TEST REPORT

Engineering recommendation G99/1

Requirements for the connection of generation equipment in parallel with public Low Voltage Distribution Networks.

Report reference number.............. :	**SGR-ESH-P19121001-2**
Date of issue.................................... :	2020-01-22
Total number of pages..................... :	86
Testing laboratory name .... :	**Bureau Veritas LCIE China Company Limited**
Address.. :	Building 4, No. 518, Xinzhuan Road, Caohejing Songjiang High-Tech Park, Shanghai, P.R. China (201612)
Applicant's name .... :	**SUNGROW POWER SUPPLY CO., LTD**
Address.. :	No,1699 Xiyou Rd, New & High Technology Industrial Development Zone, Hefei, 230088 P,R, China,
Test specification	
Standard .... :	G99 Issue 1 Amendment 5: 2019
Certificate .... :	N/A
Test report form number. .... :	TEST REPORT G99/1 VER.0
Master TRF...................................... :	Bureau Veritas Consumer Products Services Germany GmbH
Test item description..................... :	**Grid-tied photovoltaic inverter**
Trademark.. :	SUNGROW
Model / Type .... :	SG33CX, SG40CX, SG50CX

Ratings.. :	SG33CX	SG40CX	SG50CX
Input DC voltage range [V] .... :	MPPT: 200-1000, 1100(Max.)		
Input DC current [A] .... :	26(Max.)*3	26(Max.)*4	26(Max.)*5
Output AC voltage [V] .... :	3/N/PE,400/230, 50Hz/60Hz		
Max. Output AC current [A].............. :	55,2	66,9	83,6
Rated output power [kW] .... :	33	40	50

Testing Location	**Wuxi institute of supervision & testing on product quality.**
Address	No.8 Chun Xin Road, Dong Ting, Wuxi, Jiangsu P.R.CHINA
Tested by (name and signature)	Tony Huang Test engineer
Approved by (name and signature)	Harvey Wang Project Manager
Manufacturer's name	**SUNGROW POWER SUPPLY CO., LTD**
Factory address	No.1699 Xiyou Rd, New & High Technology Industrial Development Zone, Hefei, 230088 P.R.China.
Factory's name 1	**SUNGROW POWER SUPPLY CO.,LTD**
Factory address	No. 608 Changning Avenue, New & High Technology Industrial Development Zone, Hefei 230088 P.R. China
Factory's name 2	**Sungrow Developers (India) Private Limited**
Factory address	No. 85, Kaniminike village, Kengeri hobli Bangalore South Taluk, 560074 Bangalore, India

Document History			
Date	**Internal reference**	**Modification / Change / Status**	**Revision**
2020-01-22	Tony Huang	Initial report was written	0
Supplementary information:			

Test items particulars

Equipment mobility ....:	Permanent connection
Operating condition ....:	Continuous
Class of equipment..........................:	Class I
Protection against ingress of water ..:	IP66 according to EN 60529
Mass of equipment [kg] ....:	50kg for SG33CX 58kg for SG40CX 62kg for SG50CX

Test case verdicts

Test case does not apply to the test object ....:	N/A
Test item does meet the requirement ....:	P(ass)
Test item does not meet the requirement ....:	F(ail)

Testing

Date of receipt of test item ....:	2019-10-12
Date(s) of performance of test..........:	2019-10-12 to 2020-01-21

General remarks:

The test result presented in this report relate only to the object(s) tested. The report shall state compliance of the tested objects with the Type B, Type C requirements of G99-1. This report must not be reproduced in part or in full without the written approval of the issuing testing laboratory.

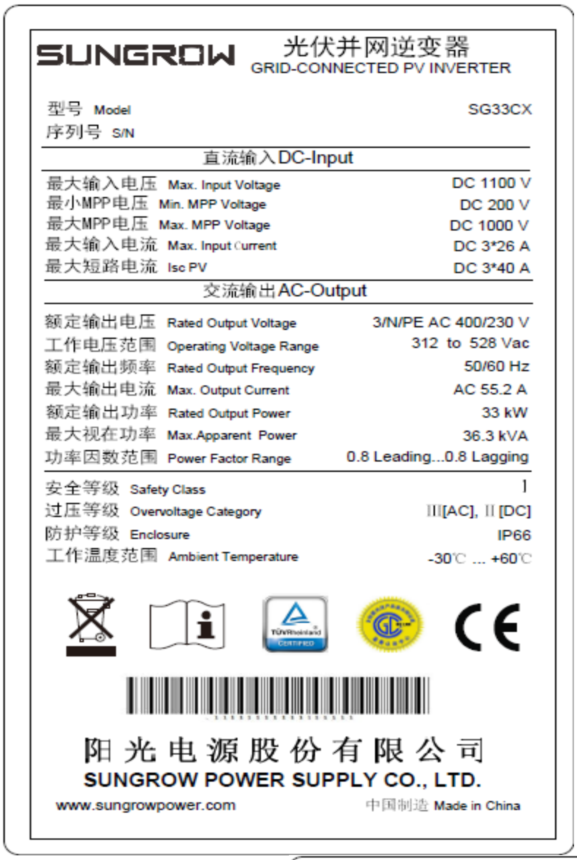
"(see Annex #)" refers to additional information appended to the report.
"(see appended table)" refers to a table appended to the report.

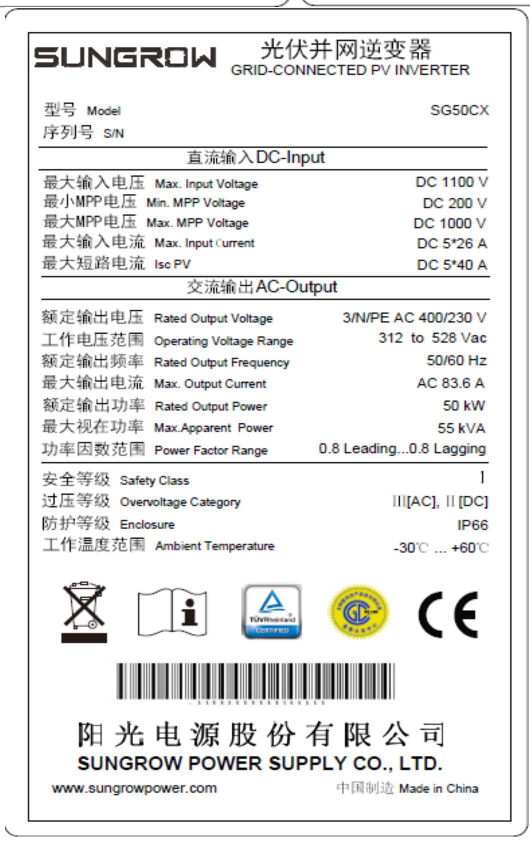
Throughout this report a comma is used as the decimal separator.

This Test Report consists of the following documents:

1. Test Results
2. Annex No. 1 – EMC Test Report
3. Annex No. 2 – Pictures of the unit
4. Annex No. 3 – Test equipment list

Copy of marking plate





General product information:

The Solar converter converts DC voltage into AC voltage.

The input and output are protected by varistors to earth. The unit is providing EMC filtering at the input and output towards mains. The output is switched off redundant by the high power switching bridge and two relay in series. This assures that the opening of the output circuit will also operate in case of one error.

Differences of the models:

Model	SG33CX	SG40CX	SG50CX
No. of independent MPPT inputs	3	4	5
Rate output power	33	40	50

Hardware:

Model	SG33CX	SG40CX	SG50CX
Hardware	SG33CX	SG40CX	SG50CX

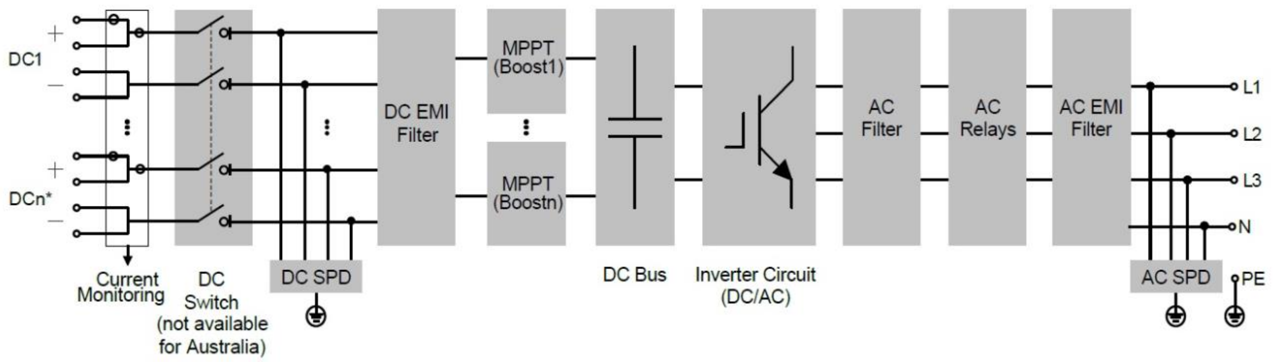
Software:

Model	SG33CX	SG40CX	SG50CX
LCD	LCD_AGATE-S_V11_V01_A		
MDSP	MDSP_AGATE-S_V11_V01_A		

Description of the electrical circuit:

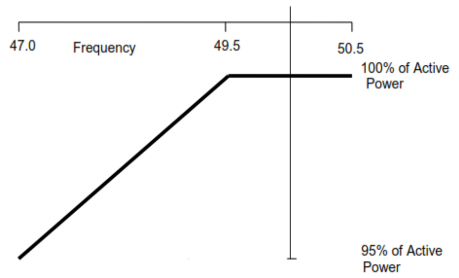
The internal control is redundant built, It consists of master controller(U2) and slave controller(U1), the master controller(U2) can control relays, measures voltage, frequency, AC current with injected DC, insulation resistance and residual current. The slave controller (U1)can control the relays, measures the voltage and frequency. Both controllers communicate with each other.
The voltage and frequency measurement is achieved with resistors in serial which are connected directly to line and neutral. Both controllers get these signals and calculate the data.
The unit provides two relays in series in each phase. The relays are tested before each start up. In addition the power bridge can be stopped by both controllers.

Block diagram of the utility interactive inverter:



Engineering recommendation G99-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
11	**Type A Power Generating Module Technical Requirements**		
11.1	**Power Generating Module Performance and Control Requirements – General**		**P**
11.1.1	The requirements of this Section 11 do not apply in full to: (a) Power Generation Facilities that are designed and installed for infrequent short-term parallel operation only; or (b) Electricity Storage Power Generation Modules within the Power Generating Facility. Refer to Annex A.4 for details.	See test report: SGR-ESH-P19121001-1	**P**
11.1.2	The Active Power output of a Power Generating Module should not be affected by voltage changes within the statutory limits declared by the DNO in accordance with the ESQCR.	See test report: SGR-ESH-P19121001-1	**P**
11.1.3	Power Generating Modules connected to the DNO's Distribution Network shall be equipped with a logic interface (input port) in order to cease Active Power output within 5 s following an instruction being received at the input port.	See test report: SGR-ESH-P19121001-1	**P**
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.		**P**
11.1.4	Each item of a Power Generating Module and its associated control equipment shall be designed for stable operation in parallel with the Distribution Network.		**P**
11.1.5	When operating at rated power the Power Generating Module shall be capable of operating at a Power Factor within the range 0,95 lagging to 0,95 leading relative to the voltage waveform unless otherwise agreed with the DNO.	See test report: SGR-ESH-P19121001-1	**P**
11.1.6	As part of the connection application process the Generator shall agree with the	See test report: SGR-ESH-P19121001-1	**P**

