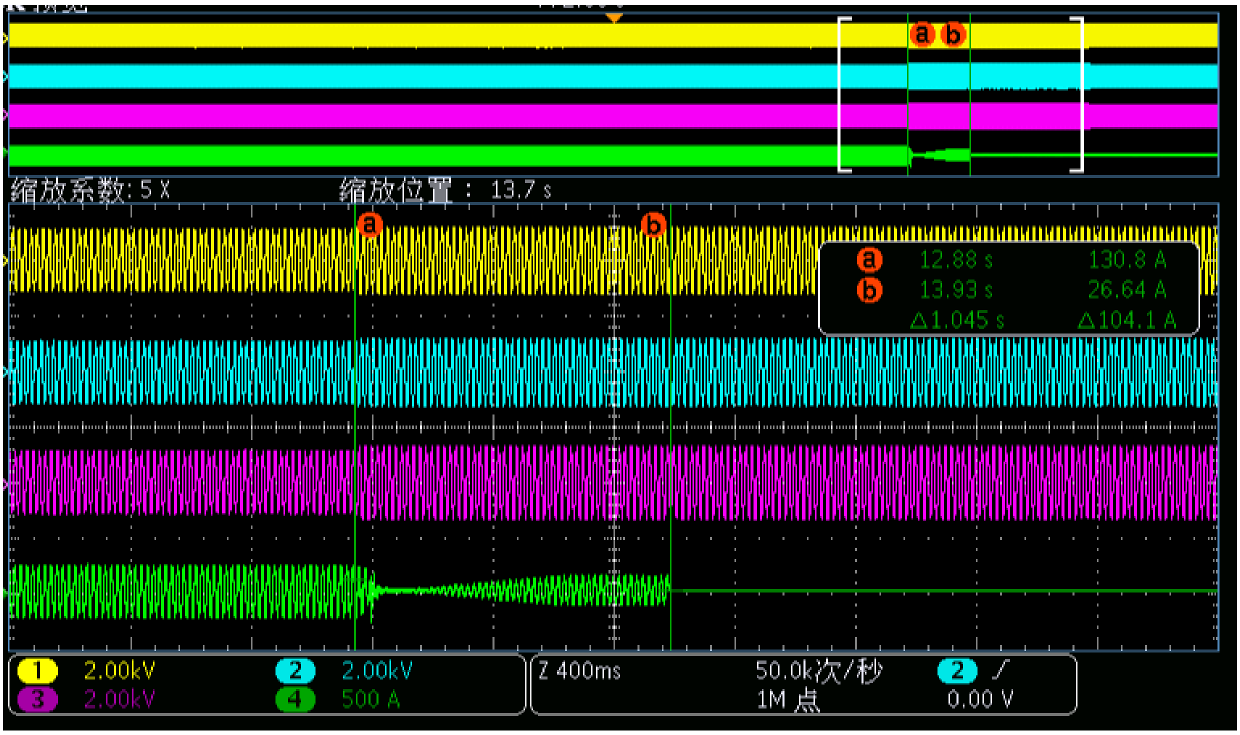


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Graph of U/V L3-L1 Phase

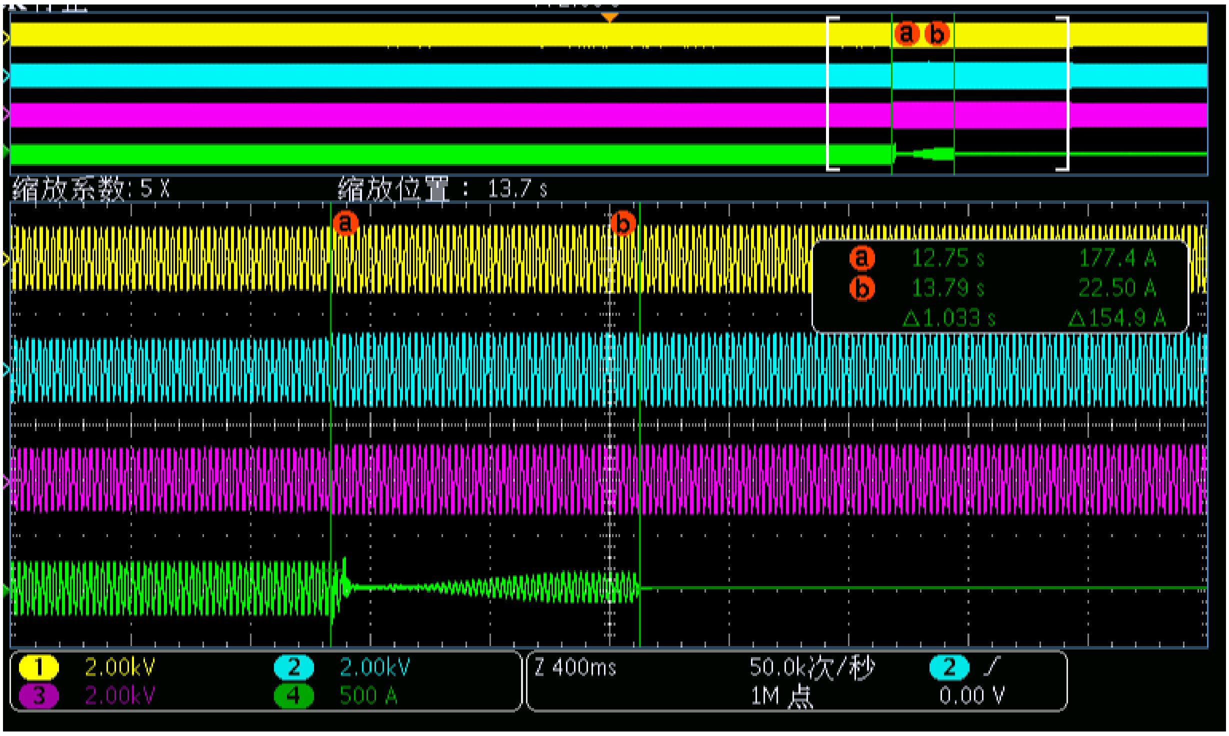


Graph of O/V stage 1 L1-L2 Phase

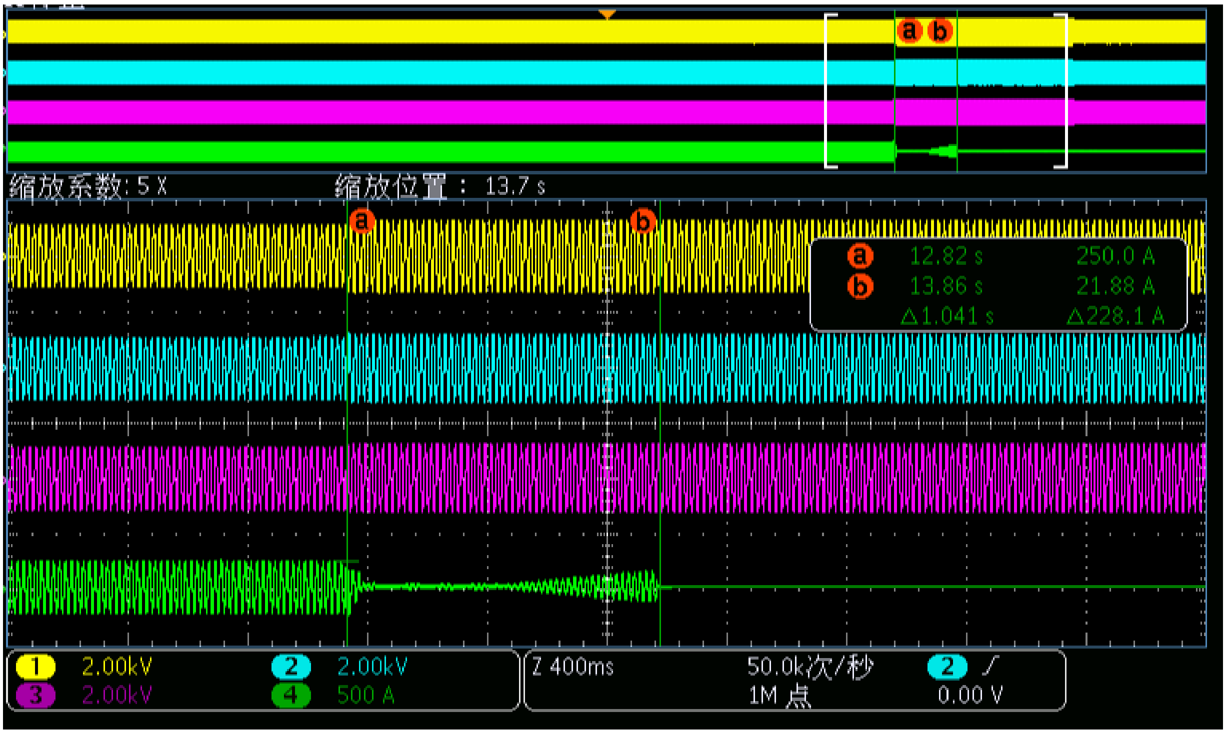


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Graph of O/V stage 1 L2-L3 Phase

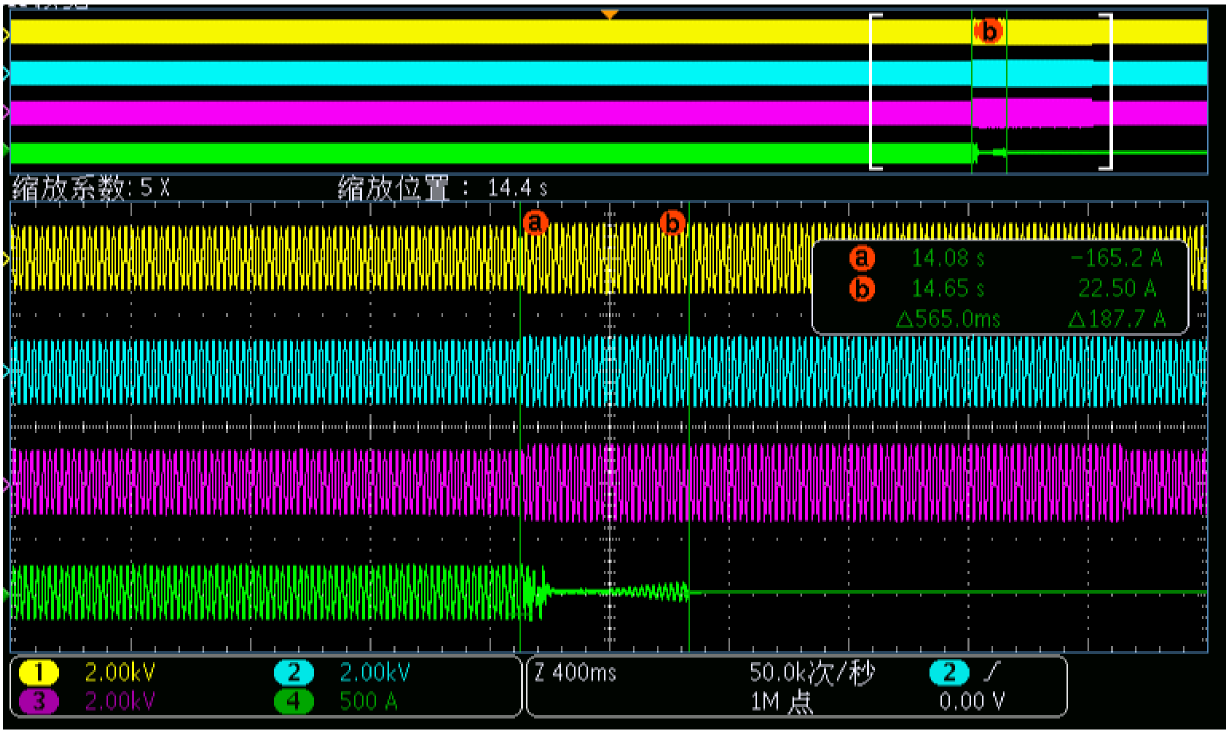


Graph of O/V stage 1 L3-L1 Phase

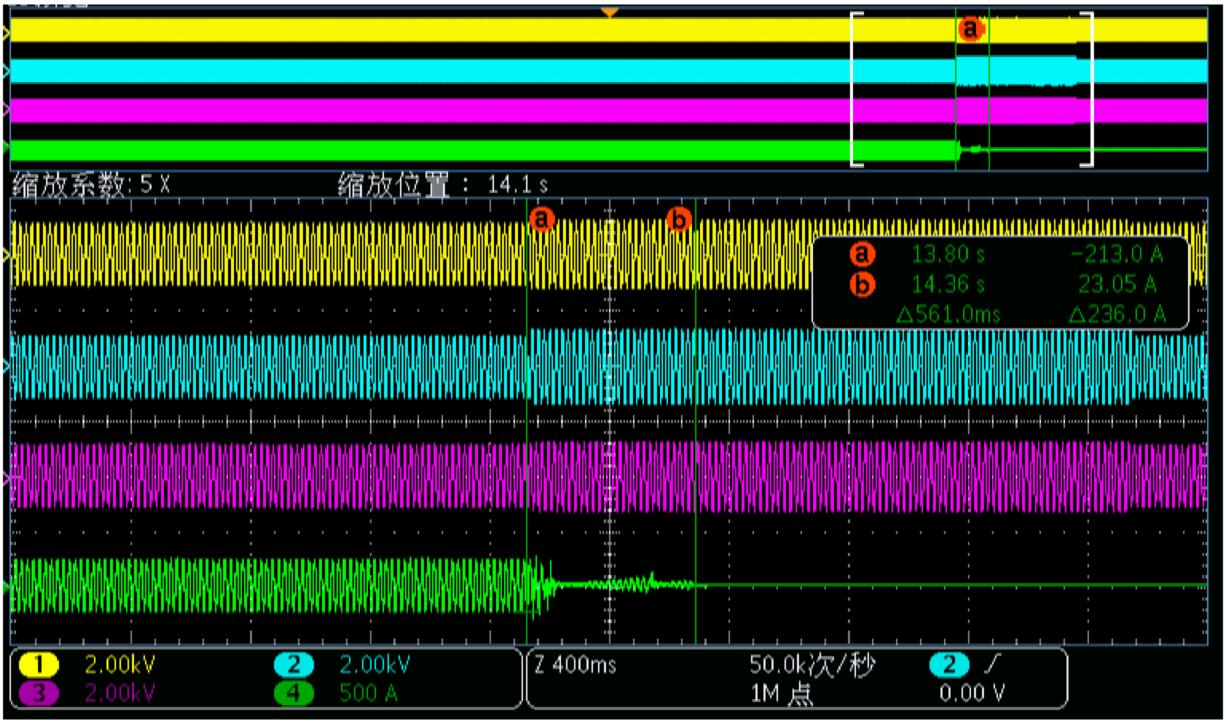


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Graph of O/V stage 2 L1-L3 Phase

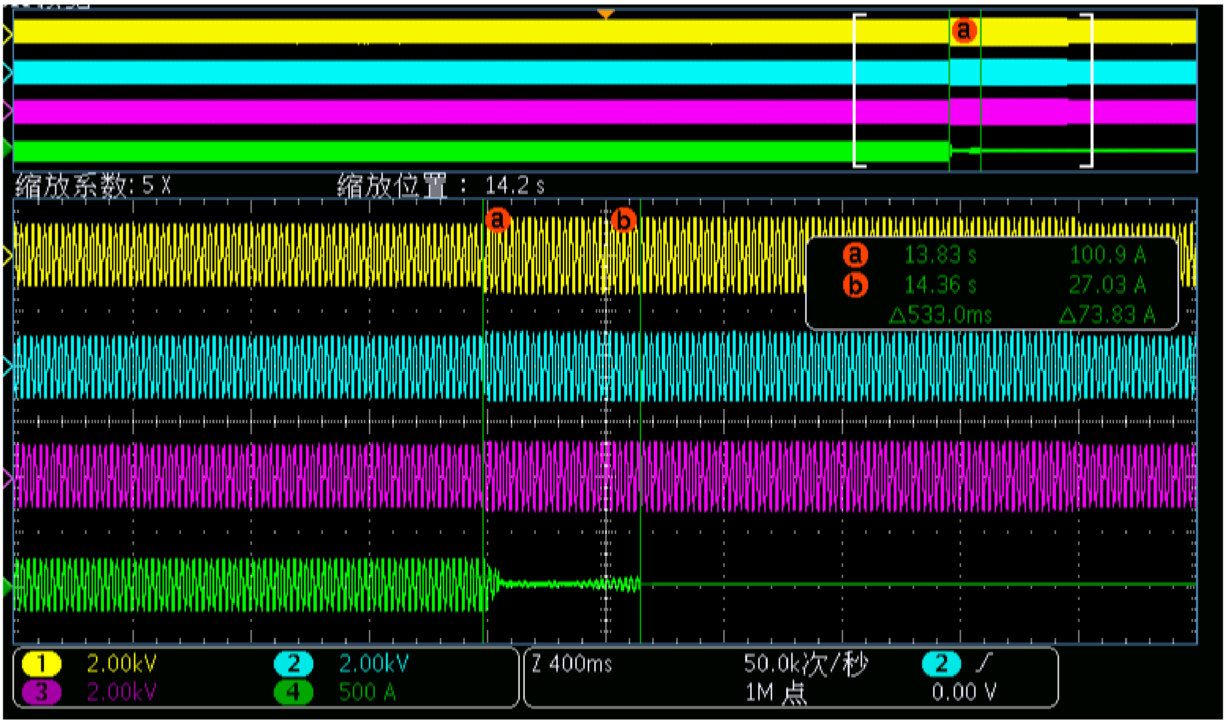


Graph of O/V stage 2 L2-L3 Phase



G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Graph of O/V stage 2 L3-L1 Phase



G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

10.6.7.1 Protection – Voltage tests **Type B, C – HV Protection**						**P**
Model: SG250HX						
L1-L2 Phase						
Function	Setting		Trip test		"No trip tests"	
	Voltage	Time delay	Voltage	Time delay	Voltage /time	Confirm no trip
U/V	0.8 pu (640 V)	2.5 s	637 V	2.545 s	654.3 V 5.0 s	No trip
					626.1 V 2.45 s	No trip
O/V stage 1	1.10 pu (880 V)	1.0 s	883 V	1.052 s	866.1 V 5.0 s	No trip
O/V stage 2	1.13 pu (904 V)	0.5 s	907 V	0.536 s	886.4 V 0.95 s	No trip
					917.6 V 0.45 s	No trip
L2-L3 Phase						
Function	Setting		Trip test		"No trip tests"	
	Voltage	Time delay	Voltage	Time delay	Voltage/time	Confirm no trip
U/V	0.8 pu (640 V)	2.5 s	637 V	2.537 s	654.3 V 5.0 s	No trip
					626.1 V 2.45 s	No trip
O/V stage 1	1.10 pu (880 V)	1.0 s	883 V	1.056 s	866.1 V 5.0 s	No trip
O/V stage 2	1.13 pu (904 V)	0.5 s	907 V	0.560 s	886.4 V 0.95 s	No trip
					917.6 V 0.45 s	No trip
L3-L1 Phase						
Function	Setting		Trip test		"No trip tests"	
	Voltage	Time delay	Voltage	Time delay	Voltage/time	Confirm no trip
U/V	0.8 pu (640 V)	2.5 s	637 V	2.553	654.3 V 5.0 s	No trip
					626.1 V 2.45 s	No trip

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

O/V stage 1	1.10 pu (880 V)	1.0 s	883 V	1.064 s	866.1 V 5.0 s	No trip
O/V stage 2	1.13 pu (904 V)	0.5 s	907 V	0.568 s	886.4 V 0.95 s	No trip
					917.6 V 0.45 s	No trip

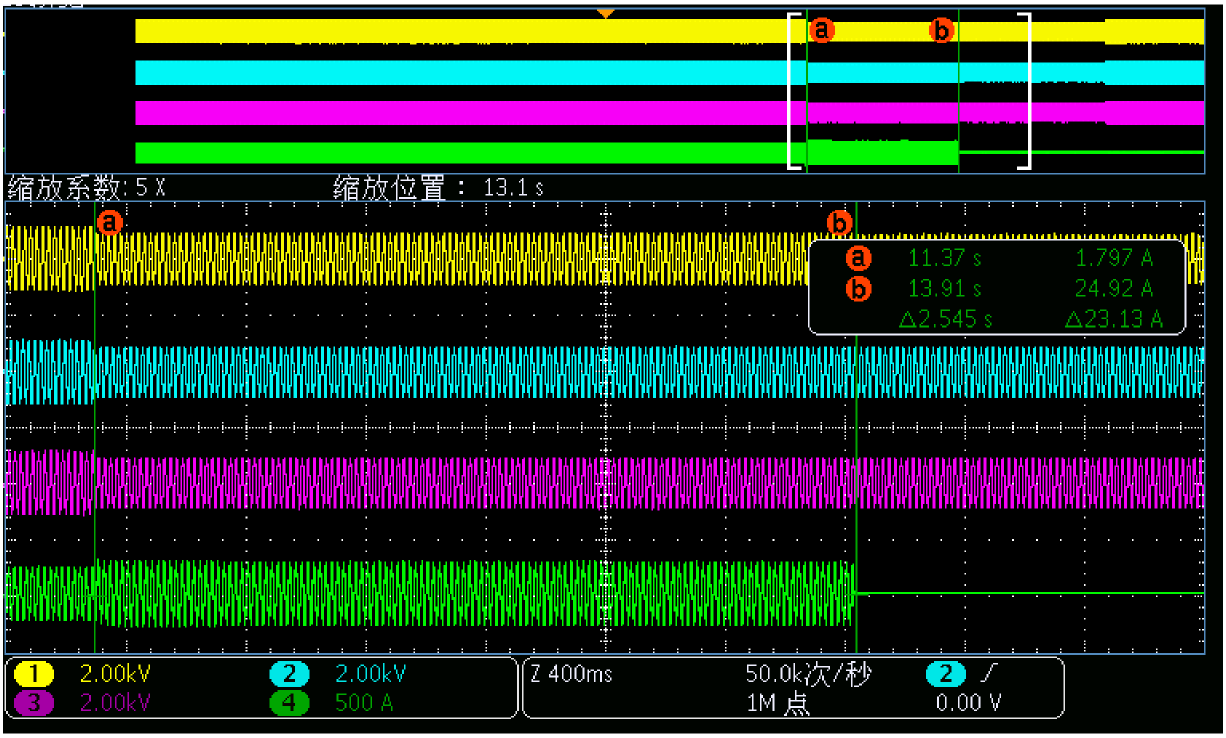
Note:

Note for Voltage tests the Voltage required to trip is the setting ±1.5% of the nominal value. The time delay can be measured at a larger deviation than the minimum required to operate the protection. The No trip tests need to be carried out at the setting ±2% of the nominal value and for the relevant times as shown in the table above to ensure that the protection will not trip in error.

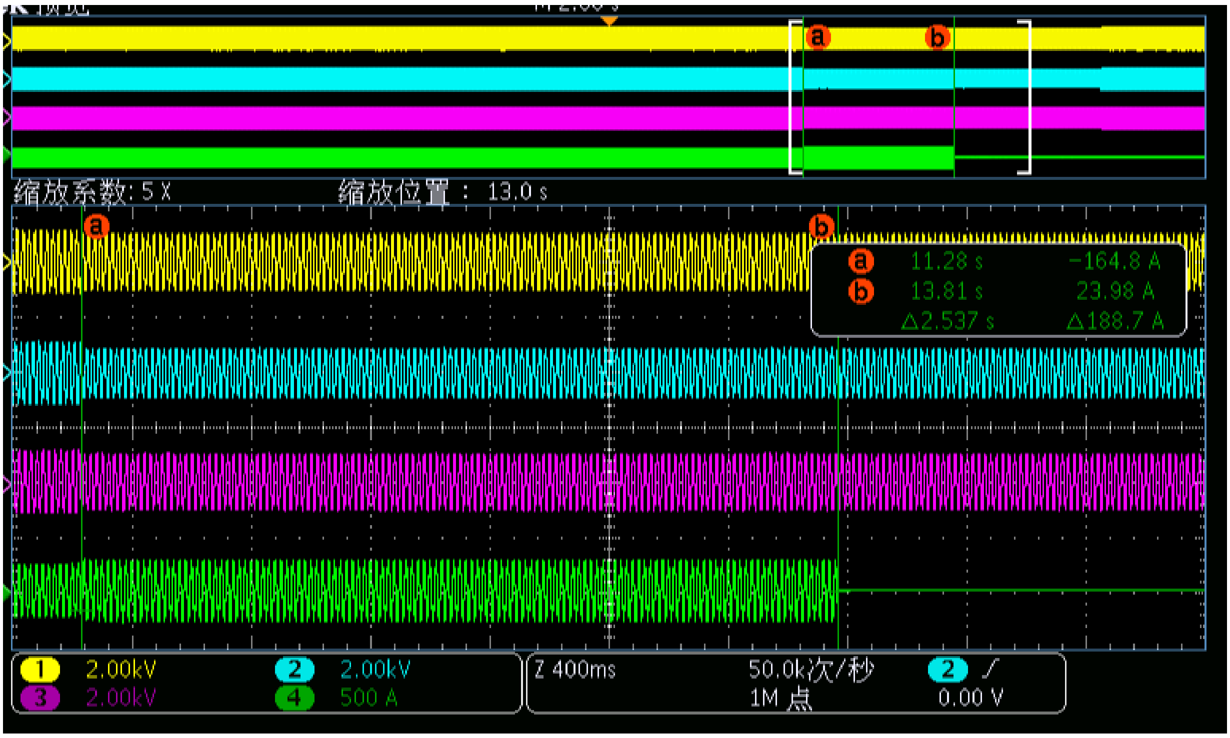
Over and Under voltage protection shall operate independently for all three phases in all cases.

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Graph of U/V L1-L2 Phase

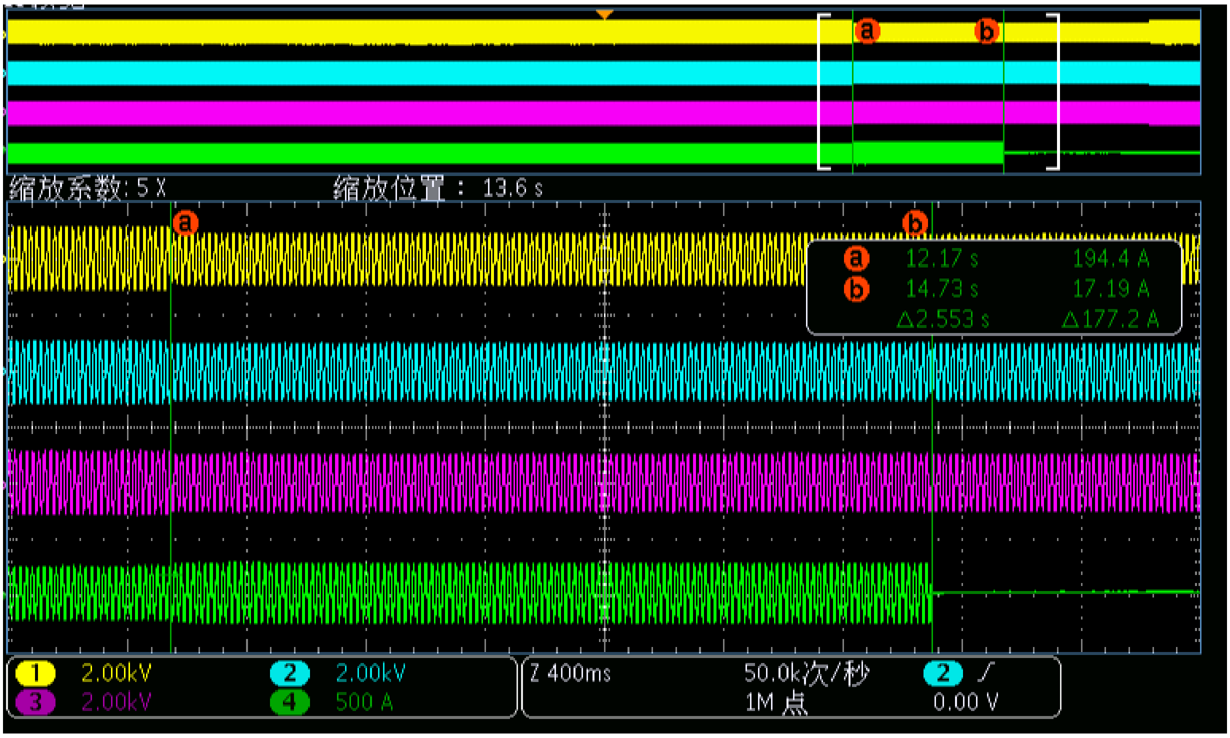


Graph of U/V L2-L3 Phase

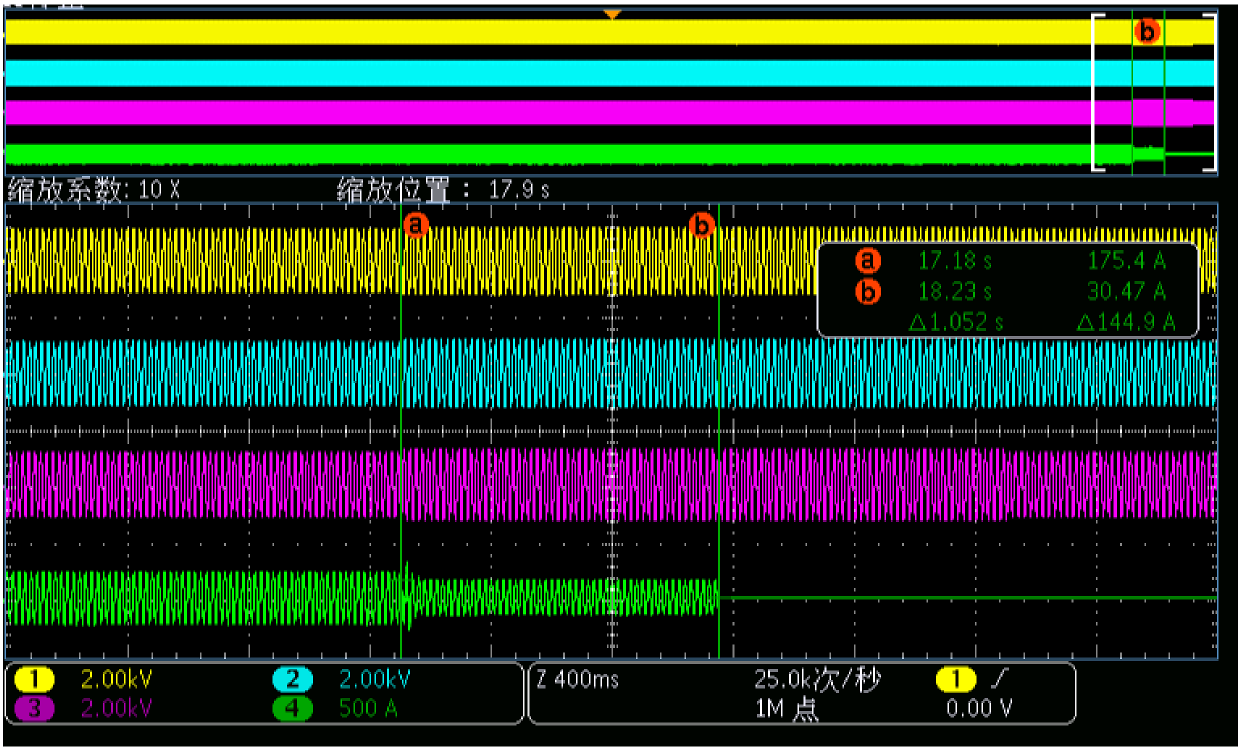


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Graph of U/V L3-L1 Phase

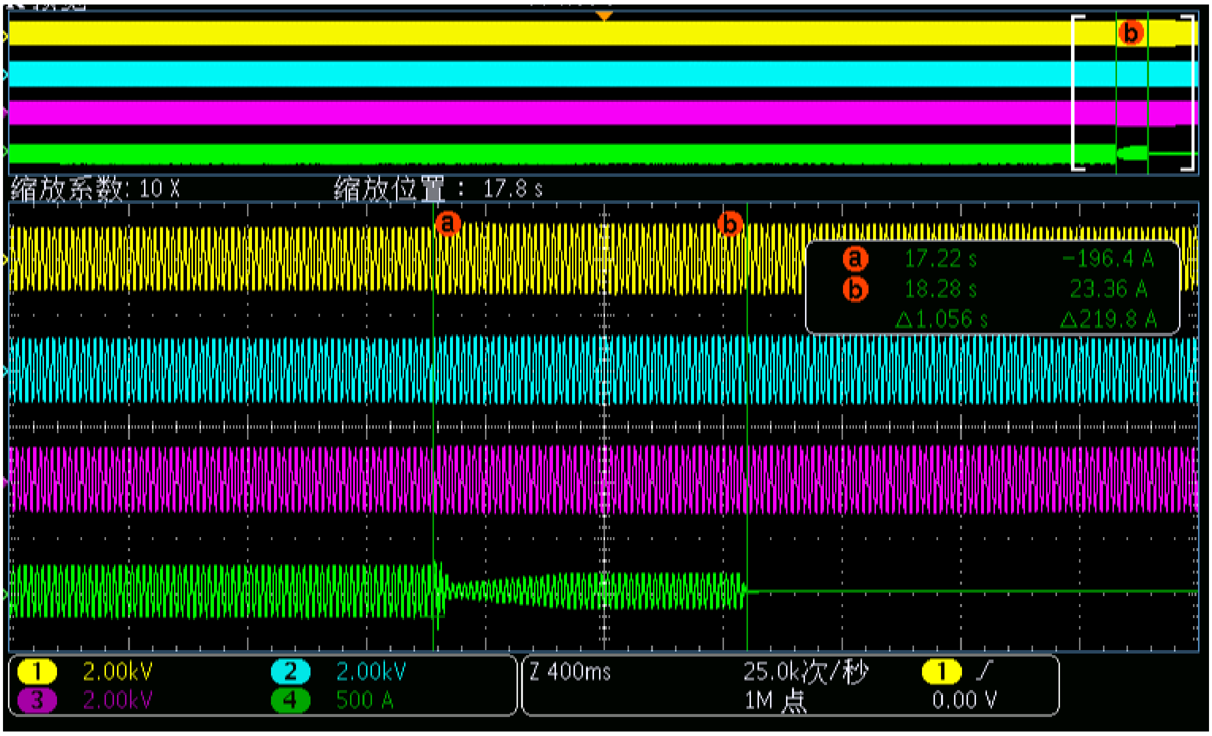


Graph of O/V stage 1 L1-L2 Phase

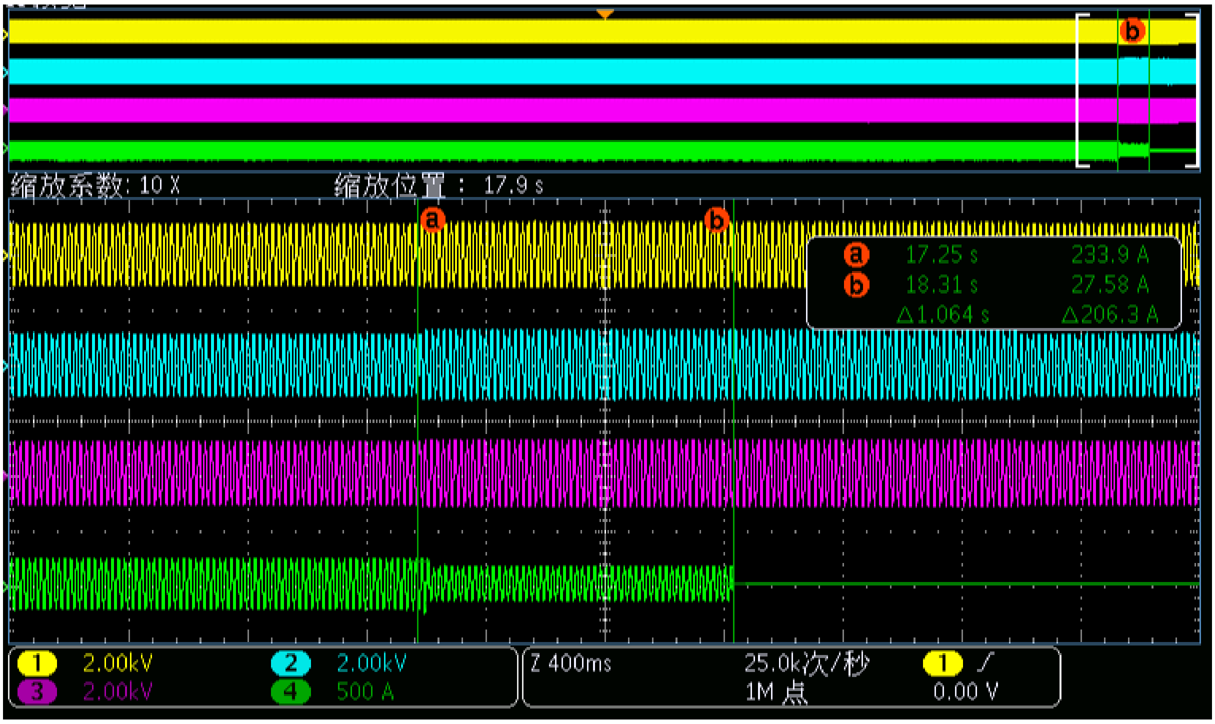


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Graph of O/V stage 1 L2-L3 Phase

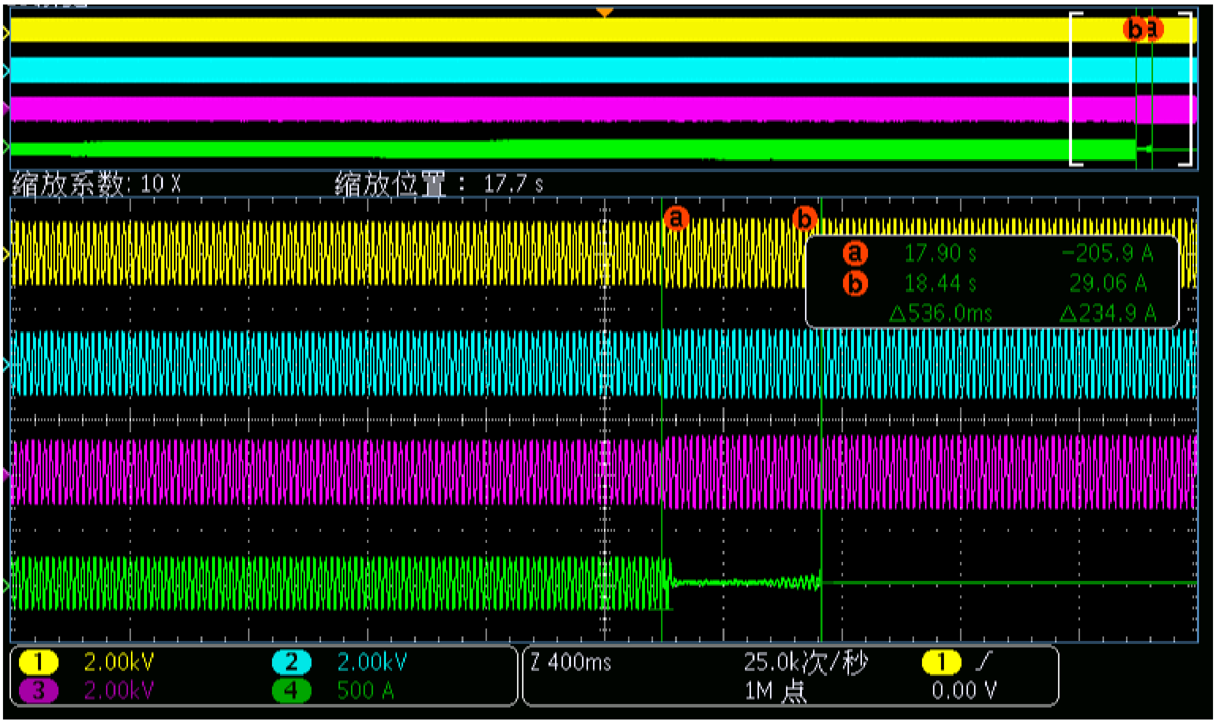


Graph of O/V stage 1 L3-L1 Phase

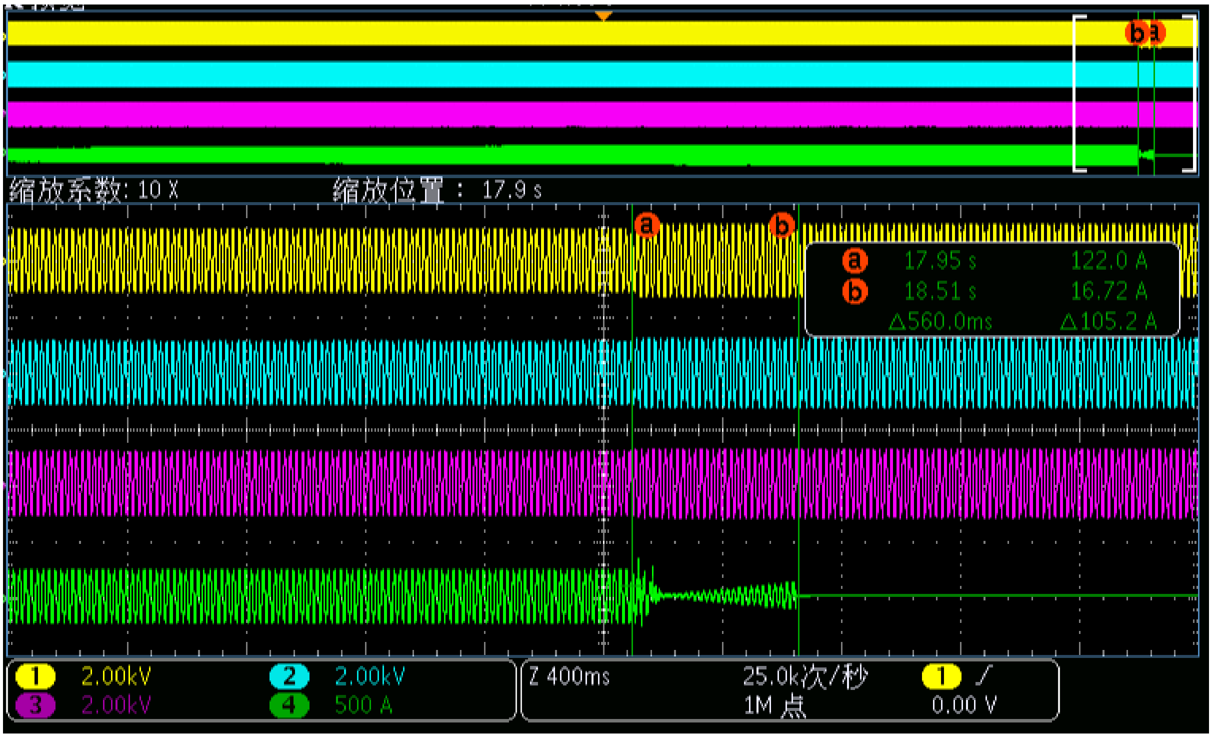


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Graph of O/V stage 2 L1-L3 Phase

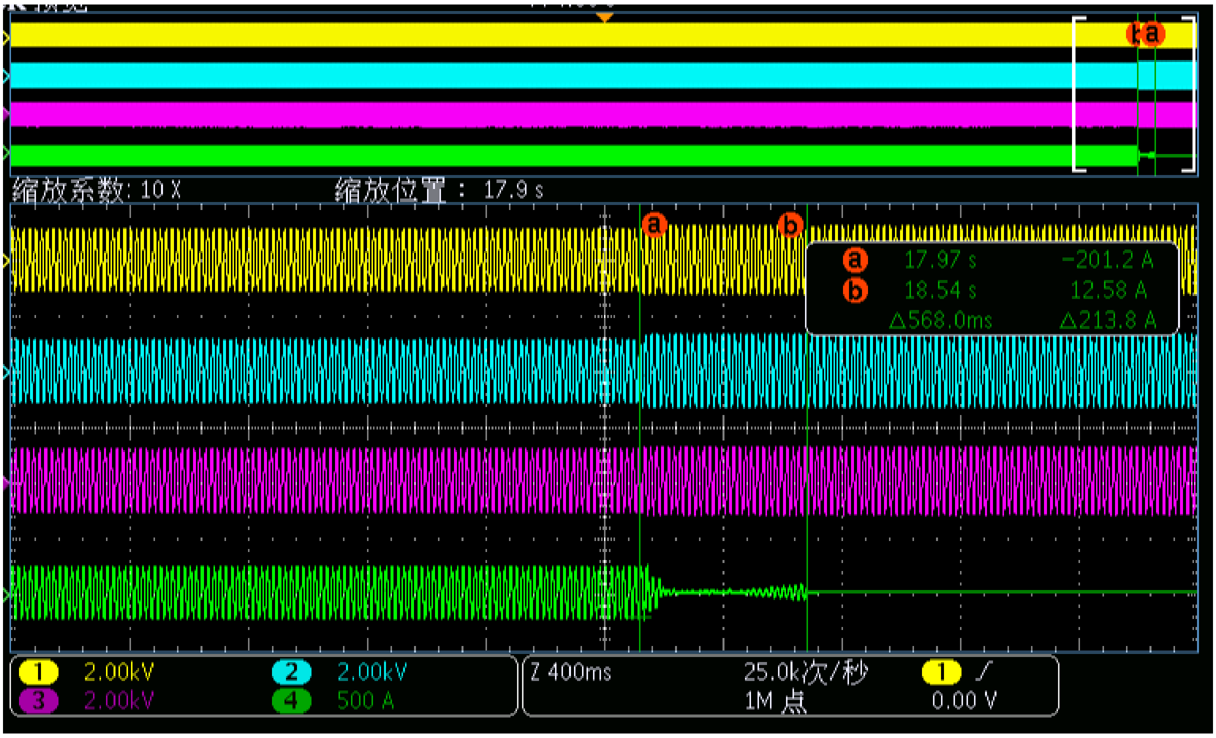


Graph of O/V stage 2 L2-L3 Phase



G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Graph of O/V stage 2 L3-L1 Phase



G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

10.6.7.1 Protection – Voltage tests

Type D — **P**

These tests should be carried out in accordance with Annex A.7.1.2.2. For trip tests, voltage and time delay should be stated. For “no trip tests”, “no trip” can be stated.