Engineering recommendation G99-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	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.		
11.1.7	Load flow and System Stability studies may be necessary to determine any output constraints or post fault actions necessary for n-1 fault conditions and credible n-2 conditions (where n-1 and n-2 conditions are the first and second outage conditions as, for example, specified in EREC P2) involving a mixture of fault and planned outages. The Connection Agreement should include details of the relevant outage conditions. It may be necessary under these fault conditions, where the combination of Power Generating Module output, load and through flow levels leads to circuit overloading, to rapidly disconnect or constrain the Power Generating Module.	See test report: SGR-ESH-P19121001-1	**P**
11.2	**Frequency response**		**P**
11.2.1	Under abnormal conditions automatic low-frequency load-shedding provides for load reduction down to 47 Hz. In exceptional circumstances, the frequency of the DNO's Distribution Network could rise above 50.5 Hz. Therefore all Power Generating Modules should be capable of continuing to operate in parallel with the Distribution Network in accordance with the following: (a) 47 Hz – 47.5 Hz Operation for a period of at least 20 s is required each time the frequency is within this range. (b) 47.5 Hz – 49.0 Hz Operation for a period of at least 90 minutes is required each time the frequency is within this range. (c) 49.0 Hz – 51.0 Hz Continuous operation of the Power Generating Module is required. (d) 51.0 Hz –51.5 Hz Operation for a period of at least 90 minutes is required each time the frequency is within this range. (e) 51.5 Hz – 52 Hz Operation for a period of at least 15 minutes is required each	See test report: SGR-ESH-P19121001-1	**P**

Engineering recommendation G99-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	time the frequency is within this range.		
11.2.2	With regard to the rate of change of frequency withstand capability, a Power Generating Module shall be 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 unless disconnection was triggered by a rate of change of frequency type loss of mains protection or by the Power Generating Module's own protection system for a co-incident internal fault as detailed in paragraph 10.6.18.	See test report: SGR-ESH-P19121001-1	**P**
11.2.3	**Output power with falling frequency**		**P**
11.2.3.1	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 11.2.1) maintaining its Active Power output at a level not lower than the figure determined by the linear relationship shown in Figure 11.1 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%. 	See test report: SGR-ESH-P19121001-1	**P**
11.2.3.2	For the avoidance of doubt in the case of a Power Generating Module using an Intermittent Power Source where the power input will not be constant over time, the requirement is that the Active Power output shall be independent of system frequency under (a) above and should not drop with system frequency by greater than the amount specified in (b) above.	See test report: SGR-ESH-P19121001-1	**P**
11.2.4	**Limited Frequency Sensitive Mode – Over frequency**		**P**
11.2.4.1	Each Power Generating Module shall be	See test report: SGR-ESH-	**P**

Engineering recommendation G99-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	capable of reducing Active Power output in response to frequency on the Total System when this rises above 50.4 Hz. The Power Generating Module shall be capable of operating stably during LFSMO operation. If a Power Generating Module has been contracted to operate in Frequency Sensitive Mode the requirements of LFSM-O shall apply when frequency exceeds 50.5 Hz. (a) The rate of change of Active Power output shall be at a minimum a rate of 2% of output per 0.1 Hz deviation of system frequency above 50.4 Hz (ie a Droop of 10%) as shown in Figure 11.2. For the avoidance of doubt, this would not preclude a Generator from designing the Power Generating Module with a Droop of less than 10%, but in all cases the Droop should be 2% or greater. (b) The Power Generating Module shall be capable of initiating a power frequency response with an initial delay that is as short as possible. If the initial delay exceeds 2 s the Generator shall justify the delay, providing technical evidence to the DNO, who will pass this evidence to the NETSO. (c) For deviations in frequency up to 50.9 Hz at least half of the proportional reduction in Active Power output shall be achieved within 10 s of the time of the frequency increase above 50.4 Hz. (d) For deviations in frequency beyond 50.9 Hz the measured rate of change of Active Power reduction shall exceed 0.5% s^{-1} of the initial output. (e) The LFMS-O response shall be reduced when the frequency subsequently falls again and, when to a value less than 50.4 Hz, at least half the proportional increase in Active Power shall be achieved in 10 s. For a frequency excursion returning from beyond 50.9 Hz the measured rate of change Active Power increase shall t exceed 0.5% s^{-1}. (f) If the reduction in Active Power is such that the Power Generation Module reaches its Minimum Stable Operating Level, it shall continue to operate stably at this level.	P19121001-1	

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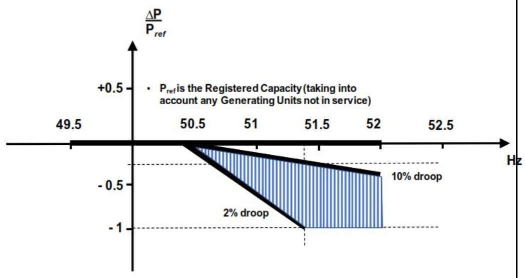
Clause	Requirement – Test	Result – Remark	Verdict
	 Pref is the reference Active Power to which ΔP is related and. ΔP is the change in Active Power output from the Power Generating Module. Figure 11.2 Active Power Frequency Response capability when operating in LFSM-O		
11.2.4.2	When the Power Generating Module is providing Limited Frequency Sensitive Mode Over frequency (LFSM-O) response it shall continue to provide the frequency response until the frequency has returned to, or is below, 50.4 Hz.	See test report: SGR-ESH-P19121001-1	**P**
11.2.4.3	Steady state operation below Minimum Stable Operating Level is not expected but if system operating conditions cause operation below Minimum Stable Operating Level which give rise to operational difficulties then the Generator shall be able to return the output of the Power Generating Module to an output of not less than the Minimum Stable Operating Level.	See test report: SGR-ESH-P19121001-1	**P**
11.3	**Fault Ride Through and Phase Voltage Unbalance**		**N/A**
11.3.1	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.	Rely on the agreement with the DNO.	**N/A**
11.3.2	In the case of phase to phase faults on the DNO's Distribution Network that are cleared by system back-up protection	Rely on the agreement with the DNO.	**N/A**

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Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	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.		
11.4	**Voltage Limits and Control**		**N/A**
11.4.1	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, subject to design appraisal of individual installations.	Rely on the agreement with the DNO.	**N/A**
11.4.2	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.	Rely on the agreement with the DNO.	**N/A**
11.4.3	The final responsibility for control of Distribution Network voltage does however remain with the DNO.	Rely on the agreement with the DNO.	**N/A**
11.4.4	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.	Rely on the agreement with the DNO.	**N/A**

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Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
11.4.5	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.	Rely on the agreement with the DNO.	**N/A**
12	**Type B Power Generating Module Technical Requirements**		
12.1	**Power Generating Module Performance and Control Requirements – General**		**P**
12.1.1	The requirements of this Section 12 do not apply in full to:		
	a) Power Generation Facilities that are designed and installed for infrequent short-term parallel operation only; or	Considered.	**P**
	(b) Electricity Storage Power Generation Modules within the Power Generating Facility.	Considered.	**P**
12.1.2	The Active Power output of a Power Generating Module should not be affected by voltage changes within the statutory limits declared by the DNO in accordance with the ESQCR.	Considered.	**P**
12.1.3	Power Generating Modules shall be equipped with a communication interface (input port) in order to be able to reduce Active Power output following an instruction at the input port.	Considered.	**P**
12.1.3.1	DNOs currently are developing active network management approaches and there is no common standard for communication interfaces	Considered.	**P**
12.1.3.2	Protocols currently in use between **DNO**s and **Generator**s include simple current loop; DNP3 and IEC 61850	Considered.	**P**
12.1.3.3	The **DNO** will discuss and agree with the **Generator** for each **Power Generating Facility** the protocol to be used, including how any risks of maloperation etc are to be managed.	Considered.	**P**
12.1.3.4	By default if nothing is specified by the **DNO** then a simple hard-wired current loop interface should be provided where a 4 mA to 20 mA DC signal corresponding to 0 pu to 1.0 pu of **Registered Capacity Active Power**.	Considered.	**P**

Engineering recommendation G99-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
12.1.3.5	The Active Power reduction will be either between 1.0 pu 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.	Considered.	**P**
12.1.3.6	If the DNO wishes to make use of the facility to reduce Active Power output the DNO will agree with the Generator the communication interface and other necessary equipment that will be needed.	Considered.	**P**
12.1.4	The **Power Generating Module** and its associated control equipment shall be designed for stable operation in parallel with the **Distribution Network**		**P**
12.1.5	Load flow and System Stability studies may be necessary to determine any output constraints or post fault actions necessary for n-1 fault conditions and credible n-2 conditions (where n-1 and n-2 conditions are the first and second outage conditions as, for example, specified in EREC P2) involving a mixture of fault and planned outages. The Connection Agreement should include details of the relevant outage conditions. It may be necessary under these fault conditions, where the combination of **Power Generating Module** output, load and through flow levels leads to circuit overloading, to rapidly disconnect or constrain the **Power Generating Module**.		**P**
12.2	**Frequency response**		**P**
12.2.1	Under abnormal conditions automatic low-frequency load-shedding provides for load reduction down to 47 Hz. In exceptional circumstances, the frequency of the DNO's Distribution Network could rise above 50.5 Hz. Therefore all Power Generating Modules should be capable of continuing to operate in parallel with the Distribution Network in accordance with the following:	Considered. See appended test table.	**P**
	(a) 47 Hz – 47.5 Hz Operation for a period of at least 20 s is required each time the frequency is within this range.		**P**
	(b) 47.5 Hz – 49.0 Hz Operation for a		**P**

Engineering recommendation G99-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	period of at least 90 minutes is required each time the frequency is within this range.		
	(c) 49.0Hz – 51.0 Hz Continuous operation of the Power Generating Module is required.		**P**
	(d) 51.0 Hz –51.5 Hz Operation for a period of at least 90 minutes is required each time the frequency is within this range.		**P**
	(e) 51.5 Hz – 52 Hz Operation for a period of at least 15 minutes is required each time the frequency is within this range.		**P**
12.2.2	With regard to the rate of change of frequency withstand capability, a Power Generating Module shall be capable of staying connected to the Distribution Network and operate at rates of change of frequency up to 1 Hz/s as measured over a period of 500 ms unless disconnection was triggered by a rate of change of frequency type loss of mains protection or by the Power Generating Module's own protection system for a co-incident internal fault as detailed in paragraph 10.6.18.	Considered. See appended test table.	**P**
12.2.3	Output power with falling frequency	Considered. See appended test table.	**P**
12.2.3.1	Each Power Generating Module, shall be capable of:		**P**
	(a) continuously maintaining constant Active Power output for system frequency changes within the range 50.5 to 49.5 Hz; and		**P**
	(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%.		**P**

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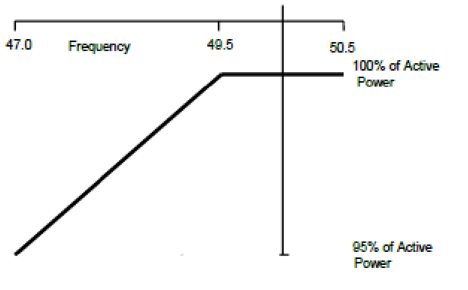
Clause	Requirement – Test	Result – Remark	Verdict
	 Figure 12.1 Change in Active Power with falling frequency		
12.2.3.2	For the avoidance of doubt in the case of a **Power Generating Module** using an **Intermittent Power Source** where the power input will not be constant over time, the requirement is that the **Active Power** output shall be independent of system frequency under (a) above and should not drop with system frequency by greater than the amount specified in (b) above.		**P**
12.2.4	Limited Frequency Sensitive Mode – Over frequency	Considered. See appended test table.	**P**
12.2.4.1	Each Power Generating Module shall be capable of reducing Active Power output in response to frequency on the Total System when this rises above 50.4 Hz. The Power Generating Module shall be capable of operating stably during LFSMO operation. If a Power Generating Module, has been contracted to operate in Frequency Sensitive Mode the requirements of LFSM-O shall apply when frequency exceeds 50.5 Hz.		**P**
	(a) The rate of change of Active Power output shall be at a minimum a rate of 2% of output per 0.1 Hz deviation of system frequency above 50.4 Hz (ie a Droop of 10%) as shown in Figure 12.2. For the avoidance of doubt, this would not preclude a Generator from designing the Power Generating Module with a Droop of less than 10%, but in all cases the Droop should be 2% or greater.	Considered.	**P**
	(b) The Power Generating Module shall be capable of initiating a power frequency response with an initial delay that is as short as possible. If the initial delay exceeds 2 s the Generator shall justify the delay, providing technical evidence to the DNO, who will pass this evidence to the NETSO.	Considered.	**P**
	(c) For deviations in frequency up to 50.9 Hz at least half of the proportional reduction in **Active**	Considered.	**P**

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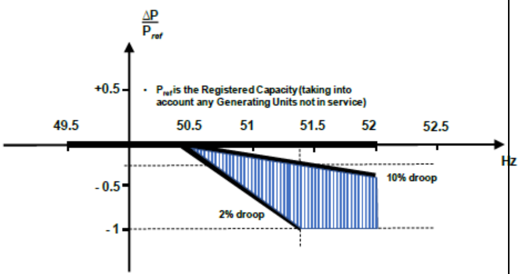
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	Power output shall be achieved within 10 s of the time of the frequency increase above 50.4 Hz.		
	(d) For deviations in frequency beyond 50.9 Hz the measured rate of change of **Active Power** reduction shall exceed 0.5% s^{-1} of the initial output.	Considered.	**P**
	(e) The LFMS-O response shall be reduced when the frequency subsequently falls again and, when to a value less than 50.4 Hz, at least half the proportional increase in Active Power shall be achieved in 10 s. For a frequency excursion returning from beyond 50.9 Hz the measured rate of change Active Power increase shall exceed 0.5% s-1.	Considered.	**P**
	(f) If the reduction in Active Power is such that the Power Generation Module reaches its Minimum Stable Operating Level, it shall continue to operate stably at this level.  	Considered.	**P**
12.2.4.2	Steady state operation below Minimum Stable Operating Level is not expected but if system operating conditions cause operation below Minimum Stable Operating Level which give rise to operational difficulties then the Generator shall be able to return the output of the Power Generating Module to an output of not less than the Minimum Stable Operating Level.	Considered.	**P**
12.3	**Fault Ride Through and Phase Voltage** Unbalance		**P**
12.3.1	Paragraphs 12.3.1.1 to 12.3.1.7 inclusive set out the Fault Ride Through, principles and concepts applicable to **Synchronous Power Generating Modules** and **Power Park Modules**, subject to disturbances from faults on the **Network** up to 140 ms in duration.	Considered. See appended test table	**P**
12.3.1.1	Each Synchronous Power Generating Module and Power Park Module is required to remain connected and stable for any balanced and unbalanced fault	Considered.	**P**

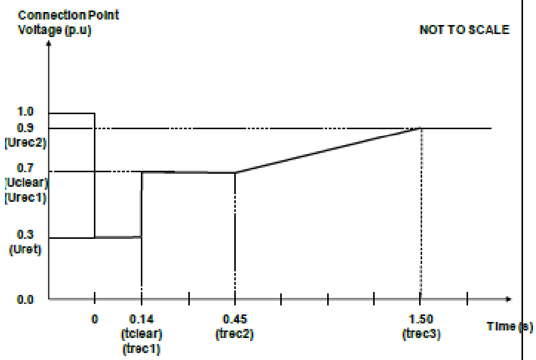
<table>
<tr><th colspan="4">Engineering recommendation G99-1</th></tr>
<tr><th>Clause</th><th>Requirement – Test</th><th>Result – Remark</th><th>Verdict</th></tr>
<tr><td></td><td>where the voltage at the Connection Point remains on or above the heavy black line shown in Figures 12.3 and 12.4 below.</td><td></td><td></td></tr>
<tr><td>12.3.1.2</td><td>The voltage against time curves defined in Table 12.1 and Table 12.2 express the lower limit (expressed as the ratio of its actual value and its reference 1pu) of the actual course of the phase to phase voltages (or phase to earth voltage in the case of asymmetrical/unbalanced faults) on the network voltage level at the Connection Point during a symmetrical or asymmetrical/unbalanced fault, as a function of time before, during and after the fault</td><td>Considered.</td><td>P</td></tr>
<tr><td>12.3.1.3</td><td>


Figure 12.3 - Voltage against time curve applicable to Type B Synchronous Power Generating Modules</td><td>Power park modules type</td><td>N/A</td></tr>
<tr><td>12.3.1.4</td><td>Table 12.1 Voltage against time parameters applicable to Type B Synchronous Power Generating Modules

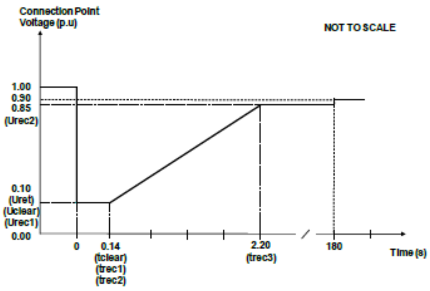
<table>
<tr><th colspan="2">Voltage parameters (pu)</th><th colspan="2">Time parameters (s)</th></tr>
<tr><td>U_{ret}</td><td>0.3</td><td>t_{clear}</td><td>0.14</td></tr>
<tr><td>U_{clear}</td><td>0.7</td><td>t_{rec1}</td><td>0.14</td></tr>
<tr><td>U_{rec1}</td><td>0.7</td><td>t_{rec2}</td><td>0.45</td></tr>
<tr><td>U_{rec2}</td><td>0.9</td><td>t_{rec3}</td><td>1.5</td></tr>
</table></td><td>Power park modules type</td><td>N/A</td></tr>
<tr><td>12.3.1.5</td><td>


Figure 12.4 - Voltage against time curve applicable to Type B Power Park Modules</td><td>Considered.</td><td>P</td></tr>
</table>

Engineering recommendation G99-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
12.3.1.6	Table 12.2 Voltage against time parameters applicable to Type B Power Park Modules Voltage parameters (pu) / Time parameters (s): U_{ret} 0.1 / t_{clear} 0.14 U_{clear} 0.10 / t_{rec1} 0.14 U_{rec1} 0.10 / t_{rec2} 0.14 U_{rec2} 0.85 / t_{rec3} 2.2	Considered.	**P**
12.3.1.7	In addition to the requirements in 12.3.1.2 to 12.3.1.6:	considered	**P**
	(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 12.5.1.		**P**
	(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.		**P**
	(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.		**P**
	(d) The protection schemes and settings for internal electrical faults shall not jeopardise Fault Ride Through performance as specified in Section 12.3. 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.		**P**
	(e) Each Power Generating Module shall be designed such that 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		**P**

Engineering recommendation G99-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	Active Power output has been restored to the required level, Active Power oscillations shall be acceptable provided that:		
12.3.2	In addition to paragraphs 12.3.1.1 – 12.3.1.7, 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**
12.3.3	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**
12.3.4	Other Fault Ride Through Requirements		**P**
	(a) In the case of a Power Park Module, the requirements in this Section 12.3. 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		**P**
	(b) For the avoidance of doubt the requirements specified in this Section 12.3 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**
12.4	**Voltage Limits and Control**		**P**
12.4.1	Where a Power Generating Module is remote from a Network voltage control point it may be required to withstand	Considered.	**P**

Engineering recommendation G99-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	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, subject to design appraisal of individual installations		
12.4.2	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.	Considered.	**P**
12.4.3	Excitation Performance Requirements		**P**
12.4.3.1	Each Synchronous Generating Unit within a Synchronous Power Generating Module shall be equipped with a permanent automatic Excitation System that has the capability to provide constant terminal voltage (assuming a high enough Network source impedance to allow the Power Generating Module to achieve this while remaining within its ratings) at a selectable setpoint without instability over the entire operating range of the Synchronous Power Generating Module.		
12.4.3.2	The DNO will agree with the Generator the operation of the control system of the Synchronous Power Generating Module or Power Park Module such that it shall contribute, as agreed, to voltage control or Reactive Power control or Power Factor control at the Connection Point. In some cases, for example, on large industrial sites etc where the Power Generating Module is embedded in the Generator's Installation, 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.		**P**
12.4.3.3	As part of the connection application process the **Generator** shall agree		**P**

Engineering recommendation G99-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	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.		
12.4.4	The final responsibility for control of Distribution Network voltage does however remain with the DNO.		**P**
12.4.5	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**
12.4.6	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**
12.5	**Reactive Capability**		**P**
12.5.1	When supplying Registered Capacity all Power Generating Modules shall be capable of continuous operation at any points between the limits of 0.95 Power Factor lagging and 0.95 Power Factor leading at the Connection Point or the Generating Unit terminals as appropriate for the Power Generating Facility and as	Considered. See appended test table	**P**

Engineering recommendation G99-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	agreed with the DNO.		
12.5.2	At Active Power output levels other than Registered Capacity, all Synchronous Power Generating Modules or Generating Units within a Power Park Module shall be capable of continuous operation at any point between the Reactive Power capability limits identified on the Generator Performance Chart. Generators should take any site demand such as auxiliary supplies and the Active Power and Reactive Power losses of the Power Generating Module transformer or Station Transformer into account unless advised otherwise by the DNO.	Considered. See appended test table	**P**
12.6	**Fast Fault Current Injection**		**P**
12.6.1	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 those will tend to have longer clearing times than those of the Transmission System for which Fast Fault Current injection is designed. In this Section 12.6 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	Considered. See appended test table	**P**
12.6.2	Each Power Park Module shall be required to satisfy the following requirements:	Considered. See appended test table	**P**
	(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 a reactive current IR that lies above the heavy black line shown in Figure 12.5. (b) Figure 12.5 defines the reactive current IR that is to be supplied during a fault on the Transmission System and which is dependent on the pre-fault operating conditions, and the voltage retained at the Connection Point. Each Power Park Module shall inject a reactive current IR which shall not be less that 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		**P**

Engineering recommendation G99-1			
Clause	Requirement – Test	Result – Remark	Verdict

rating of the Power Park Module is not exceeded.

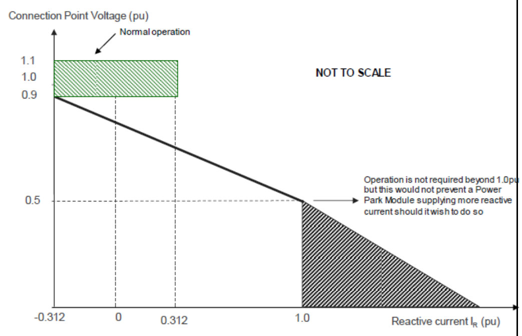


Figure 12.5 – locus of magnitude of injected Reactive Current

(c) In addition each Power Park Module shall be required to satisfy the reactive current requirements shown in Figures 12.6 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 12.6 (a) and Figure 12.6 (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.

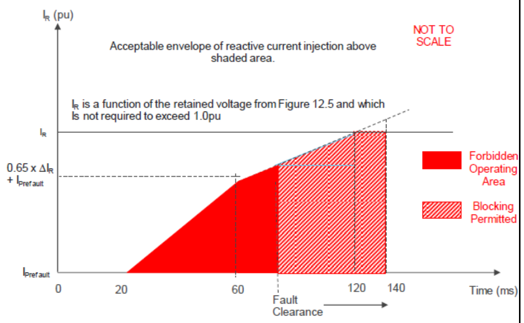


Figure 12.6(a) Chart showing area of reactive current injections for voltage depressions of ≤ 140 ms duration

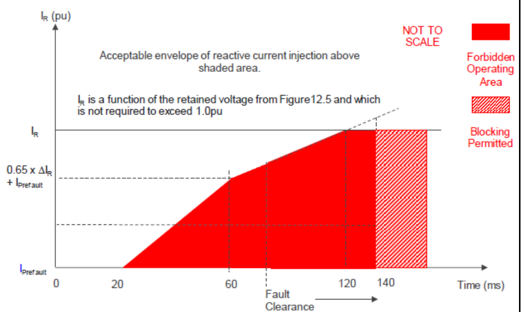


Figure 12.6(b) Chart showing area of Reactive Current injections for voltage depressions of > 140 ms duration

(d) For the purposes of this requirement,

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Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	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. For example, in the case of a 1 MW Power Park Module the Registered Capacity would be taken as 1 MW and the rated Reactive Power would be taken as 0.33 MVAr (ie Rated MW output operating at 0.95 Power Factor lead or 0.95 Power Factor lag) giving a MVA rating of 1.05 MVA. If, in this example, the Power Park Module consisted of 5 x 200kW Generating Units and 1 x 100kVAr reactive compensation equipment, each Generating Unit would need to be rated to produce 200 kW and (330 kVAr – 100 kVAr) ÷ 5, ie 205.2 kVA. (e) All Power Park Module equipment shall be designed to ensure a smooth transition between any of its voltage, power factor or reactive 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. (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 overvoltage would otherwise exceed the 1.05 pu of nominal. Figures 12.6 (a) and Figure 12.6 (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 overvoltage 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		