Note that the value of voltage stated below assumes a **LV** connection This should be adjusted for **HV** taking account of the VT ratio as required.

Model: SG250HX

L1-L2 Phase

Function	Setting		Trip test		“No trip tests”	
	Voltage	Time delay	Voltage	Time delay	Voltage /time	Confirm no trip
U/V	0.8 pu (640 V)	2.5 s	637 V	2.553 s	654.3 V 5.0 s	No trip
					626.1 V 2.45 s	No trip
O/V stage 1	1.1 pu (880 V)	1.0 s	883 V	1.046 s	866.1 V 5.0 s	No trip
					893.6 V 0.95 s	No trip

L2-L3 Phase

Function	Setting		Trip test		“No trip tests”	
	Voltage	Time delay	Voltage	Time delay	Voltage/time	Confirm no trip
U/V	0.8 pu (640 V)	2.5 s	637 V	2.545 s	654.3 V 5.0 s	No trip
					626.1 V 2.45 s	No trip
O/V stage 1	1.1 pu (880 V)	1.0 s	883 V	1.038 s	866.1 V 5.0 s	No trip
					893.6 V 0.95 s	No trip

L3-L1 Phase

Function	Setting		Trip test		“No trip tests”	
	Voltage	Time delay	Voltage	Time delay	Voltage/time	Confirm no trip
U/V	0.8 pu (640 V)	2.5 s	637 V	2.553 s	654.3 V 5.0 s	No trip
					626.1 V 2.45 s	No trip
O/V stage 1	1.1 pu	1.0 s	883 V	1.046 s	866.1 V	No trip

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

	(880 V)				5.0 s	
					893.6 V 0.95 s	No trip

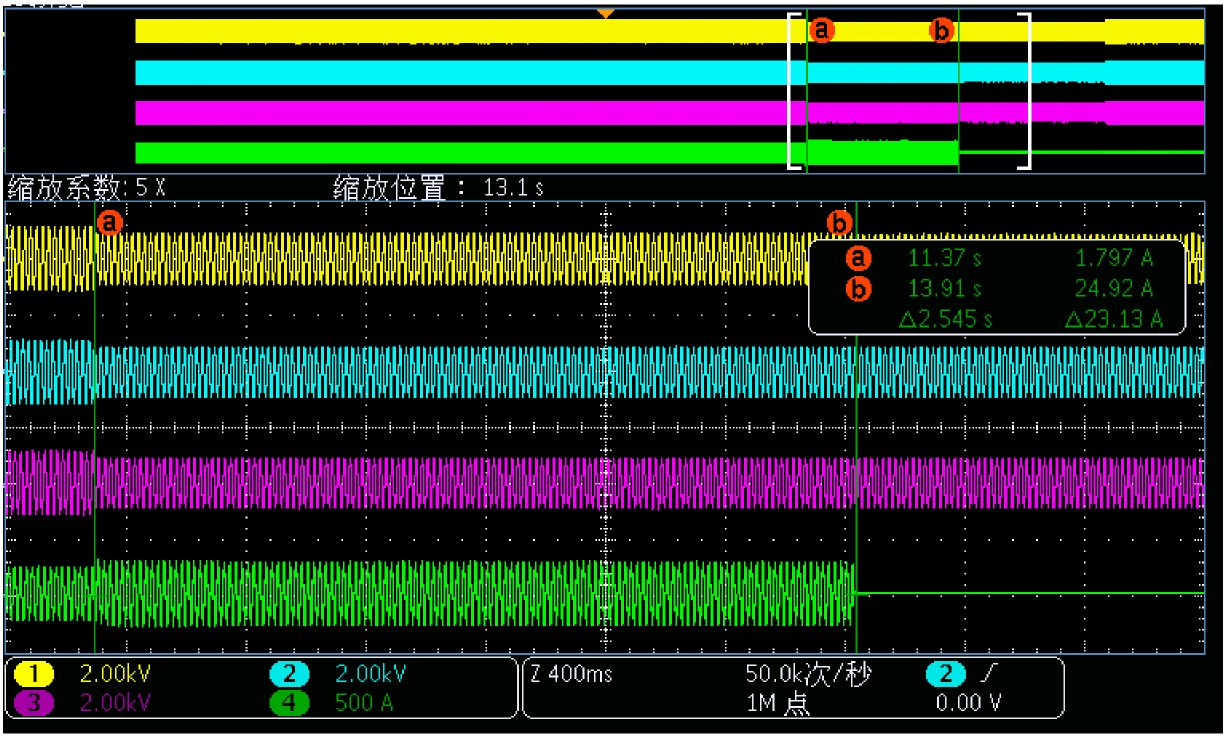
Note:

Note for Voltage tests the Voltage required to trip is the setting ±1.5% of the nominal value. The time delay can be measured at a larger deviation than the minimum required to operate the protection. The No trip tests need to be carried out at the setting ±2% of the nominal value and for the relevant times as shown in the table above to ensure that the protection will not trip in error.

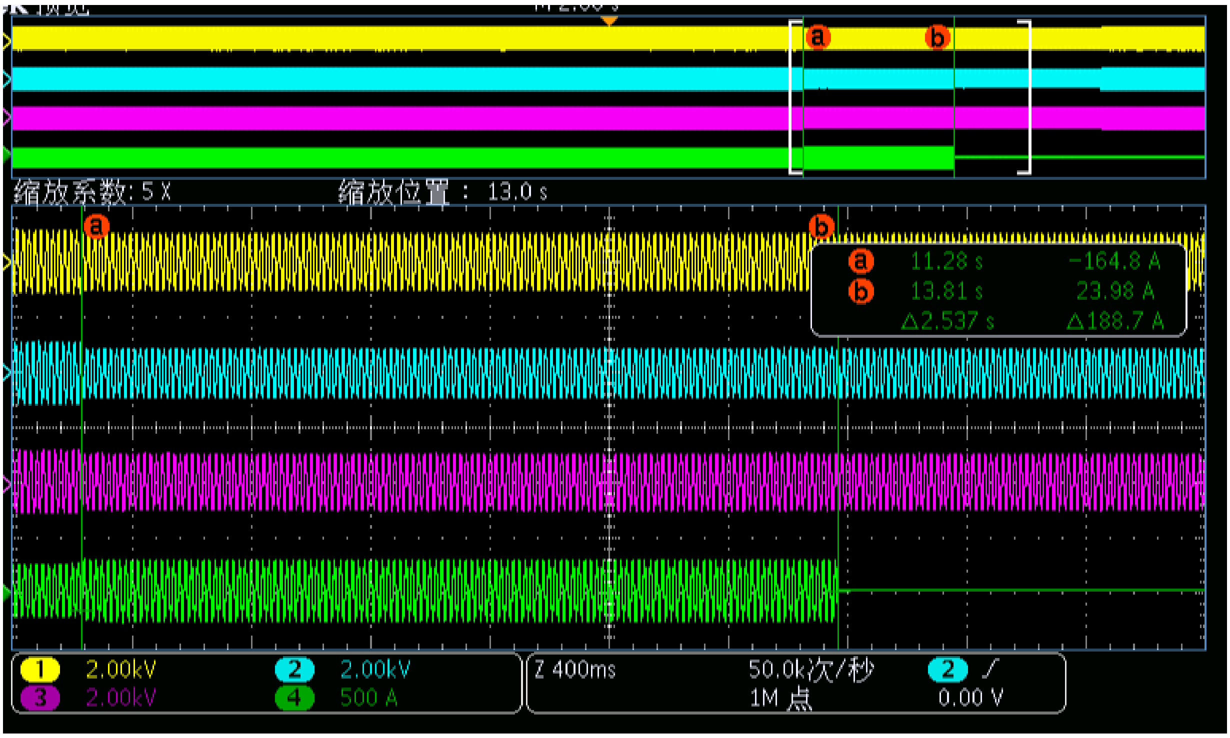
Over and Under voltage protection shall operate independently for all three phases in all cases.

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Graph of U/V L1-L2 Phase

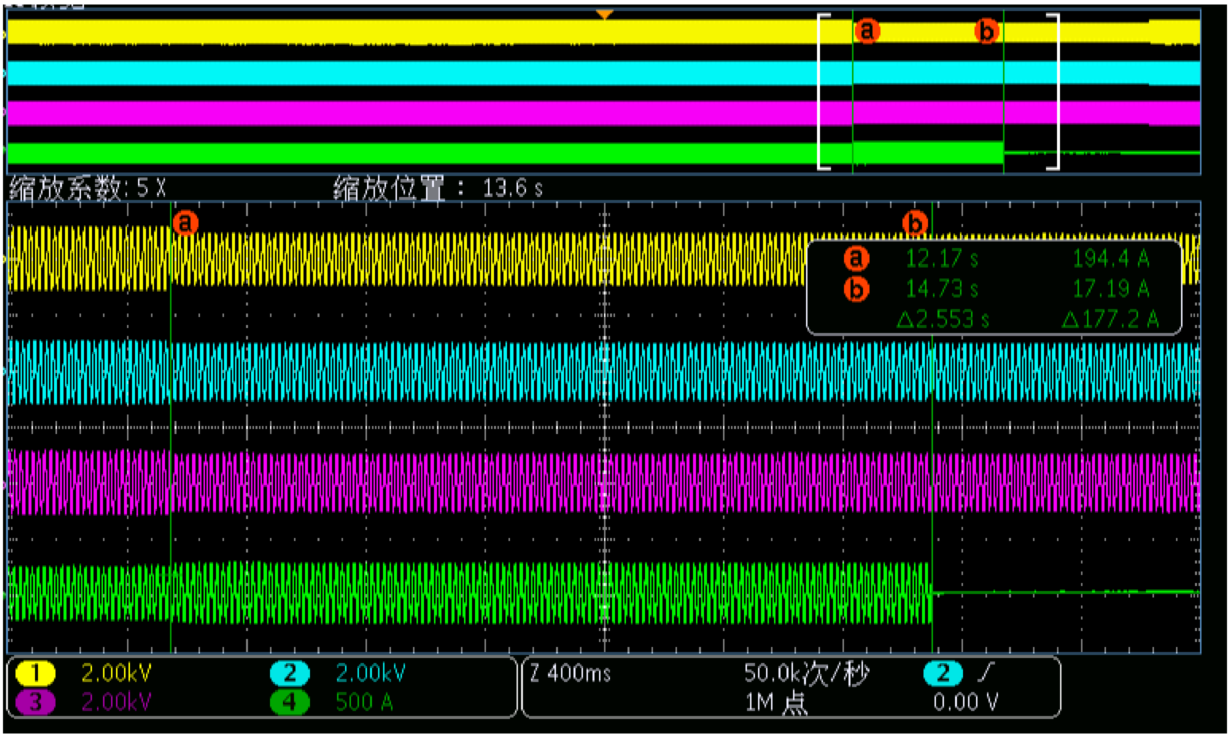


Graph of U/V L2-L3 Phase

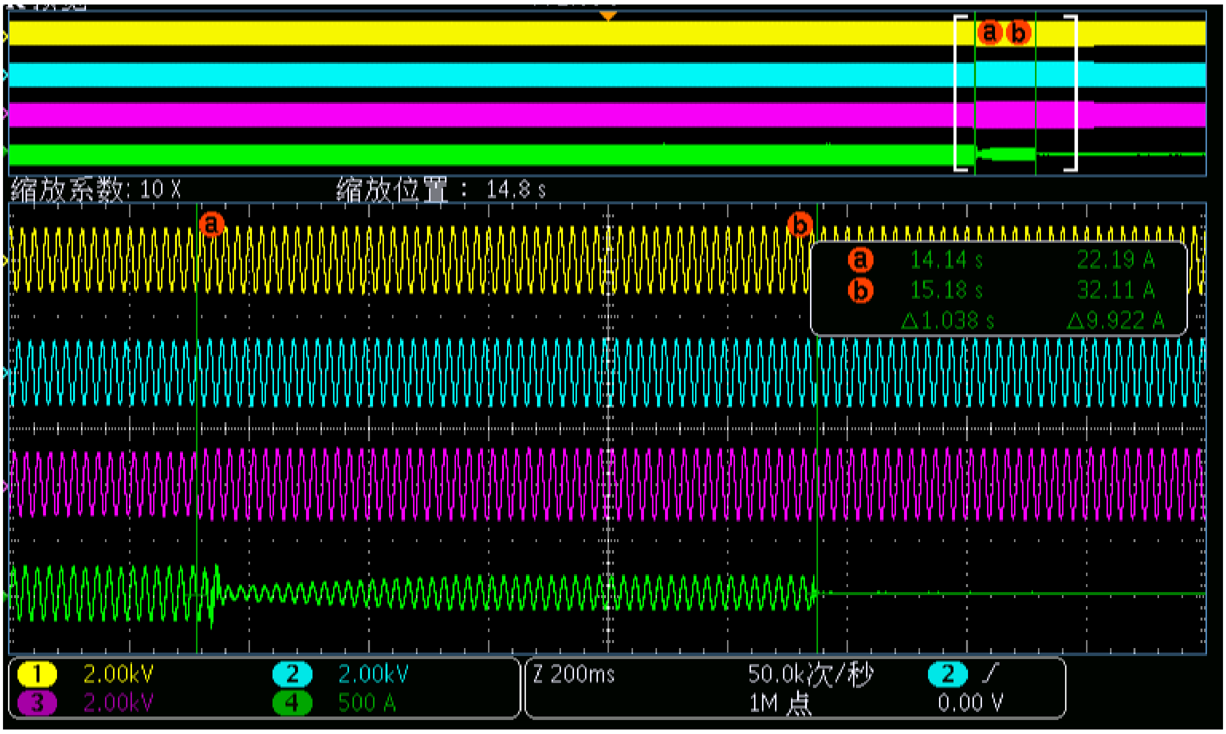


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Graph of U/V L3-L1 Phase

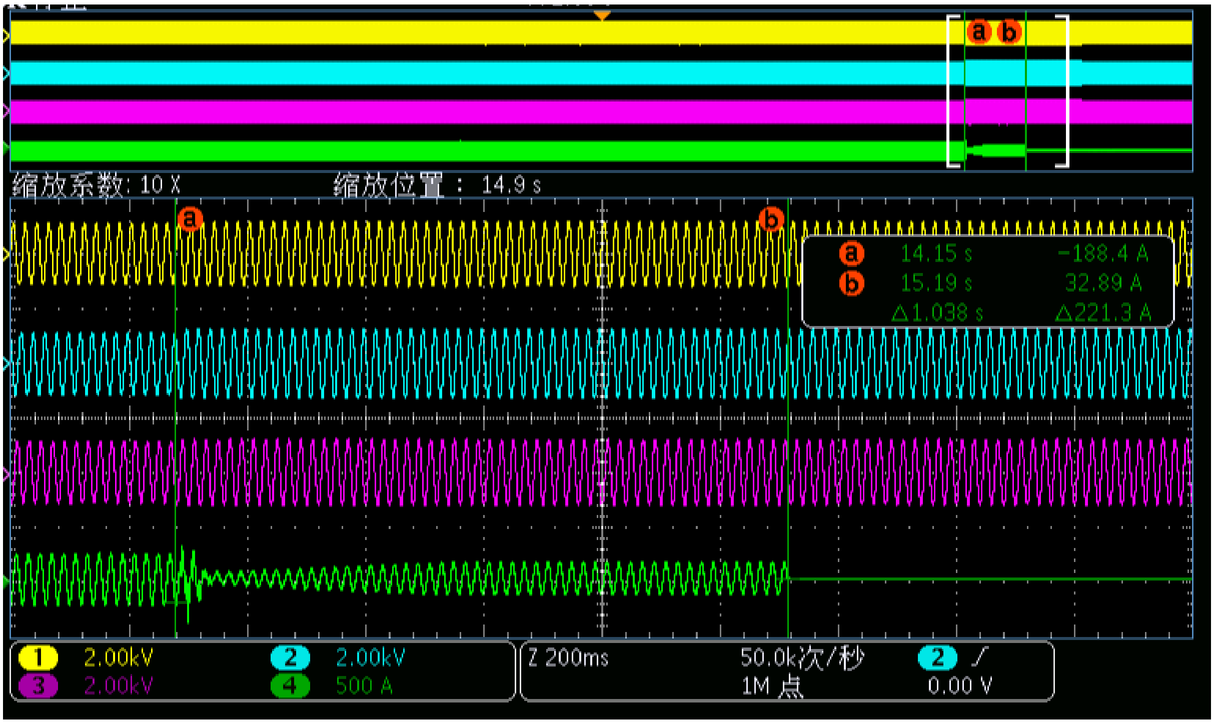


Graph of O/V stage L1-L2 Phase

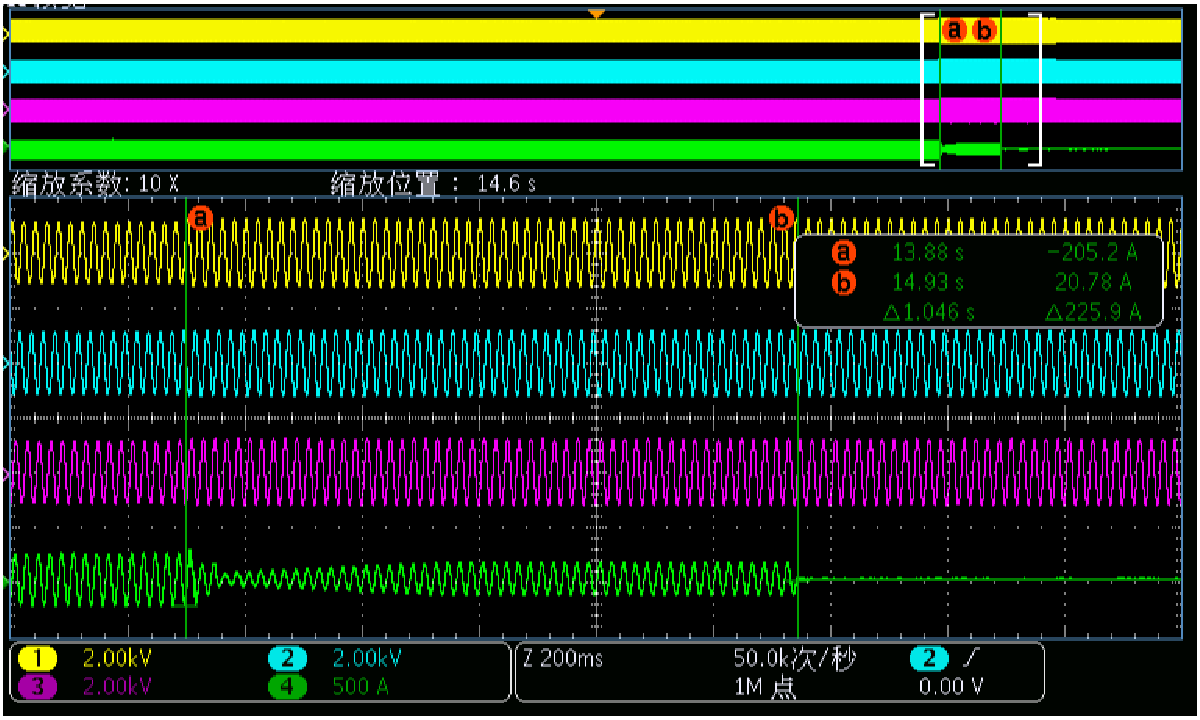


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Graph of O/V stage L2-L3 Phase



Graph of O/V stage L3-L1 Phase



G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

9.6 Protection – Loss of Mains test	**P**
These tests should be carried out in accordance with BS EN 62116. Annex A.7.1.2.4. For test condition A, EUT output = 100 % P_n, test condition B, EUT output = 50 % to 66 % P_n, and test condition C, EUT output = 25 % to 33 % P_n.	
Model: SG250HX	
The following sub set of tests should be recorded in the following table.	

Test Power and imbalance	33% -5% Q Test 22	66% -5% Q Test 12	100% -5% P Test 5	33% +5% Q Test 31	66% +5% Q Test 21	100% +5% P Test 10
Trip time. **Limit is 0.5s**	235 ms	241.0 ms	264.0 ms	229 ms	259.0 ms	251.0 ms

No.	P_{EUT} a) (% of EUT rating)	Reactive load (% of Q_L)	P_{AC} b) (% of nominal)	Q_{AC} c) (% of nominal)	Run-on time (ms)	P_{EUT} (W)	Actual Q_f	V_{DC} d)	Remarks e)
1	100	100	0	0	255.2	225	1.00	1190	/
2	66	66	0	0	202.2	148.5	1.00	1050	/
3	33	33	0	0	274.0	74.25	1.00	900	/
4	100	100	-5	-5	282.0	225	1.03	1190	Test A at IB
5	100	100	-5	0	264.0	225	1.05	1190	Test A at IB
6	100	100	-5	+5	255.0	225	1.08	1190	Test A at IB
7	100	100	0	-5	440.0	225	0.97	1190	Test A at IB
8	100	100	0	+5	473.0	225	1.02	1190	Test A at IB
9	100	100	+5	-5	272.0	225	0.96	1190	Test A at IB
10	100	100	+5	0	251.0	225	0.94	1190	Test A at IB
11	100	100	+5	+5	260.0	225	0.98	1190	Test A at IB
12	66	66	0	-5	241.0	148.5	0.97	1050	Test B at IB
13	66	66	0	-4	280.0	148.5	0.98	1050	Test B at IB
14	66	66	0	-3	256.0	148.5	0.98	1050	Test B at IB
15	66	66	0	-2	159.2	148.5	0.99	1050	Test B at IB
16	66	66	0	-1	199.0	148.5	0.99	1050	Test B at IB
17	66	66	0	+1	254.2	148.5	1.00	1050	Test B at IB
18	66	66	0	+2	481.0	148.5	1.01	1050	Test B at IB
19	66	66	0	+3	391.0	148.5	1.01	1050	Test B at IB
20	66	66	0	+4	267.0	148.5	1.02	1050	Test B at IB
21	66	66	0	+5	259.0	148.5	1.02	1050	Test B at IB
22	33	33	0	-5	235.0	74.25	0.97	900	Test B at IB
23	33	33	0	-4	232.0	74.25	0.98	900	Test C at IB
24	33	33	0	-3	253.0	74.25	0.98	900	Test C at IB

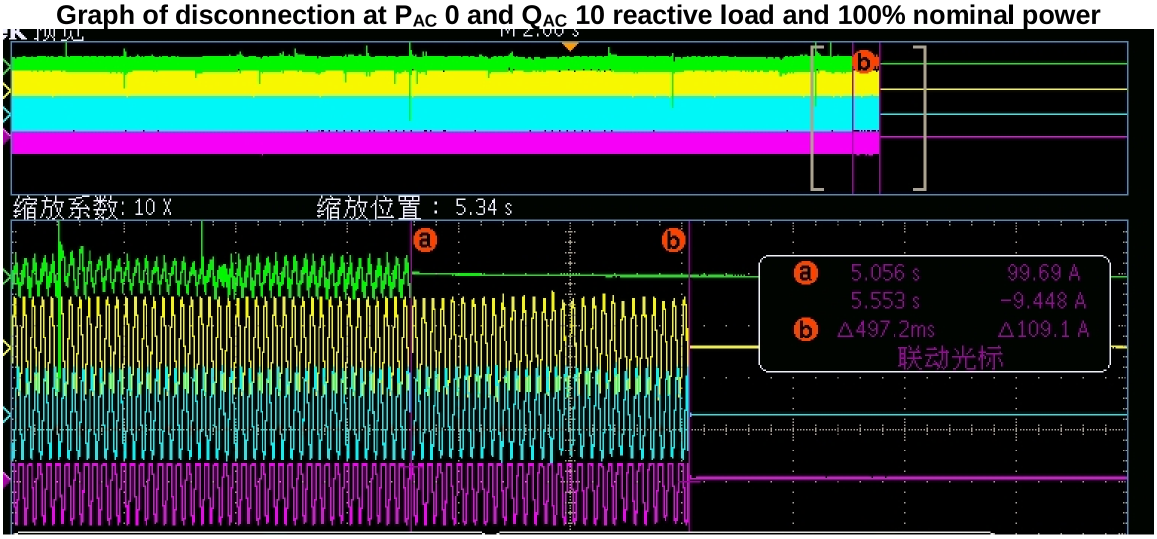
G99/1-8		
Clause	Requirement - Test	Result - Remark	Verdict

25	33	33	0	-2	271.0	74.25	0.99	900	Test C at IB
26	33	33	0	-1	271.0	74.25	0.99	900	Test C at IB
27	33	33	0	+1	280.0	74.25	1.00	900	Test C at IB
28	33	33	0	+2	277.0	74.25	1.01	900	Test C at IB
29	33	33	0	+3	271.0	74.25	1.01	900	Test C at IB
30	33	33	0	+4	211.0	74.25	1.02	900	Test C at IB
31	33	33	0	+5	229.0	74.25	1.02	900	Test C at IB

Note:
[a]PEUT: EUT output power.
[b]Pac: Active power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.
[c]Q_{ac}: Reactive power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.
[d]For test condition A, > 75 % of rated input voltage range used, for test condition B, 50 % of rated input voltage range, ±10 % used, for test condition C, < 20 % of rated input voltage range used. Based on EUT rated input operating range. For example, if range is between X volts and Y volts, 75 % of range = X + 0,75 × (Y – X). Y shall not exceed 0,8 × EUT maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the EUT should not be operated outside of its allowable input voltage range.
[e]BL: Balance condition, IB: Imbalance condition.

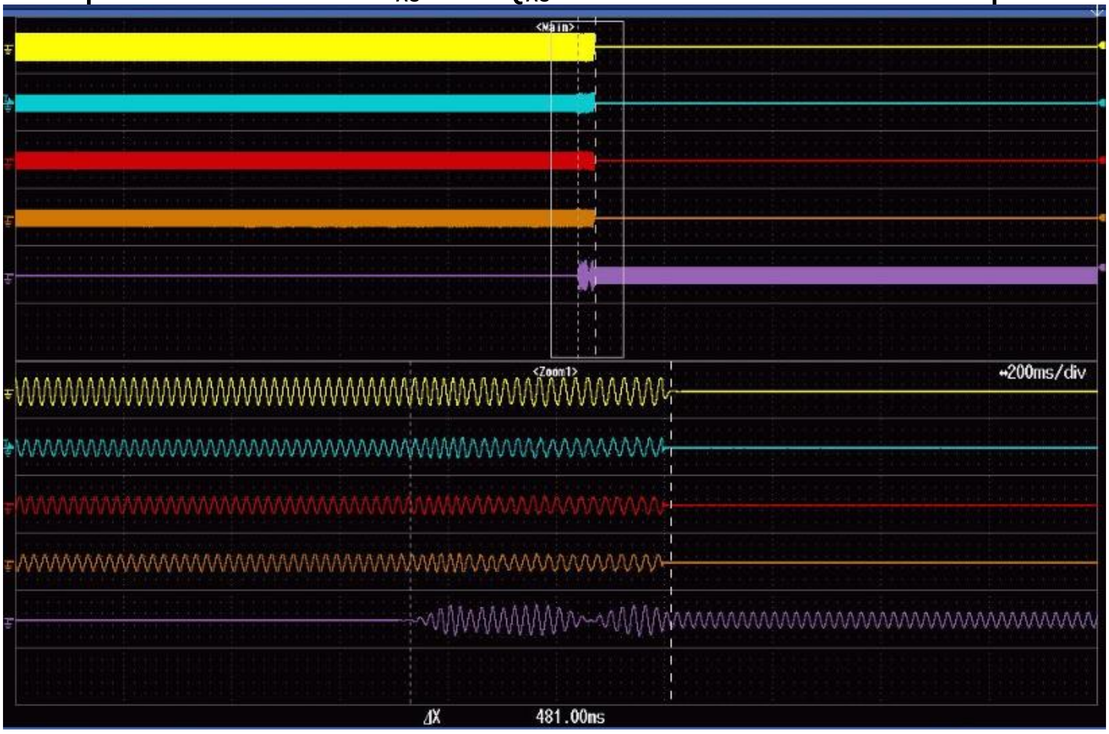
If the device requires additional shut down time (beyond 0.5 s but less than 1 s) then this should be stated on this form.

Graph of disconnection at P_{AC} 0 and Q_{AC} 10 reactive load and 100% nominal power

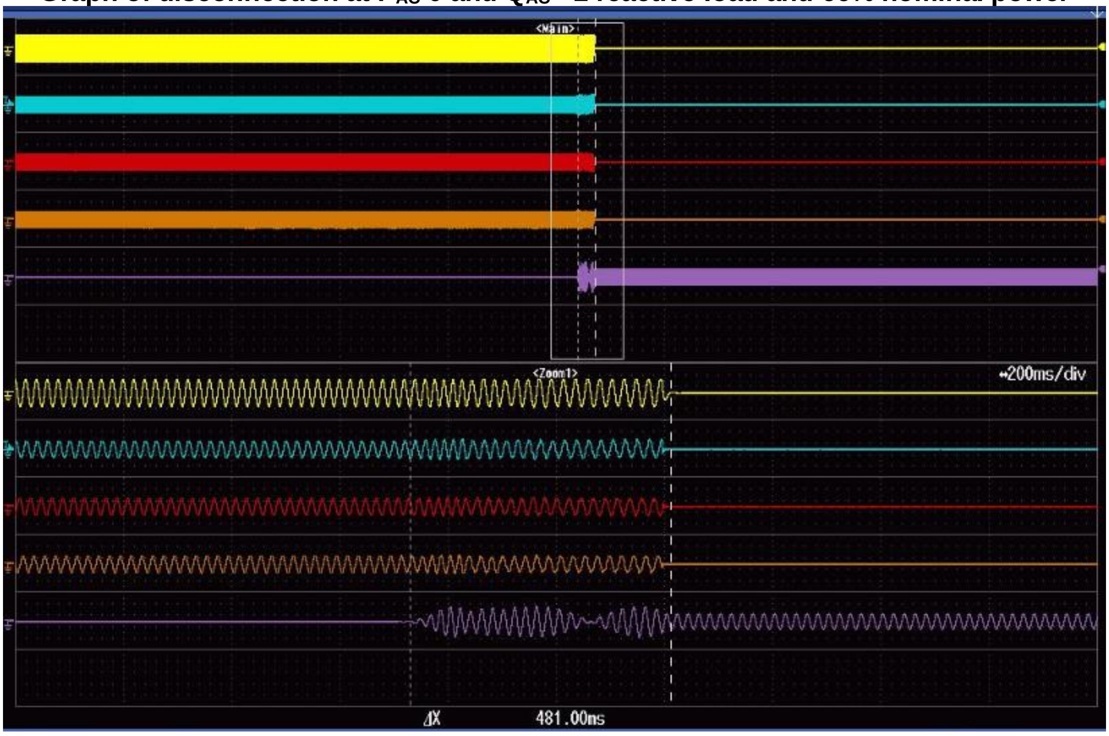


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Graph of disconnection at P_{AC} 0 and Q_{AC} +2 reactive load and 66% nominal power



Graph of disconnection at P_{AC} 0 and Q_{AC} +2 reactive load and 66% nominal power



G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

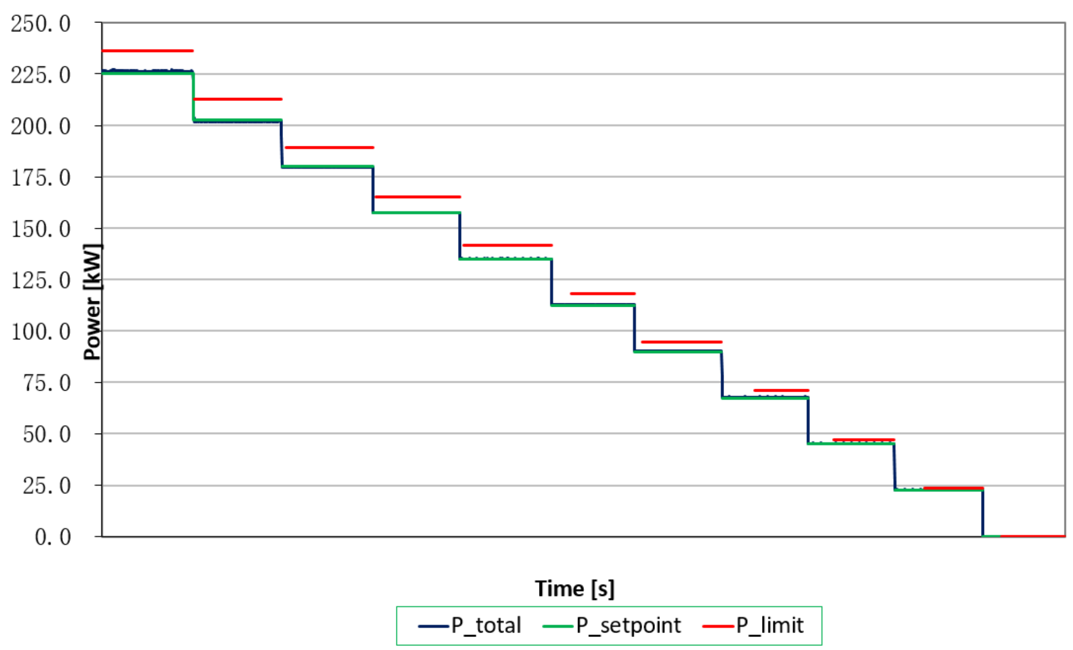
10.6.2 Loss of Mains Protection, Vector Shift Stability test			**P**
This test should be carried out in accordance with Annex A.7.1.2.6. Confirmation is required that the **Power Generating Module** does not trip under positive / negative vector shift.			
Model: SG250HX			
	Start Frequency	Change	Confirm no trip
Positive Vector Shift	49.5 Hz	+50 degrees	No trip
Negative Vector Shift	50.5 Hz	- 50 degrees	No trip
10.6.2 Loss of Mains Protection, RoCoF Stability test			**P**
This test should be carried out in accordance with Annex A.7.1.2.6. Confirmation is required that the **Power Generating Module** does not trip for the duration of the ramp up and ramp down test.			
Model: SG250HX			
Ramp range	Test frequency ramp:	Test Duration	Confirm no trip
49.0 Hz to 51.0 Hz	+0.95 Hzs^{-1}	2.1 s	No trip
51.0 Hz to 49.0 Hz	-0.95 Hzs^{-1}	2.1 s	No trip

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

12.1.3 13.1.3	**TABLE: Reduction of active power on setpoint (for Type B, Type C, Type D)**										**P**
Model	SG250HX										
1-min mean value, P/P_n [%]	100	90	80	70	60	50	40	30	20	10	0
$P_{Setpoint}$[kW]:	225.0	202.5	180.0	157.5	135.0	112.5	90.0	67.5	45.0	22.5	0
P_{E60} [kW]:	226.401	201.961	179.777	157.508	135.142	112.744	90.329	67.856	45.301	22.710	0
$\Delta P_{E60}/P_{Emax}$ [%]:	0.62	-0.24	-0.10	0	0.06	0.11	0.15	0.16	0.13	0.09	0
Limit reduce time [s]	5 s										
Graph of the setting accuracy:											

Note:
The **Active Power** reduction will be either between 1.0 p.u. of **Registered Capacity Active Power** and zero, or between 1.0 pu of **Registered Capacity Active Power** and **Minimum Stable Operating Level**. In the latter case the **Generator** will agree with the **DNO** how zero output can be achieved, including the option of using the logic interface as described in paragraph 11.1.3.1.

11.1.3.1 By default the **DNO** logic interface will take the form of a simple binary output that can be operated by a simple switch or contactor. When the switch is closed the **Power Generating Module** can operate normally. When the switch is opened the **Power Generating Module** will reduce its **Active Power** to zero within 5 s. The signal from the **Power Generating Module** that is being switched can be either AC (maximum value 240 V) or DC (maximum value 110 V). If the **DNO** wishes to make use of the facility to cease **Active Power** output the **DNO** will agree with the **Generator** how the communication path is to be achieved.

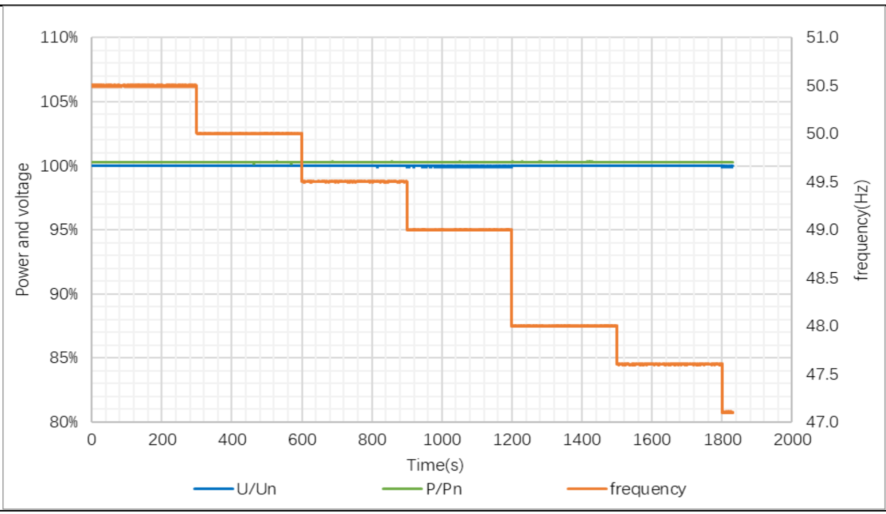


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

12.2.3 13.2.3	**TABLE: Output power with falling frequency**			P
Model	SG250HX			
Voltage	Un=800Vac			
Test sequence	Measured **Active Power** Output (kW)	Acceptable **Active Power**	Frequency (Hz)	Primary power source
50.5 Hz for 5 minutes	225.62	100% **Registered Capacity**	50.50	Photovoltaic array simulator
50.0 Hz for 5 minutes	225.62	100% **Registered Capacity**	50.00	Photovoltaic array simulator
49.5 Hz for 5 minutes	225.62	100% **Registered Capacity**	49.50	Photovoltaic array simulator
49.0 Hz for 5 minutes	225.63	99% **Registered Capacity**	49.00	Photovoltaic array simulator
48.0 Hz for 5 minutes	225.64	97% **Registered Capacity**	48.00	Photovoltaic array simulator
47.6 Hz for 5 minutes	225.63	96.2% **Registered Capacity**	47.60	Photovoltaic array simulator
47.1 Hz for 20 s	225.62	95% **Registered Capacity**	47.10	Photovoltaic array simulator

Notes:
Each **Power Generating Module**, shall be capable of:
(a) continuously maintaining constant **Active Power** output for system frequency changes within the range 50.5 to 49.5 Hz; and

(b) (subject to the provisions of paragraph 12.2.1) maintaining its **Active Power** output at a level not lower than the figure determined by the linear relationship shown in Figure 12.1 for system frequency changes within the range 49.5 to 47 Hz for all ambient temperatures up to and including 25°C, such that if the system frequency drops to 47 Hz the **Active Power** output does not decrease by more than 5%.



G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

12.2.4 13.2.4 B.4.5	**Limited Frequency Sensitive Mode – Over frequency test:**	**P**
The test should be carried out using the specific threshold frequency of 50.4 Hz and **Droop** of 10%.		
Active Power response to rising frequency/time plots are attached if frequency injection tests are undertaken in accordance with Annex B.6.2		Y
Model: SG250HX		
Alternatively, simulation results should be noted below:		

Test sequence at **Registered Capacity** >80%	Measured **Active Power** Output (W)	Frequency (Hz)	Calculated droop (%)	Primary Power Source	**Active Power** Gradient
Step a) 50.00 Hz ±0.01 Hz	224.566	50.00	-	Photovoltaic array simulator	-
Step b) 50.45 Hz ±0.05 Hz	222.267	50.45	9.77		-
Step c) 50.70 Hz ±0.10 Hz	210.060	50.70	9.29		-
Step d) 51.15 Hz ±0.05 Hz	188.058	51.15	9.23		-
Step e) 50.70 Hz ±0.10 Hz	209.905	50.70	9.19		-
Step f) 50.45 Hz ±0.05 Hz	222.176	50.45	9.40		-
Step g) 50.00 Hz ±0.01 Hz	224.555	50.00	-		-
Test sequence at **Registered Capacity** 40-60%	Measured **Active Power** Output (W)	Frequency (Hz)	Calculated droop (%)	Primary Power Source	**Active Power** Gradient
Step a) 50.00 Hz ±0.01 Hz	112.543	50.00	-	Photovoltaic array simulator	-
Step b) 50.45 Hz ±0.05 Hz	110.289	50.45	9.98		-
Step c) 50.70 Hz ±0.10 Hz	98.205	50.70	9.42		-
Step d) 51.15 Hz ±0.05 Hz	76.138	51.15	9.27		-
Step e) 50.70 Hz ±0.10 Hz	97.966	50.70	9.26		-
Step f) 50.45 Hz ±0.05 Hz	110.106	50.45	9.23		-
Step g) 50.00 Hz ±0.01 Hz	112.572	50.00	-		-

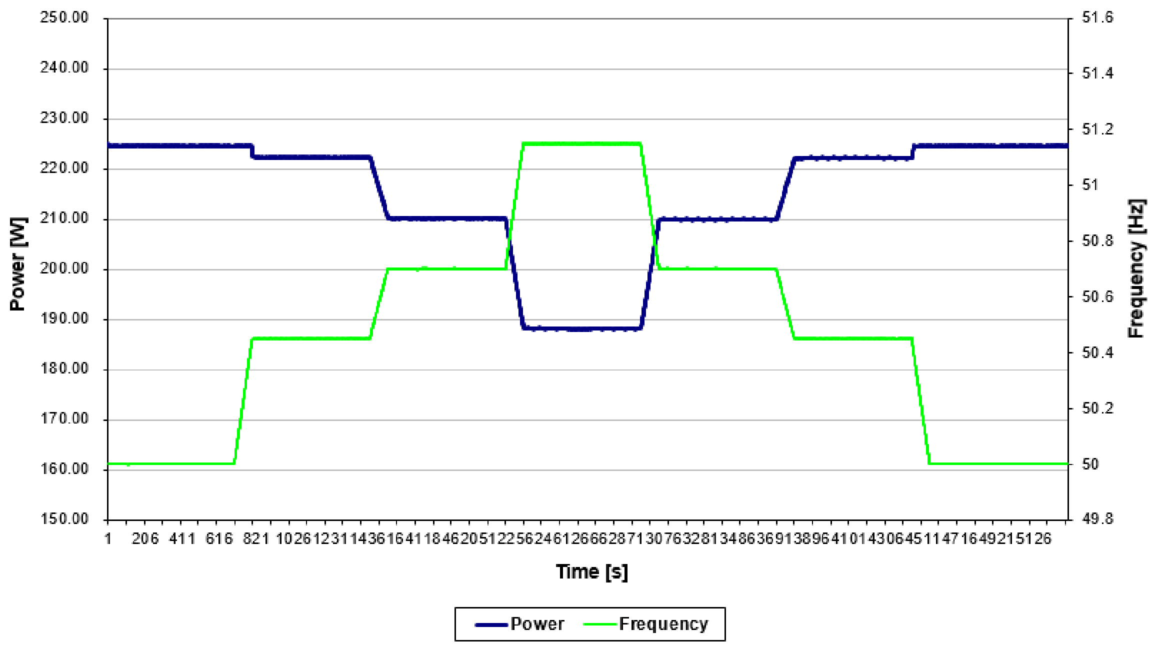
Note:
The simulation study event shall be equivalent to:
(i) a sufficiently large increase in the measured system frequency ramped over 10 s to cause a decrease in **Active Power** output in accordance with the **Droop** setting followed by
(ii) 60 s of steady state with the measured system frequency increased to the same level as in B.4.5.4 (i) as illustrated in Figure B.4.1 below
(iii) then decrease of the measured system frequency ramped over 10 s to cause an increase in **Active Power** output back to the maximum **Active Power** level followed by at least 60 s of steady output.

The allowed tolerance for the frequency measurement shall be ± 0.05 Hz. The allowed tolerance for Active Power output measurement shall be ±10% of the required change in Active Power.

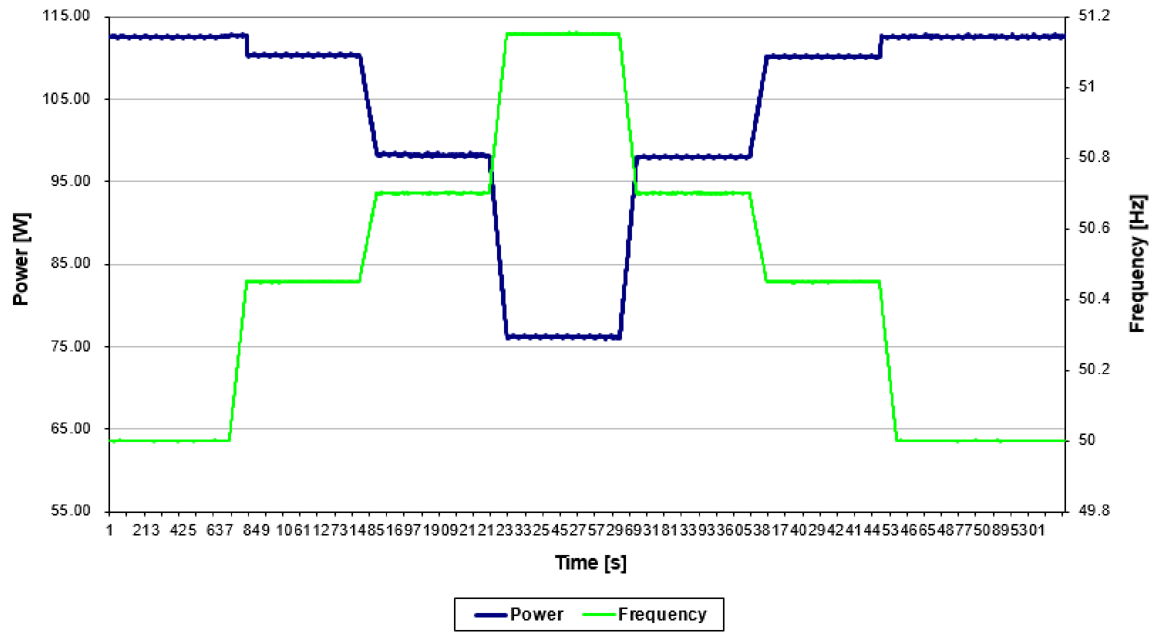
The resulting overall tolerance range for a nominal 10% Droop is +2.8% and – 1.5%, ie a Droop less than 12.8% and greater than 8.5%.

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Limited Frequency Sensitive Mode – Over frequency test (100%Pn)



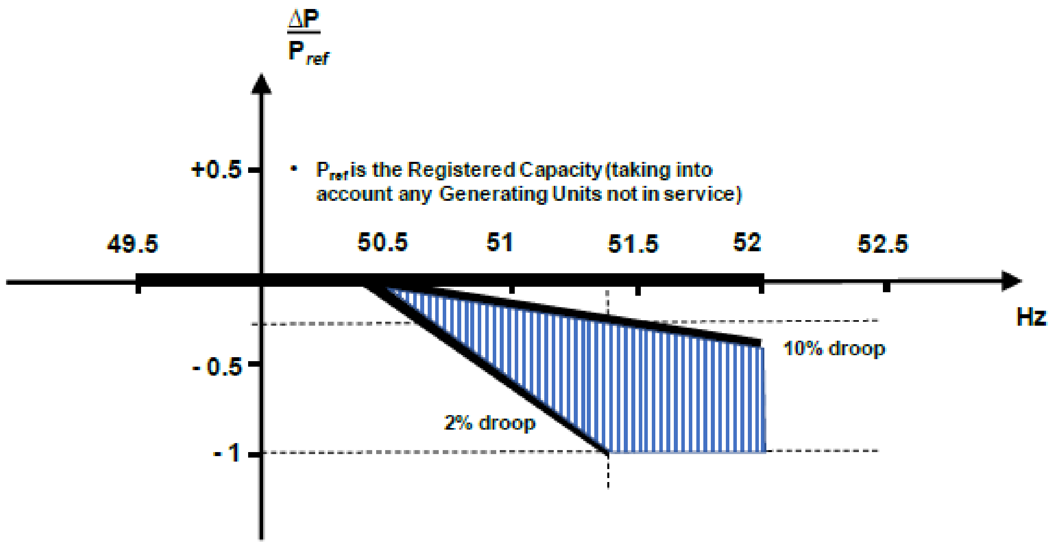
Limited Frequency Sensitive Mode – Over frequency test (50%Pn)



G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

B.6.2	**Frequency Response Tests** **Active Power** response to rising frequency/time plots are attached if frequency injection tests are undertaken in accordance with Annex B.6.2. **(for Type B, Type C, Type D)**	**P**

Test sequence at **Registered Capacity** >65%	Measured **Active Power** Output (kW)	Frequency (Hz)	Calculate droop (%)	Primary Power Source	**Active Power** Gradient
Step a) 50.00 Hz ±0.01 Hz	227.705	50.00	-	Photovoltaic array simulator	-
Step b) 52.00 Hz ±0.01 Hz	153.329	52.00	9.68		P
Step c) 50.00 Hz ±0.01 Hz	227.835	50.00	-		-



P_{ref} is the reference Active Power to which ΔP is related and. ΔP is the change in Active Power output from the Power Generating Module.

Figure 13.2 Active Power Frequency Response capability when operating in LFSM-O

1. The frequency input and the expected Active Power response which are illustrated for different time periods from 0 s to 130 s in Figures B.6.1 for a step change in frequency.

2. The response should commence within 2 s and the response shall be to the left of the red line (ie between the green and red lines), and as close to the green line as possible when following the frequency step or ramp. Note that the red line represents the 0.5% s-1 specified in paragraph 12.2.4.

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

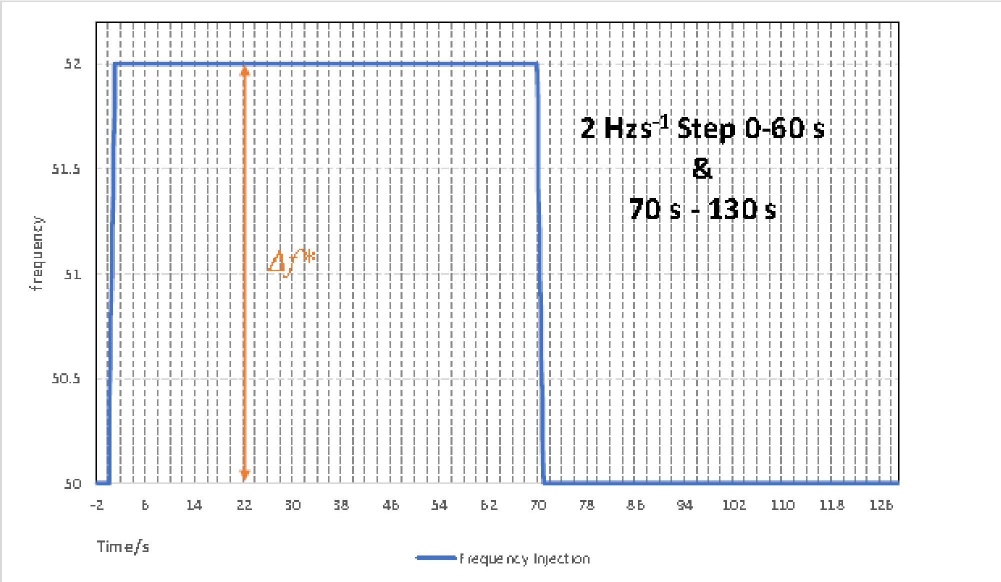
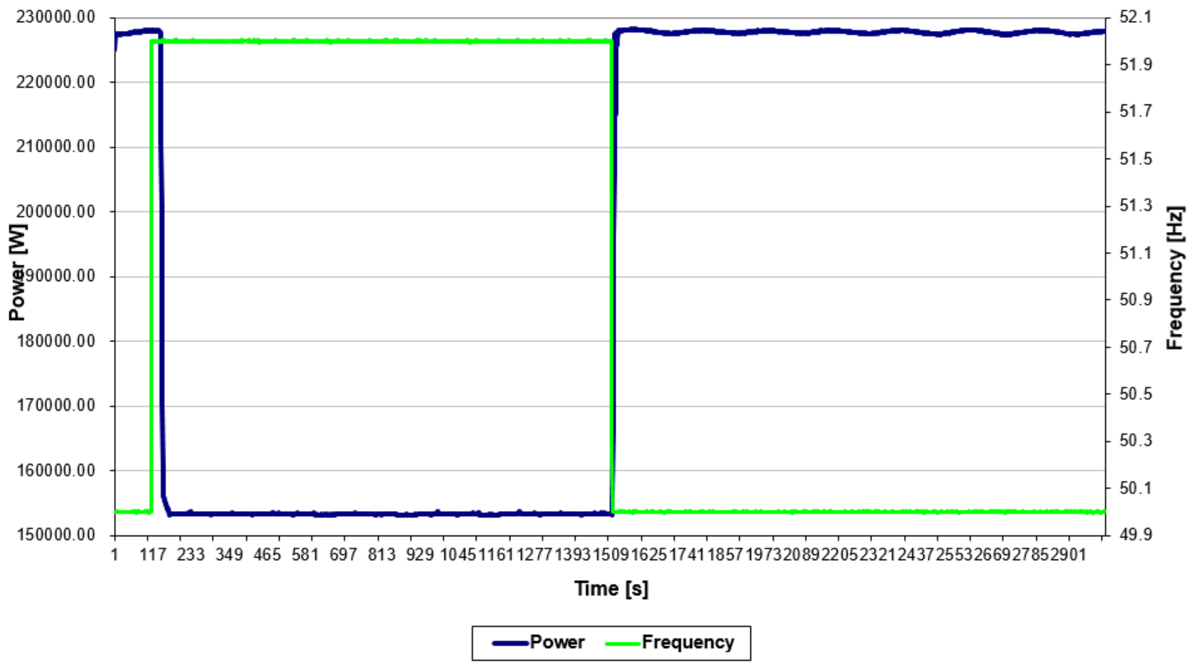


Figure B.6.1(i): LFSM-O step response test – frequency injection

Figure B.6.1(ii): LFSM-O step response test – target response and limits

Frequency response Test

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict



G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test sequence at **Registered Capacity** >80%	Measured **Active Power** Output (kW)	Frequency (Hz)	$\Delta P_{E60}/Pn$ (%)	Primary Power Source	**Active Power** Gradient
Step a) 50.00 Hz ±0.01 Hz	224.655	50.00	-	Photovoltaic array simulator	-
Step b) 50.60 Hz ±0.01 Hz	215.482	50.60	9.99		P
Step c) 50.00 Hz ±0.01 Hz	224.610	50.00	-		-

1.Initial output is 100%, droop is 10%. (20%Pn/Hz)

2.Ramp of frequency change is 0.02 Hz/s.

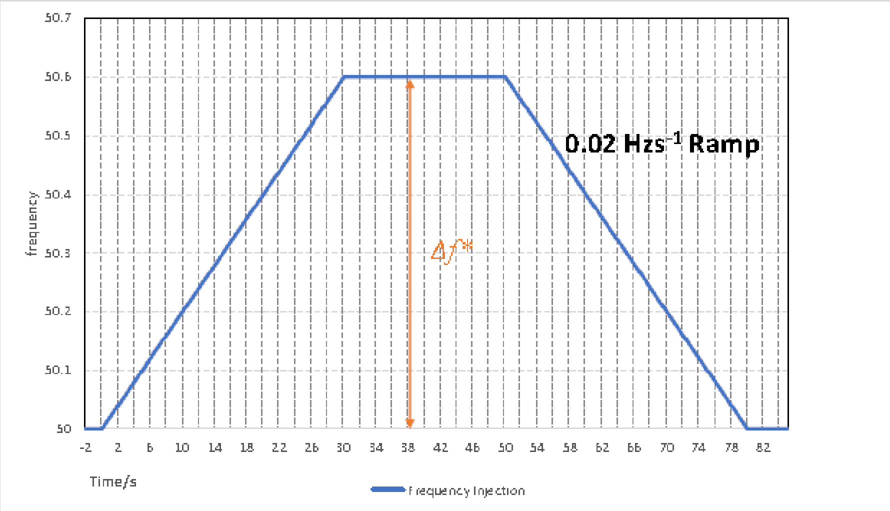


Figure B.6.2(i): LFSM-O BC2 ramp response test – frequency injection

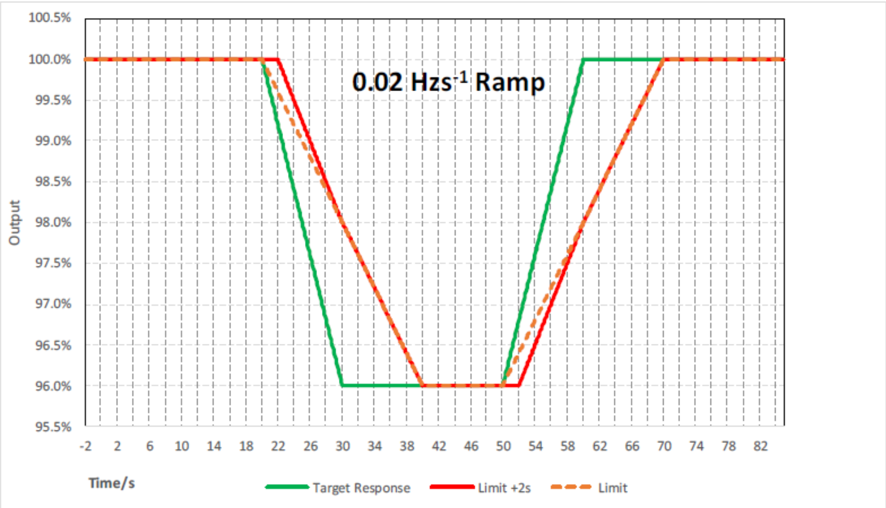
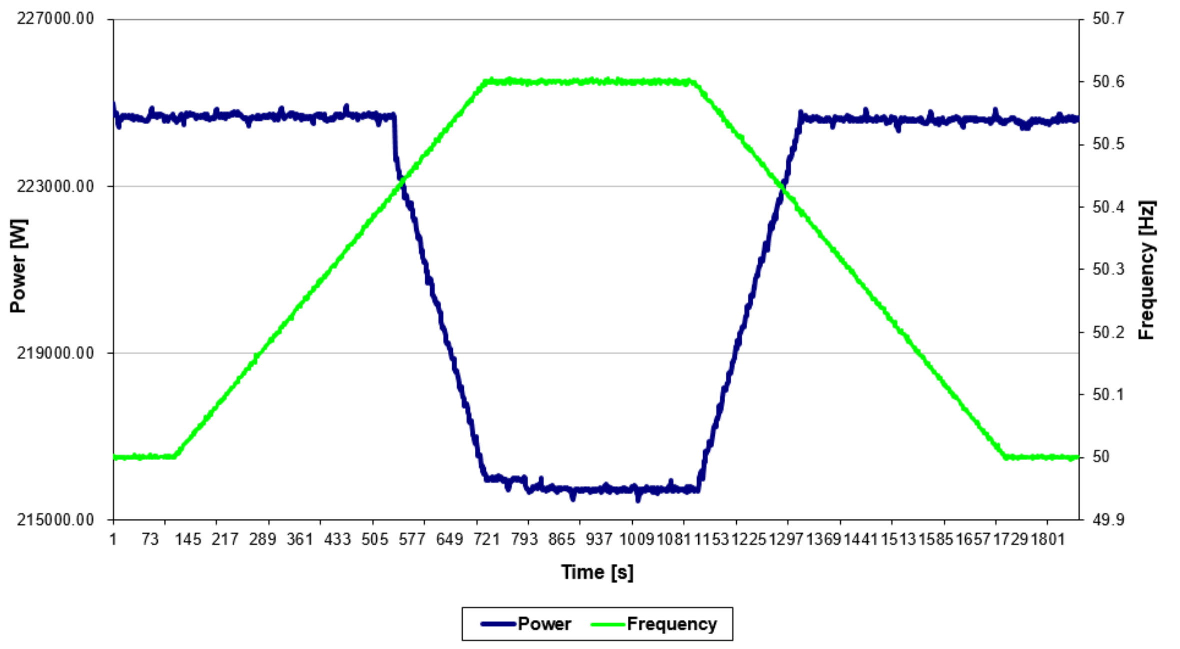


Figure B.6.2(ii): LFSM-O BC2 ramp response test – target response and limits

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Response

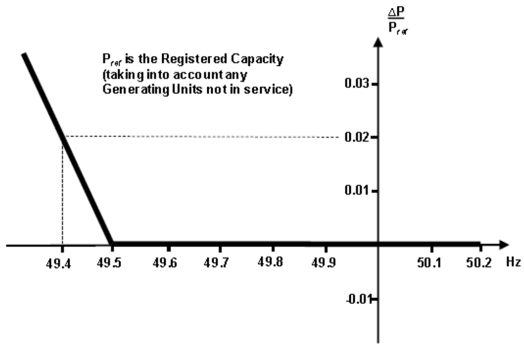


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

13.2.5 Limited Frequency Sensitive Mode – Under frequency (LFSM-U) Shall be capable of increasing active power output in response to system when this falls below 49.5Hz. Droop of 10%. Annex C.7.8					**P**
Test sequence at **Registered Capacity** 80% Pn	Measured **Active Power** Output (kW)	Frequency (Hz)	Calculate droop (%)	Primary Power Source	**Active Power** Gradient
Step a) 50.00 Hz ±0.01 Hz	180.006	50.00	-	Photovoltaic array simulator	-
Step b) 49.50 Hz ±0.01 Hz	180.004	49.50	-		-
Step c) 49.40 Hz ±0.01 Hz	184.596	49.40	9.79		P
Step d) 48.50 Hz ±0.01 Hz	225.031	48.50	9.99		P
Step e) 49.40 Hz ±0.01 Hz	184.714	49.40	9.55		P
Step f) 49.50 Hz ±0.01 Hz	181.869	49.50	-		-
Step g) 50.00 Hz ±0.01 Hz	181.866	50.00	-		-

Notes:

1. Droop is 10%.
2. In LFSM-U Mode the inverter shall be capable of providing a power increase up to its Registered Capacity.
3. A sufficiently large reduction in the measured system frequency ramped over 10 s.
4. Then increase of the measured system frequency ramped over 10 s to cause a reduction in Active Power output back to the original Active Power level followed by at least 60 s of steady output.



P_{ref} is the **Registered Capacity**, taking into account any **Interface Protections** not in service to which ΔP is related and ΔP is the change in **Active Power** output from the **Power Generating Module**. The **Power Generating Module** has to provide a positive **Active Power** output change with a **Droop** of 10% or less based on P_{ref}.

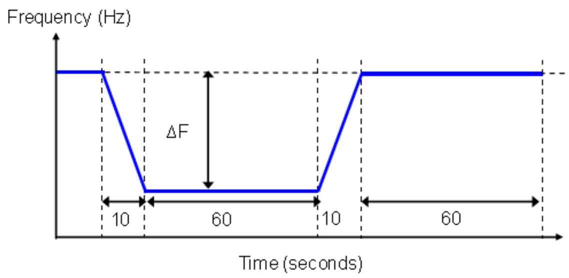
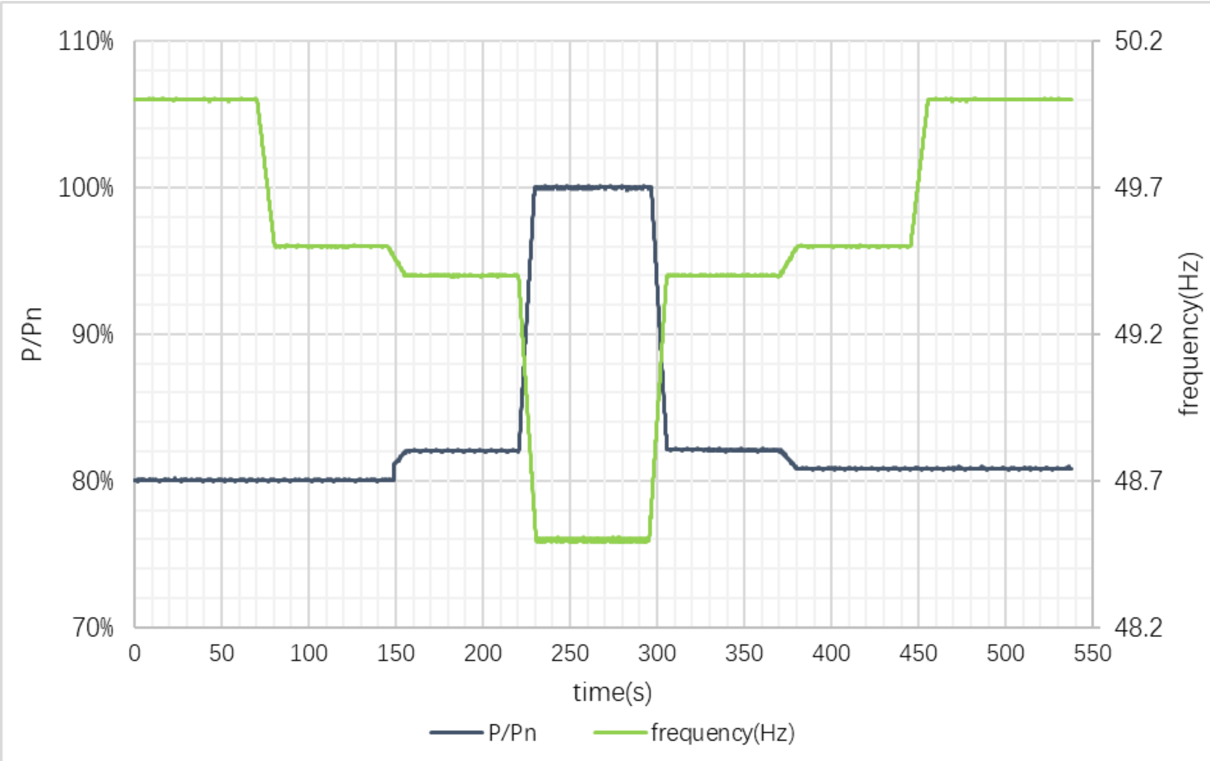


Figure C.7.3 LFSM-U step response simulation

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Diagram



G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

13.2.6 Frequency Sensitive Mode – (FSM) (for Type C, Type D) The test should be carried out using the specific threshold frequency of 50Hz and **Droop** of 4%. (50%Pn/Hz)					**P**
Test sequence **start at 80% Registered Capacity**	Measured **Active Power** Output (kW)	Frequency (Hz)	Calculate droop (%)	Primary Power Source	**Active Power** Gradient
Step a) 50.00 Hz ±0.01 Hz	179.745	50.00	-	Photovoltaic array simulator	-
Step b) 50.10 Hz ±0.01 Hz	170.230	50.10	4.73		P
Step c) 50.20 Hz ±0.01 Hz	157.968	50.20	4.13		P
Step d) 50.30 Hz ±0.01 Hz	157.926	50.30	-		-
Step e) 50.40 Hz ±0.01 Hz	157.892	50.40	-		-
Step f) 50.30 Hz ±0.01 Hz	157.893	50.30	-		-
Step g) 50.20 Hz ±0.01 Hz	157.955	50.20	4.13		P
Step h) 50.10 Hz ±0.01 Hz	170.221	50.10	4.72		P
Step i) 50.00 Hz ±0.01 Hz	179.615	50.00	-		-
Step j) 49.90 Hz ±0.01 Hz	189.832	49.90	4.40		P
Step k) 49.80 Hz ±0.01 Hz	202.048	49.80	4.01		P
Step l) 49.70 Hz ±0.01 Hz	202.116	49.70	-		-
Step m) 49.60 Hz ±0.01 Hz	202.121	49.60	-		-
Step n) 49.70 Hz ±0.01 Hz	202.114	49.70	-		-
Step o) 49.80 Hz ±0.01 Hz	202.117	49.80	4.00		P
Step p) 49.90 Hz ±0.01 Hz	189.845	49.90	4.40		P
Step q) 50.00 Hz ±0.01 Hz	179.846	50.00	-		-

1. Power Generating Modules shall be capable of providing Active Power Frequency Response in accordance with the performance characteristic shown in Figure 13.4 and parameters in Table 13.1.

2. In satisfying the performance requirements specified in paragraph 13.2.6.1 Generators in respect of each Power Generating Module should be aware: -

i. in the case of over frequency, the Active Power Frequency Response is limited by the Minimum Stable Operating Level,

ii. in the case of under frequency, the Active Power Frequency Response is limited by the Registered Capacity,

iii. the actual delivery of Active Power Frequency Response depends on the operating and ambient

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

conditions of the Power Generating Module when this response is triggered, in particular limitations on operation near Registered Capacity at low frequencies as specified in 13.2.5 and available primary energy sources.

iv. The frequency control device (or speed governor) shall also be capable of being set so that it operates with an overall speed Droop of between 3 – 5%. The Frequency Response Dead band and Droop shall be able to be reset at any time and as required by the DNO. For the avoidance of doubt, in the case of a Power Park Module the speed Droop should be equivalent of a fixed setting between 3% and 5% applied to each Generating Unit in service.

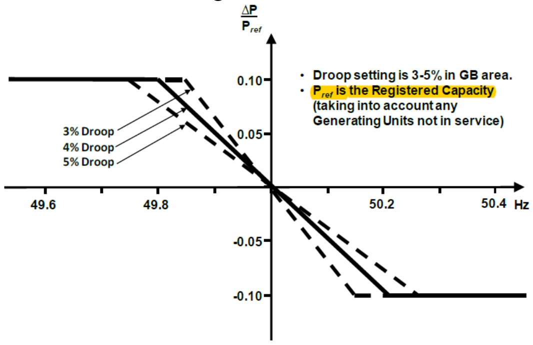
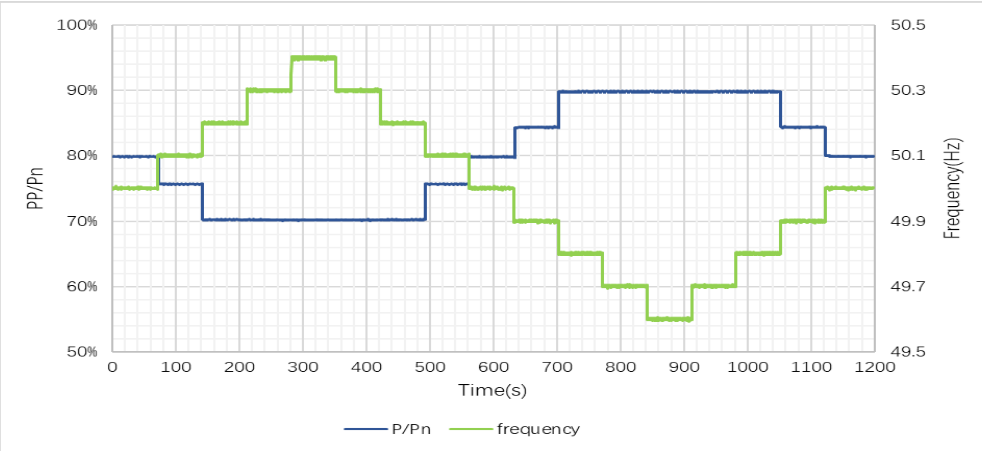
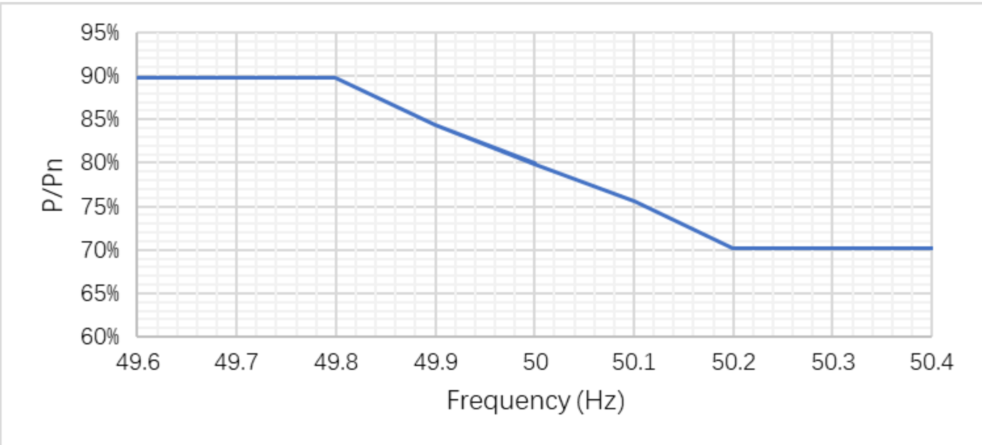


Figure 13.4 – Frequency Sensitive Mode capability of Power Generating Modules and Power Park Modules

Diagram





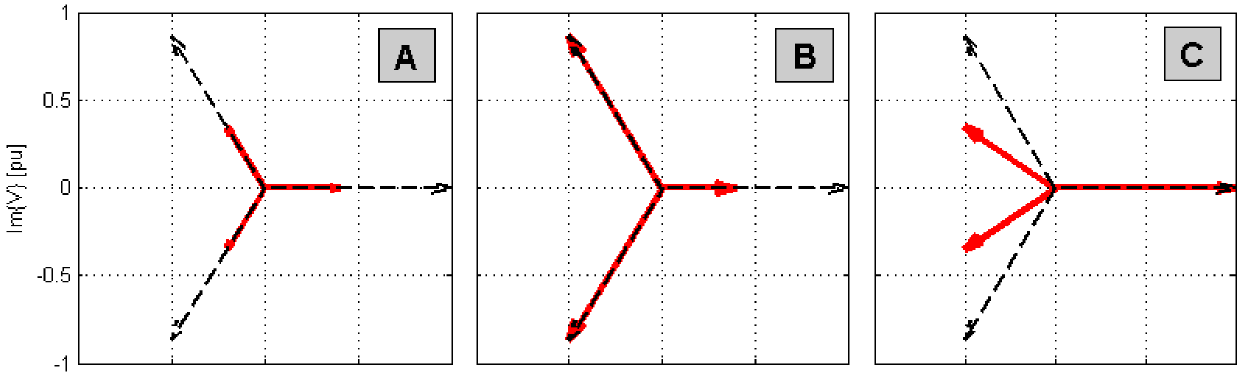
G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

12.3, 12.6 13.3, 13.6	**Fault Ride Through and Fast Fault Injection (For Type B, Type C, Type D)**						**P**
Test number	U/Un [pu]	No. of phases fault	Output power level P set point (%P_n)	Required fault duration [ms]	Percent of Injected current after 60 ms [p.u.]	Percent of Injected current after 120 ms [p.u.]	Duration of restoring network [ms]
1	0 * Type D (>110 kV)	One phase asymmetric fault	P = 0	140	See below test graphs		140.6
2			P = 20% ± 5% Pn	140	See below test graphs		143.6
3			P = 100% ± 5% Pn	140	See below test graphs		139.9
4		Two phase asymmetric fault	P = 0	140	See below test graphs		140.2
5			P = 20% ± 5% Pn	140	See below test graphs		140.2
6			P = 100% ± 5% Pn	140	See below test graphs		140.1
7		Three phase symmetric fault	P = 0	140	See below test graphs		140.4
8			P = 20% ± 5% Pn	140	See below test graphs		139.9
9			P = 100% ± 5% Pn	140	See below test graphs		140.0
10	0.10	One phase asymmetric fault	P = 0	383	See below test graphs		399.7
11			P = 20% ± 5% Pn	383	See below test graphs		402.6
12			P = 100% ± 5% Pn	383	See below test graphs		398.2
13		Two phase asymmetric fault	P = 0	383	See below test graphs		399.3
14			P = 20% ± 5% Pn	383	See below test graphs		398.1
15			P = 100% ± 5% Pn	383	See below test graphs		398.9
16		Three phase symmetric fault	P = 0	383	See below test graphs		387.9
17			P = 20% ± 5% Pn	383	See below test graphs		398.6
18			P = 100% ± 5% Pn	383	See below test graphs		398.0
19	0.50	One phase asymmetric fault	P = 0	1352	See below test graphs		1361
20			P = 20% ± 5% Pn	1352	See below test graphs		1360
21			P = 100% ± 5% Pn	1352	See below test graphs		1361
22		Two phase asymmetric fault	P = 0	1352	See below test graphs		1357
23			P = 20% ± 5% Pn	1352	See below test graphs		1358
24			P = 100% ± 5% Pn	1352	See below test graphs		1371
25		Three phase symmetric fault	P = 0	1352	See below test graphs		1362
26			P = 20% ± 5% Pn	1352	See below test graphs		1358
27			P = 100% ± 5% Pn	1352	See below test graphs		1354
28	0.85	One phase asymmetric fault	P = 0	2200	See below test graphs		2200
29			P = 20% ± 5% Pn	2200	See below test graphs		2201
30			P = 100% ± 5% Pn	2200	See below test graphs		2201
31		Two phase asymmet	P = 0	2200	See below test graphs		2200
32			P = 20% ± 5% Pn	2200	See below test graphs		2201

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

12.3, 12.6 13.3, 13.6	**Fault Ride Through and Fast Fault Injection (For Type B, Type C, Type D)**					**P**
33		ric fault	P = 100% ± 5% Pn	2200	See below test graphs	2200
34		Three phase symmetric fault	P = 0	2200	See below test graphs	2199
35			P = 20% ± 5% Pn	2200	See below test graphs	2208
36			P = 100% ± 5% Pn	2200	See below test graphs	2208

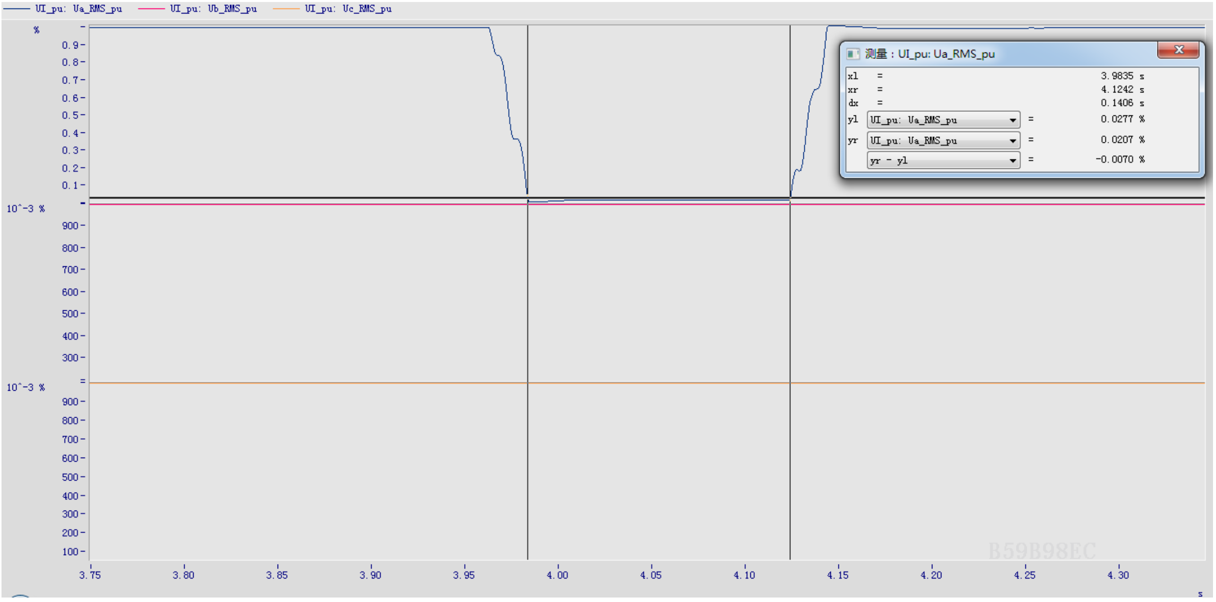
Note:
*Addtional test condition only for Type D Power Generating Modules above 110 kV.