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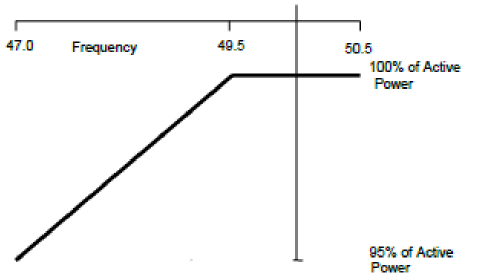
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	excursions Generators are required to both advise and agree with the DNO the control strategy, which must also include the approach taken to de-blocking. (g) To permit additional flexibility for example from Power Park Modules made up of full converter Generating Units, DFIG Generating Units or induction Generating Units, the DNO will permit transient deviations below the shaded area shown in Figures 12.6 (a) or Figure 12.6 (b) provided that the overall reactive current supplied over time is greater than the minimum requirement shown in Figures 12.6 (a) or Figure 12.6 (b). This agreement will be formalised in the Connection Agreement. (h) In the case of an unbalanced fault, each 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 (or constituent element thereof).		
12.7	**Operational monitoring**		**P**
12.7.1	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.	Considered.	**P**
13	**Type C and Type D Power Generating Module Technical Requirements**		
13.1	**Power Generating Module Performance and Control Requirements – General**		**P**
13.1.1	The requirements of this Section 13 do not apply in full to:	Considered.	**P**
	(a) Power Generation Facilities that are designed and installed for infrequent short-term parallel operation only; or	Considered.	**P**
	(b) Electricity Storage Power Generation Modules within the Power Generating Facility.	Considered.	**P**
13.1.2	The Active Power output of a Power Generating Module should not be affected by voltage changes within the statutory limits declared by the DNO in accordance with the ESQCR.	Considered.	**P**
13.1.3	Power Generating Modules shall be capable of adjusting the Active Power setpoint in accordance with instructions	Considered. See appended test table	**P**

Engineering recommendation G99-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	issued by the DNO.		
13.1.3.1	DNOs currently are developing active network management approaches and there is no common standard for communication interfaces.	Considered.	**P**
13.1.3.2	Protocols currently in use between DNOs and Generators include simple current loop; DNP3 and IEC 61850.	Considered.	**P**
13.1.3.3	The DNO will discuss and agree with the Generator for each Power Generating Facility the protocol to be used, including how any risks of maloperation etc are to be managed.	Considered.	**P**
13.1.3.4	By default if nothing it specified by the DNO then a simple hard-wired current loop interface should be provided where a 4 mA to 20 mA DC signal corresponding to 0 pu to 1.0 pu of Registered Capacity Active Power.	Considered.	**P**
13.1.3.5	The Active Power reduction will be either between 1.0 pu 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.	Considered.	**P**
13.1.3.6	If the DNO wishes to make use of the facility to reduce Active Power output the DNO will agree with the Generator the communication interface and other necessary equipment that will be needed.	Considered.	**P**
13.1.4	Any changes to the Active Power or voltage/Reactive Power control setpoints shall result in the Power Generating Module achieving the new Active Power or voltage/Reactive Power output, as appropriate, within 2 minutes.	Considered.	**P**
13.1.5	Each item of a Power Generating Module and its associated control equipment shall be designed for stable operation in parallel with the Distribution Network	Considered.	**P**
13.1.6	Load flow and System Stability studies may be necessary to determine any output constraints or post fault actions necessary for n-1 fault conditions and credible n-2 conditions (where n-1 and n-2 conditions are the first and second outage conditions as, for example, specified in EREC P2) involving a mixture of fault and planned outages. The Connection Agreement should include details of the relevant outage conditions. It may be	Considered.	**P**

Engineering recommendation G99-1			
Clause	Requirement – Test	Result – Remark	Verdict
	necessary under these fault conditions, where the combination of Power Generating Module output, load and through flow levels leads to circuit overloading, to rapidly disconnect or constrain the Power Generating Module.		
13.2	**Frequency response**		**P**
13.2.1	Under abnormal conditions automatic low-frequency load-shedding provides for load reduction down to 47 Hz. In exceptional circumstances, the frequency of the DNO's Distribution Network could rise above 50.5 Hz. Therefore all Power Generating Modules should be capable of continuing to operate in parallel with the Distribution Network in accordance with the following:	See appended test table	**P**
	a) 47 Hz – 47.5 Hz Operation for a period of at least 20 s is required each time the frequency is within this range.		**P**
	b) 47.5 Hz – 49.0 Hz Operation for a period of at least 90 minutes is required each time the frequency is within this range.		**P**
	c) 49.0 Hz – 51.0 Hz Continuous operation of the Power Generating Module is required		**P**
	d) 51.0 Hz –51.5 Hz Operation for a period of at least 90 minutes is required each time the frequency is within this range.		**P**
	e) 51.5 Hz – 52 Hz Operation for a period of at least 15 minutes is required each time the frequency is within this range.		**P**
13.2.2	With regard to the rate of change of frequency withstand capability, a Power Generating Module shall be capable of staying connected to the Distribution Network and operate at rates of change of frequency up to 1 Hz/s as measured over a period of 500 ms unless disconnection was triggered by a rate of change of frequency type loss of mains protection or by the Power Generating Module's own protection system for a co-incident internal fault as detailed in paragraph 10.6.18.	Considered.	**P**
13.2.3	Output power with falling frequency	See appended test table	**P**
13.2.3.1	Each Power Generating Module, shall be capable of:		**P**
	(a) continuously maintaining constant Active Power output for system frequency		**P**

Engineering recommendation G99-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	changes within the range 50.5 to 49.5 Hz; and		
	(b) (subject to the provisions of paragraph 13.2.1) maintaining its Active Power output at a level not lower than the figure determined by the linear relationship shown in Figure 13.1 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%.  Figure 13.1 Change in Active Power with falling frequency		**P**
13.2.3.1	For the avoidance of doubt in the case of a Power Generating Module using an Intermittent Power Source where the power input will not be constant over time, the requirement is that the Active Power output shall be independent of system frequency under (a) above and should not drop with system frequency by greater than the amount specified in (b) above.		**P**
13.2.4	Limited Frequency Sensitive Mode – Over frequency	See appended test table	**P**
13.2.4.1	Each Power Generating Module shall be capable of reducing Active Power output in response to frequency on the Total System when this rises above 50.4 Hz. The Power Generating Module shall be capable of operating stably during LFSMO operation. If a Power Generating Module, has been contracted to operate in Frequency Sensitive Mode the requirements of LFSM-O shall apply when frequency exceeds 50.5 Hz.		**P**
	(a) The rate of change of Active Power output shall be at a minimum a rate of 2% of output per 0.1 Hz deviation of system frequency above 50.4 Hz (ie a Droop of 10%) as shown in Figure 13.2. For the avoidance of doubt, this would not preclude a Generator from designing the Power Generating Module with a Droop of		**P**

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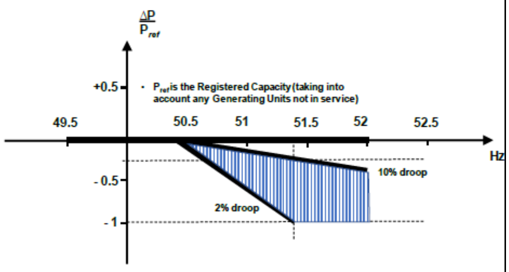
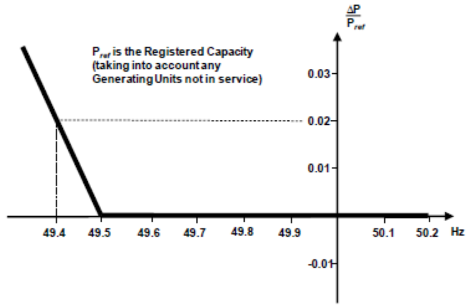
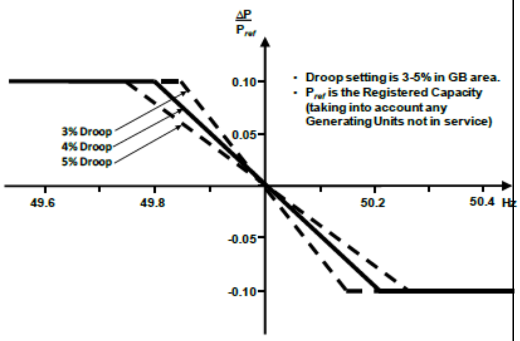
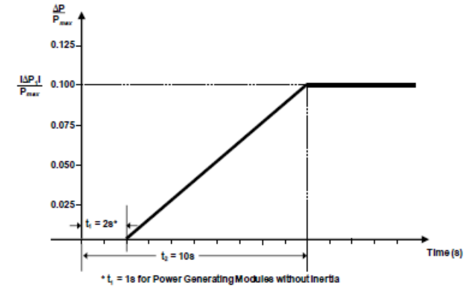
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	less than 10%, (for example between 3 – 5%), but in all cases the Droop should be 2% or greater.		
	(b) The reduction in Active Power output shall be continuously and linearly proportional, as far as is practicable, to the excess of frequency above 50.4 Hz and shall be provided increasingly with time over the period specified in (c) below.		**P**
	(c) As much as possible of the proportional reduction in Active Power output shall result from the frequency control device (or speed governor) action and shall be achieved within 10 s of the time of the frequency increase above 50.4 Hz. The Power Generating Module shall be capable of initiating a power frequency response with an initial delay that is as short as possible. If the delay exceeds 2 s the Generator shall justify the delay, providing technical evidence to the DNO, who will pass this evidence to the NETSO.  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**		**P**
13.2.4.2	When the Power Generating Module is providing Limited Frequency Sensitive Mode Over frequency (LFSM-O) response it shall continue to provide the frequency response until the frequency has returned to or below 50.4 Hz.		**P**
13.2.4.3	Steady state operation below Minimum Stable Operating Level is not expected but if system operating conditions cause operation below Minimum Stable Operating Level which give rise to operational difficulties then the Generator shall be able to return the output of the Power Generating Module to an output of not less than the Minimum Stable Operating Level.		**P**
13.2.5	Limited Frequency Sensitive Mode – Under frequency (LFSM-U)	See appended test table	**P**
13.2.5.1	Each Power Generating Module shall be		**P**

Engineering recommendation G99-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	capable of increasing Active Power output in response to system frequency when this falls below 49.5 Hz. it is not anticipated Power Generating Modules are operated in an inefficient mode to facilitate delivery of LFSM-U response, but any inherent capability should be made available without undue delay. The Power Generating Module shall be capable of stable operation during LFSM-U Mode.		
	a) The rate of change of Active Power output shall be at a minimum a rate of 2 percent of output per 0.1 Hz deviation of system frequency below 49.5 Hz (ie a Droop of 10%) as shown in Figure 13.3 below. This requirement only applies if the Power Generating Module has headroom and the ability to increase Active Power output. In the case of a Power Park Module the requirements of Figure 13.3 shall be reduced pro-rata to the amount of Generating Units in service and available to generate. For example, for a Power Park Module with a Registered Capacity of 40 MW but with only 80% of the Generating Units in service Pref would be 32 MW. For the avoidance of doubt, this would not preclude a Generator from designing the Power Generating Module with a lower Droop setting, for example between 3 – 5%.		P
	(b) As much as possible of the proportional increase in Active Power output shall result from the frequency control device (or speed governor) action and shall be achieved for frequencies below 49.5 Hz. The Power Generating Module shall be capable of initiating a power frequency response with minimal delay. If the delay exceeds 2 s the Generator shall justify the delay, providing technical evidence to the DNO who will pass this evidence to the NETSO.		P
	c) The actual delivery of Active Power Frequency Response in LFSM-U mode shall take into account • The ambient conditions when the response is to be triggered. • The operating conditions of the Power Generating Module. In particular limitations on operation near Registered Capacity at low frequencies. • The availability of primary energy sources.		P