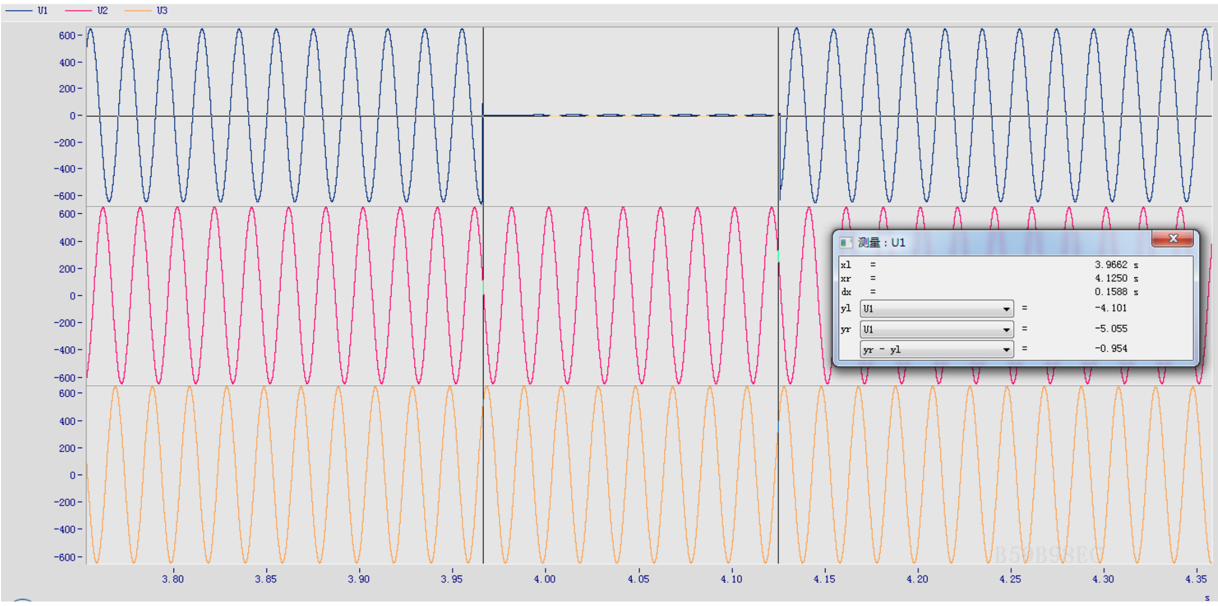
A: three-pole short circuit
B: single-pole short circuit with earth contact
C: two-pole short circuit without earth contact

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 1 – One-phase asymmetrical fault (U/U_n = 0): Voltage, active power and reactive current of the positive and negative sequence system, P = 0, L1 phase fault, T_{fault}

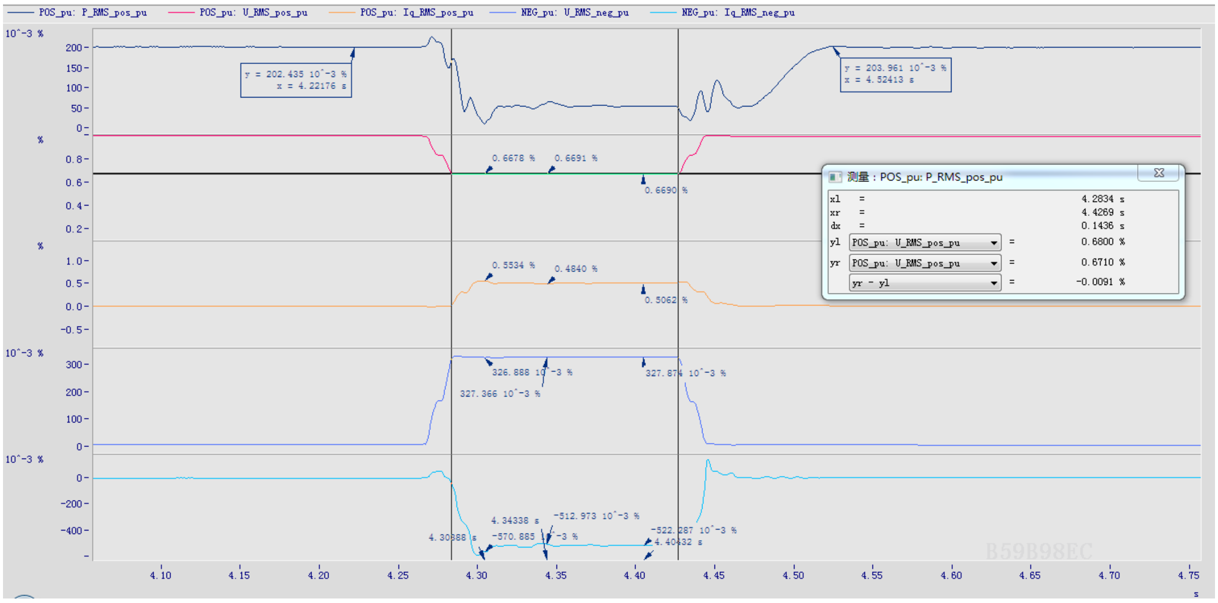


Test 1 – One-phase asymmetrical fault (U/U_n = 0): Phase current and voltage of the whole failure P = 0, L1 phase fault, wave of the whole failure

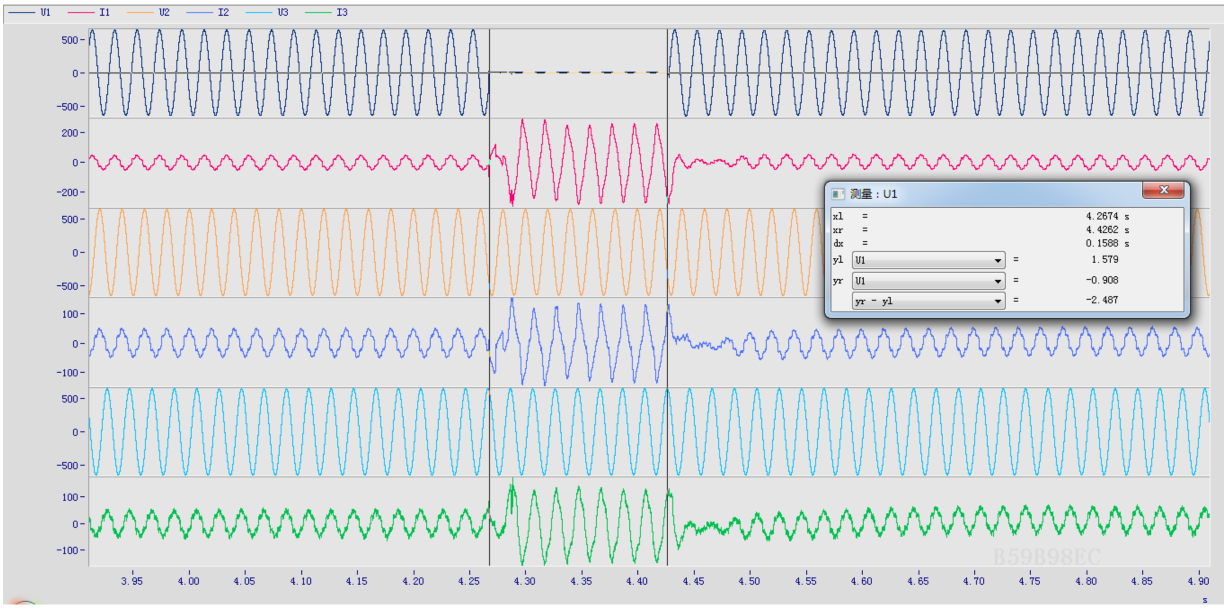


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 2 – One-phase asymmetrical fault (U/U_n = 0): Voltage, active power and reactive current of the positive and negative sequence system, P = 20%Pn, L1 phase fault, T_{fault}

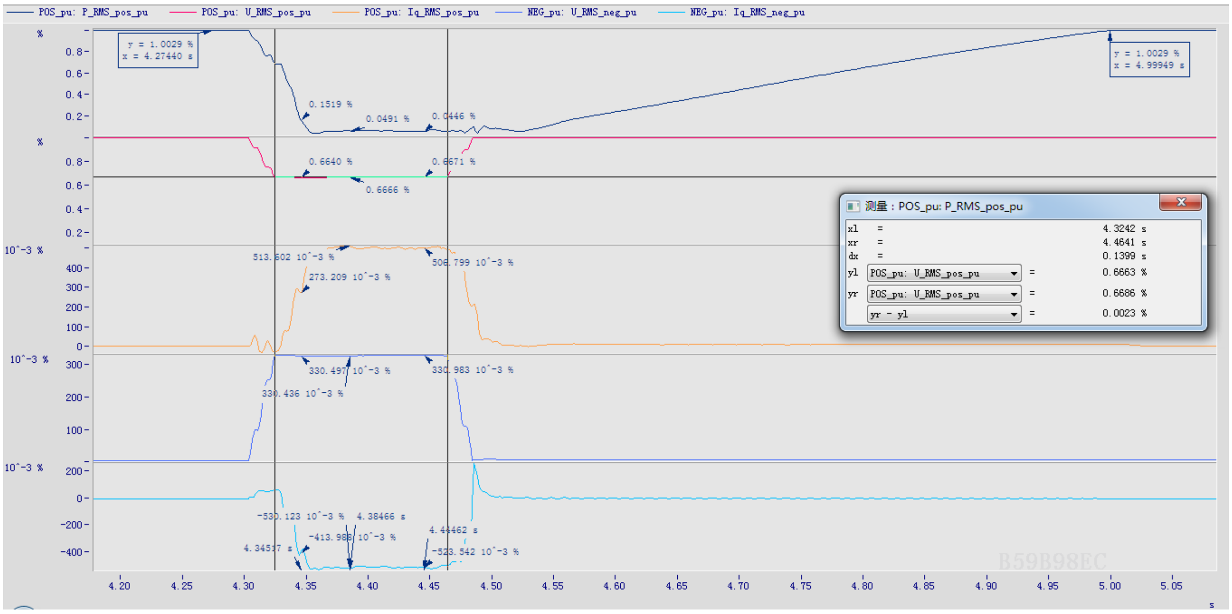


Test 2 – One-phase asymmetrical fault (U/U_n = 0): Phase current and voltage of the whole failure P = 20%Pn, L1 phase fault, wave of the whole failure

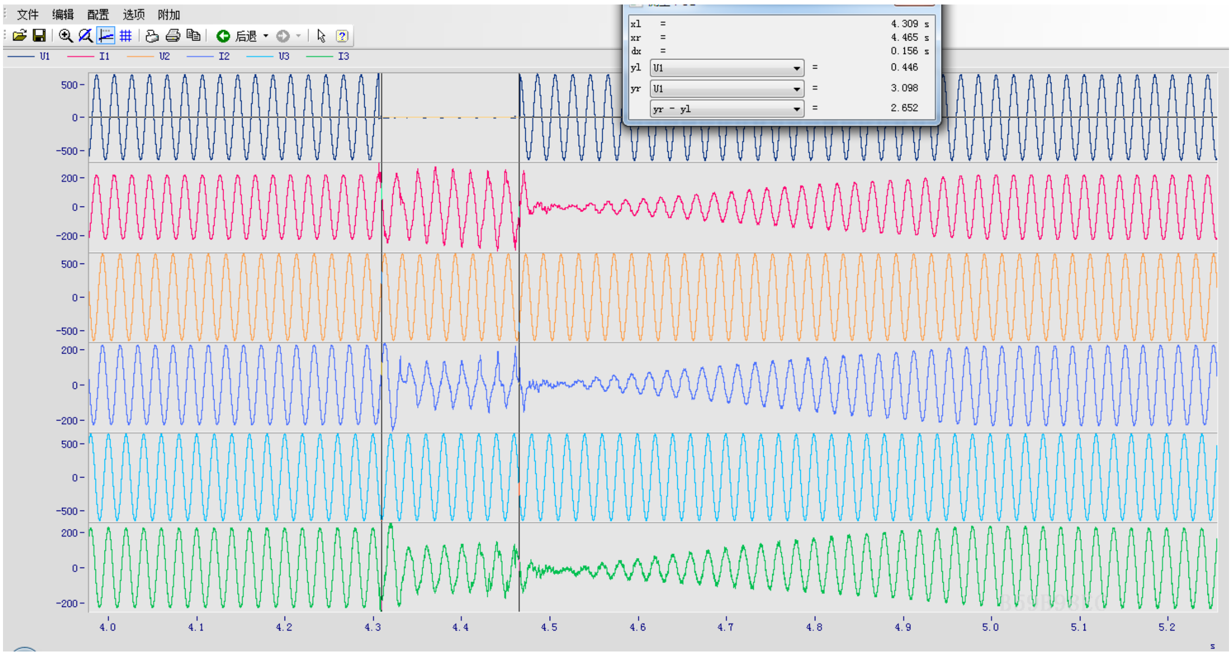


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 3– One-phase asymmetrical fault (U/U$_n$ = 0): Voltage, active power and reactive current of the positive and negative sequence system, P = 100%Pn, L1 phase fault, T$_{fault}$

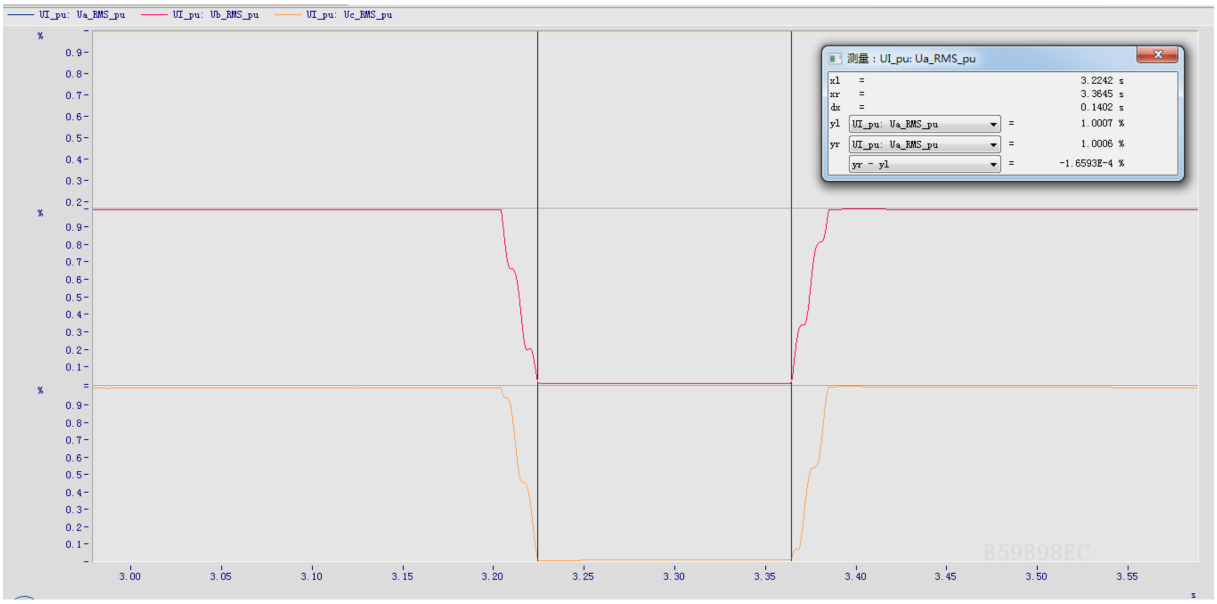


Test 3 – One-phase asymmetrical fault (U/U$_n$ = 0): Phase current and voltage of the whole failure P = 100%Pn, L1 phase fault, wave of the whole failure

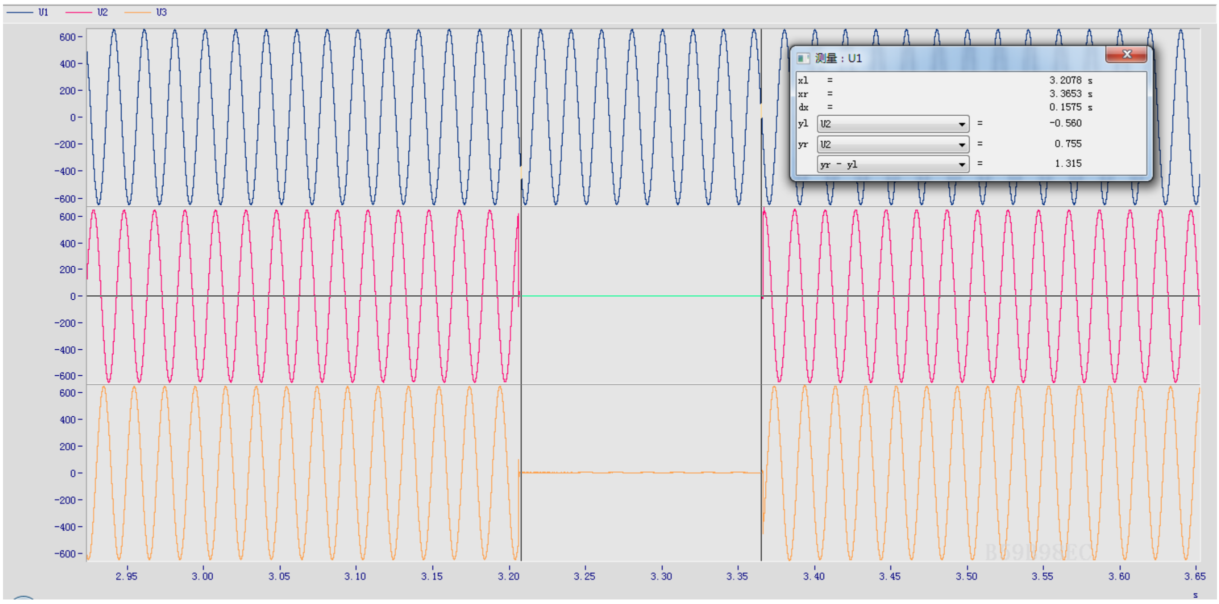


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 4 – Two-phase asymmetrical fault (U/U_n = 0): Voltage, active power and reactive current of the positive and negative sequence system, P = 0, L2, L3 phase fault, T_{fault}

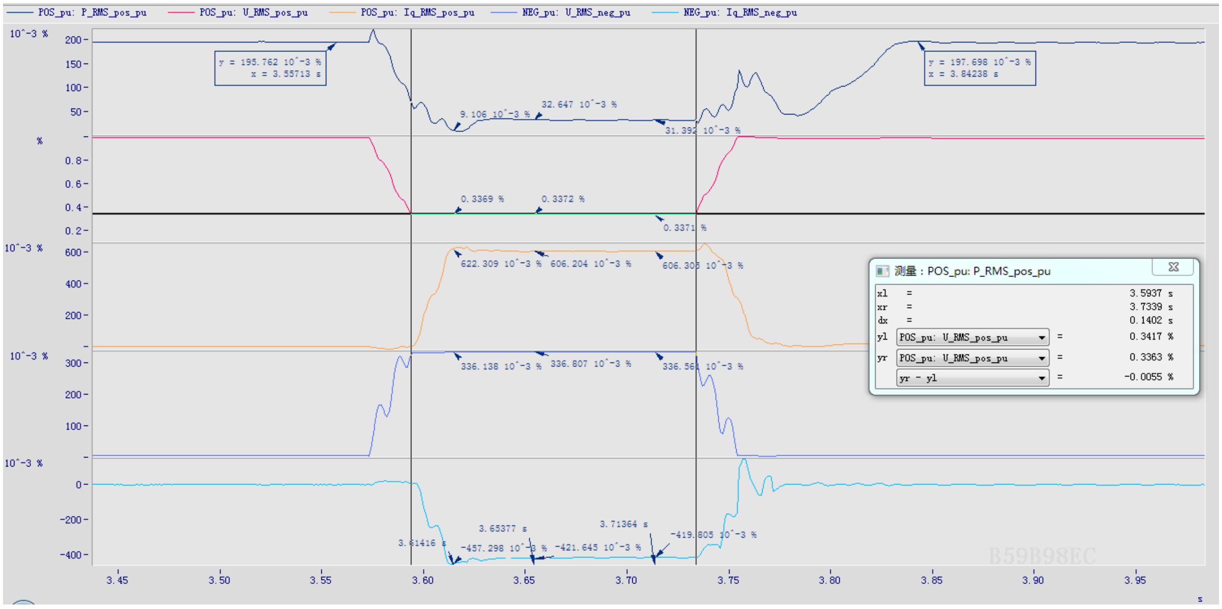


Test 4 – Two-phase asymmetrical fault (U/U_n = 0): Phase current and voltage of the whole failure P = 0, L2, L3 phase fault, wave of the whole failure

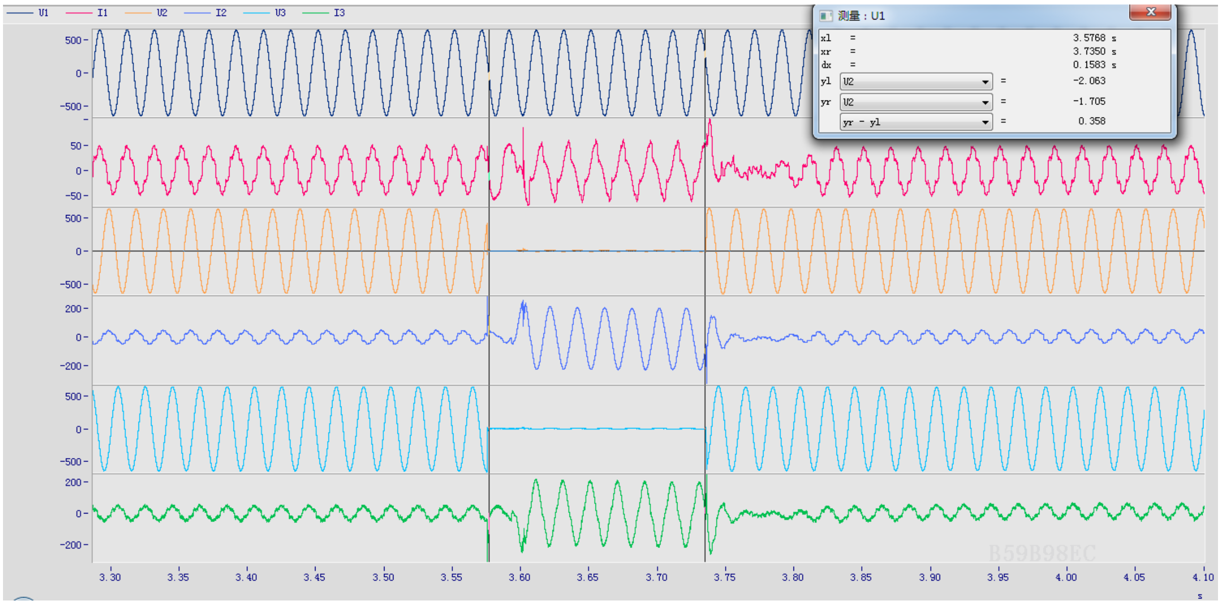


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 5 – Two-phase asymmetrical fault (U/U_n = 0): Voltage, active power and reactive current of the positive and negative sequence system, P = 20%Pn, L2, L3 phase fault, T_{fault}

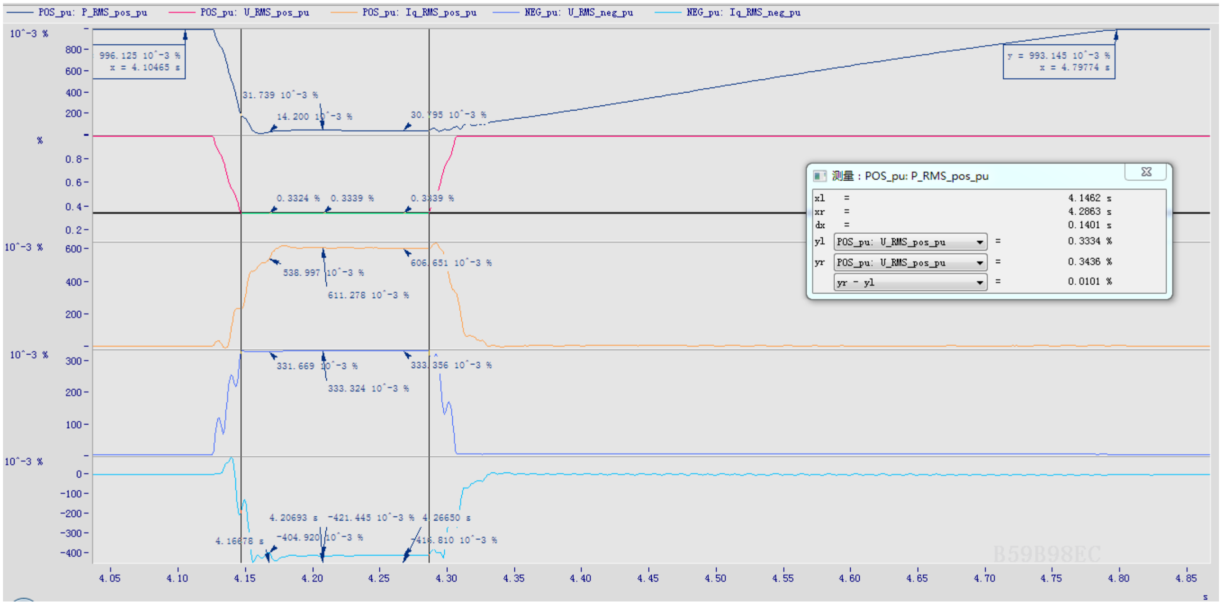


Test 5 – Two-phase asymmetrical fault (U/U_n = 0): Phase current and voltage of the whole failure P = 20%Pn, L2, L3 phase fault, wave of the whole failure

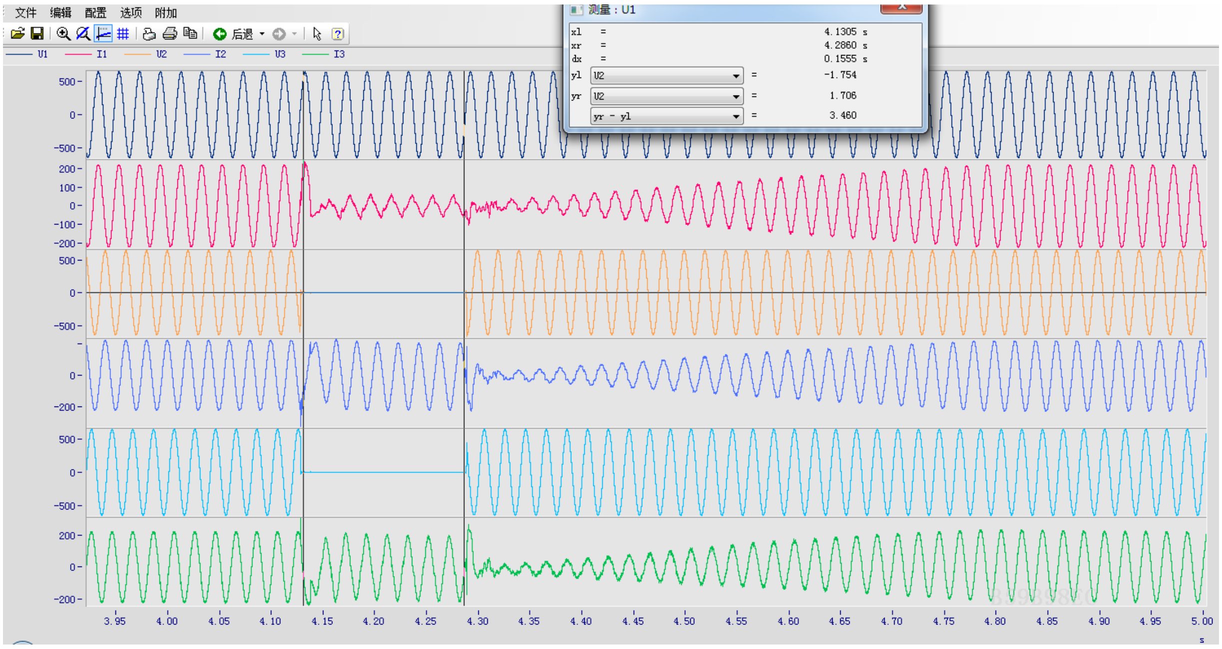


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 6 – Two-phase asymmetrical fault (U/U_n = 0): Voltage, active power and reactive current of the positive and negative sequence system, P = 100%Pn, L2, L3 phase fault, T_{fault}

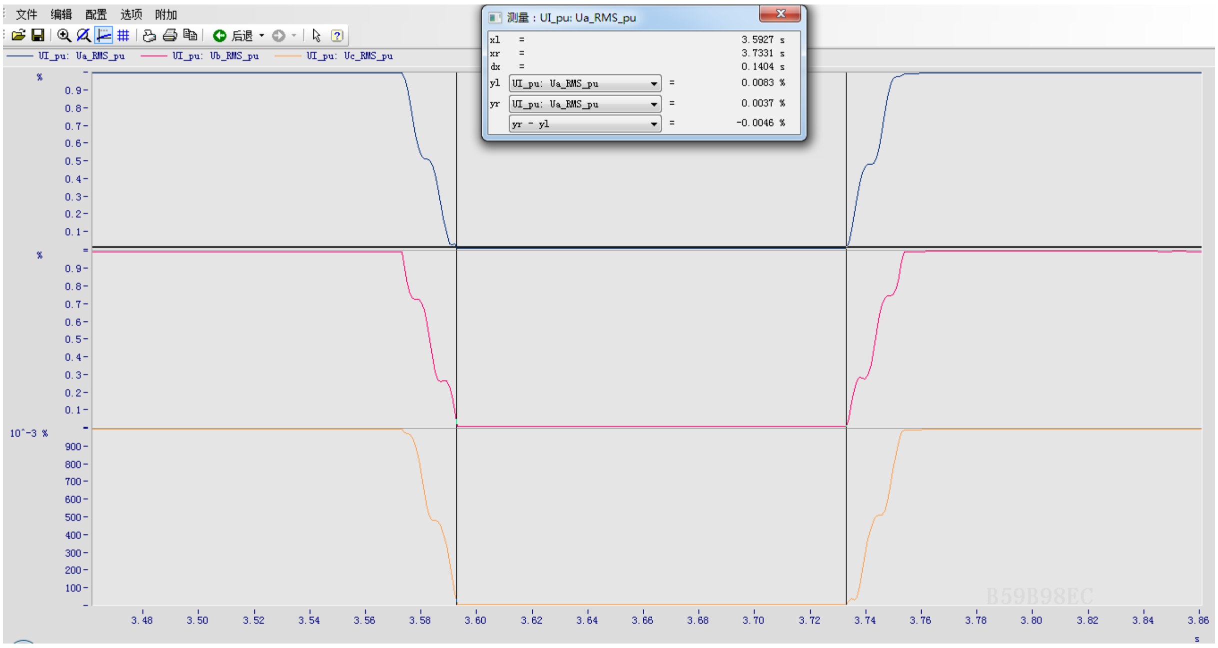


Test 6 – Two-phase asymmetrical fault (U/U_n = 0): Phase current and voltage of the whole failure P = 100%Pn, L2, L3 phase fault, wave of the whole failure

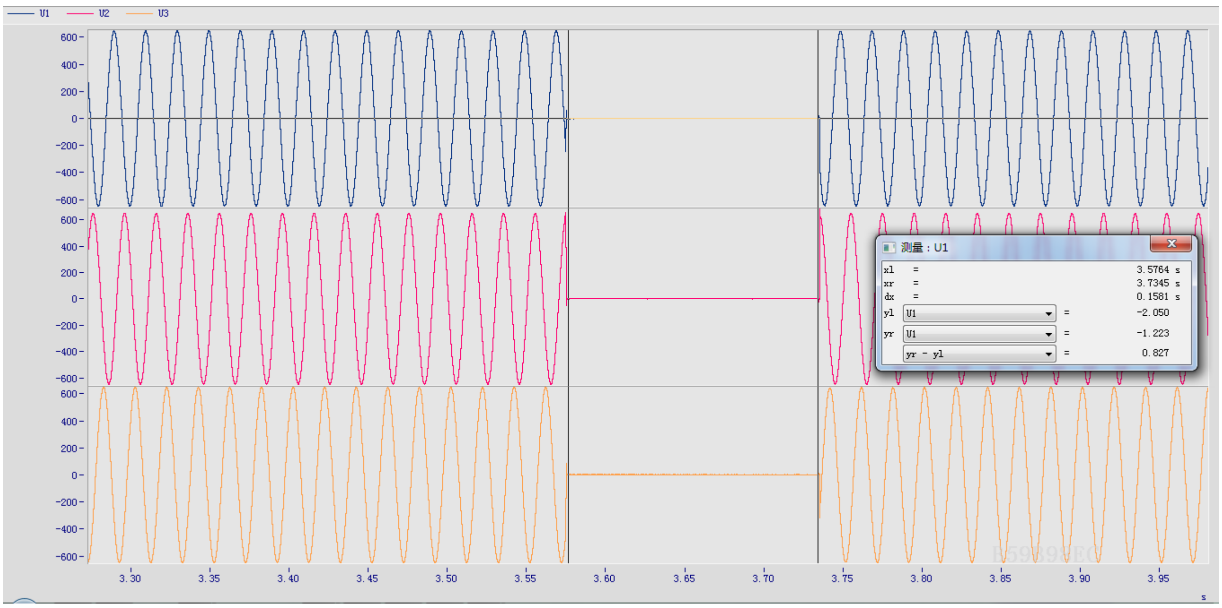


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 7 – Three-phase symmetrical fault (U/U_n = 0): Voltage, active power and reactive current of the positive and negative sequence system, P = 0, All phase fault, T_{fault}

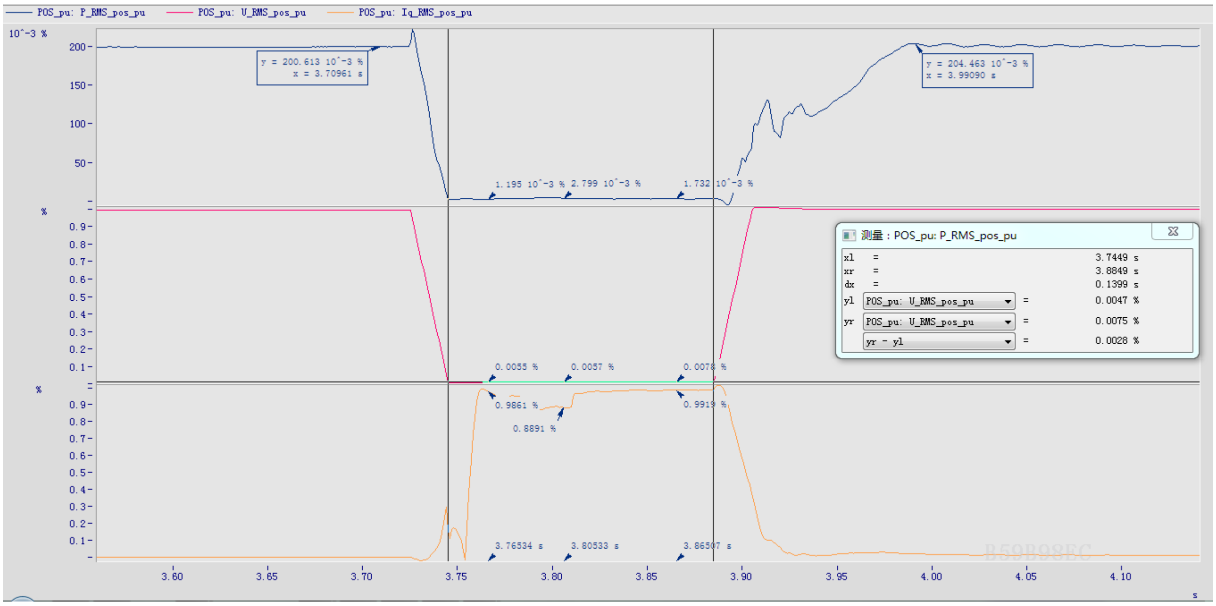


Test 7 – Three-phase symmetrical fault (U/U_n = 0): Phase current and voltage of the whole failure P = 0, All phase fault, wave of the whole failure

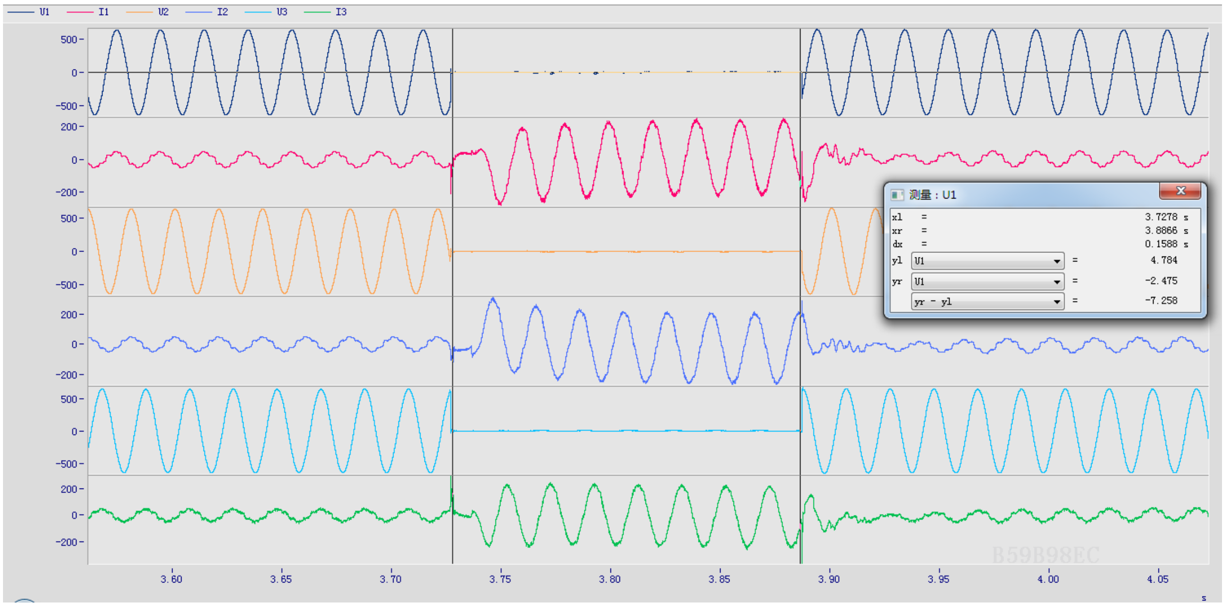


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 8 – Three-phase symmetrical fault (U/U$_n$ = 0): Voltage, active power and reactive current of the positive and negative sequence system, P = 20%Pn, All phase fault, T$_{fault}$

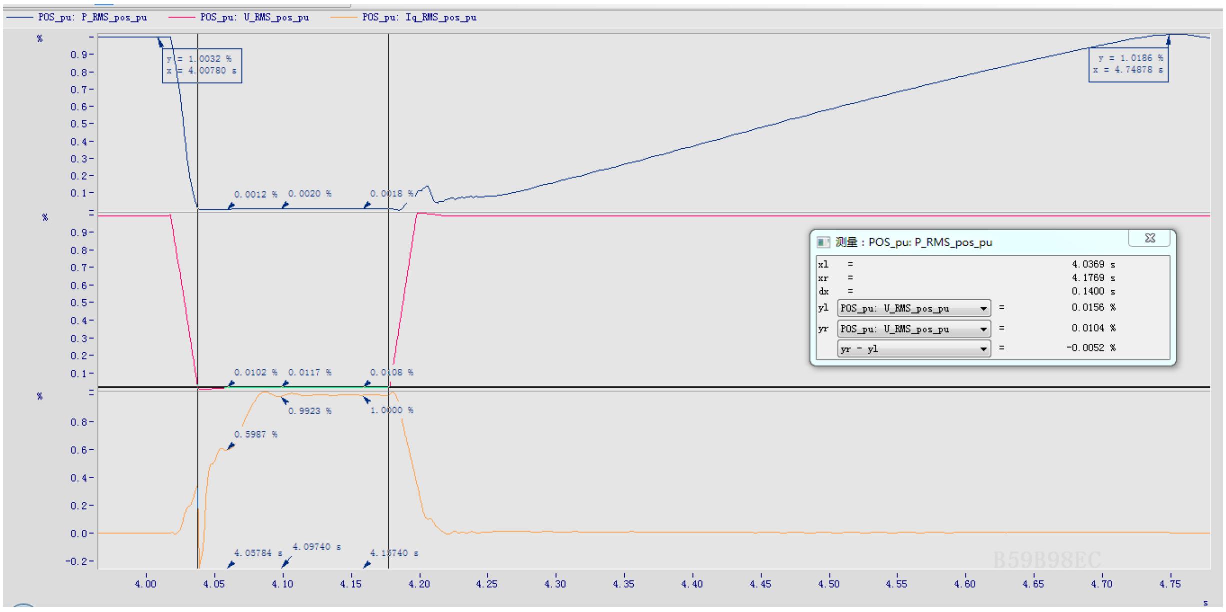


Test 8 – Three-phase symmetrical fault (U/U$_n$ = 0): Phase current and voltage of the whole failure P = 20%Pn, All phase fault, wave of the whole failure

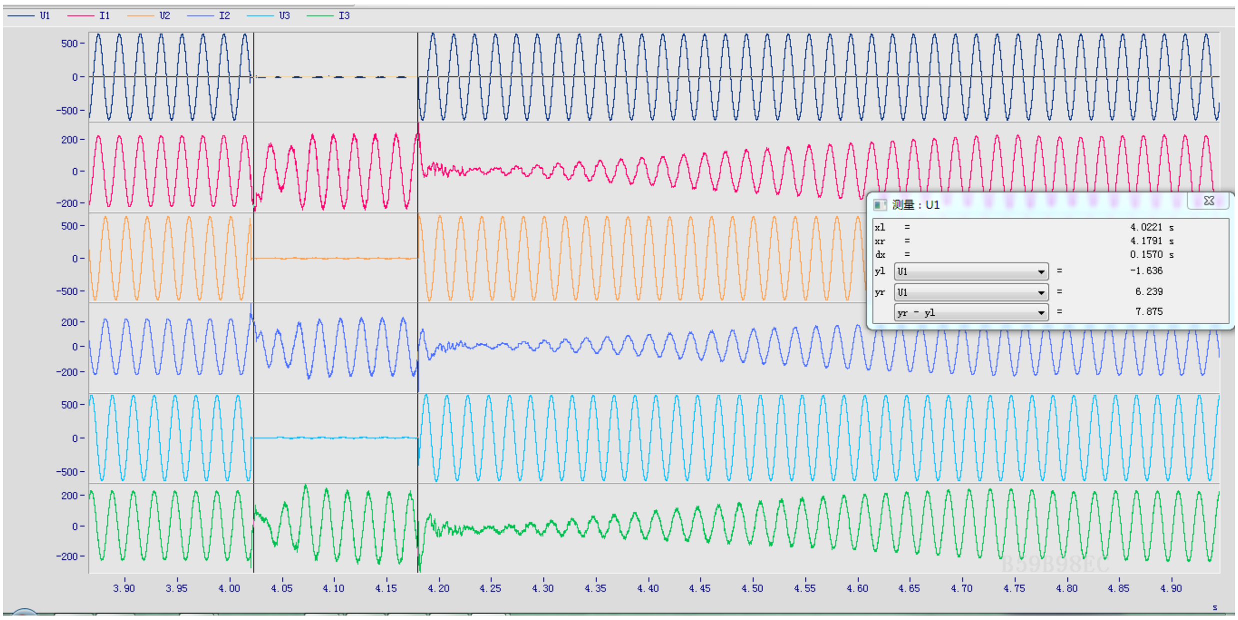


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 9 – Three-phase symmetrical fault (U/U$_n$ = 0): Voltage, active power and reactive current of the positive and negative sequence system, P = 100%Pn, All phase fault, T$_{fault}$