Engineering recommendation G99-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	(d) In LFSM-U Mode the Power Generating Module shall be capable of providing a power increase up to its Registered Capacity (based on the number of Generating Units in service at that point in time).  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 13.3 - Limited Frequency Sensitive Mode – Under frequency capability of Power Generating Modules**		**P**
13.2.6	Frequency Sensitive Mode – (FSM)	See appended test table	**P**
13.2.6.1	Each Power Generating Module shall be fitted with a fast acting proportional frequency control device (or turbine speed governor) and unit load controller or equivalent control device to provide frequency response under normal operational conditions. In the case of a Power Park Module the frequency or speed control device(s) may be on the Power Park Module or on each individual Generating Unit or be a combination of both.		**P**
13.2.6.2	The frequency control device (or speed governor) in co-ordination with other control devices shall t control each Power Generating Module Active Power output with stability over the entire operating range of the Power Generating Module; and		**P**
13.2.6.3	Power Generating Modules shall also meet the following minimum requirements:		**P**
	(a) 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.		**P**

Engineering recommendation G99-1			
Clause	Requirement – Test	Result – Remark	Verdict
	 Figure 13.4 – Frequency Sensitive Mode capability of Power Generating Modules and Power Park Modules		
	(b) 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 overfrequency, the Active Power Frequency Response is limited by the Minimum Stable Operating Level, ii. in the case of underfrequency, 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 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 Deadband 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.		P
	(c) In the event of a frequency step change, each Power Generating Module shall be capable of activating full and stable Active Power Frequency Response (without undue power oscillations), in accordance with the performance characteristic shown in Figure 13.5 and parameters in Table 13.2.		P

Engineering recommendation G99-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	 P_{max} is the Registered Capacity to which ΔP relates. ΔP is the change in Active Power output from the Power Generating Module. The Power Generating Module has to provide Active Power output ΔP up to the point $ΔP_1$ in accordance with the times t_1 and t_2 with the values of $ΔP_1$, t_1 and t_2 being specified in Table 13.2. t_1 is the initial delay. t_2 is the time for full activation. Figure 13.5 Active Power Frequency Response capability		
	(d) The initial activation of Active Power primary frequency response shall not be unduly delayed. For Power Generating Modules with inertia the delay in initial Active Power Frequency Response shall not be greater than 2 s. For Power Generating Modules without inertia the delay in initial Active Power Frequency Response shall not be greater than 1 s. If the Generator cannot meet this requirement the Generator shall provide technical evidence to the DNO, who will pass this evidence to the NETSO, demonstrating why a longer time is needed for the initial activation of Active Power Frequency Response.		**P**
	(e) with regard to disconnection due to underfrequency, Generators responsible for Power Generating Modules capable of acting as a load, including but not limited to pumped-storage Power Generating Modules, shall be capable of disconnecting their load in case of underfrequency which will be agreed with the DNO. For the avoidance of doubt this requirement does not apply to station auxiliary supplies.		**P**
	(f) In addition to the requirements of Section 13.2.6 each Power Generating Module shall be capable of meeting the minimum frequency response requirement profile subject to and in accordance with the provisions of Annex C.10.		**P**
13.3	**Fault Ride Through**		**P**
13.3.1	Paragraphs 13.3.1.1 to 13.3.1.10 inclusive set out the Fault Ride Through, principles and concepts applicable to Synchronous Power Generating Modules and Power Park Modules, subject to disturbances	See appended test table	**P**

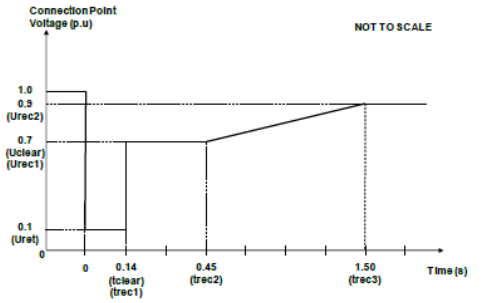
<table>
<tr><th colspan="4">Engineering recommendation G99-1</th></tr>
<tr><th>Clause</th><th>Requirement – Test</th><th>Result – Remark</th><th>Verdict</th></tr>
<tr><td></td><td>from faults on the Network up to 140 ms in duration.</td><td></td><td></td></tr>
<tr><td>13.3.1.1</td><td>Each Synchronous Power Generating Module and Power Park Module is required to remain connected and stable for any balanced and unbalanced fault where the voltage at the Connection Point remains on or above the heavy black line shown in Figures 13.6 to 13.9 below.</td><td></td><td></td></tr>
<tr><td>13.3.1.2</td><td>The voltage against time curves defined in Table 13.3 to Table 13.6 expresses the lower limit (expressed as the ratio of its actual value and its reference 1 pu) of the actual course of the phase to phase voltages (or phase to earth voltage in the case of asymmetrical/unbalanced faults) on the network voltage level at Connection Point during a symmetrical or asymmetrical/unbalanced fault, as a function of time before, during and after the fault.


Figure 13.6 Voltage against time curve applicable to Type C and Type D Synchronous Power Generating Modules connected below 110 kV</td><td>Power park modules type</td><td>N/A</td></tr>
<tr><td>13.3.1.4</td><td>Table 13.3 Voltage against time parameters applicable to Type C and D Synchronous Power Generating Modules connected below 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>0.1</td><td>t_{clear}</td><td>0.14</td></tr>
<tr><td>U_{clear}</td><td>0.7</td><td>t_{rec1}</td><td>0.14</td></tr>
<tr><td>U_{rec1}</td><td>0.7</td><td>t_{rec2}</td><td>0.45</td></tr>
<tr><td>U_{rec2}</td><td>0.9</td><td>t_{rec3}</td><td>1.5</td></tr>
</table></td><td>Power park modules type</td><td>N/A</td></tr>
</table>

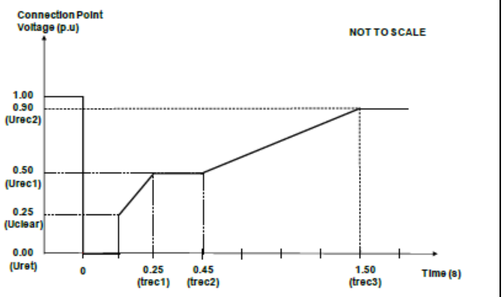
<table>
<tr><th colspan="4">Engineering recommendation G99-1</th></tr>
<tr><th>Clause</th><th>Requirement – Test</th><th>Result – Remark</th><th>Verdict</th></tr>
<tr><td>13.3.1.5</td><td>

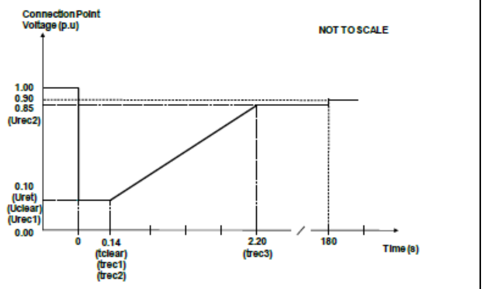
Figure 13.7 - Voltage against time curve applicable to Type D Synchronous Power Generating Modules connected at or above 110 kV</td><td>See appended test table</td><td>P</td></tr>
<tr><td>13.3.1.6</td><td>Table 13.4 Voltage against time parameters applicable to Type D Synchronous Power Generating Modules 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>0.25</td><td>t_{rec1}</td><td>0.25</td></tr>
<tr><td>U_{rec1}</td><td>0.5</td><td>t_{rec2}</td><td>0.45</td></tr>
<tr><td>U_{rec2}</td><td>0.9</td><td>t_{rec3}</td><td>1.5</td></tr>
</table></td><td>See appended test table</td><td>P</td></tr>
<tr><td>13.3.1.7</td><td>

Figure 13.8 - Voltage against time curve applicable to Type C and Type D Power Park Modules connected below 110 kV</td><td>See appended test table</td><td>P</td></tr>
<tr><td>13.3.1.8</td><td>Table 13.5 Voltage against time parameters applicable to Type C and Type D Power Park Modules connected below 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>0.1</td><td>t_{clear}</td><td>0.14</td></tr>
<tr><td>U_{clear}</td><td>0.10</td><td>t_{rec1}</td><td>0.14</td></tr>
<tr><td>U_{rec1}</td><td>0.10</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>See appended test table</td><td>P</td></tr>
</table>

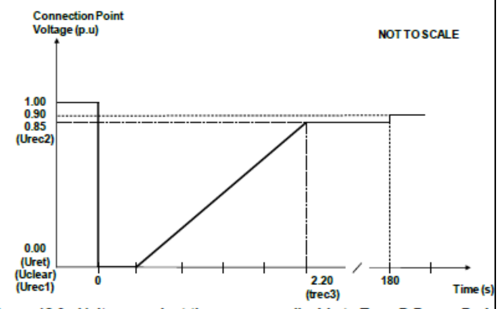
<table>
<tr><th colspan="4">Engineering recommendation G99-1</th></tr>
<tr><th>Clause</th><th>Requirement – Test</th><th>Result – Remark</th><th>Verdict</th></tr>
<tr><td>13.3.1.9</td><td>

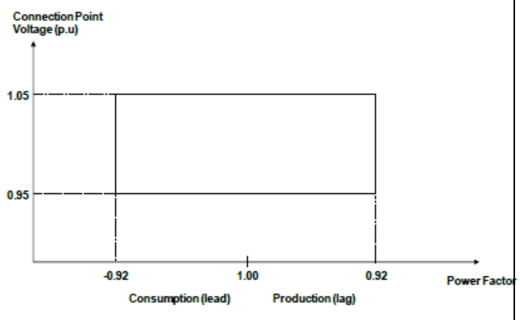
Figure 13.9 - Voltage against time curve applicable to Type D Power Park Modules connected at or above 110 kV</td><td>See appended test table</td><td>P</td></tr>
<tr><td>13.3.1.10</td><td>Table 13.6 Voltage against time parameters applicable to Type D Power Park Modules connected at or above 110 kV
<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>See appended test table</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:</td><td>Considered</td><td>P</td></tr>
<tr><td></td><td>(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</td><td></td><td>P</td></tr>
</table>

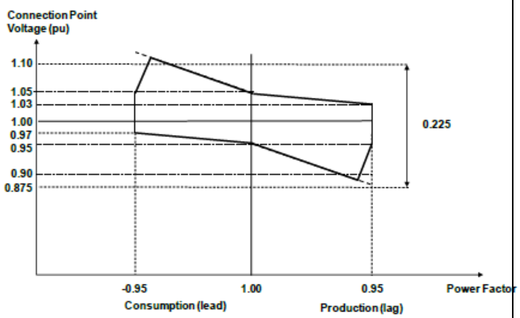
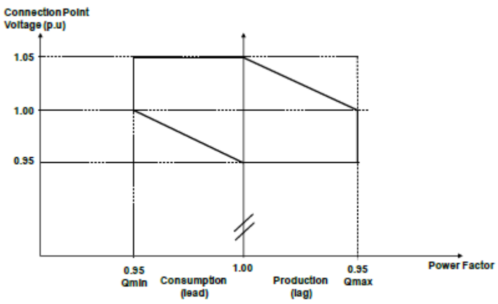
Engineering recommendation G99-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	13.3. For the avoidance of doubt where an internal fault on the Power Generating Module occurs during a Fault Ride Through condition, the Power Generating Module's internal protection should trip the module to ensure safety and minimise damage		
	(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 ratingon the DNO's Distribution Network		**P**

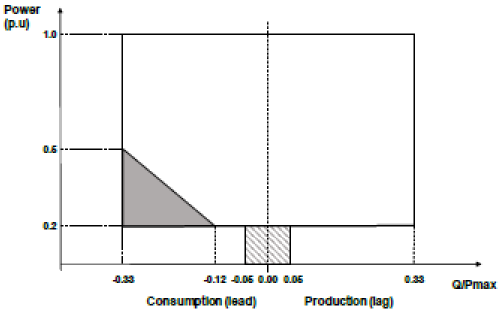
Engineering recommendation G99-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	the DNO, on request during the connection process, will advise the Generator of the expected Phase (Voltage) Unbalance.		
13.3.4	Other Fault Ride Through Requirements		**P**
	(a) In the case of a Power 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.		**P**
	(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**
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.	Considered	**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	Power park modules type	**N/A**
13.4.3.1	Each Synchronous Generating Unit within a Synchronous Power Generating Module		**N/A**