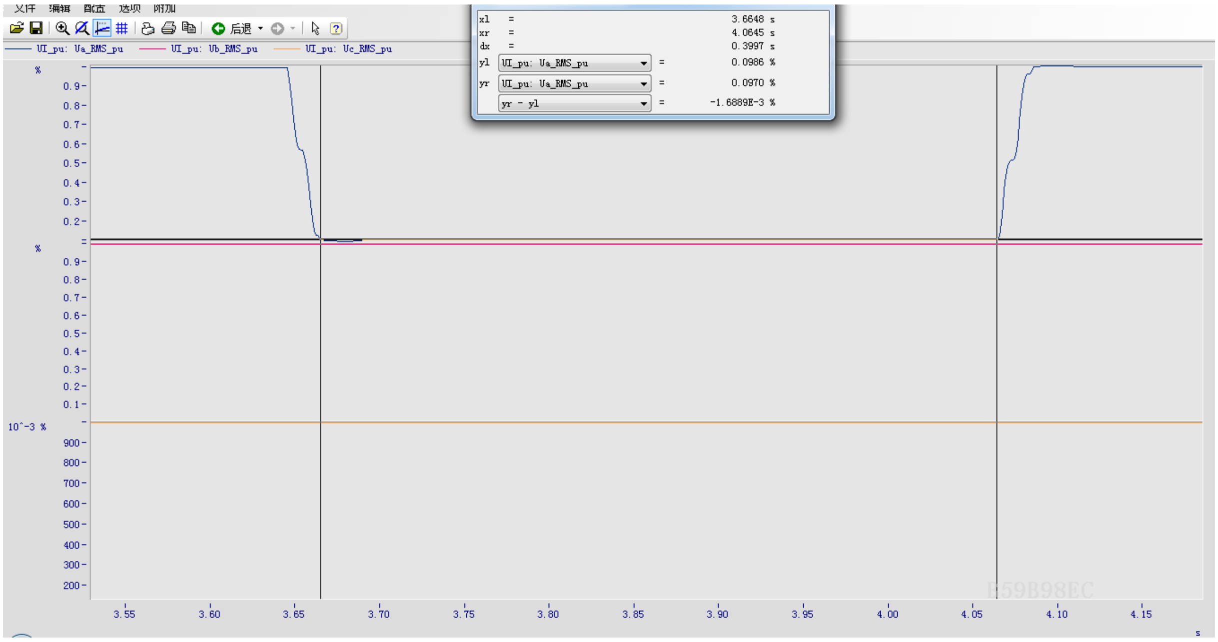


Test 9 – Three-phase symmetrical fault (U/U$_n$ = 0): Phase current and voltage of the whole failure P = 100%Pn, All phase fault, wave of the whole failure

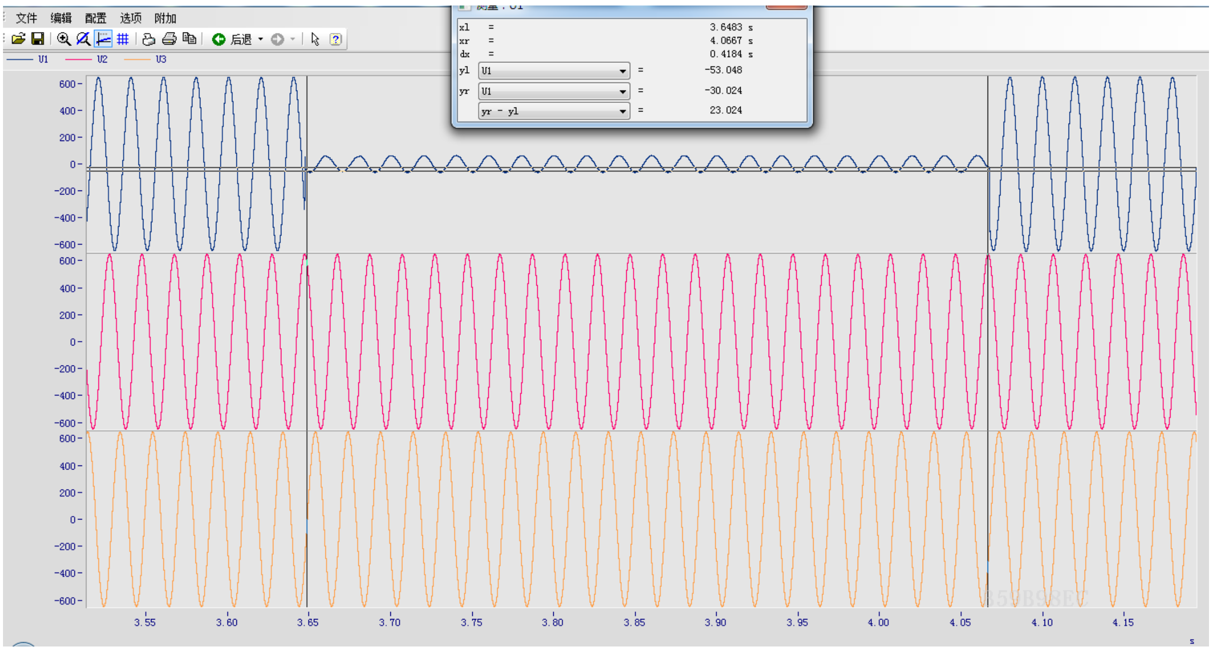


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 10 – One-phase asymmetrical fault (U/U_n = 0.1): Voltage, active power and reactive current of the positive and negative sequence system, P = 0, L1 phase fault, T_{fault}

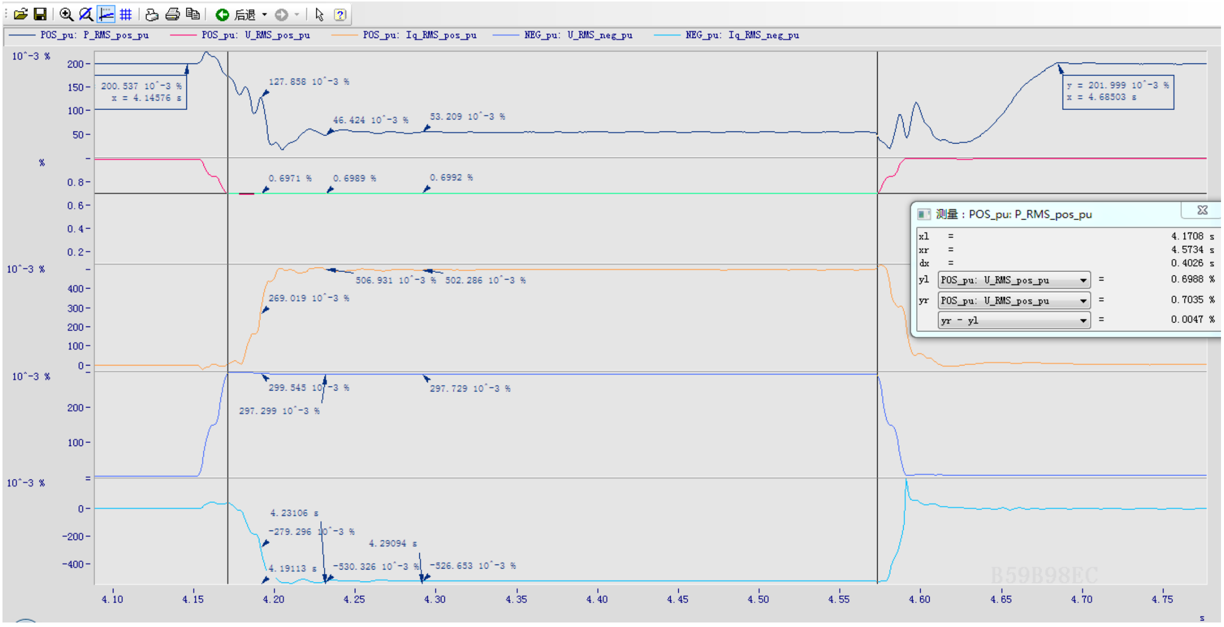


Test 10 – One-phase asymmetrical fault (U/U_n = 0.1): Phase current and voltage of the whole failure P = 0, L1 phase fault, wave of the whole failure

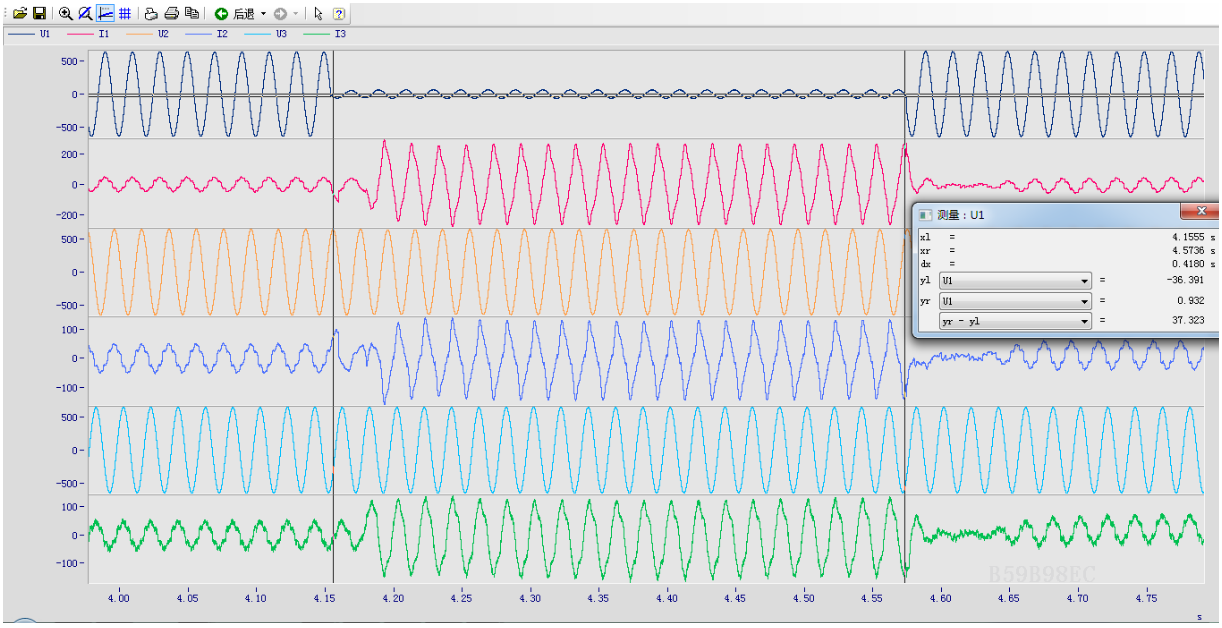


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 11 – One-phase asymmetrical fault (U/U_n = 0.1): Voltage, active power and reactive current of the positive and negative sequence system, P = 20%Pn, L1 phase fault, T_{fault}

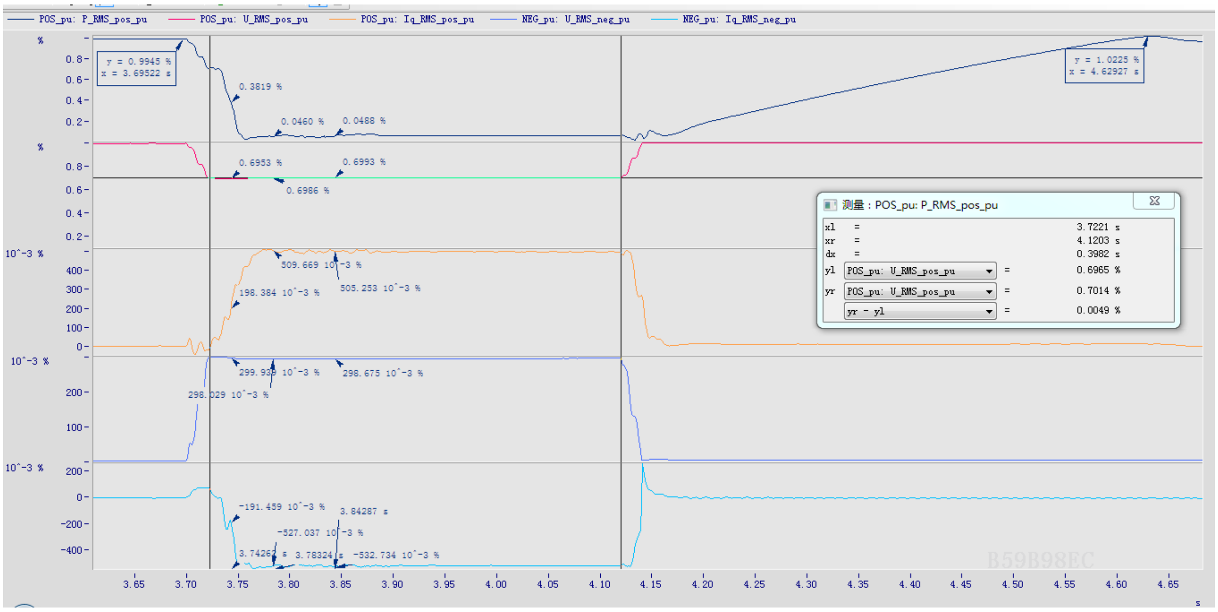


Test 11 – One-phase asymmetrical fault (U/U_n = 0.1): Phase current and voltage of the whole failure P = 20%Pn, L1 phase fault, wave of the whole failure

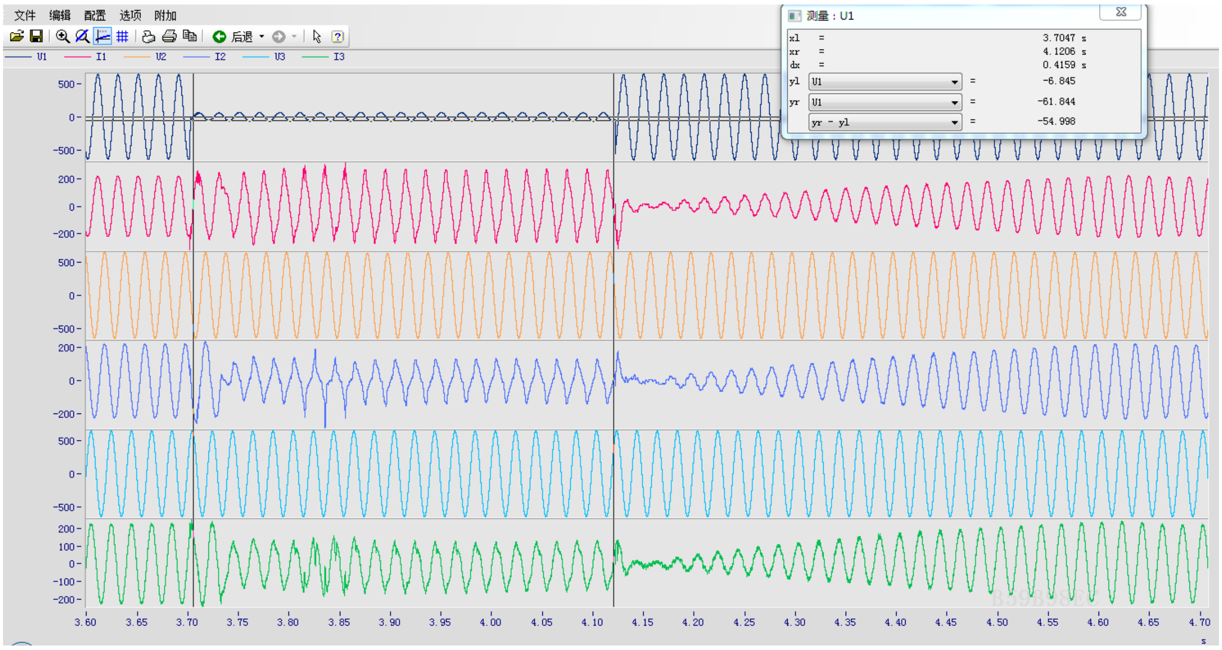


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 12– One-phase asymmetrical fault (U/U_n = 0.1): Voltage, active power and reactive current of the positive and negative sequence system, P = 100%Pn, L1 phase fault, T_{fault}

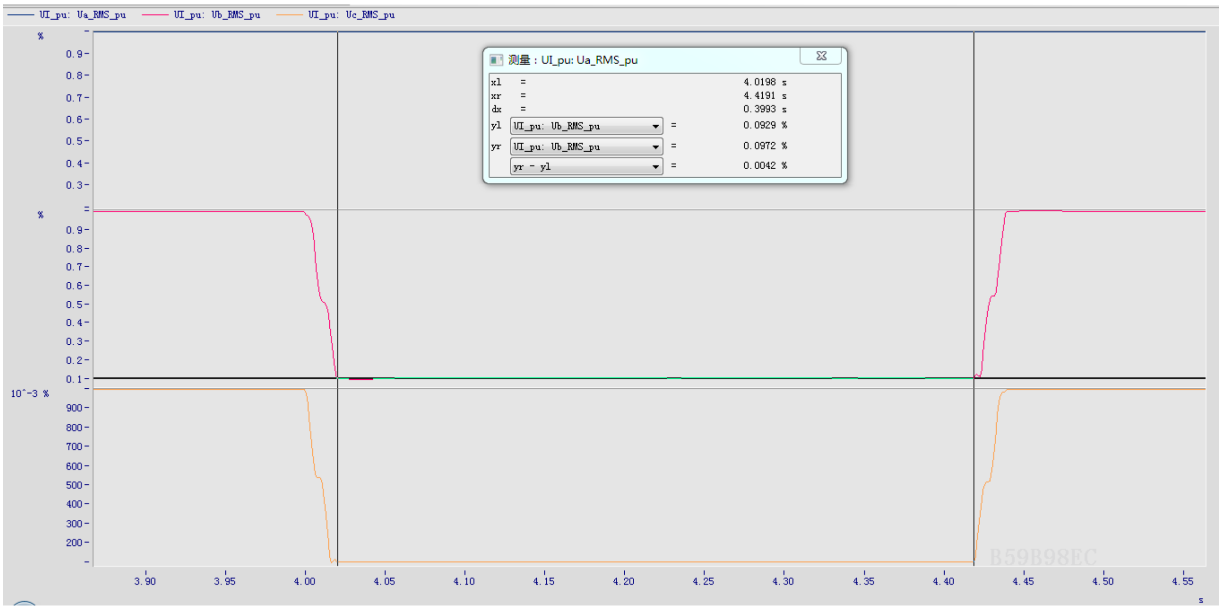


Test 12 – One-phase asymmetrical fault (U/U_n = 0.1): Phase current and voltage of the whole failure P = 100%Pn, L1 phase fault, wave of the whole failure

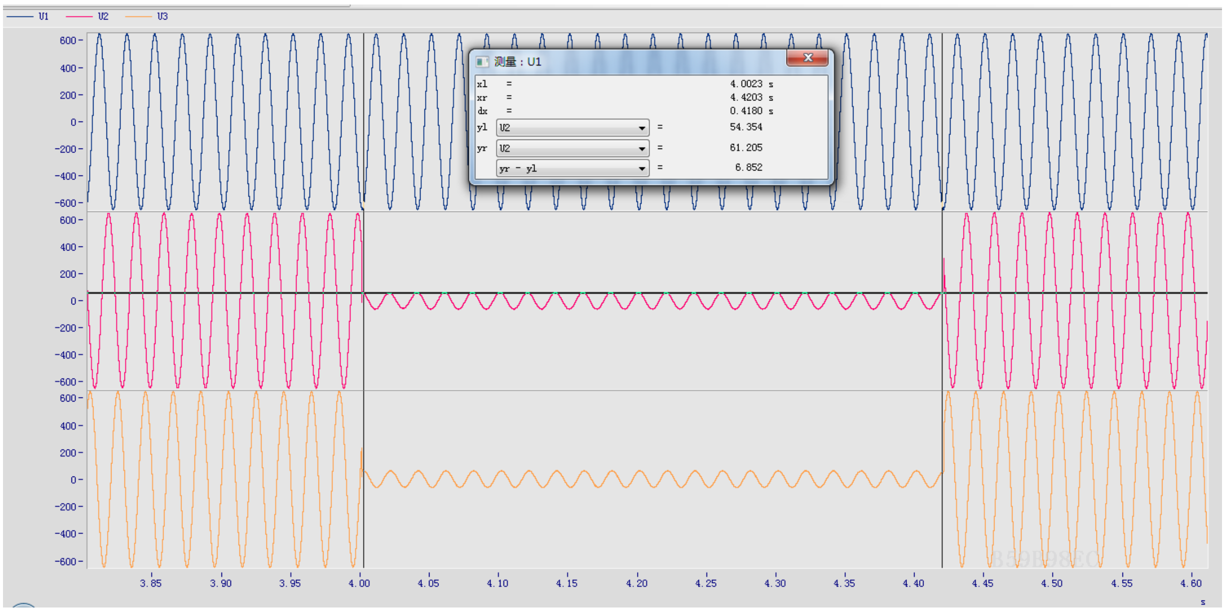


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 13 – Two-phase asymmetrical fault (U/U$_n$ = 0.1): Voltage, active power and reactive current of the positive and negative sequence system, P = 0, L2, L3 phase fault, T$_{fault}$

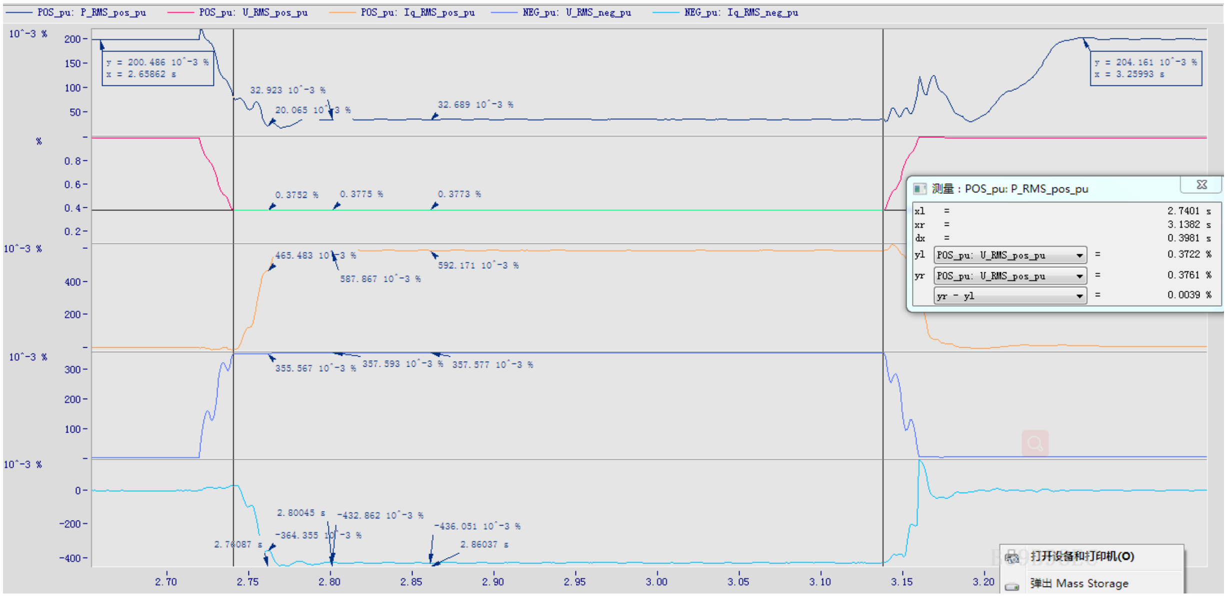


Test 13 – Two-phase asymmetrical fault (U/U$_n$ = 0.1): Phase current and voltage of the whole failure P = 0, L2, L3 phase fault, wave of the whole failure

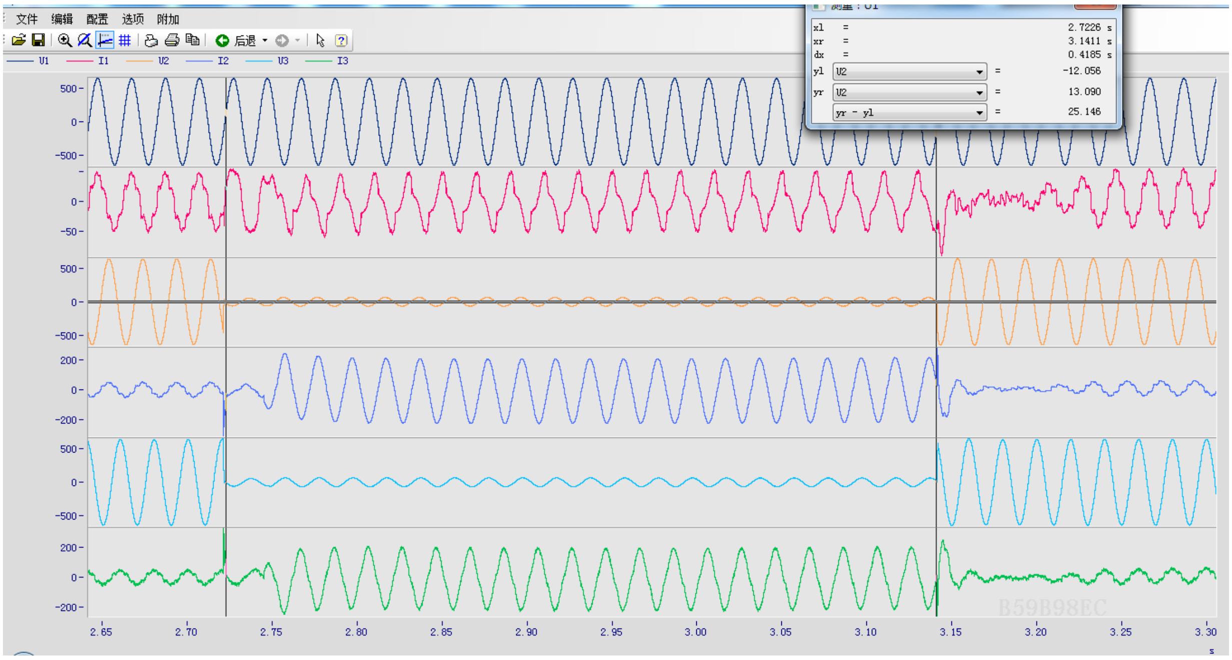


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 14 – Two-phase asymmetrical fault (U/U$_n$ = 0.1): Voltage, active power and reactive current of the positive and negative sequence system, P = 20%Pn, L2, L3 phase fault, T$_{fault}$

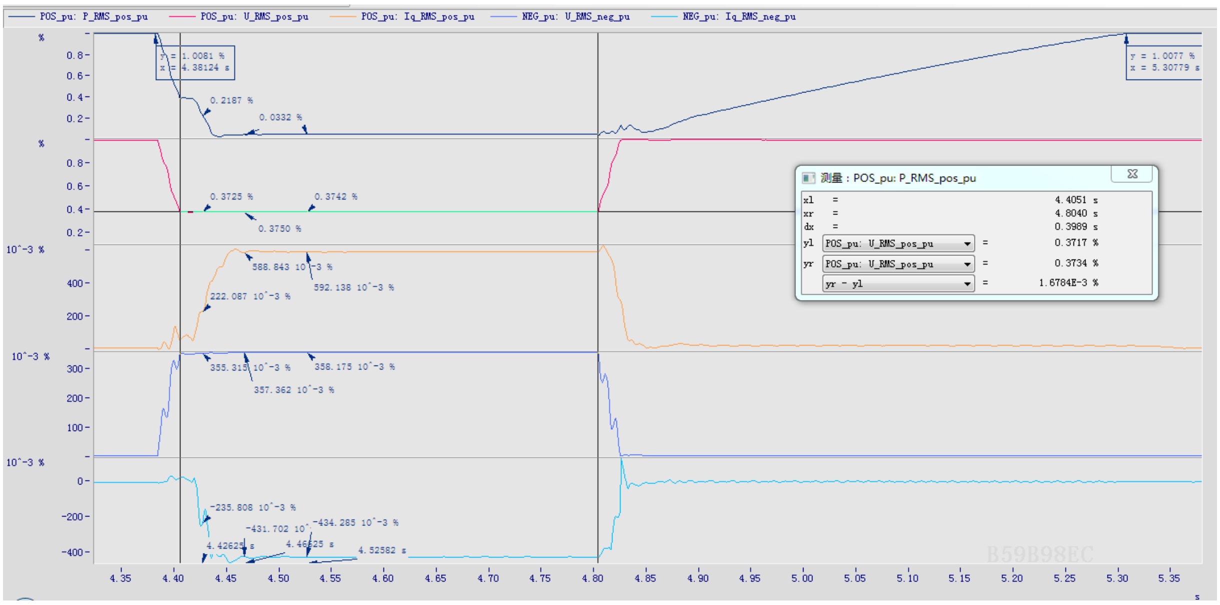


Test 14 – Two-phase asymmetrical fault (U/U$_n$ = 0.1): Phase current and voltage of the whole failure P = 20%Pn, L2, L3 phase fault, wave of the whole failure

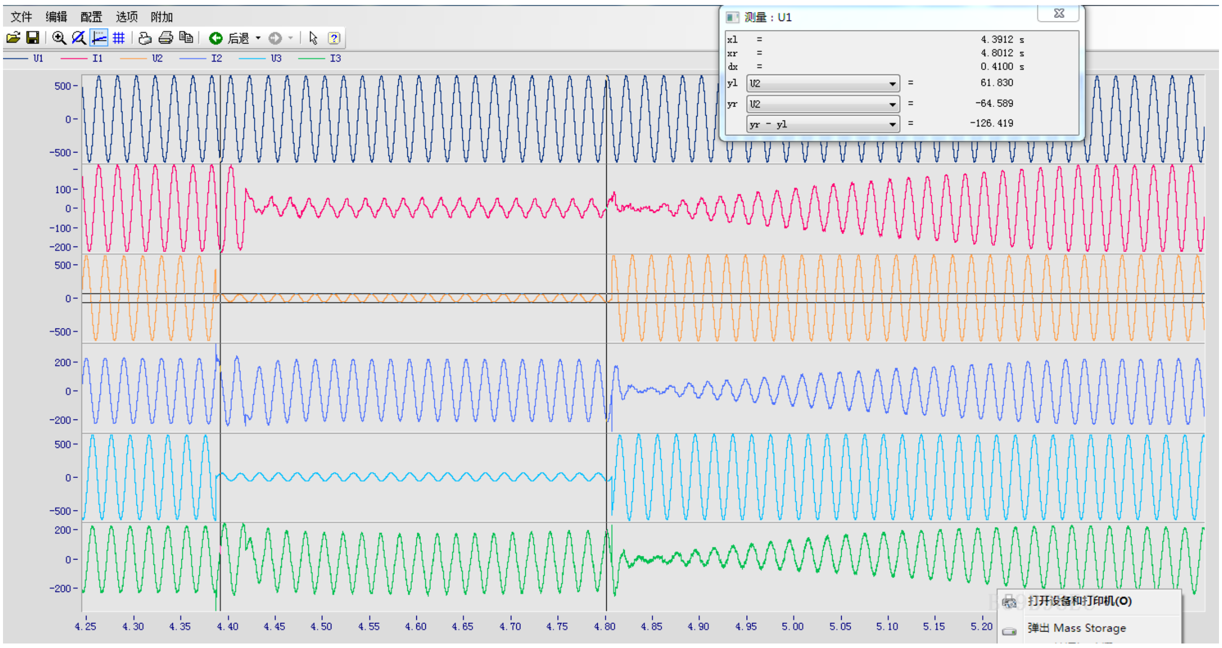


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 15 – Two-phase asymmetrical fault (U/U_n = 0.1): Voltage, active power and reactive current of the positive and negative sequence system, P = 100%Pn, L2, L3 phase fault, T_{fault}

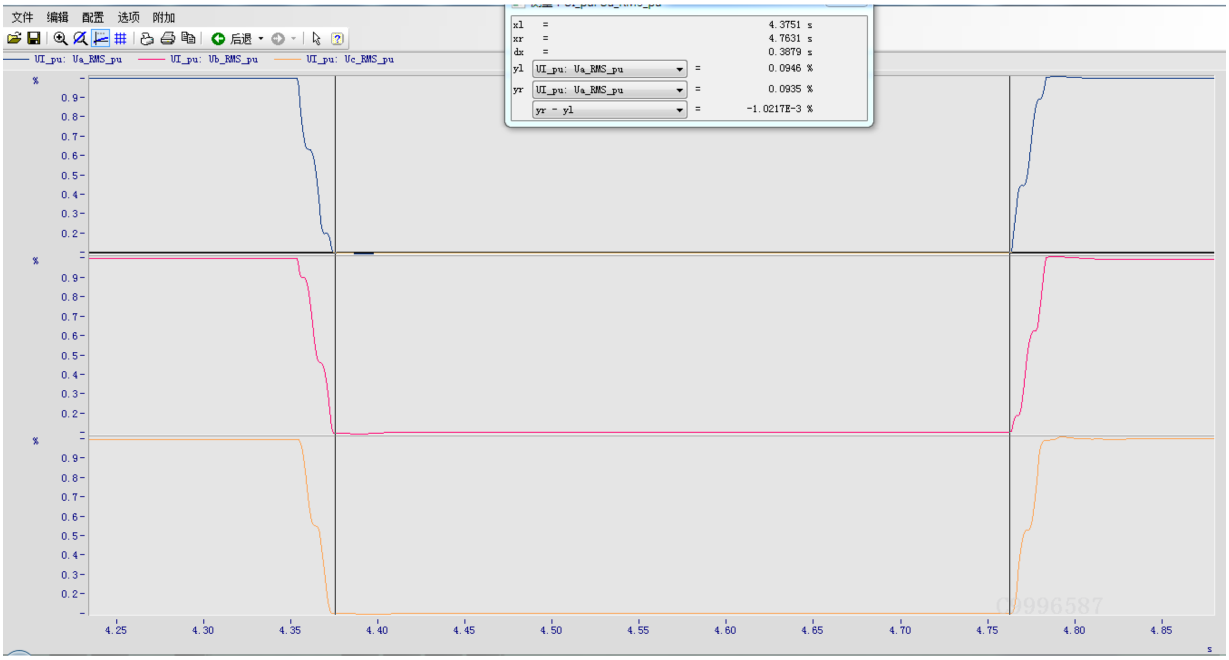


Test 15 – Two-phase asymmetrical fault (U/U_n = 0.1): Phase current and voltage of the whole failure P = 100%Pn, L2, L3 phase fault, wave of the whole failure

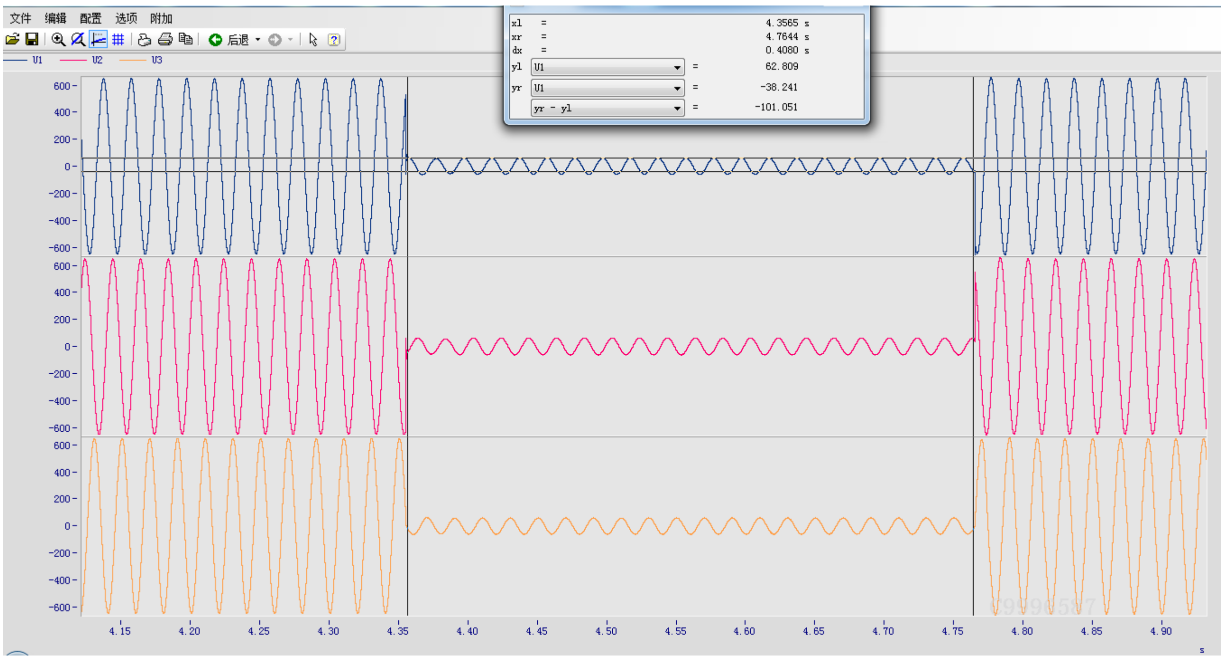


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 16 – Three-phase symmetrical fault (U/U_n = 0.1): Voltage, active power and reactive current of the positive and negative sequence system, P = 0, All phase fault, T_{fault}

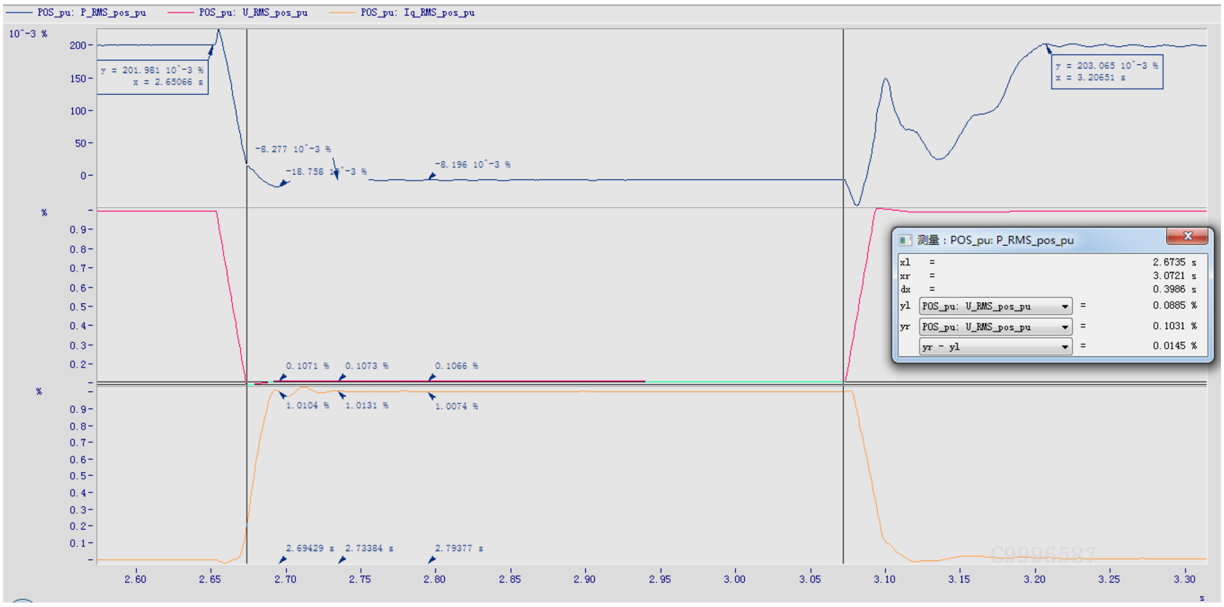


Test 16 – Three-phase symmetrical fault (U/U_n = 0.1): Phase current and voltage of the whole failure, P = 0, All phase fault, wave of the whole failure

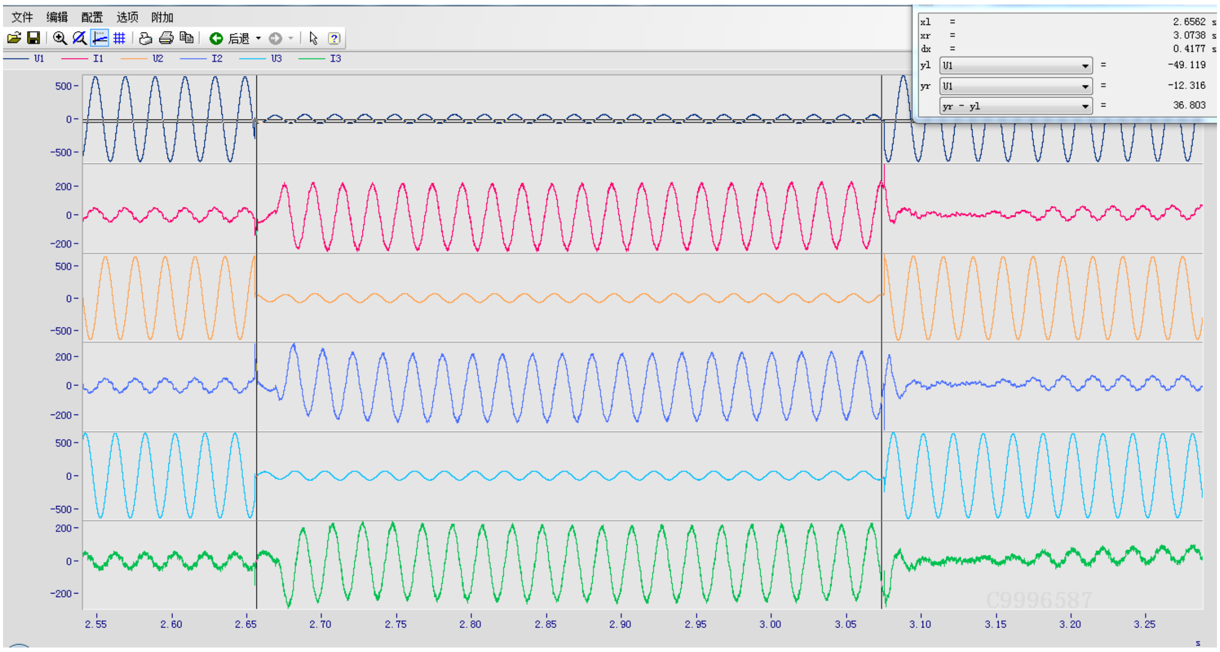


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 17 – Three-phase symmetrical fault (U/U_n = 0.1): Voltage, active power and reactive current of the positive and negative sequence system, P = 20%Pn, All phase fault, T_{fault}