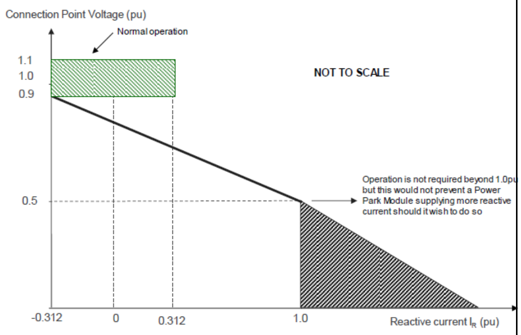
Engineering recommendation G99-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	shall be equipped with a permanent automatic Excitation System that has the capability to provide constant terminal voltage (assuming a high enough Network source impedance to allow the Power Generating Module to achieve this while remaining within its ratings) at a selectable setpoint without instability over the entire operating range of the Synchronous Power Generating Module.		
13.4.3.2	The requirements for Synchronous Generating Unit excitation control facilities are specified in Annex C.4. The DNO will agree any site specific requirements with the Generator.		**N/A**
13.4.3.3	Unless otherwise required for testing in accordance with Annex C.8.2, the automatic excitation control system of a Synchronous Power Generating Module shall always be operated such that it controls the Synchronous Generating Unit terminal voltage to a value that is • equal to its rated value; or • only where provisions have been made in the Connection Agreement, greater than its rated value.		**N/A**
13.4.3.4	some cases, particularly on large industrial sites etc where the Power Generating Module is embedded in the Generator’s Installation, the DNO and Generator might agree a different control point, such as the Connection Point.		**N/A**
13.4.4	Voltage Control Performance Requirements for Power Park Modules	Considered	**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		**P**

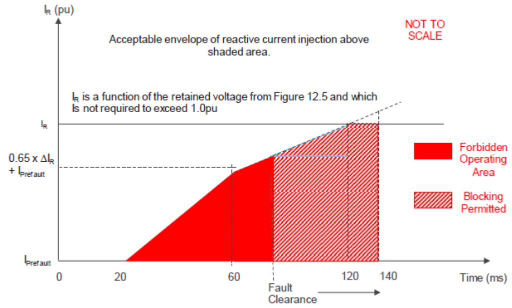
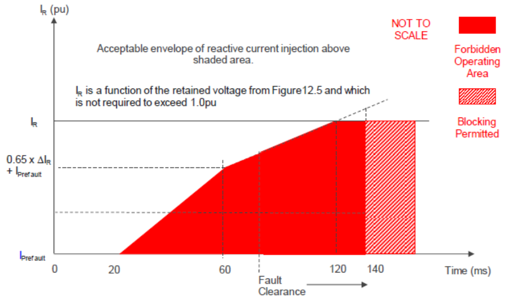
Engineering recommendation G99-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	output and the non-shaded area above 20% of Active Power output in Figure 13.13.		
13.4.4.2	The performance requirements for a continuously acting Automatic Voltage Control system that shall be complied 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**
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 Poperate 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**

Engineering recommendation G99-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
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 13.10 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 13.10, ie an envelope agreed between the DNO and the Generator within the rectangle of Figure 13.10. 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.	Power park modules type	**N/A**
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.  Figure 13.10 Reactive Power capability requirements (Synchronous Power Generating Modules)	Power park modules type	**N/A**
13.5.3	At voltages above 1.05 pu, or below 0.95 pu a Synchronous Power Generating	Power park modules type	**N/A**

Engineering recommendation G99-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	Module shall maintain the Reactive Power output and Power Factor as far as possible recognizing that outside of the envelope of Figure 13.10 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.		
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 13.11 when operating at Registered Capacity.  Figure 13.11 Reactive Power capability requirements (Power Park Modules operating at Registered Capacity, voltage above 33 kV)	Considered	**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 13.12 when operating at Registered Capacity.  Figure 13.12 Reactive Power capability requirements (Power Park Modules operating at Registered Capacity, voltage at or below 33 kV)	Considered	**P**
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 13.13 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 13.13 unless the requirement to maintain the Reactive Power limits defined at Registered Capacity under absorbing Reactive Power	Considered	**P**

Engineering recommendation G99-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	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 13.13 Reactive Power capability requirements (Power Park Modules operating below Registered Capacity)		
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 seen in the Distribution Network as a voltage depression.	See appended test table.	**P**
13.6.2	Each Power Park Module shall be required to satisfy the following requirements.	See appended test table.	**P**
	(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 13.14.		**P**

Engineering recommendation G99-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	 Figure 13.14 – locus of magnitude of injected reactive current		
	(b) Figure 13.14 defines the reactive current IR that is to be supplied during a fault on the Transmission System and which is dependent on the pre-fault operating conditions, and the voltage retained at the Connection Point. Each Power Park Module shall inject a reactive current IR which shall not be less that 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 13.15 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 13.15 (a) or Figure 13.6 (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.requirement to fully satisfy the Fault Ride Through requirements of paragraph 13.3.		**P**

Engineering recommendation G99-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	 **Figure 13.15(a) Chart showing area of Reactive Current injections for voltage depressions of ≤ 140 ms duration**  **Figure 13.15(b) Chart showing area of Reactive Current injections for voltage depressions of > 140 ms duration**		
	(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. For example, in the case of a 10 MW Power Park Module the Registered Capacity would be taken as 10 MW and the rated Reactive Power would be taken as 3.28 MVAr (ie Rated MW output operating at 0.95 Power Factor lead or 0.95 Power Factor lag) giving an MVA rating of 10.53 MVA. If, in this example, the Power Park Module consisted of 5 x 2 MW Generating Units and 1 x 1 MVAr reactive compensation equipment, each Generating Unit would need to be rated to produce 2 MW and (3.3 MVAr - 1.0 MVAr) ÷ 5, ie 2.05 MVA.		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		P

Engineering recommendation G99-1			
Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	operating condition of the Power Park Module and its subsequent behaviour under fault conditions		
	(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 overvoltage would otherwise exceed the 1.05 pu of nominal. Figures 13.15 (a) and Figure 13.15 (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 overvoltage 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 13.15 (a) or Figure 13.15 (b) provided that the reactive current supplied is greater than the minimum requirement shown in Figures 13.15 (a) or Figure 13.15(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**		**P**
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		**P**

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Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	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.		
13.8	**Technical Requirements for Embedded Medium Power Stations**		**N/A**
13.8.1	Where a Generator in respect of an Embedded Medium Power Station is a party to the CUSC this Section 13.8 will not apply.		**N/A**
13.8.2	In addition to the requirements of this EREC G99, the DNO has an obligation under ECC 3.3 of the Grid Code to ensure that all relevant Grid Code Connection Condition requirements are met by Embedded Medium Power Stations. These requirements are summarised in ECC 3.4 of the Grid Code. It is incumbent on the Generator who owns any Embedded Medium Power Station to comply with the relevant Grid Code requirements listed in ECC3.4 of the Grid Code as part of compliance with this EREC G99.		**N/A**
13.8.3	Where data is required by the NETSO from Embedded Medium Power Stations, nothing in the Grid Code or this EREC G99 precludes the Generator from providing the information directly to the NETSO in accordance with Grid Code requirements. However, a copy of the information should always be provided in parallel to the DNO.		**N/A**
13.8.4	Grid Code Connection Conditions Compliance		**N/A**
13.8.4.1	The technical designs and parameters of the Embedded Medium Power Station shall comply with the relevant Connection Conditions of the Grid Code. A statement to this effect, stating compliance with ECP4.3 of the Grid Code is required to be presented to the DNO for onward transmission to the NETSO, before commissioning of the Embedded Medium Power Station. Note that the statement might need to be resubmitted post commissioning when assumed values etc have been confirmed.		**N/A**
13.8.4.2	Should the Generator make any material change to such designs or parameters as will have any effect on the statement of compliance referred to in paragraph 13.8.4.1, the Generator shall notify the		**N/A**

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Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	change to the DNO, as soon as reasonably practicable, who will in turn notify the NETSO.		
13.8.4.3	Tests to ensure Grid Code compliance may be specified by the NETSO in accordance with the Grid Code. It is the Generator's responsibility to carry out these tests.		**N/A**
13.8.4.4	Where the NETSO can reasonably demonstrate that for Total System stability issues the Embedded Medium Power Station should be fitted with a Power System Stabiliser, the NETSO will notify the DNO who will then require it to be fitted.		**N/A**
13.9	**Operational monitoring**		**P**
13.9.1	With regard to information exchange:		**p**
	(a) Power Generating Facilities shall be capable of exchanging information with the DNO in real time or periodically with time stamping;		**P**
	(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;		**P**
	(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.		**P**
	(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.		**P**
	(c) The DNO may also specify that Generators shall install power quality monitoring equipment. Any such		**P**

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Clause	**Requirement – Test**	**Result – Remark**	**Verdict**
	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**
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**
13.10.1	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**

G99-1
Test Results:

For Connection Design Type B, Type C

9.4.2 Flicker (Type B/C/D)				
Max. number of switching operations, N_{10}	10			
Max. number of switching operations, N_{120}	120			
Case of switching operation	Cut-in at 10% of rated power			
Grid impedance angle, ψ_k	30°	50°	70°	85°
Flicker step factor, $k_f(\psi_k)$	0,18	0,16	0,14	0,15
Voltage change factor, $k_u(\psi_k)$	0,08	0,10	0,09	0,08
Maximum inrush current factor k_{imax}	0,10			
Case of switching operation	Cut-in at 100% of rated power			
Grid impedance angle	30°	50°	70°	85°
Flicker step factor, $k_f(\psi_k)$	0,91	0,81	0,70	0,27
Voltage change factor, $k_u(\psi_k)$	0,07	0,08	0,06	0,05
Maximum inrush current factor k_{imax}	0,08			
Case of switching operation	Service disconnection at rated power			
Grid impedance angle	30°	50°	70°	85°
Flicker step factor, $k_f(\psi_k)$	0,95	0,81	0,64	0,37
Voltage change factor, $k_u(\psi_k)$	0,21	0,17	0,10	0,07
Maximum inrush current factor k_{imax}	0,21			
Worst case over all switching operations, k_{imax}	0,21			
Note:				

9.4.2 Flicker (Type B/C/D)

Method: Measurement was carried out according to the procedure in IEC 61400-21.

Grid impedance angle, ψ_k	30°	50°	70°	85°
Flicker coefficient, $c(\psi_k)$	0,97	1,67	0,78	0,57
Short-term flicker, P_{st}	0,09	0,02	0,07	0,03

Note:

The table entries are worst case values.