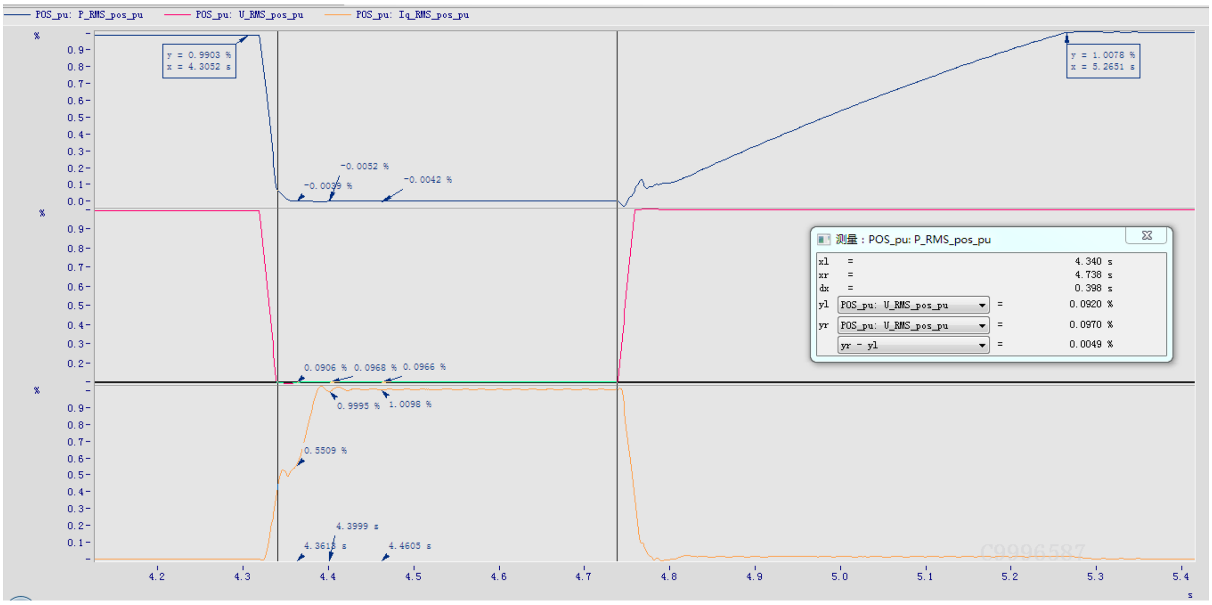


Test 17 – Three-phase symmetrical fault (U/U_n = 0.1): Phase current and voltage of the whole failure, P = 20%Pn, All phase fault, wave of the whole failure

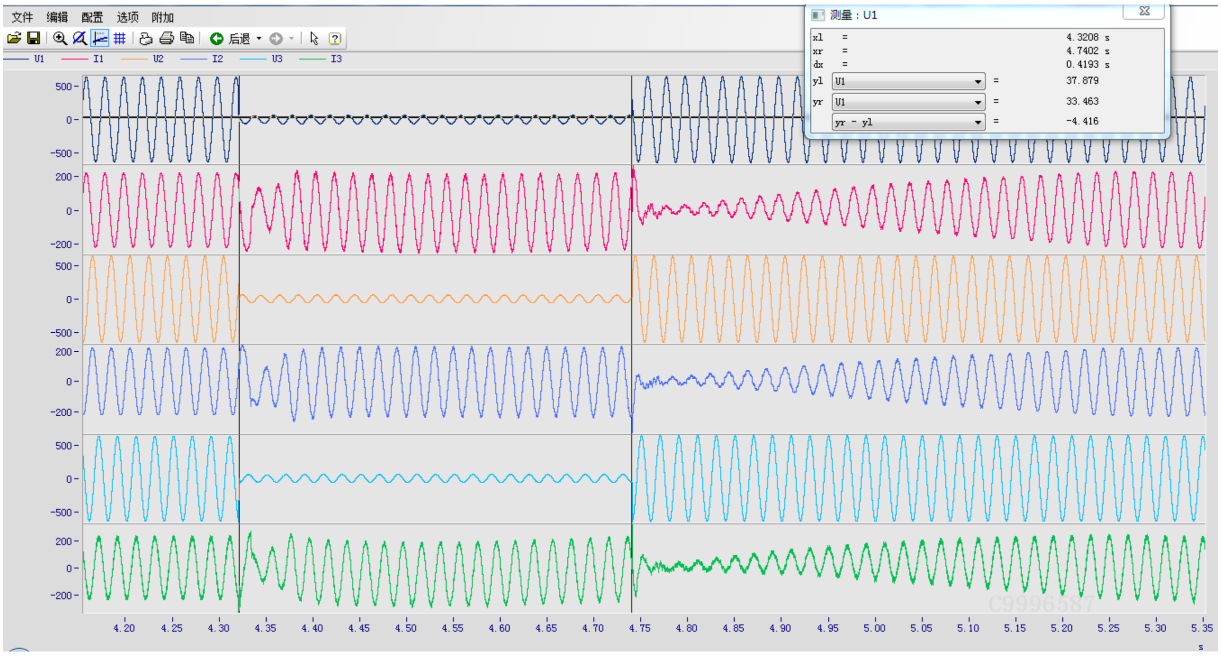


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 18 – Three-phase symmetrical fault (U/U_n = 0.1): Voltage, active power and reactive current of the positive and negative sequence system, P = 100%Pn, All phase fault, T_{fault}

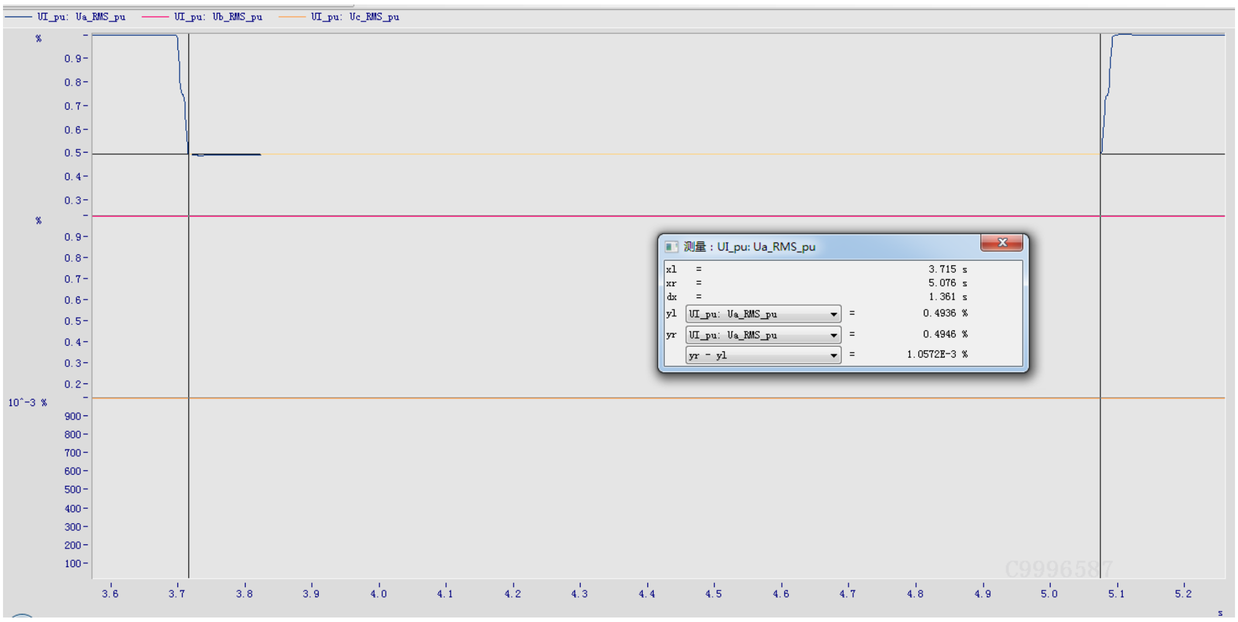


Test 18 – Three-phase symmetrical fault (U/U_n = 0.1): Phase current and voltage of the whole failure, P = 100%Pn, All phase fault, wave of the whole failure

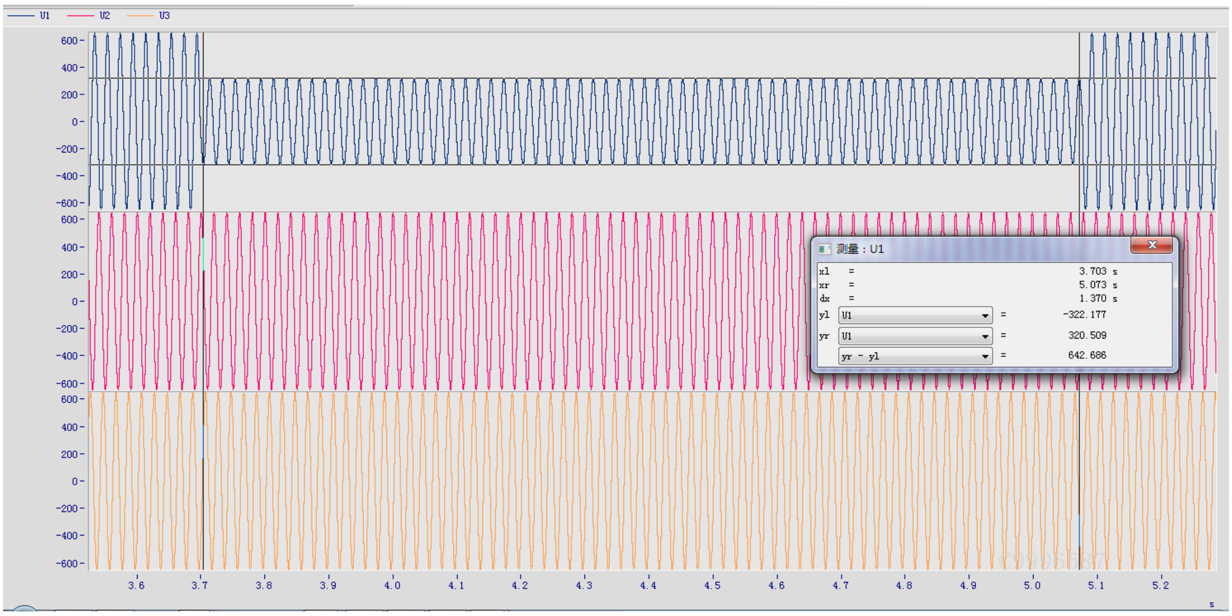


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 19 – One-phase asymmetrical fault (U/U_n = 0.5): Voltage, active power and reactive current of the positive and negative sequence system, P = 0, L1 phase fault, T_{fault}

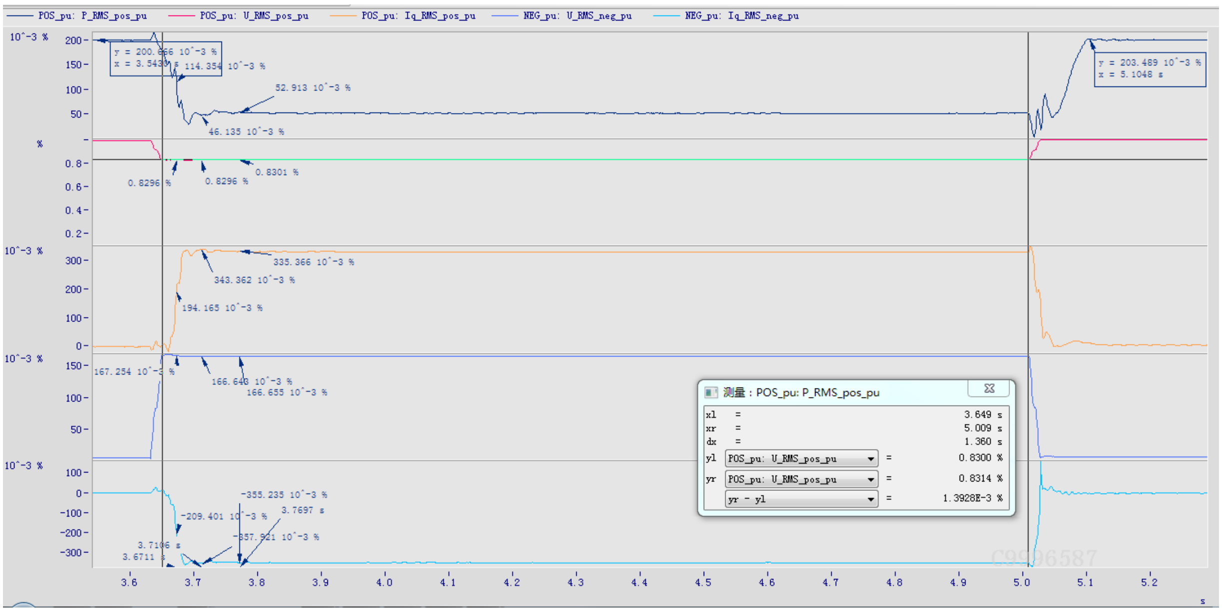


Test 19 – One-phase asymmetrical fault (U/U_n = 0.5): Phase current and voltage of the whole failure P = 0, L1 phase fault, wave of the whole failure

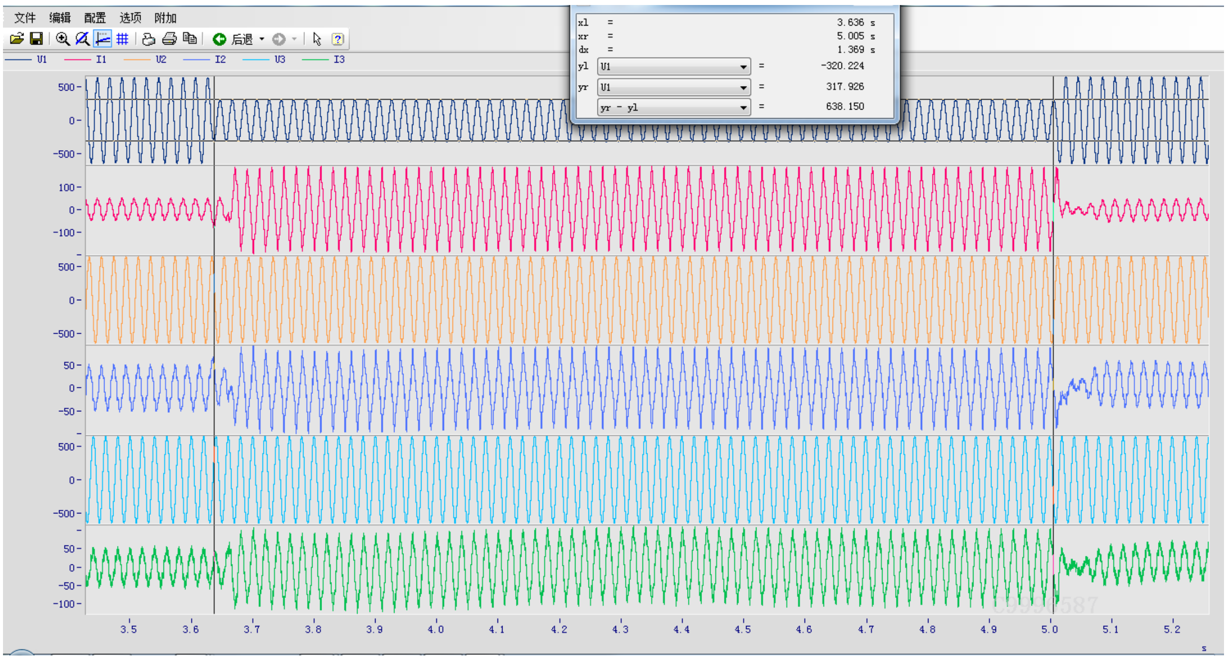


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 20 – One-phase asymmetrical fault (U/U_n = 0.5): Voltage, active power and reactive current of the positive and negative sequence system, P = 20%Pn, L1 phase fault, T_{fault}

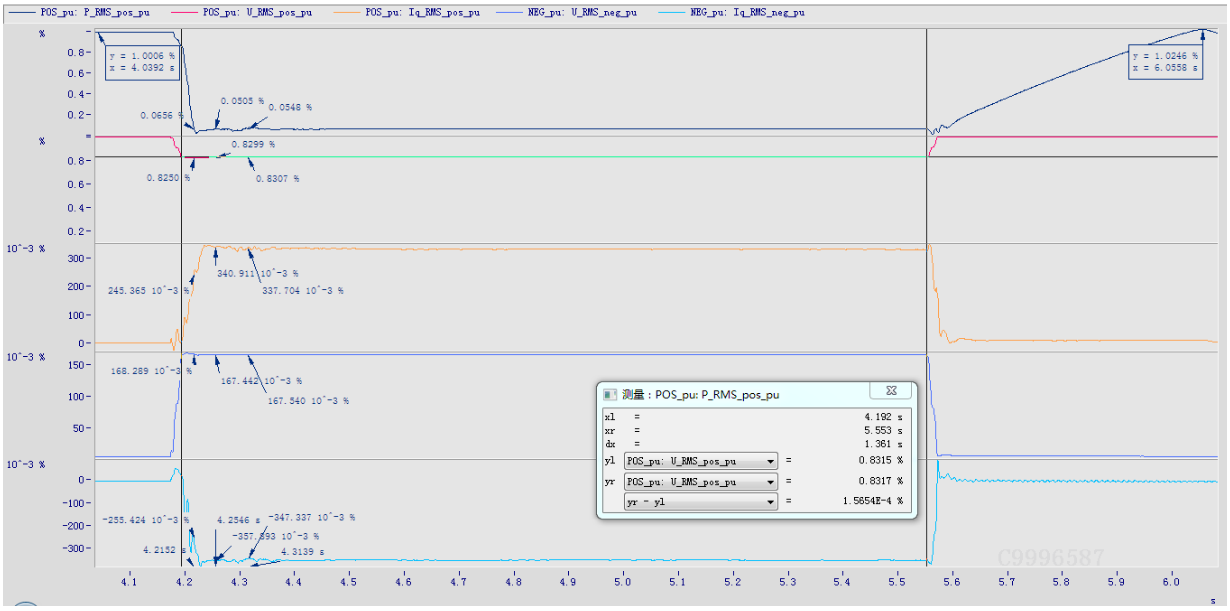


Test 20 – One-phase asymmetrical fault (U/U_n = 0.5): Phase current and voltage of the whole failure P = 20%Pn, L1 phase fault, wave of the whole failure

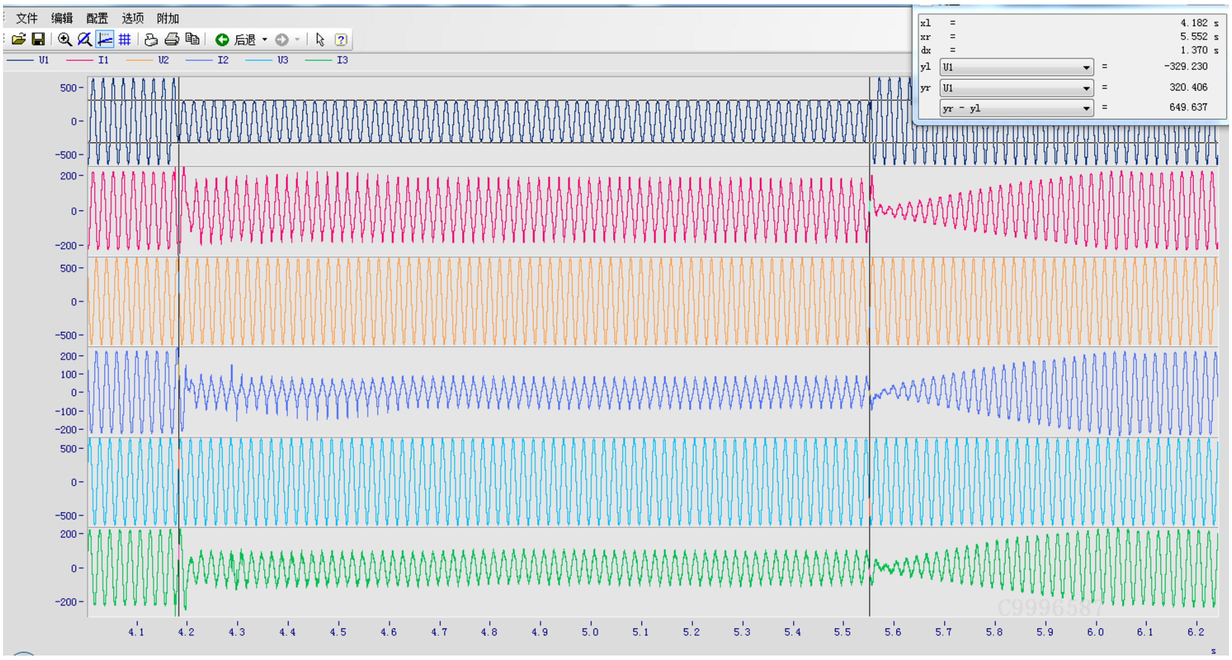


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 21 – One-phase asymmetrical fault (U/U_n = 0.5): Voltage, active power and reactive current of the positive and negative sequence system, P = 100%Pn, L1 phase fault, T_{fault}

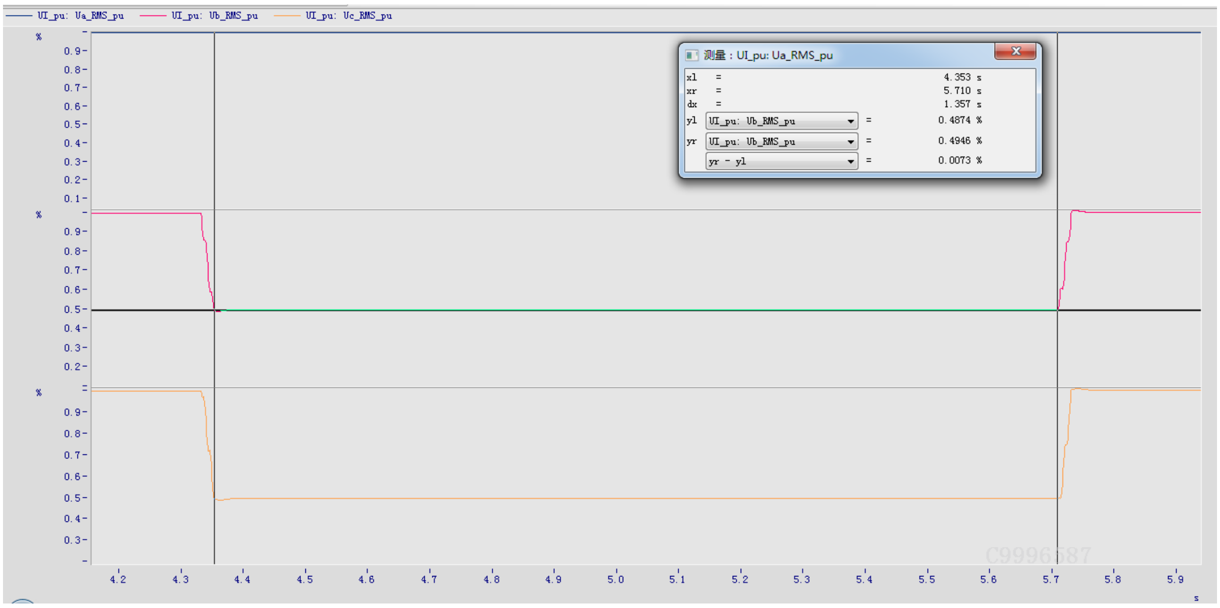


Test 21 – One-phase asymmetrical fault (U/U_n = 0.5): Phase current and voltage of the whole failure P = 100%Pn, L1 phase fault, wave of the whole failure

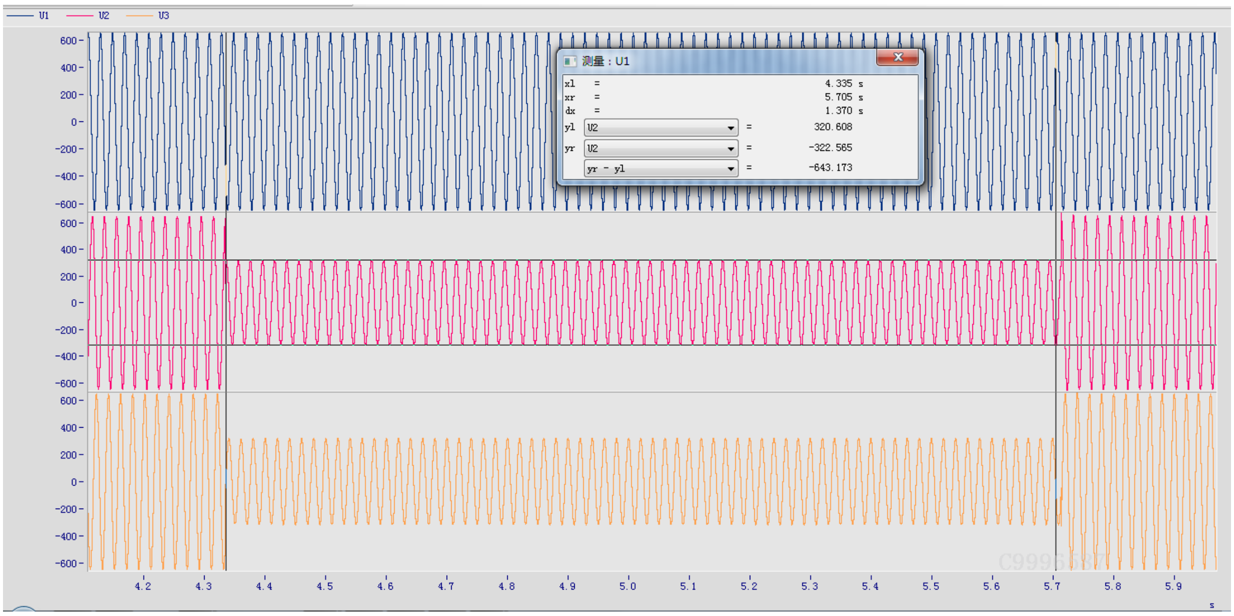


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

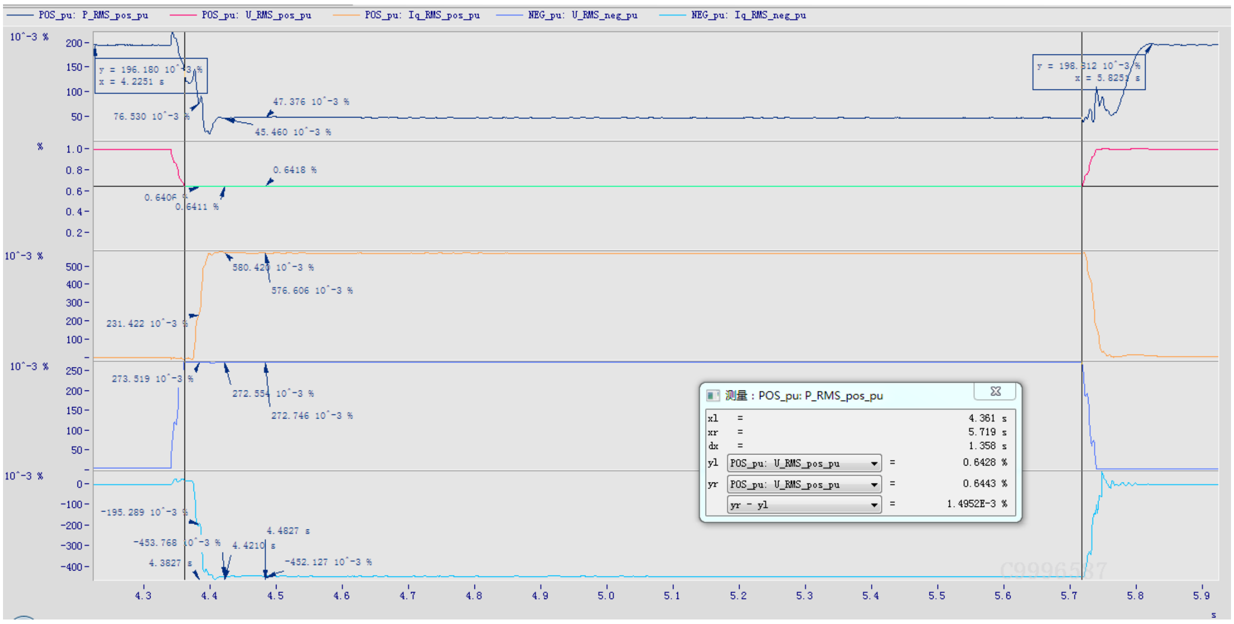
Test 22 – Two-phase asymmetrical fault (U/U_n = 0.5): Voltage, active power and reactive current of the positive and negative sequence system, P = 0, L2, L3 phase fault, T_{fault}



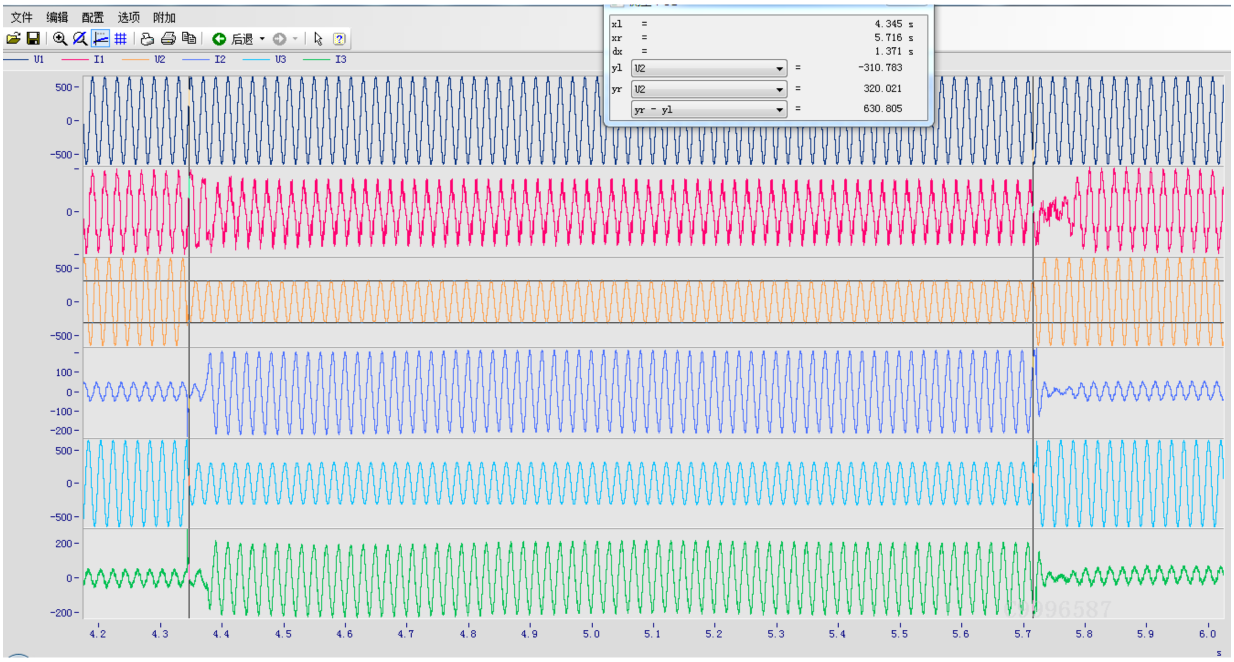
Test 22 – Two-phase asymmetrical fault (U/U_n = 0.5): Phase current and voltage of the whole failure P = 0, L2, L3 phase fault, wave of the whole failure



Test 23 – Two-phase asymmetrical fault (U/U_n = 0.5): Voltage, active power and reactive current of the positive and negative sequence system, P = 20%Pn, L2, L3 phase fault, T_{fault}

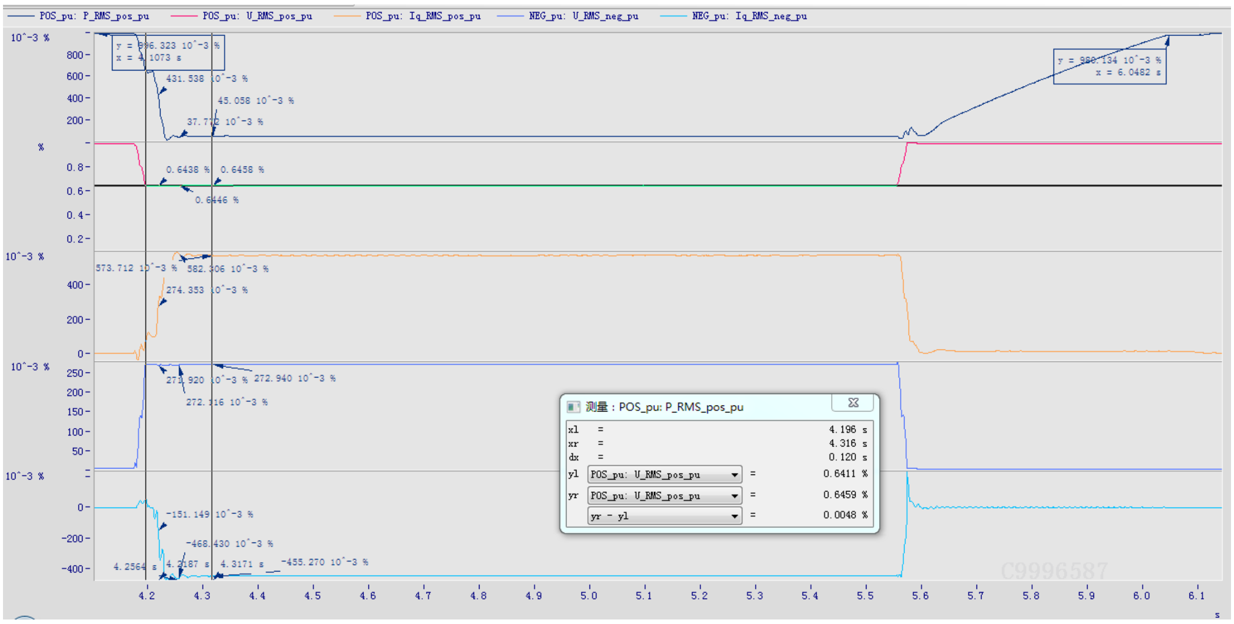


Test 23 – Two-phase asymmetrical fault (U/U_n = 0.5): Phase current and voltage of the whole failure P = 20%Pn, L2, L3 phase fault, wave of the whole failure

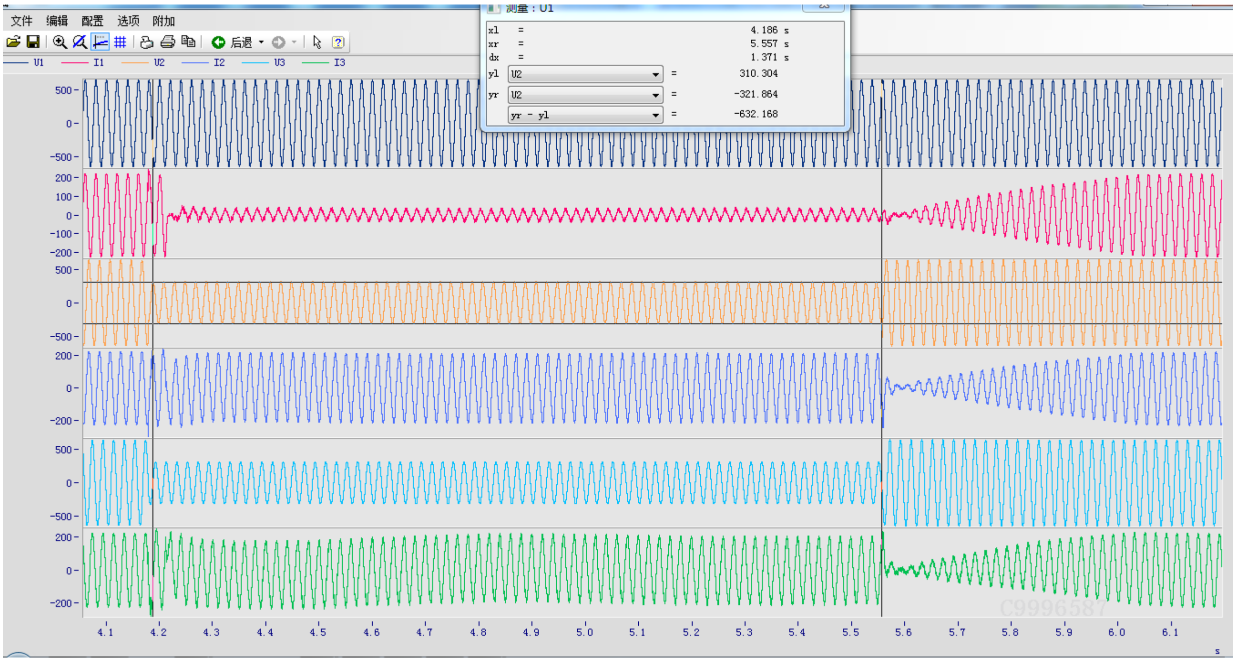


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 24 – Two-phase asymmetrical fault (U/U_n = 0.5): Voltage, active power and reactive current of the positive and negative sequence system, P = 100%Pn, L2, L3 phase fault, T_{fault}

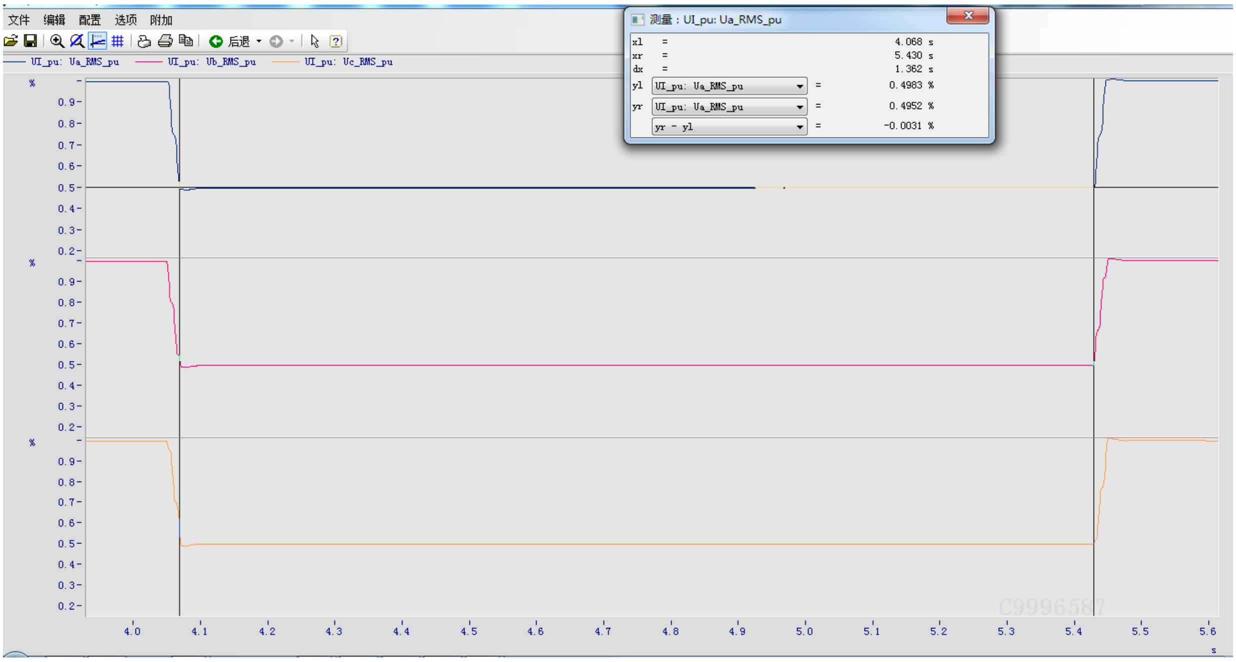


Test 24 – Two-phase asymmetrical fault (U/U_n = 0.5): Phase current and voltage of the whole failure P = 100%Pn, L2, L3 phase fault, wave of the whole failure

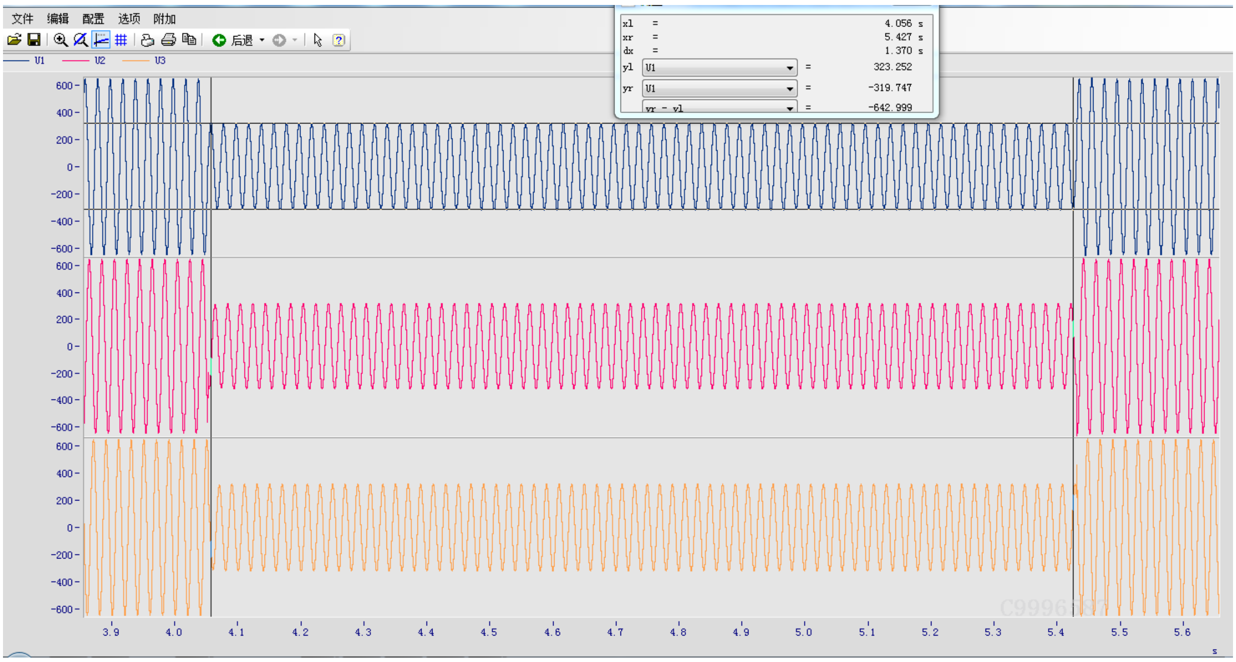


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 25 – Three-phase symmetrical fault (U/U_n = 0.5): Voltage, active power and reactive current of the positive and negative sequence system, P = 0, All phase fault, T_{fault}