$S_{k,fic}/S_n$ in the fictitious grid was set to: 20

9.4.3 Harmonic Emissions (Type B/C/D)	P
The currents of the interharmonics to 2 kHz must be measured in accordance with DIN EN 61000-4-7 (VDE 0817-4-7), Annex A. The measurements of higher-frequency harmonic currents between 2 kHz and 9 kHz must be conducted in line with DIN EN 61000-4-7 (VDE 0847-4-7), Annex B.	
Test: SG50CX	
Harmonics	

P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
Order	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]
1	6,54	10,99	20,46	30,23	40,09	49,98	59,86	69,71	78,77	88,47	98,130
2	0,001	0,104	0,113	0,089	0,128	0,121	0,131	0,112	0,105	0,115	0,110
3	0,011	0,081	0,099	0,081	0,109	0,115	0,146	0,144	0,141	0,152	0,156
4	0,001	0,068	0,090	0,087	0,149	0,159	0,173	0,167	0,156	0,157	0,185
5	0,010	0,475	0,726	0,776	1,277	1,391	2,133	2,164	2,167	2,164	2,168
6	0,001	0,073	0,079	0,064	0,084	0,087	0,080	0,080	0,062	0,091	0,084
7	0,010	0,317	0,407	0,437	0,787	0,856	1,329	1,368	1,391	1,544	1,616
8	0,001	0,072	0,068	0,053	0,080	0,077	0,072	0,076	0,077	0,081	0,076
9	0,008	0,040	0,037	0,028	0,040	0,047	0,051	0,054	0,061	0,069	0,075
10	0,001	0,025	0,026	0,023	0,035	0,037	0,039	0,043	0,044	0,055	0,057
11	0,007	0,519	0,462	0,288	0,502	0,604	0,780	0,838	0,882	0,965	1,012
12	0,001	0,030	0,036	0,027	0,036	0,033	0,036	0,037	0,037	0,040	0,043
13	0,007	0,370	0,450	0,276	0,402	0,461	0,546	0,610	0,647	0,698	0,755
14	0,001	0,026	0,030	0,026	0,036	0,036	0,037	0,036	0,030	0,040	0,044
15	0,006	0,022	0,028	0,023	0,029	0,029	0,032	0,033	0,030	0,039	0,039
16	0,001	0,018	0,019	0,018	0,028	0,030	0,028	0,029	0,029	0,029	0,032
17	0,004	0,248	0,273	0,203	0,258	0,279	0,286	0,316	0,339	0,384	0,421
18	0,001	0,014	0,014	0,015	0,021	0,022	0,019	0,019	0,021	0,025	0,028
19	0,003	0,188	0,196	0,167	0,215	0,226	0,222	0,243	0,261	0,286	0,311
20	0,001	0,015	0,017	0,015	0,023	0,023	0,019	0,021	0,019	0,022	0,025
21	0,003	0,019	0,018	0,014	0,022	0,021	0,022	0,022	0,023	0,026	0,028
22	0,001	0,012	0,014	0,011	0,017	0,019	0,015	0,017	0,017	0,019	0,023
23	0,001	0,109	0,116	0,106	0,139	0,141	0,128	0,146	0,163	0,181	0,196
24	0,001	0,011	0,011	0,010	0,014	0,015	0,014	0,014	0,014	0,017	0,018
25	0,001	0,077	0,090	0,080	0,110	0,109	0,092	0,109	0,128	0,141	0,156
26	0,001	0,014	0,017	0,012	0,017	0,019	0,017	0,019	0,019	0,021	0,025
27	0,001	0,014	0,017	0,013	0,018	0,017	0,017	0,017	0,018	0,018	0,018
28	0,001	0,015	0,014	0,012	0,018	0,017	0,017	0,018	0,019	0,021	0,026
29	0,001	0,055	0,065	0,037	0,070	0,063	0,046	0,051	0,066	0,086	0,104
30	0,001	0,008	0,008	0,007	0,011	0,012	0,010	0,011	0,011	0,014	0,014
31	0,001	0,033	0,046	0,026	0,052	0,051	0,037	0,033	0,044	0,061	0,079
32	0,001	0,012	0,011	0,008	0,011	0,011	0,011	0,011	0,011	0,012	0,015
33	0,001	0,012	0,012	0,010	0,014	0,014	0,012	0,014	0,014	0,015	0,014
34	0,001	0,010	0,012	0,008	0,014	0,011	0,010	0,011	0,011	0,012	0,014
35	0,001	0,022	0,018	0,017	0,025	0,029	0,022	0,017	0,015	0,026	0,041
36	0,001	0,008	0,008	0,010	0,014	0,011	0,008	0,010	0,008	0,010	0,012
37	0,001	0,015	0,018	0,014	0,021	0,022	0,019	0,017	0,015	0,017	0,028
38	0,001	0,007	0,008	0,008	0,014	0,015	0,010	0,008	0,010	0,010	0,011
39	0,001	0,008	0,011	0,009	0,014	0,017	0,014	0,014	0,012	0,014	0,014
40	0,001	0,007	0,008	0,008	0,014	0,015	0,010	0,008	0,010	0,010	0,011

Interharmonics											
P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
f [Hz]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]
75	0,006	0,051	0,065	0,051	0,075	0,080	0,076	0,087	0,091	0,097	0,102
125	0,001	0,032	0,037	0,034	0,050	0,051	0,055	0,055	0,058	0,062	0,081
175	0,001	0,023	0,028	0,028	0,040	0,040	0,048	0,050	0,047	0,052	0,062
225	0,003	0,022	0,026	0,029	0,041	0,044	0,054	0,054	0,054	0,055	0,063
275	0,001	0,026	0,025	0,027	0,040	0,039	0,046	0,047	0,047	0,054	0,059
325	0,001	0,022	0,023	0,028	0,040	0,041	0,048	0,050	0,050	0,055	0,062
375	0,003	0,026	0,026	0,027	0,039	0,040	0,044	0,046	0,047	0,057	0,058
425	0,001	0,021	0,025	0,027	0,039	0,039	0,046	0,044	0,047	0,052	0,059
475	0,001	0,021	0,025	0,027	0,039	0,039	0,041	0,043	0,043	0,050	0,057
525	0,001	0,021	0,023	0,027	0,037	0,039	0,043	0,044	0,044	0,050	0,055
575	0,001	0,023	0,025	0,025	0,035	0,036	0,037	0,039	0,040	0,047	0,052
625	0,001	0,021	0,022	0,027	0,037	0,037	0,039	0,040	0,043	0,050	0,054
675	0,001	0,021	0,025	0,024	0,036	0,033	0,033	0,035	0,035	0,041	0,047
725	0,001	0,019	0,022	0,023	0,032	0,033	0,033	0,035	0,037	0,040	0,047
775	0,001	0,017	0,021	0,021	0,030	0,030	0,028	0,030	0,030	0,036	0,041
825	0,001	0,017	0,021	0,019	0,028	0,029	0,029	0,028	0,030	0,037	0,039
875	0,001	0,017	0,018	0,019	0,026	0,026	0,025	0,025	0,026	0,030	0,036
925	0,001	0,015	0,017	0,018	0,026	0,026	0,023	0,025	0,026	0,029	0,033
975	0,001	0,017	0,017	0,016	0,025	0,025	0,022	0,022	0,023	0,026	0,032
1025	0,001	0,014	0,017	0,016	0,022	0,023	0,021	0,022	0,022	0,026	0,029
1075	0,001	0,014	0,015	0,015	0,021	0,022	0,019	0,021	0,021	0,023	0,029
1125	0,001	0,014	0,015	0,015	0,021	0,021	0,021	0,021	0,021	0,023	0,028
1175	0,001	0,012	0,014	0,014	0,019	0,019	0,018	0,019	0,021	0,022	0,025
1225	0,001	0,012	0,012	0,013	0,019	0,019	0,017	0,018	0,018	0,022	0,025
1275	0,001	0,012	0,014	0,013	0,019	0,021	0,018	0,018	0,019	0,022	0,028
1325	0,001	0,011	0,014	0,013	0,018	0,019	0,017	0,018	0,018	0,022	0,023
1375	0,001	0,011	0,012	0,012	0,018	0,018	0,017	0,018	0,018	0,021	0,025
1425	0,001	0,011	0,012	0,012	0,018	0,017	0,017	0,017	0,017	0,019	0,022
1475	0,001	0,010	0,011	0,011	0,015	0,015	0,014	0,015	0,015	0,017	0,019
1525	0,001	0,010	0,010	0,010	0,015	0,015	0,014	0,014	0,015	0,017	0,019
1575	0,001	0,011	0,011	0,010	0,014	0,015	0,012	0,014	0,015	0,017	0,018
1625	0,001	0,011	0,011	0,011	0,014	0,014	0,014	0,014	0,014	0,017	0,018
1675	0,001	0,011	0,011	0,010	0,014	0,014	0,012	0,012	0,014	0,015	0,018
1725	0,001	0,015	0,010	0,011	0,014	0,014	0,012	0,014	0,014	0,015	0,017
1775	0,001	0,012	0,011	0,012	0,015	0,014	0,011	0,012	0,012	0,014	0,017
1825	0,001	0,011	0,010	0,012	0,017	0,014	0,011	0,012	0,012	0,014	0,015
1875	0,001	0,011	0,010	0,010	0,017	0,017	0,011	0,011	0,012	0,015	0,015
1925	0,001	0,010	0,011	0,010	0,017	0,017	0,012	0,012	0,012	0,014	0,015
1975	0,001	0,011	0,008	0,008	0,014	0,017	0,014	0,012	0,012	0,012	0,015

Higher Frequencies											
P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
f [kHz]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]	I [%]
2,1	0,004	0,058	0,040	0,027	0,039	0,035	0,032	0,033	0,032	0,039	0,039
2,3	0,007	0,041	0,044	0,032	0,047	0,048	0,046	0,040	0,041	0,046	0,047
2,5	0,007	0,051	0,051	0,039	0,054	0,058	0,051	0,052	0,050	0,048	0,050
2,7	0,004	0,086	0,088	0,064	0,086	0,083	0,084	0,088	0,090	0,090	0,084
2,9	0,004	0,041	0,041	0,030	0,040	0,041	0,037	0,040	0,043	0,044	0,051
3,1	0,006	0,035	0,032	0,025	0,037	0,035	0,035	0,032	0,033	0,030	0,030
3,3	0,006	0,047	0,048	0,029	0,040	0,037	0,040	0,039	0,036	0,036	0,032
3,5	0,007	0,032	0,035	0,026	0,035	0,035	0,035	0,030	0,030	0,032	0,030
3,7	0,010	0,030	0,033	0,026	0,035	0,035	0,032	0,032	0,030	0,030	0,032
3,9	0,011	0,030	0,035	0,025	0,035	0,035	0,033	0,033	0,032	0,032	0,033
4,1	0,023	0,018	0,021	0,016	0,022	0,022	0,022	0,022	0,021	0,021	0,022
4,3	0,057	0,015	0,018	0,013	0,018	0,018	0,018	0,019	0,018	0,018	0,019
4,5	0,025	0,011	0,014	0,011	0,014	0,014	0,014	0,014	0,014	0,015	0,014
4,7	0,025	0,014	0,015	0,011	0,015	0,015	0,015	0,015	0,015	0,017	0,017
4,9	0,008	0,007	0,008	0,006	0,008	0,008	0,010	0,008	0,008	0,010	0,010
5,1	0,007	0,007	0,008	0,006	0,008	0,008	0,008	0,008	0,008	0,008	0,010
5,3	0,006	0,007	0,007	0,005	0,007	0,008	0,007	0,008	0,007	0,008	0,008
5,5	0,006	0,007	0,008	0,007	0,011	0,012	0,012	0,014	0,014	0,014	0,012
5,7	0,006	0,007	0,008	0,007	0,011	0,012	0,014	0,014	0,014	0,015	0,012
5,9	0,006	0,006	0,007	0,005	0,007	0,007	0,007	0,007	0,007	0,007	0,008
6,1	0,006	0,007	0,007	0,005	0,007	0,007	0,007	0,007	0,007	0,008	0,008
6,3	0,006	0,007	0,006	0,005	0,007	0,007	0,007	0,007	0,007	0,007	0,008
6,5	0,004	0,006	0,006	0,005	0,007	0,007	0,007	0,007	0,007	0,007	0,008
6,7	0,004	0,006	0,007	0,005	0,007	0,007	0,007	0,007	0,007	0,007	0,008
6,9	0,004	0,006	0,006	0,005	0,007	0,007	0,007	0,007	0,007	0,007	0,008
7,1	0,006	0,008	0,007	0,006	0,007	0,007	0,008	0,008	0,008	0,008	0,008
7,3	0,004	0,007	0,007	0,004	0,007	0,007	0,007	0,007	0,007	0,007	0,007
7,5	0,004	0,007	0,006	0,005	0,007	0,007	0,007	0,007	0,007	0,007	0,008
7,7	0,004	0,006	0,006	0,005	0,007	0,007	0,007	0,007	0,007	0,007	0,008
7,9	0,004	0,007	0,007	0,005	0,007	0,007	0,007	0,007	0,007	0,008	0,008
8,1	0,004	0,007	0,006	0,005	0,007	0,007	0,007	0,007	0,007	0,007	0,008
8,3	0,004	0,007	0,007	0,005	0,007	0,007	0,007	0,007	0,007	0,007	0,008
8,5	0,004	0,007	0,007	0,005	0,007	0,007	0,007	0,007	0,007	0,008	0,008
8,7	0,004	0,007	0,007	0,005	0,007	0,007	0,007	0,007	0,007	0,008	0,008
8,9	0,004	0,007	0,006	0,005	0,007	0,007	0,007	0,007	0,008	0,007	0,008
Note:											