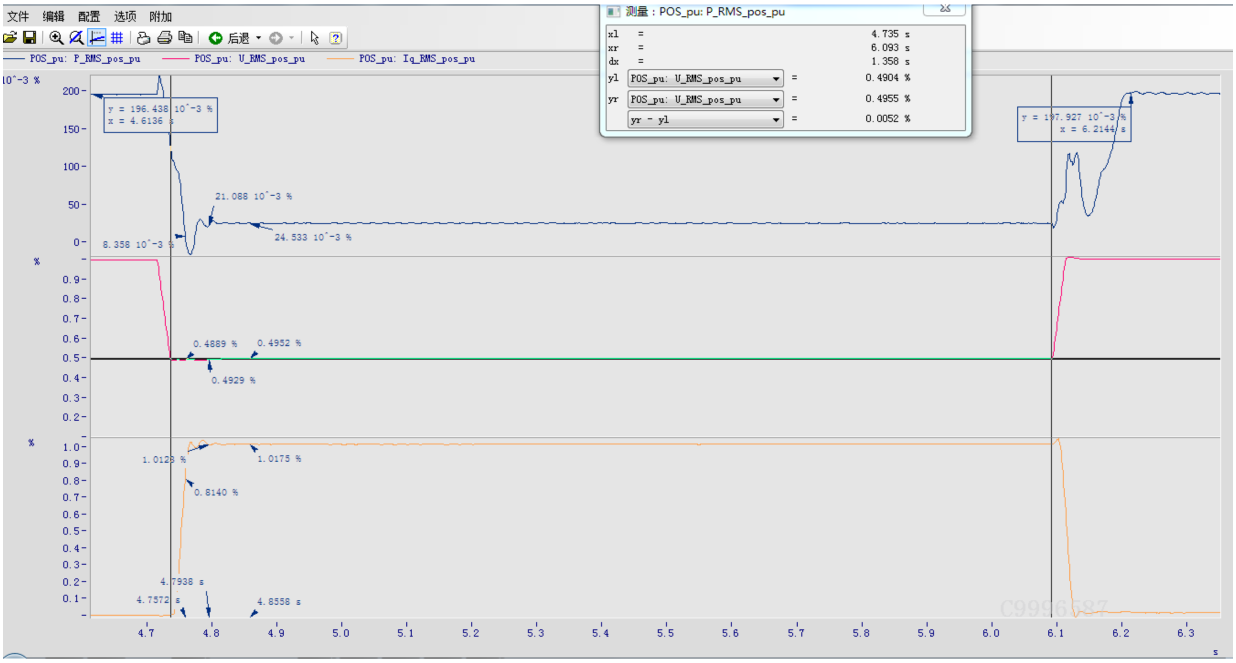


Test 25 – Three-phase symmetrical fault (U/U_n = 0.5): Phase current and voltage of the whole failure, P = 0, All phase fault, wave of the whole failure

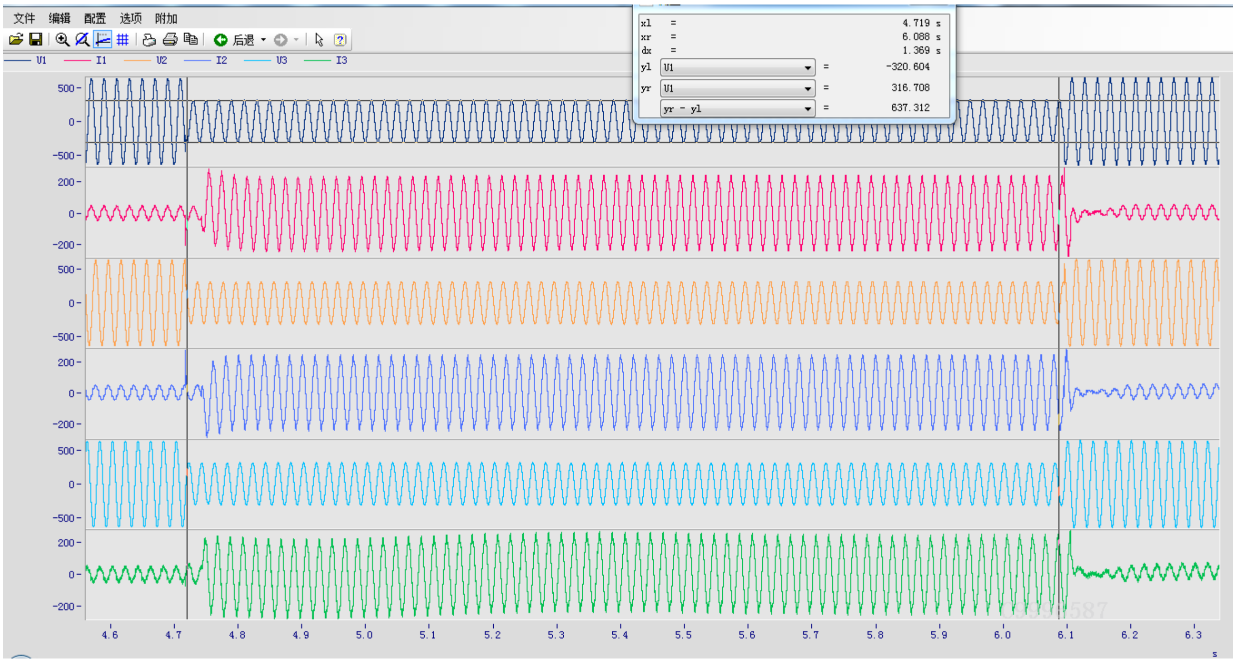


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 26 – Three-phase symmetrical fault (U/U_n = 0.5): Voltage, active power and reactive current of the positive and negative sequence system, P = 20%Pn, All phase fault, T_{fault}

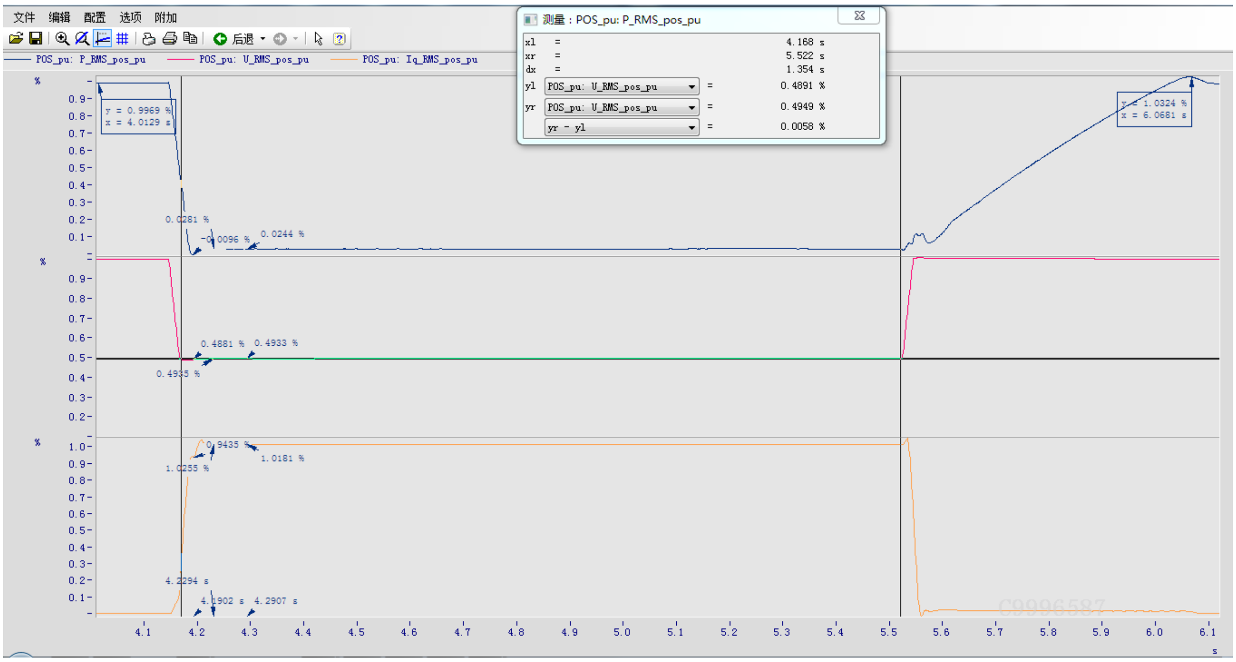


Test 26 – Three-phase symmetrical fault (U/U_n = 0.5): Phase current and voltage of the whole failure, P = 20%Pn, All phase fault, wave of the whole failure

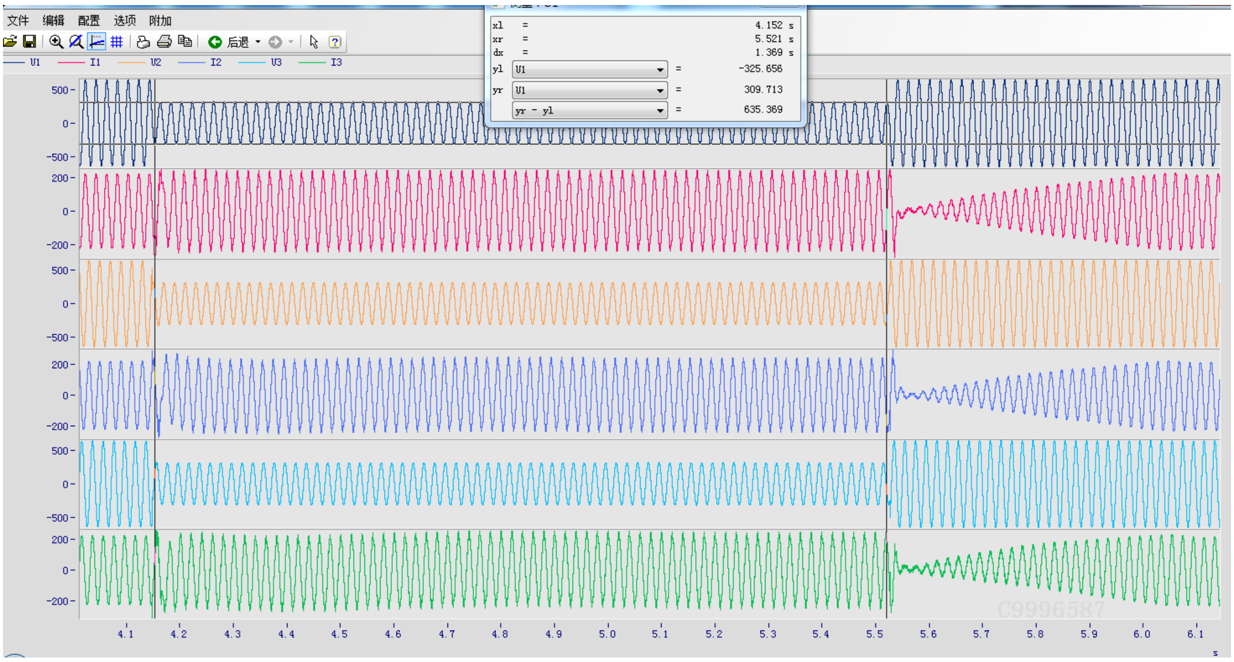


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 27 – Three-phase symmetrical fault (U/U_n = 0.5): Voltage, active power and reactive current of the positive and negative sequence system, P = 100%Pn, All phase fault, T_{fault}

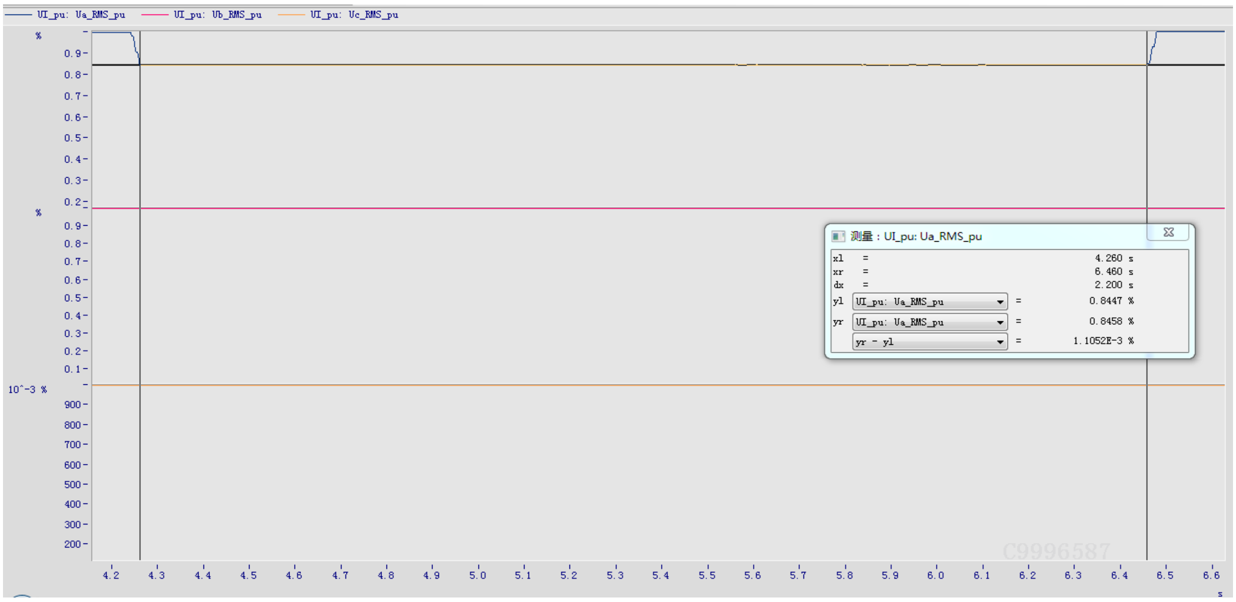


Test 27 – Three-phase symmetrical fault (U/U_n = 0.5): Phase current and voltage of the whole failure, P = 100%Pn, All phase fault, wave of the whole failure

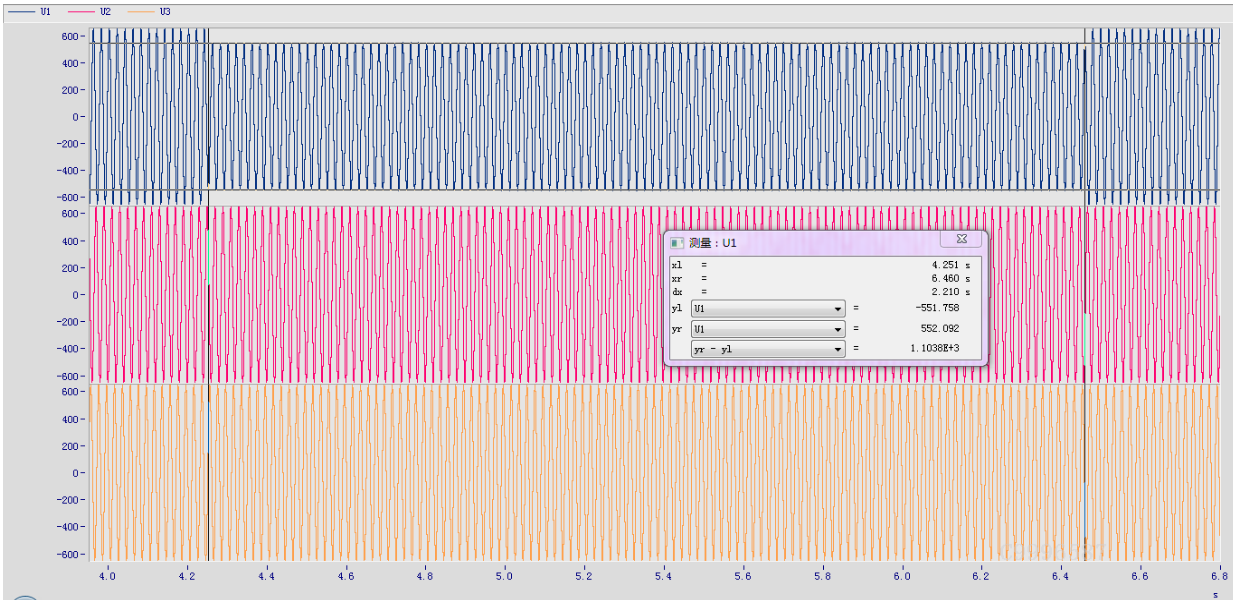


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 28 – One-phase asymmetrical fault (U/U_n = 0.85): Voltage, active power and reactive current of the positive and negative sequence system, P = 0, L1 phase fault, T_{fault}

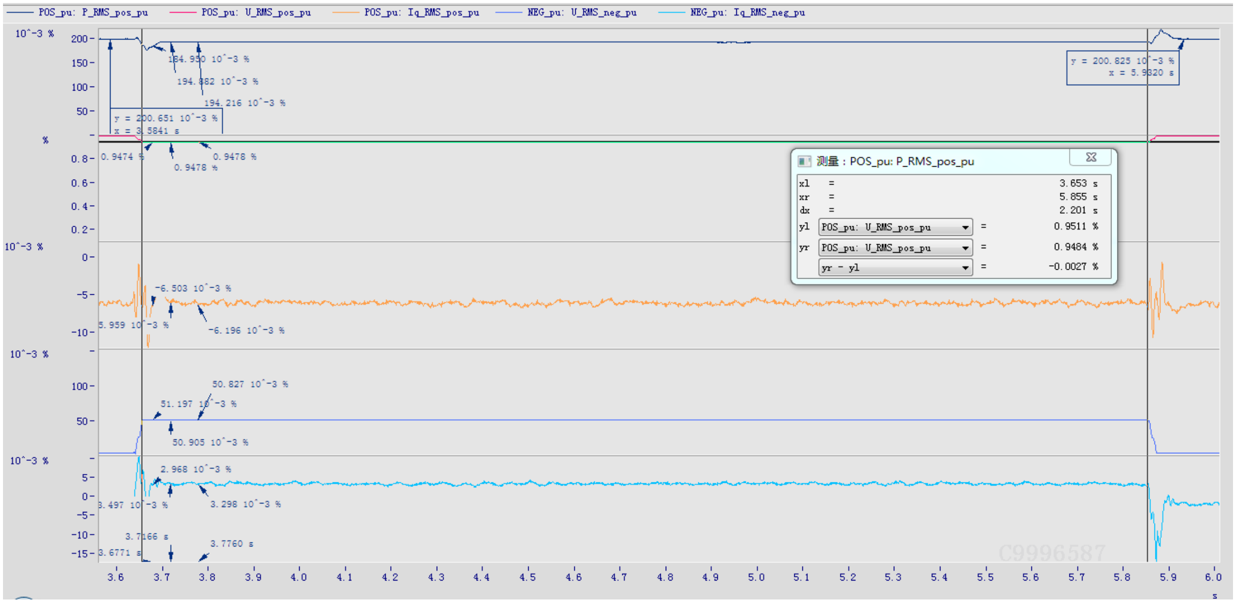


Test 28 – One-phase asymmetrical fault (U/U_n = 0.85): Phase current and voltage of the whole failure, P = 0, L1 phase fault, wave of the whole failure

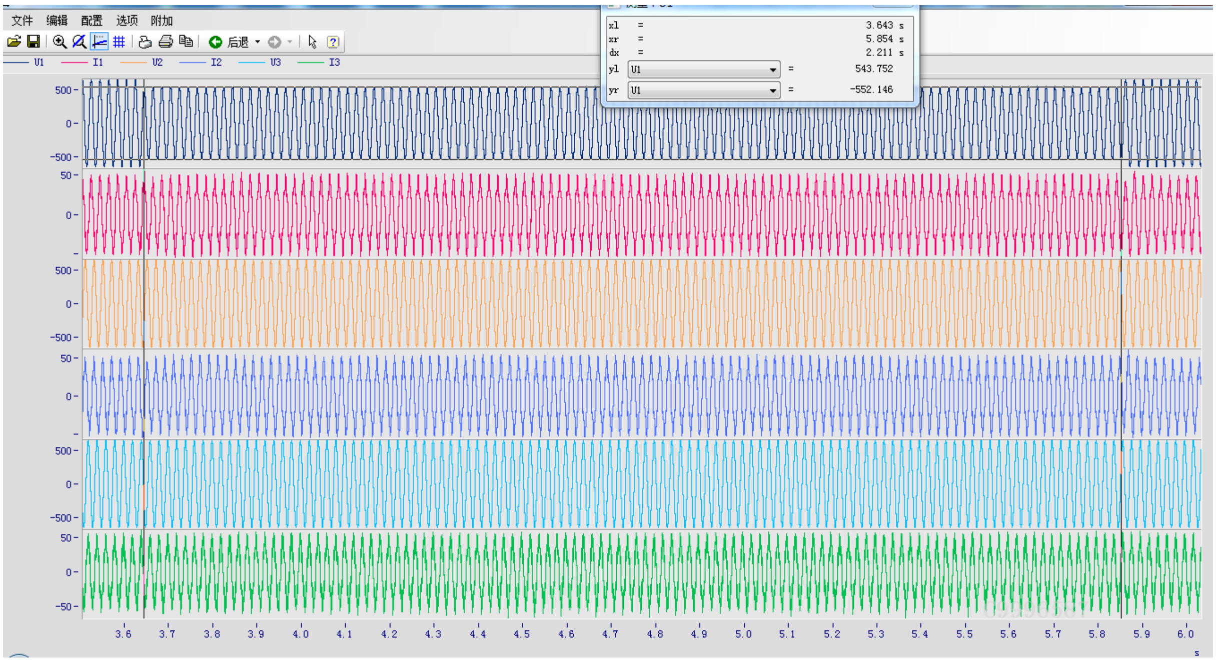


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 29 – One-phase asymmetrical fault (U/U_n = 0.85): Voltage, active power and reactive current of the positive and negative sequence system, P = 20%Pn, L1 phase fault, T_{fault}

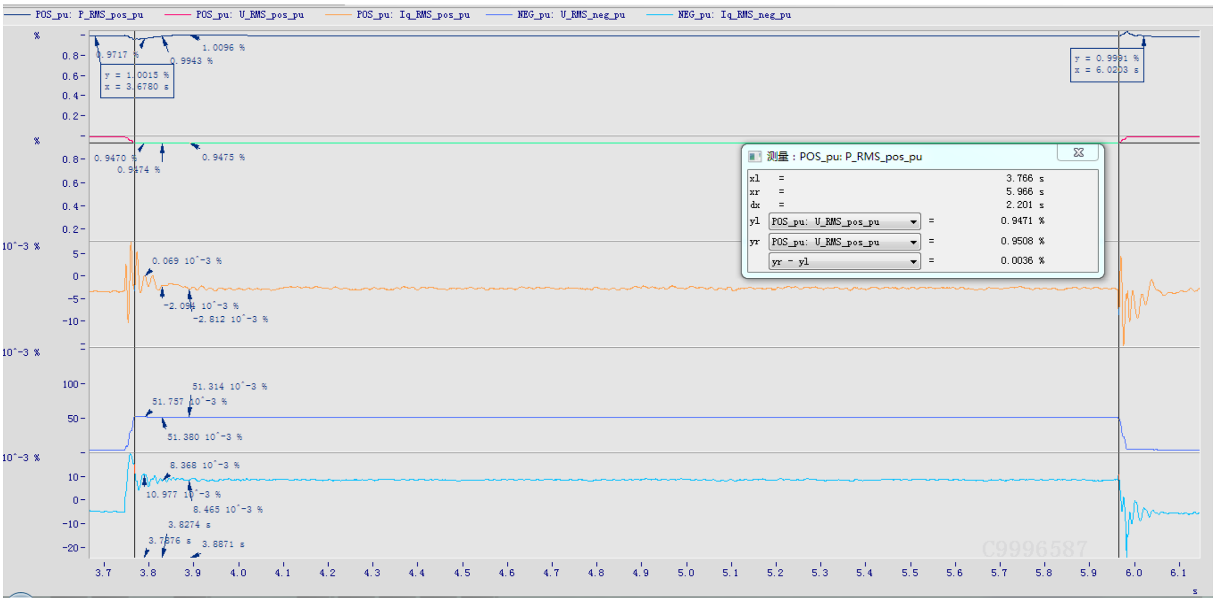


Test 29 – One-phase asymmetrical fault (U/U_n = 0.85): Phase current and voltage of the whole failure, P = 20%Pn, L1 phase fault, wave of the whole failure

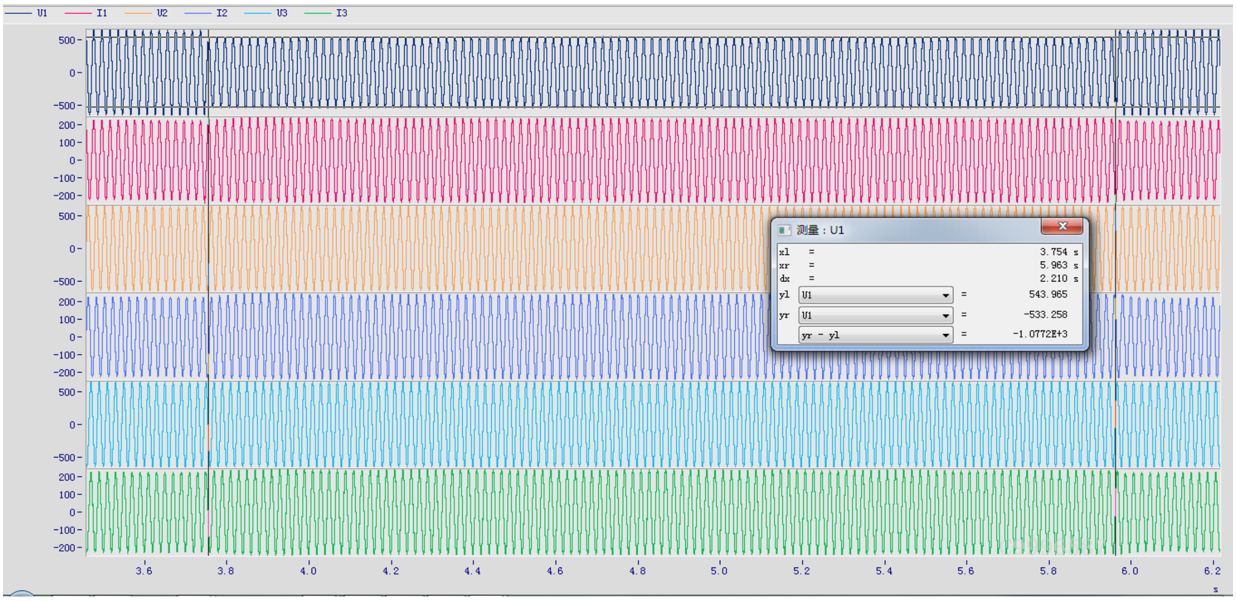


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 30 – One-phase asymmetrical fault (U/U_n = 0.85): Voltage, active power and reactive current of the positive and negative sequence system, P = 100%Pn, L1 phase fault, T_{fault}

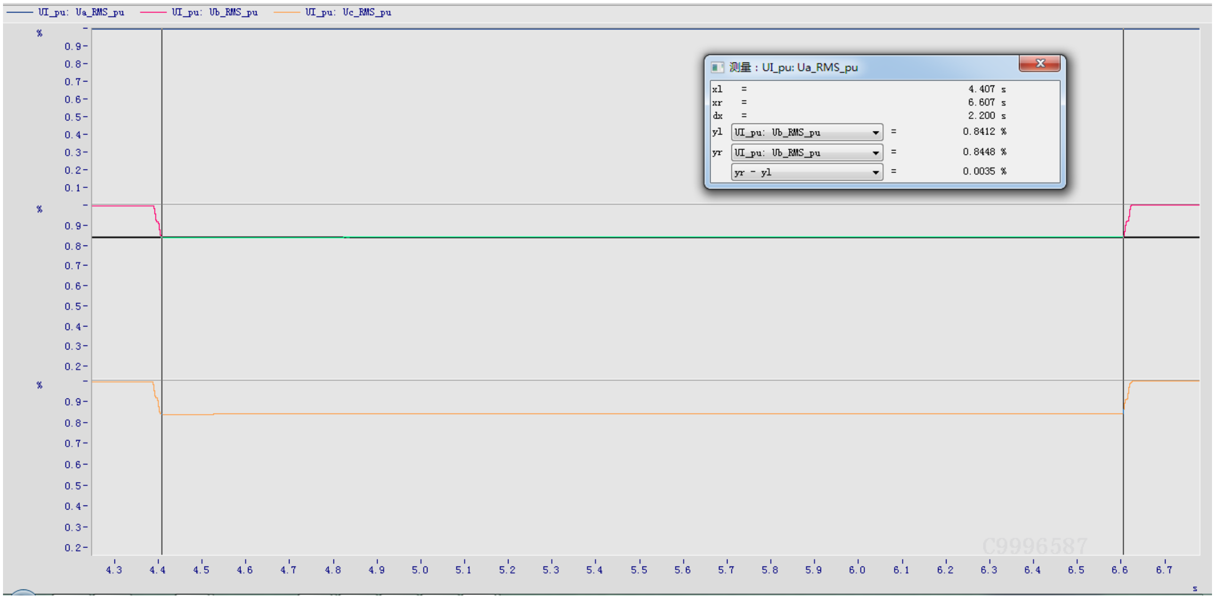


Test 30 – One-phase asymmetrical fault (U/U_n = 0.85): Phase current and voltage of the whole failure, P = 100%Pn, L1 phase fault, wave of the whole failure

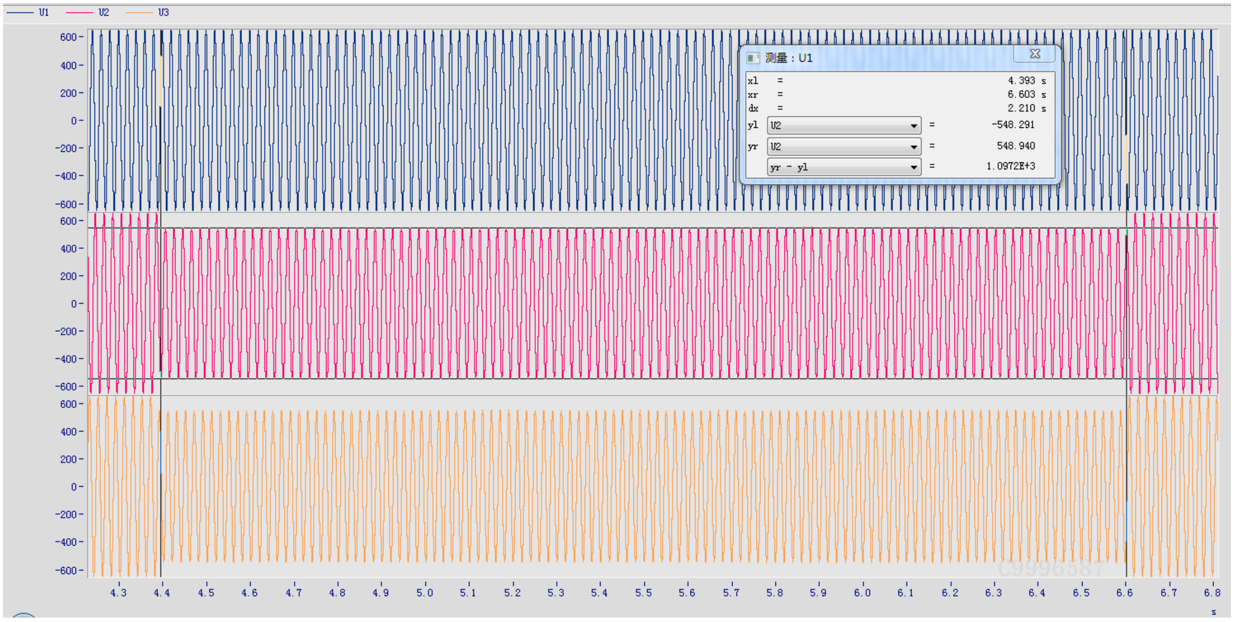


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 31 – Two-phase asymmetrical fault (U/U_n = 0.85): Voltage, active power and reactive current of the positive and negative sequence system, P = 0, L2, L3 phase fault, T_{fault}

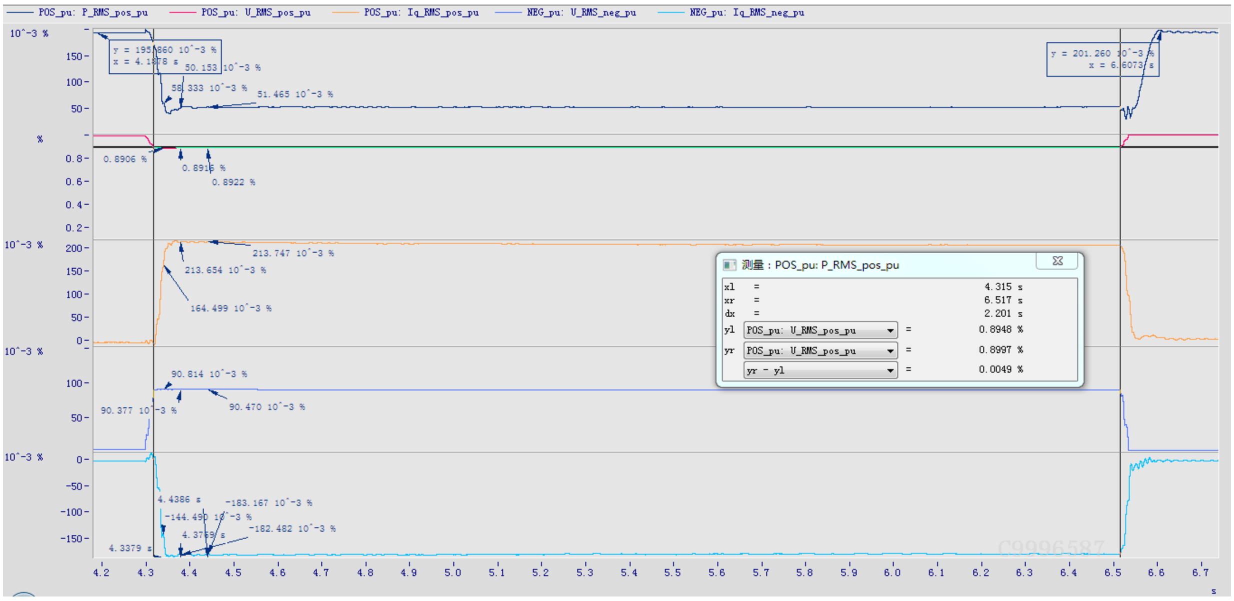


Test 31 – Two-phase asymmetrical fault (U/U_n = 0.85): Phase current and voltage of the whole failure, P = 0, L2, L3 phase fault, wave of the whole failure

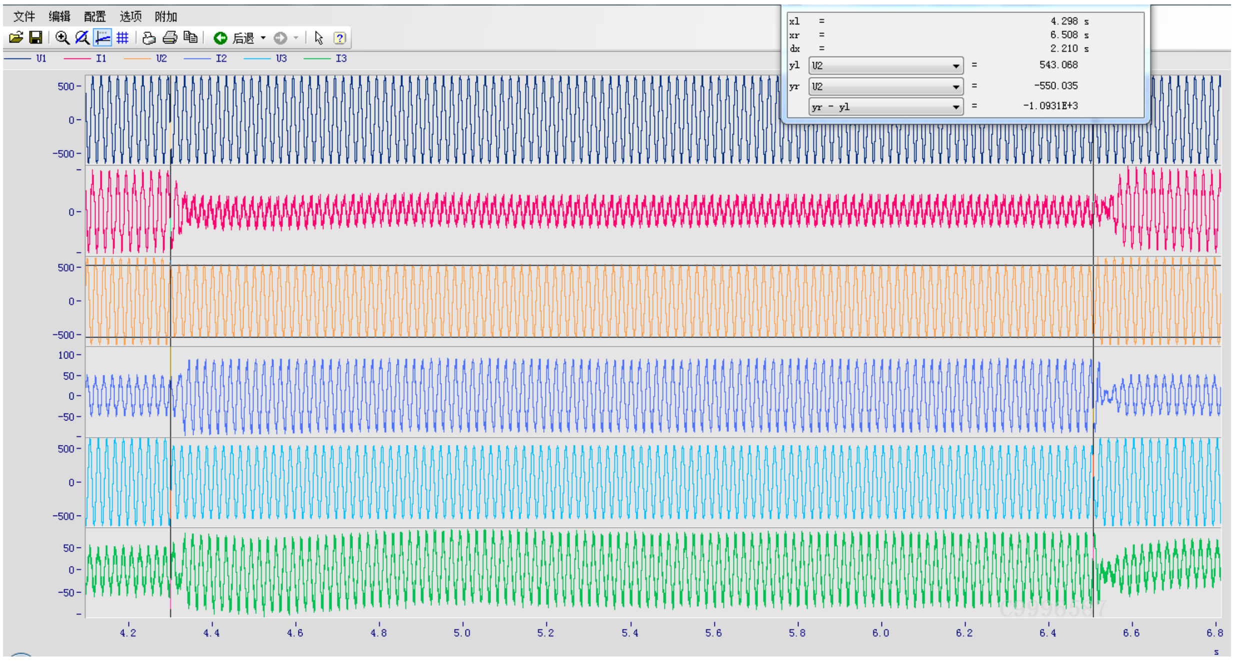


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 32 – Two-phase asymmetrical fault (U/U_n = 0.85): Voltage, active power and reactive current of the positive and negative sequence system, P = 20%Pn, L2, L3 phase fault, T_{fault}

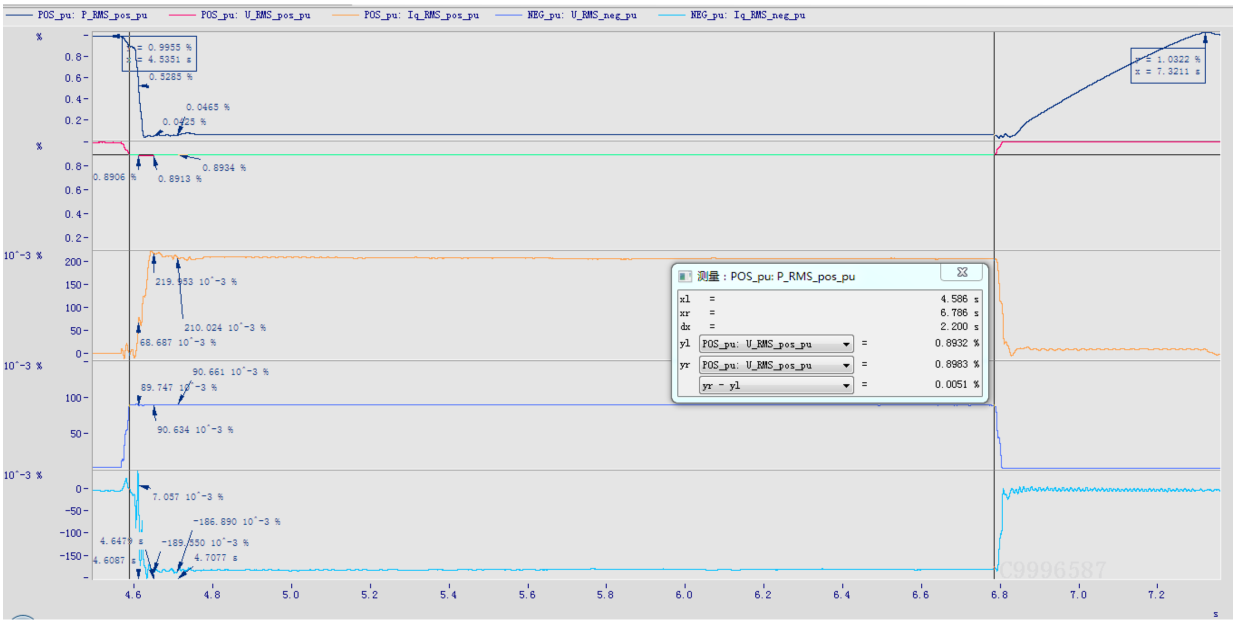


Test 32 – Two-phase asymmetrical fault (U/U_n = 0.85): Phase current and voltage of the whole failure, P = 20%Pn, L2, L3 phase fault, wave of the whole failure

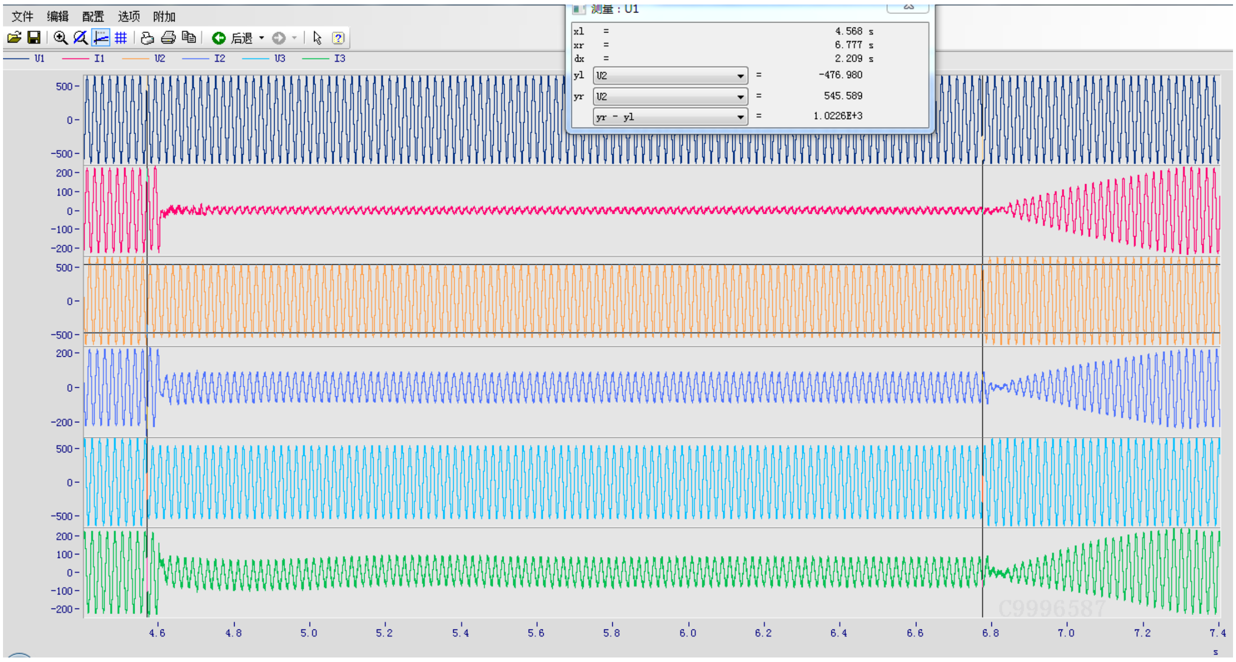


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 33 – Two-phase asymmetrical fault (U/U_n = 0.85): Voltage, active power and reactive current of the positive and negative sequence system, P = 100%Pn, L2, L3 phase fault, T_{fault}

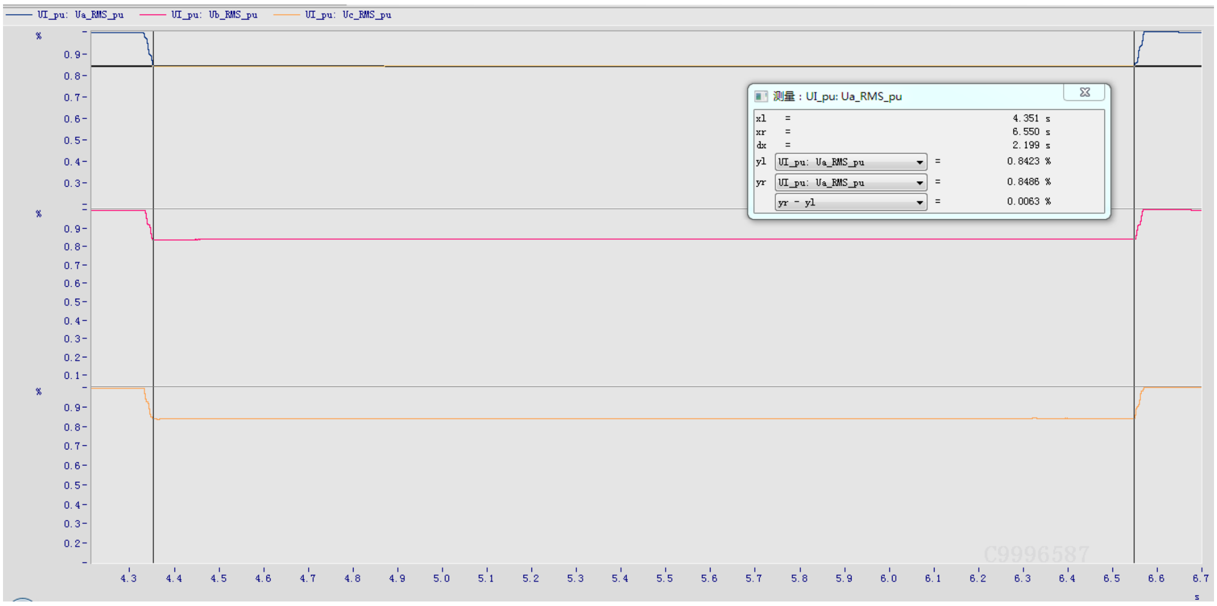


Test 33 – Two-phase asymmetrical fault (U/U_n = 0.85): Phase current and voltage of the whole failure, P = 100%Pn, L2, L3 phase fault, wave of the whole failure

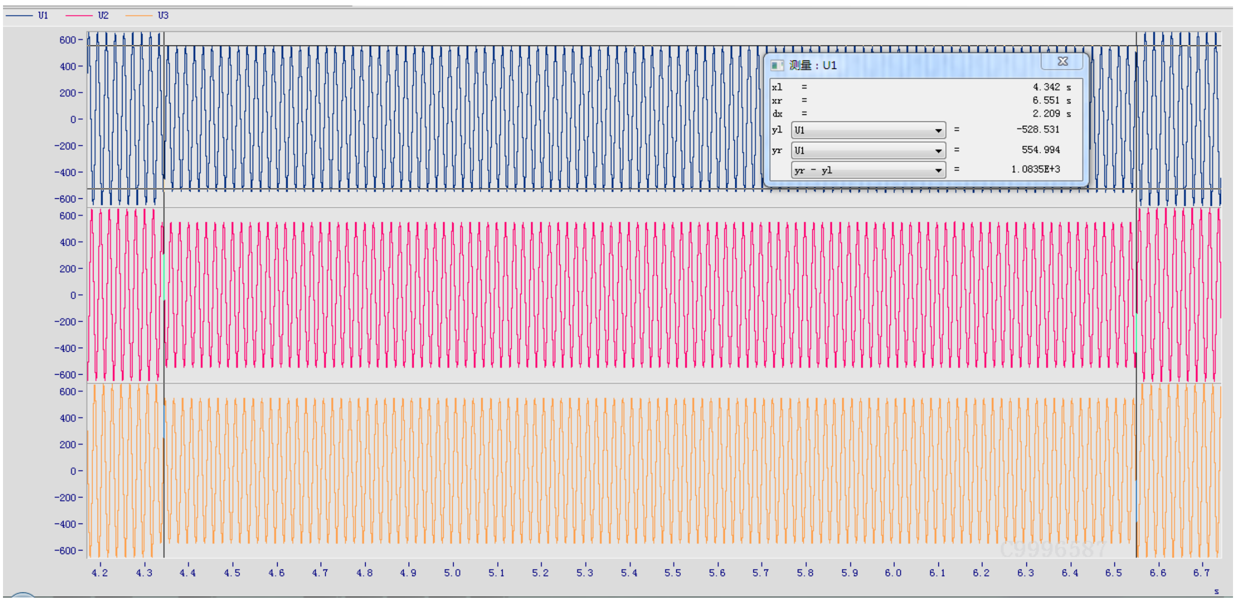


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 34 – Three-phase symmetrical fault (U/U$_n$ = 0.85): Voltage, active power and reactive current of the positive and negative sequence system, P = 0, All phase fault, T$_{fault}$

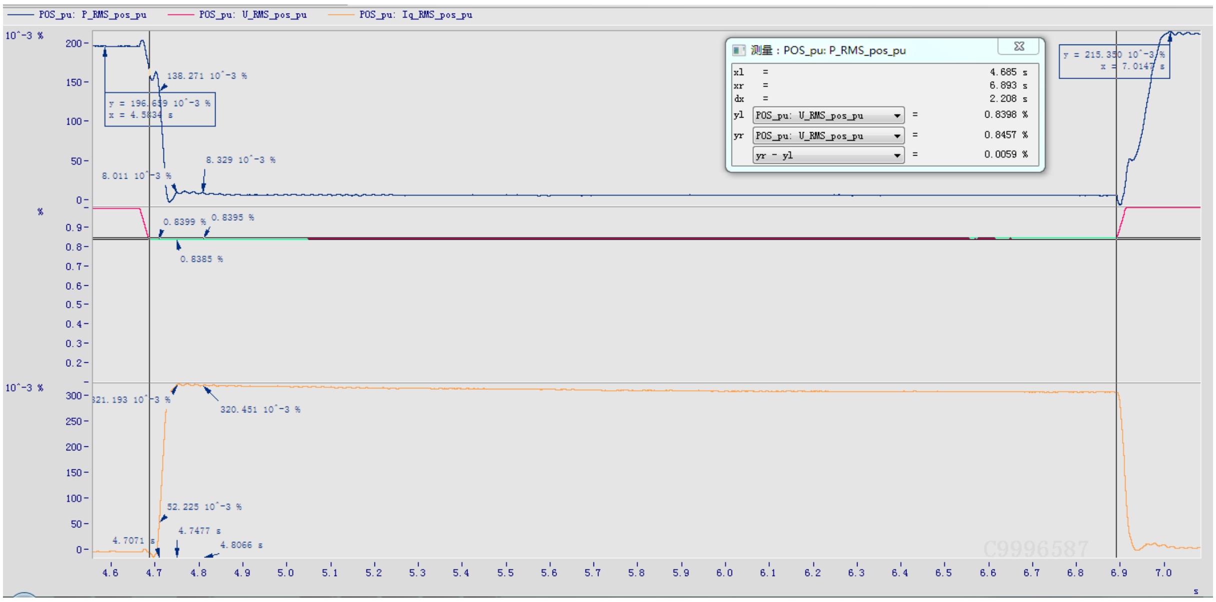


Test 34 – Three-phase symmetrical fault (U/U$_n$ = 0.85): Phase current and voltage of the whole failure, P = 0, All phase fault, wave of the whole failure

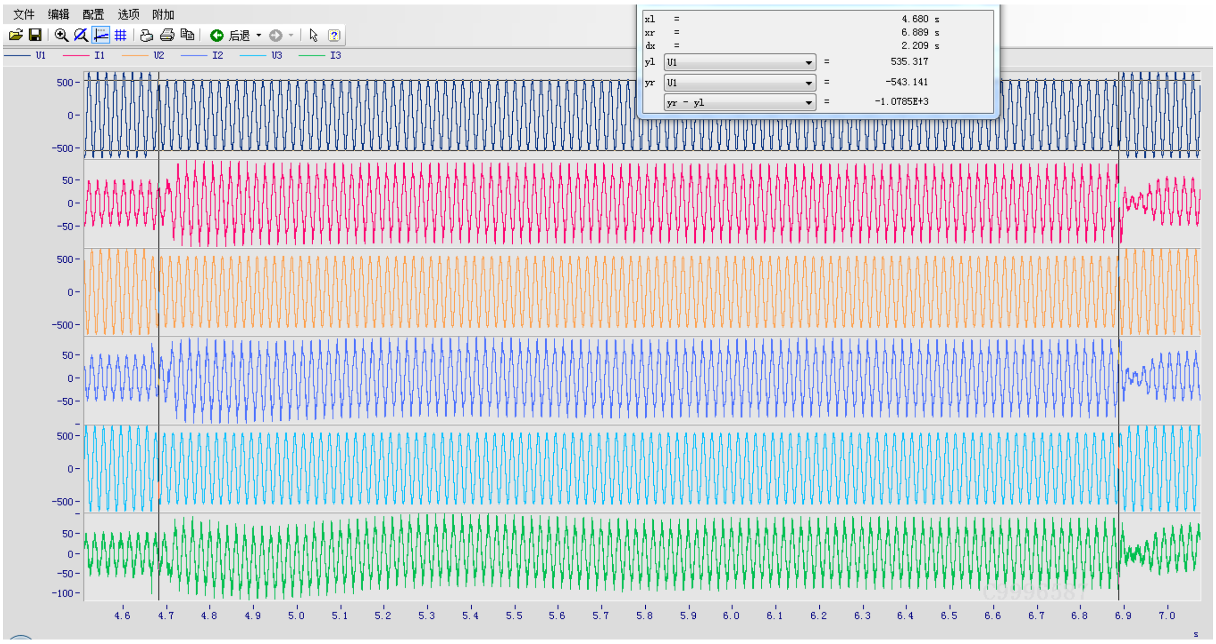


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 35 – Three-phase symmetrical fault (U/U_n = 0.85): Voltage, active power and reactive current of the positive sequence system, P = 20%Pn, All phase fault, T_{fault}

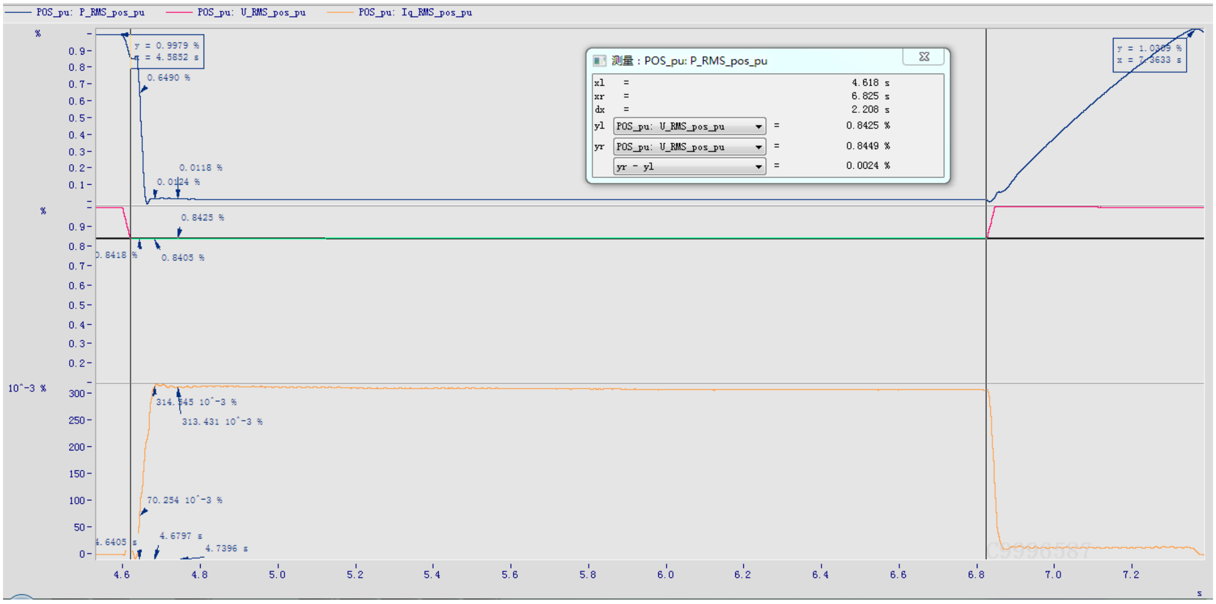


Test 35 – Three-phase symmetrical fault (U/U_n = 0.85): Phase current and voltage of the whole failure, P = 20%Pn, All phase fault, wave of the whole failure

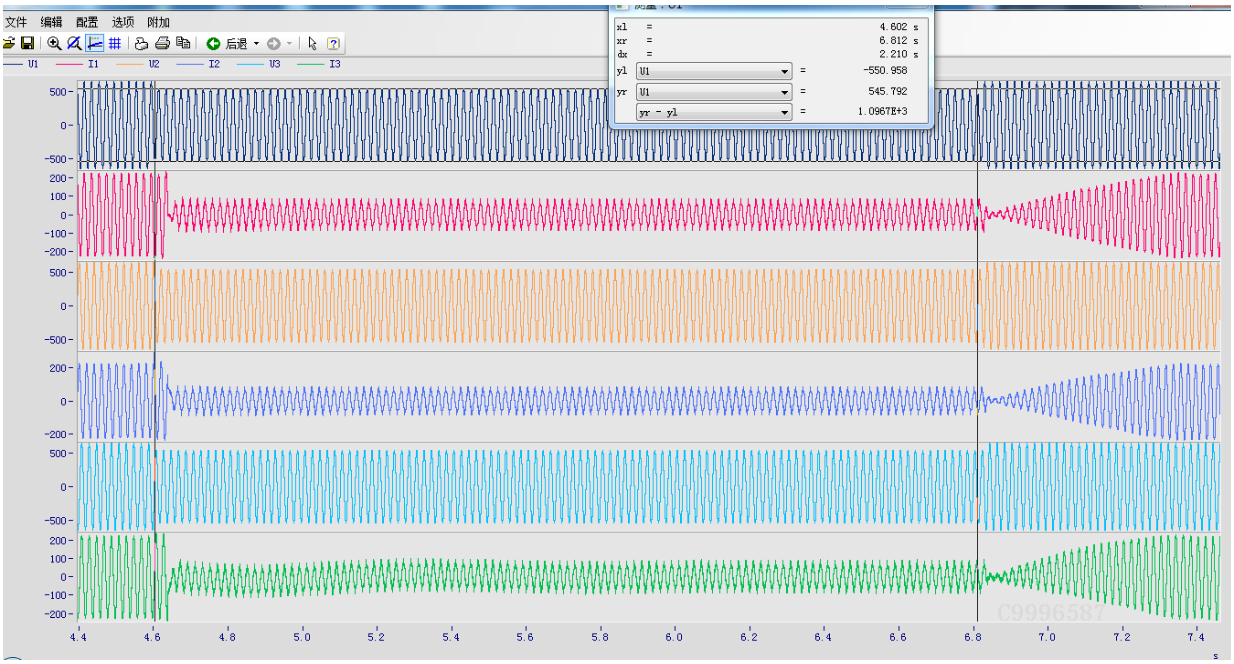


G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Test 36 – Three-phase symmetrical fault (U/U$_n$ = 0.85): Voltage, active power and reactive current of the positive sequence system, P = 100%Pn, All phase fault, T$_{fault}$



Test 36 – Three-phase symmetrical fault (U/U$_n$ = 0.85): Phase current and voltage of the whole failure, P = 100%Pn, All phase fault, wave of the whole failure



G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

13.5.4, 13.5.5	**TABLE: Reactive Power capability requirements – Versus Voltage (For Type C and Type D)**				**P**
Model: SG250HX					
Inductive supply reactive power					
Rating voltage [%]	Active power [kW]	Reactive Power [kVar]	Q/Pn [%]	Power factor [cos φ]	Voltage [V]
100%	198.480	151.069	67.14	0.801	804.4
99%	198.075	150.953	67.09	0.800	796.3
98%	190.239	150.771	67.01	0.796	788.4
97%	191.946	150.803	67.02	0.791	780.4
96%	188.906	150.563	66.92	0.786	772.5
95%	185.732	150.330	66.81	0.781	764.5
94%	182.388	150.327	66.81	0.775	756.6
93%	179.013	150.236	66.77	0.769	748.5
92%	175.869	149.911	66.63	0.764	740.5
91%	172.321	150.044	66.69	0.757	732.6
90%	169.112	149.818	66.59	0.748	724.6
87.5%	160.807	149.675	66.52	0.734	704.7
100%	198.480	151.069	67.14	0.801	804.4
101%	198.623	151.029	67.12	0.801	812.4
102%	198.470	151.255	67.22	0.800	820.3
103%	200.965	152.914	67.96	0.798	821.8
104%	198.510	151.285	67.24	0.801	836.2
105%	194.540	151.318	67.25	0.794	844.2
106%	196.015	151.176	67.19	0.797	852.3
107%	198.614	151.311	67.25	0.801	860.2
108%	226.694	89.857	39.94	0.926	864.8
109%	226.289	89.635	39.84	0.926	872.9
110%	225.807	89.332	39.70	0.926	880.7
Capacitive supply reactive power					
Rating voltage [%]	Active power [kW]	Reactive Power [kVar]	Q/Pn [%]	Power factor [cos φ]	Voltage [V]
100%	195.997	-152.584	67.82	0.791	797.8
99%	193.218	-152.354	67.71	0.787	789.6
98%	190.034	-152.321	67.70	0.782	781.6
97%	186.766	-152.277	67.68	0.777	773.6
96%	183.467	-152.179	67.64	0.771	765.6
95%	180.208	-151.990	67.55	0.766	757.5
94%	176.761	-152.002	67.56	0.759	749.5
93%	173.253	-151.919	67.52	0.753	741.3
92%	169.891	-151.837	67.48	0.747	733.3
91%	166.447	-151.841	67.48	0.740	725.3
90%	163.623	-151.556	67.36	0.731	717.6

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

87.5%	154.624	-151.792	67.46	0.714	697.1
100%	195.997	-152.584	67.82	0.791	797.8
101%	199.384	-152.799	67.91	0.796	805.8
102%	201.134	-152.724	67.88	0.799	813.8
103%	200.996	-152.867	67.94	0.798	821.8
104%	201.064	-152.860	67.94	0.798	829.8
105%	201.148	-152.751	67.89	0.799	837.8
106%	196.677	-152.769	67.90	0.792	846.0
107%	201.002	-152.912	67.96	0.798	854.0
108%	226.598	-91.824	40.81	0.925	864.5
109%	226.136	-91.534	40.68	0.925	872.6
110%	225.883	-91.365	40.61	0.925	880.4

Note:
The PV inverter maximum reactive power set point Q more than 33%Pn.

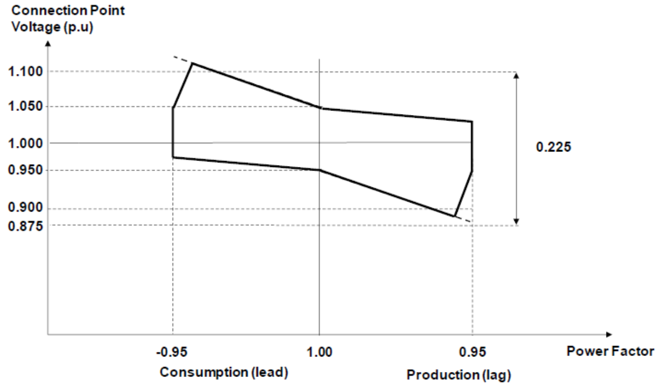


Figure 13.11 Reactive Power capability requirements (Power Park Modules operating at Registered Capacity, voltage above 33 kV)

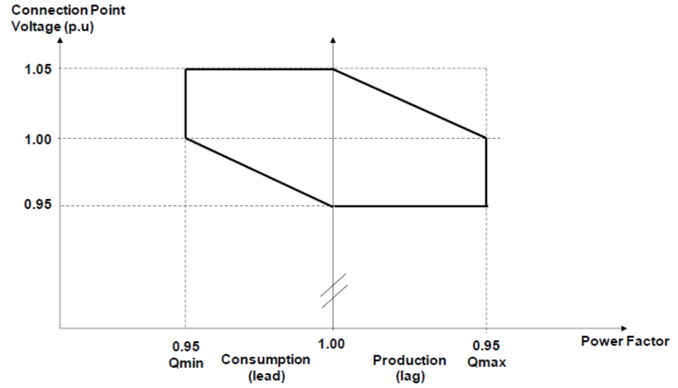


Figure 13.12 Reactive Power capability requirements (Power Park Modules operating at Registered Capacity, voltage at or below 33 kV)

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

13.5.6	**TABLE: Reactive Power capability requirements – Q setpoint mode (For Type C and Type D)**				**P**
Model: SG250HX					
Inductive supply reactive power					
Rating power [%]	Active power [kW]	Reactive Power [kVar]	Q/Pn [%]	Power factor [cos φ]	Voltage [V]
10%	21.960	148.187	65.86	0.147	800.4
20%	44.497	147.923	65.74	0.288	800.5
30%	67.033	147.789	65.68	0.413	800.5
40%	89.581	147.799	65.69	0.519	800.5
50%	111.989	147.947	65.75	0.605	800.6
60%	133.146	148.171	65.85	0.670	800.7
70%	155.586	148.608	66.05	0.725	800.7
80%	177.912	148.988	66.22	0.770	800.8
90%	203.130	140.284	62.35	0.829	800.8
100%	224.063	96.783	43.01	0.914	800.8
Capacitive supply reactive power					
Rating power [%]	Active power [kW]	Reactive Power [kVar]	Q/Pn [%]	Power factor [cos φ]	Voltage [V]
10%	23.410	-147.756	65.67	0.157	799.9
20%	45.665	-147.872	65.72	0.295	799.9
30%	68.126	-148.114	65.83	0.418	800.0
40%	90.612	-148.283	65.90	0.522	800.0
50%	113.050	-148.516	66.01	0.606	800.1
60%	135.544	-148.838	66.15	0.674	800.2
70%	157.969	-149.057	66.25	0.728	800.2
80%	180.104	-149.519	66.45	0.771	800.3
90%	202.295	-140.281	62.35	0.825	800.3
100%	224.197	-98.751	43.89	0.913	800.5
Note: The PV inverter maximum reactive power set point Q more than 33%Pn.					

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

13.5 C.7.4	**TABLE: Voltage Control and Reactive power Stability (For Type C and Type D)**				**P**
Model: SG250HX					
Inductive supply reactive power(100%Pn)					
Rating Voltage [%]	Active power [kW]	Reactive Power [kVar]	Q/Pn [%]	Power factor [cos φ]	Voltage [V]
100%	225.763	-0.326	0	1.000	800.8
(i) 95%	224.915	70.099	31.11	0.953	760.5
(iii) 93%	218.747	72.725	32.32	0.947	744.4
Capacitive supply reactive power(100%Pn)					
Rating Voltage [%]	Active power [kW]	Reactive Power [kVar]	Q/Pn [%]	Power factor [cos φ]	Voltage [V]
100%	225.674	-0.272	0	1.000	800.8
(ii) 105%	222.117	-74.184	32.97	0.947	840.9
(iv)107%	219.491	-74.174	32.97	0.946	856.8

Note:
For step injection into the **Power Park Module** voltage Setpoint, steps of ±1% and ±2% (or larger if required by the **DNO**) shall be applied to the voltage control system Setpoint summing junction. The injection shall be maintained for 10 s as per Figure C.9.2.
The PV inverter maximum reactive power set point Q = 33%Pn.

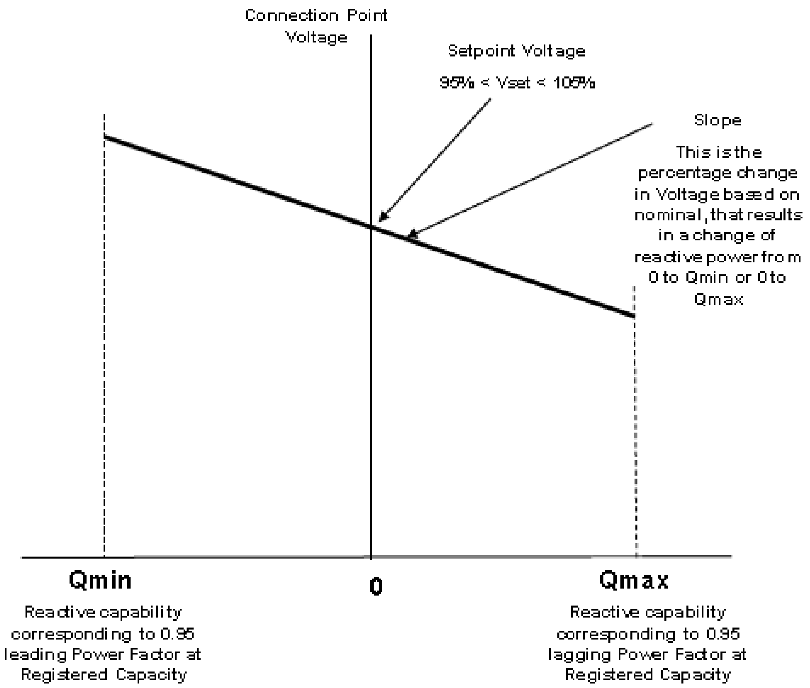


Figure C.5.1 Setpoint Voltage and Slope Characteristic

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

13.5 C.9.3	**TABLE: Reactive power output capability (For Type C and Type D)**				**P**
Model: SG250HX					
Power level [%]	Active power [kW]	Reactive Power [kVar]	Q/Pn [%]	Power factor [cos φ]	Duration [mins]
i.60%	132.535	150.187	66.75	0.663	30
ii.60%	136.242	-149.485	66.44	0.674	30
iii.50%	111.102	149.757	66.56	0.596	30
iv.50%	112.838	-149.468	66.43	0.603	30
v.20%	46.414	-149.165	66.30	0.297	60
vi.20%	43.658	149.493	66.44	0.280	60
vii.<20%	20.261	149.719	66.54	0.134	5
viii.0%	5.483	-149.043	66.24	0.037	5
ix.0%	1.878	149.743	66.55	0.013	5

Note:

(i) Operation in excess of 60% **Registered capacity** and maximum continuous lagging **Reactive Power** for 30 minutes.
(ii) Operation in excess of 60% **Registered capacity** and maximum continuous leading **Reactive Power** for 30 minutes.
(iii) Operation at 50% **Registered capacity** and maximum continuous leading **Reactive Power** for 30 minutes.
(iv)Operation at 50% **Registered capacity** and maximum continuous lagging **Reactive Power** for 30 minutes.
(v) Operation at 20% **Registered capacity** and maximum continuous leading **Reactive Power** for 60 minutes.
(vi) Operation at 20% **Registered capacity** and maximum continuous lagging **Reactive Power** for 60 minutes.
(vii) Operation at less than 20% **Registered capacity** and unity **Power Factor** for 5 minutes. This test only applies to systems which do not offer voltage control below 20% of **Registered capacity**.
(viii) Operation at the lower of the **Minimum Generation** or 0% **Registered capacity** and maximum continuous leading **Reactive Power** for 5 minutes. This test only applies to systems which offer voltage control below 20% and hence establishes actual capability rather than required capability.
(ix) Operation at the lower of the **Minimum Generation** or 0% **Registered capacity** and maximum continuous lagging **Reactive Power** for 5 minutes. This test only applies to systems which offer voltage control below 20% and hence establishes actual capability rather than required capability.

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

C.7.8.2	**TABLE: Voltage and Frequency Controller Model Verification and Validation (For Type C and Type D)**				**P**
Model: SG250HX					
Test (80%Pn)					
Frequency [Hz]	Active power [kW]	Reactive Power [kVar]	Q/Pn [%]	Power factor [cos φ]	Time [s]
50.0	179.899	0.986	0.44	0.999	10
50.0->49.5	179.894	0.930	0.41	0.999	10
49.5	179.893	0.888	0.39	0.999	20
49.5->49.8	179.899	0.914	0.41	0.999	30
49.8	179.912	0.940	0.42	0.999	60
49.8->50.0	179.906	0.956	0.42	0.999	10

Note:
Power Park Module operating at 80% of **Registered Capacity**.
(i) a ramped reduction in the measured system frequency of 0.5Hz in 10 s followed by
(ii) 20 s of steady state with the measured system frequency depressed by 0.5Hz followed by
(iii) a ramped increase in measured system frequency of 0.3Hz over 30 s followed by
(iv) 60 s of steady state with the measured system frequency depressed by 0.2Hz as illustrated in Figure C.7.4 below.

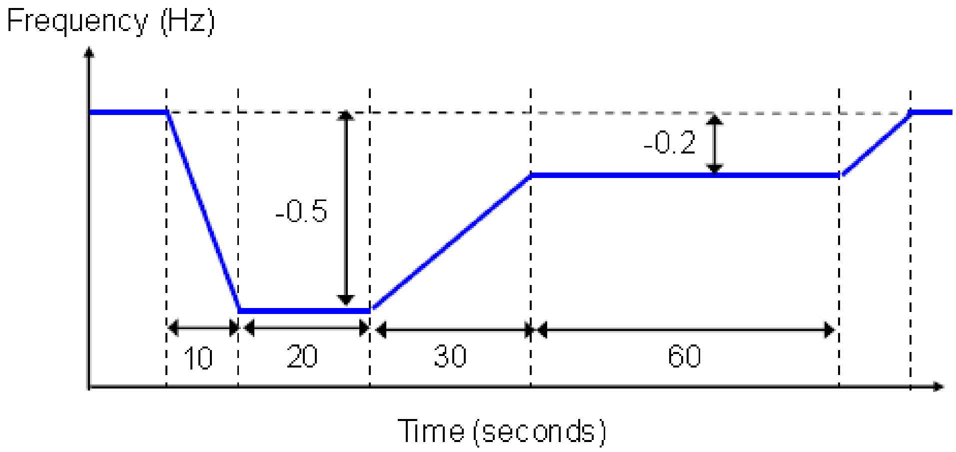


Figure C.7.4 Controller simulation

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

C.7.8.4	**TABLE: Voltage and Frequency Controller Model Verification and Validation (For Type C and Type D)**				**P**
Model: SG250HX					
Test (100%Pn)					
Rated Voltage [%]	Active power [kW]	Reactive Power [kVar]	Q/Pn [%]	Power factor [cos φ]	Voltage [V]
100%	225.871	1.764	0.78	0.999	800.7
102%	225.810	1.684	0.75	0.999	816.6
104%	225.739	1.608	0.71	0.999	832.5
106%	225.667	1.524	0.68	0.999	848.6
108%	225.335	1.441	0.64	0.999	864.5
110%	224.709	1.369	0.61	0.999	874.4
Note: the **Power Park Module** operating at **Registered Capacity** and unity **Power Factor** at the **Connection Point** to a 2% step increase in the voltage reference. The simulation study shall show the terminal voltage, **Active Power**, **Reactive Power** and **Power System Stabiliser** output signal as appropriate.					

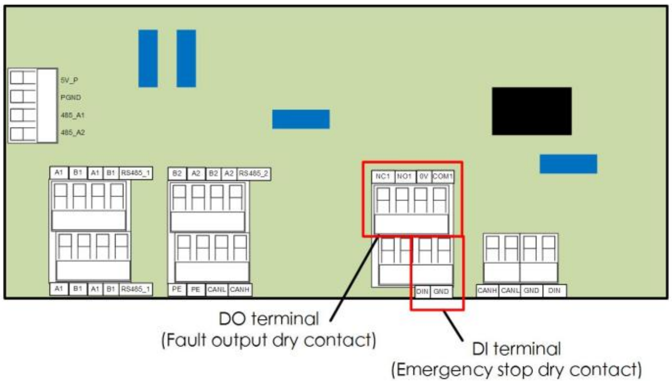
10. Protection – Re-connection timer					**P**
Model: SG250HX					
Test should prove that the reconnection sequence starts after a minimum delay of 20 s for restoration of voltage and frequency to within the stage 1 settings of Table 10.1. Both the time delay setting and the measured delay should be provided in this form; both should be greater than 20 s to pass. Confirmation should be provided that the **Power Generating Module** does not reconnect at the voltage and frequency settings below; a statement of “no reconnection” can be made.					
Time delay setting	Measured delay	Checks on no reconnection when voltage or frequency is brought to just outside stage 1 limits of Table 10.1.			
60 s	60.8 s	At 1.16 pu (266.2 V **LV** connection, 127.6 V **HV** connection assuming 110 Vph-ph VT)	At 0.78 pu (180.0 V **LV** connection, 85.8 V **HV** connection assuming 110 V ph-ph VT)	At 47.4 Hz	At 52.1 Hz
Confirmation that the **Power Generating Module** does not re-connect.		No Reconnection	No Reconnection	No Reconnection	No Reconnection

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict

Fault level contribution:		**P**
These tests shall be carried out in accordance with EREC G99 Annex A.7.1.5. Please complete each entry, even if the contribution to the fault level is zero.		
Model: SG250HX		
For Inverter output		
Time after fault	Volts	Amps
20ms	153.8 V	20.8 A
100ms	53.7 V	0.9 A
250ms	32.1 V	0.5 A
500ms	19.5 V	0.1 A
Time to trip	0.05	In seconds

12.7/13.9 Self-Monitoring solid state switching: No specified test requirements. Refer to Annex A.7.1.7.	
It has been verified that in the event of the solid state switching device failing to disconnect the **Power Park Module**, the voltage on the output side of the switching device is reduced to a value below 50 volts within 0.5 s.	N/A
15.2 Wiring functional tests: If required by para 15.2.1.	
Confirm that the relevant test schedule is attached (tests to be undertaken at time of commissioning)	N/A
11.1.3.1/12.1.3.1/ 13.1.3.1Logic interface (input port).	
Confirm that an input port is provided and can be used to shut down the module.	P
9.1.7 Cyber security	
Confirm that the Power Generating Module has been designed to comply with cyber security requirements, as detailed in 9.1.7.	P
Additional comments.	
Logic Interface: The dry contact can be configured to control the inverter to normal or shutdown active power of output. The DI terminal (logic interface) is provided that can be operated by an external switch or contactor. Users can install by themselves. When the DI contact and GND contact are shorted by external controlled switch, the inverter will cease to export active power within 5 seconds. The following figure shows the typical application of local stop dry contact.	

G99/1-8			
Clause	Requirement - Test	Result - Remark	Verdict



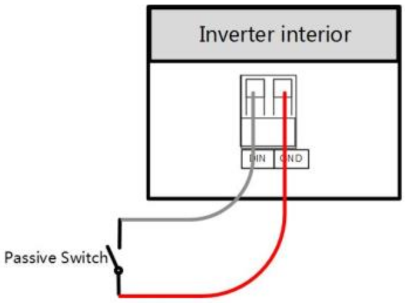
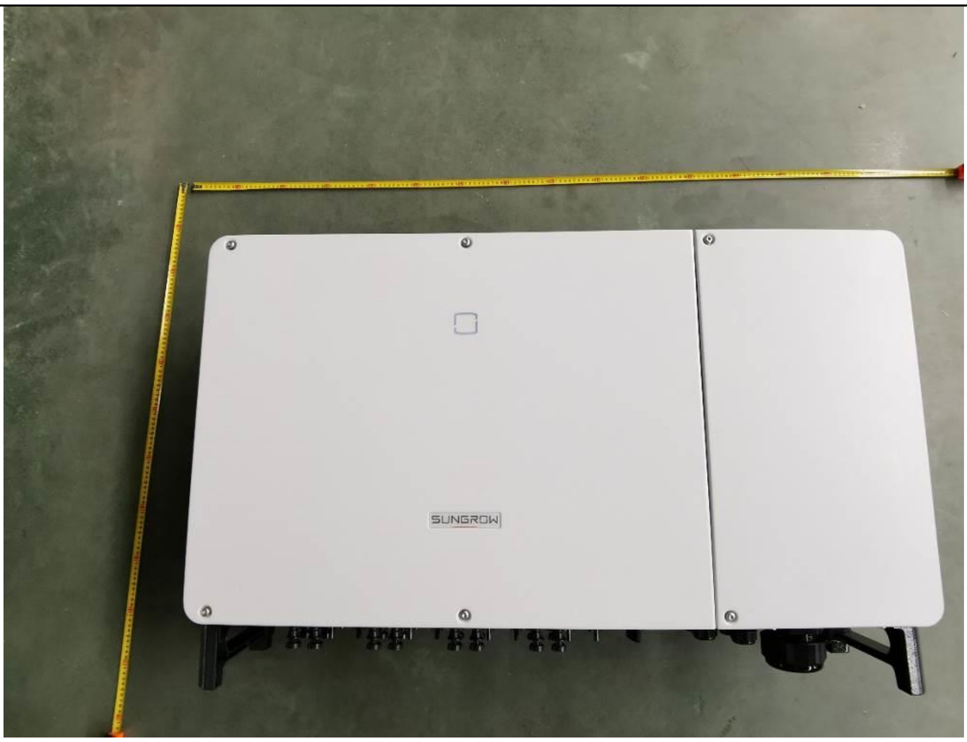


figure 5-9 Local Stop Contact

Appendix 2: Photo documentation

Enclosure Front View



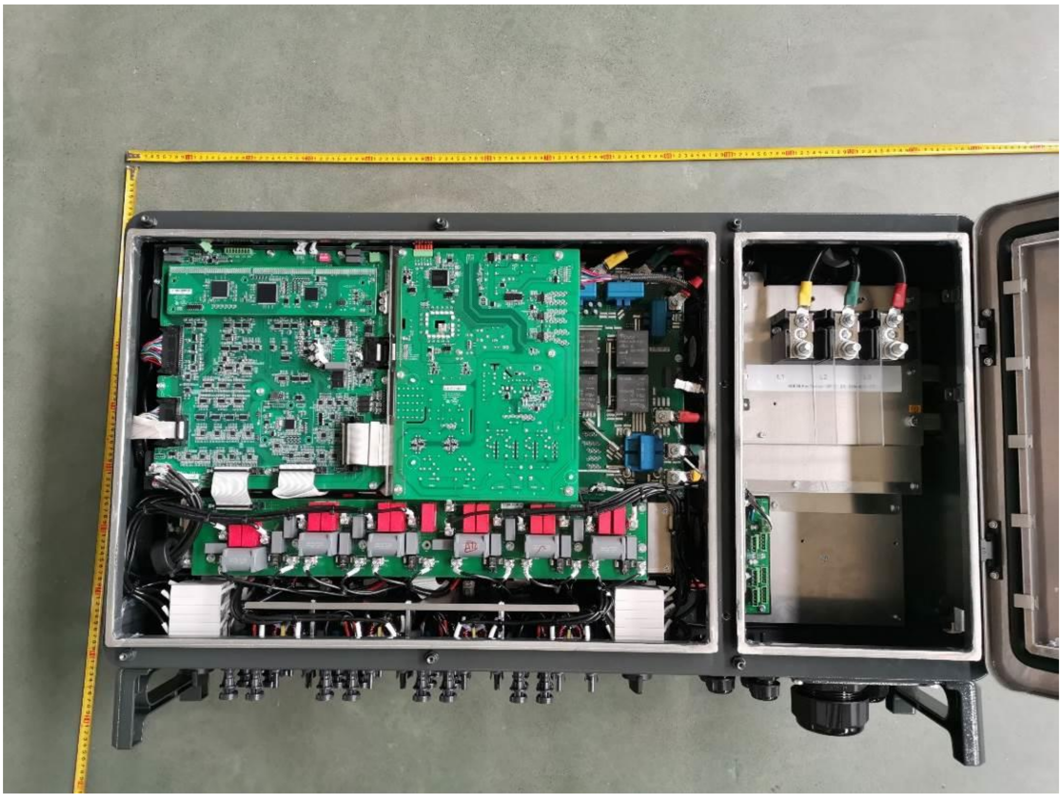
Enclosure Rear View

Enclosure Left Side View

Enclosure Right Side View


Enclosure Top Side View

Enclosure Bottom Side View


Internal View


--- End of test report---