12.2 Frequency response(Type B): **13.2 Frequency response(Type C and Type D):**	**P**
Test 1：	
Test (a):	P = 100%Pn Frequency = 47,0Hz Period of test 21 seconds
Connection:	Always connected
Limit:	Always connected
Test (b):	P = 100%Pn Frequency = 47,5 Hz Power Factor = 1 Period of test 91 minutes
Connection:	Always connected
Limit:	Always connected
Test (c):	P = 100%Pn Frequency = 49,0 Hz Power Factor = 1 Period of test 120 minutes
Connection:	Always connected
Limit:	Always connected
Test (d):	P = 100%Pn Frequency = 51,5 Hz Power Factor = 1 Period of test 91 minutes
Connection:	Always connected
Limit:	Always connected
Test (e):	P = 100%Pn Frequency = 52,0 Hz Power Factor = 1 Period of test 16 minutes
Connection:	Always connected
Limit:	Always connected
Test 2：	
Test :	P = 50%Pn 49 Hz to 51 Hz, frequency ramp 1Hz/s Period of test 30s
Connection:	Always connected
Limit:	Always connected
Test :	P = 100%Pn 51 Hz to 49 Hz, frequency ramp 1Hz/s Period of test 30s
Connection:	Always connected
Limit:	Always connected

Note. Under abnormal conditions automatic low-frequency load-shedding provides for load reduction down to 47 Hz. In exceptional circumstances, the frequency of the DNO's Distribution Network could rise above 50.5 Hz. Therefore all Power Generating Modules should be capable of continuing to operate in parallel with the Distribution Network in accordance with the following: (a) 47 Hz – 47.5 Hz Operation for a period of at least 20 s is required each time the frequency is within this range. (b) 47.5 Hz – 49.0 Hz Operation for a period of at least 90 minutes is required each time the frequency is within this range. (c) 49.0Hz – 51.0 Hz Continuous operation of the Power Generating Module is required. (d) 51.0 Hz –51.5 Hz Operation for a period of at least 90 minutes is required each time the frequency is within this range. (e) 51.5 Hz – 52 Hz Operation for a period of at least 15 minutes is required each time the frequency is within this range. With regard to the rate of change of frequency withstand capability, a Power Generating Module shall be capable of staying connected to the Distribution Network and operate at rates of change of frequency up to 1 Hz/s as measured over a period of 500 ms unless disconnection was triggered by a rate of change of frequency type loss of mains protection or by the Power Generating Module's own protection system for a co-incident internal fault as detailed in paragraph 10.6.18.

Section 10: Over / Under Voltage These tests should be carried out in accordance with Annex B. Form B2-2 and Annex C. Form C2-2						**P**
L1 to N						
Function	Setting		Trip test		No trip test	
	Voltage [V]	Time delay [s]	Voltage [V]	Time delay [s]	Voltage / time	Confirm no trip
U/V*	184V	2,5	184V	2,50	188V / 2,48s	No trip
					180V / 2,45s	No trip
O/V stage 1*	262,2V	1,0	262,2V	1,00	258,2V 2,0s	No trip
					269,7V / 0,95s	No trip
O/V stage 2*	273,7V	0,5	273,7V	0,50	277,7V 0,45s	No trip
L2 to N						
Function	Setting		Trip test		No trip test	
	Voltage [V]	Time delay [s]	Voltage [V]	Time delay [s]	Voltage / time	Confirm no trip
U/V*	184V	2,5	184V	2,50	188V / 2,48s	No trip
					180V / 2,45s	No trip
O/V stage 1*	262,2V	1,0	262V	1,01	258,2V 2,0s	No trip
					269,7V / 0,95s	No trip
O/V stage 2*	273,7V	0,5	273V	0,53	277,7V 0,45s	No trip
L3 to N						
Function	Setting		Trip test		No trip test	
	Voltage [V]	Time delay [s]	Voltage [V]	Time delay [s]	Voltage / time	Confirm no trip
U/V*	184V	2,5	184V	2,50	188V / 2,48s	No trip
					180V / 2,45s	No trip
O/V stage 1*	262,2V	1,0	262,2V	1,00	258,2V 2,0s	No trip
					269,7V / 0,95s	No trip
O/V stage 2*	273,7V	0,5	273,7V	0,50	277,7V 0,45s	No trip

Note.

*The rated output voltage of unit is 230V

The total disconnection time for voltage and frequency protection, including the operating time of the disconnection device, shall be the time delay setting with a tolerance of, -0s + 0,5 s.

The Voltage required to trip is the setting ±7,5 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 ±8,7V and for the relevant times as shown in the table above to ensure that the protection will not trip in error.

Section 10: Over / Under Frequency These tests should be carried out in accordance with with Annex B. Form B2-2 and Annex C. Form C2-2						**P**
Function	Setting		Trip test		No trip test	
	Frequency [Hz]	Time delay [s]	Frequency [Hz]	Time delay [s]	Frequency / time	Confirm no trip
U/F stage 1	47,5	20	47,5	20,04	47,7Hz / 30s	No trip
U/F stage 2	47,0	0,5	47,0	0,503	47,2Hz / 19,5s	No trip
					46,8 Hz / 0,45s	No trip
O/F	52,0	0,5	52,01	0,501	51,8Hz / 120s	No trip
					52,2 Hz / 0,45s	No trip

Note.

The total disconnection time for voltage and frequency protection, including the operating time of the disconnection device, shall be the time delay setting with a tolerance of, -0s + 0,5 s.

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.

9.12. 10.3.3 /13.2 & C9.5 Frequency Response Test (type B/C/D)				P
Confirm by testing that the reconnection sequence starts after a minimum delay of 20 s for restoration of voltage and frequency in accordance with paragraph 10.3.3				
Under Voltage (182V*)				
Time delay setting [s]		Measured delay [s]		
20		24,3		
Over Voltage(275V*)				
Time delay setting [s]		Measured delay [s]		
20		20,4		
Under Frequency(47,4Hz)				
Time delay setting [s]		Measured delay [s]		
20		20,4		
Over Frequency(52,1Hz)				
Time delay setting [s]		Measured delay [s]		
20		28,2		
	Checks on no reconnection when voltage or frequency is brought to just outside stage 1 limits of table 1.			
	At 275,0V	At 180,0V	At 47,4Hz	At 52,1Hz
Confirmation that the Power Generating Module does not re-connect.	No reconnection	No reconnection	No reconnection	No reconnection
Note:				

9.3. 12.5/13.5 Reactive Power capability				P
Test: 100%U_n				
Inductive supply reactive power				
Rating power [%}	Active power [kW]	Reactive power [kVar]	Power factor [cos φ]	Voltage* [V]
10%	5,14	-2,03	0,8775	231,32
20%	9,95	-3,46	0,9445	231,32
30%	14,95	-5,13	0,9459	231,27
40%	19,98	-7,13	0,9419	231,31
50%	25,23	-8,82	0,9440	231,36
60%	30,20	-10,41	0,9454	231,41
70%	35,37	-12,09	0,9462	231,49
80%	40,27	-13,75	0,9463	231,58
90%	45,31	-15,39	0,9468	231,65
100%	49,77	-16,80	0,9475	231,71
Capacitive supply reactive power				
Rating power [%}	Active power [kW]	Reactive power [kVar]	Power factor [cos φ]	Voltage* [V]
10%	5,09	-2,61	0,8897	231,06
20%	9,87	-3,23	0,9504	231,12
30%	15,03	-5,25	0,9441	231,18
40%	20,03	-6,88	0,9457	231,23
50%	24,98	-8,49	0,9468	231,28
60%	30,19	-10,21	0,9473	231,33
70%	35,11	-11,84	0,9476	231,39
80%	40,13	-13,51	0,9477	231,45
90%	44,96	-15,19	0,9473	231,53
100%	49,72	-16,78	0,9475	231,90

Test: 95%U_n				
Inductive supply reactive power				
Rating power [%}	Active power [kW]	Reactive power [kVar]	Power factor [cos φ]	Voltage* [V]
10%	5,09	-2,64	0,8876	218,15
20%	9,94	-3,45	0,9447	218,22
30%	14,98	-5,40	0,9407	218,28
40%	20,02	-7,03	0,9436	218,35
50%	25,27	-8,72	0,9453	218,40
60%	30,21	-10,32	0,9463	218,43
70%	35,33	-11,98	0,9470	218,48
80%	40,23	-13,66	0,9469	218,54
90%	45,41	-15,37	0,9472	218,63
100%	49,67	-16,77	0,9475	218,77
Capacitive supply reactive power				
Rating power (%)	Active power [kW]	Reactive power [kVar]	Power factor [cos φ]	Voltage* [V]
10%	5,05	2,47	0,8981	218,19
20%	9,87	3,53	0,9416	218,25
30%	15,06	5,18	0,9456	218,31
40%	20,05	6,80	0,9470	218,36
50%	24,99	8,41	0,9478	218,39
60%	30,18	10,12	0,9481	218,46
70%	35,09	11,75	0,9482	218,53
80%	40,27	13,55	0,9478	218,59
90%	45,30	15,24	0,9478	218,67
100%	49,68	16,73	0,9477	218,76

Test: 105%U_n				
Inductive supply reactive power				
Rating power [%}	Active power [kW]	Reactive power [kVar]	Power factor [cos φ]	Voltage* [V]
10%	5,08	-1,88	0,8748	241,27
20%	9,88	-3,55	0.9411	241,31
30%	15,08	-5,36	0.9422	241,34
40%	20,12	-7,18	0,9418	241,36
50%	25,11	-8,78	0,9439	241,39
60%	30,08	-10,38	0,9453	241,42
70%	35,39	-12,11	0,9462	241,47
80%	40,26	-13,77	0,9462	241,51
90%	45,29	-15,40	0,9467	241,57
100%	49,52	-16,75	0,9473	241,62
Capacitive supply reactive power				
Rating power (%)	Active power [kW]	Reactive power [kVar]	Power factor [cos φ]	Voltage* [V]
10%	5,08	2,73	0,8814	241,80
20%	9,84	3,49	0,9425	241,86
30%	15,04	5,32	0,9427	241,91
40%	20,10	6,96	0,9445	241,94
50%	25,00	8,58	0,9458	241,97
60%	30,09	10,25	0,9466	241,99
70%	35,02	11,87	0,9470	242,05
80%	39,86	13,48	0,9473	242,11
90%	44,73	15,18	0,9470	242,19
100%	49,64	16,76	0,9474	242,25

Note:

Type B: When supplying Registered Capacity all Power Generating Modules shall be capable of continuous operation at any points between the limits of 0.95 Power Factor lagging and 0.95 Power Factor leading at the Connection Point or the Generating Unit terminals as appropriate for the Power Generating Facility and as agreed with the DNO.

Type C/D:

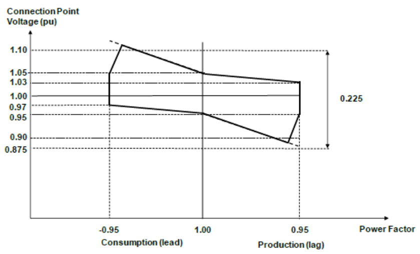


Figure 13.11 Reactive Power capability requirements (Power Park Modules operating at Registered Capacity, voltage above 33 kV)

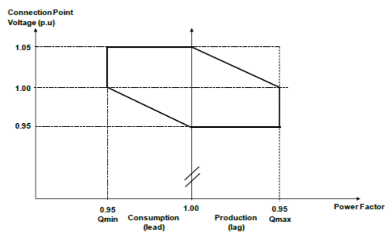
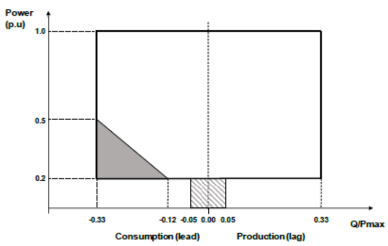


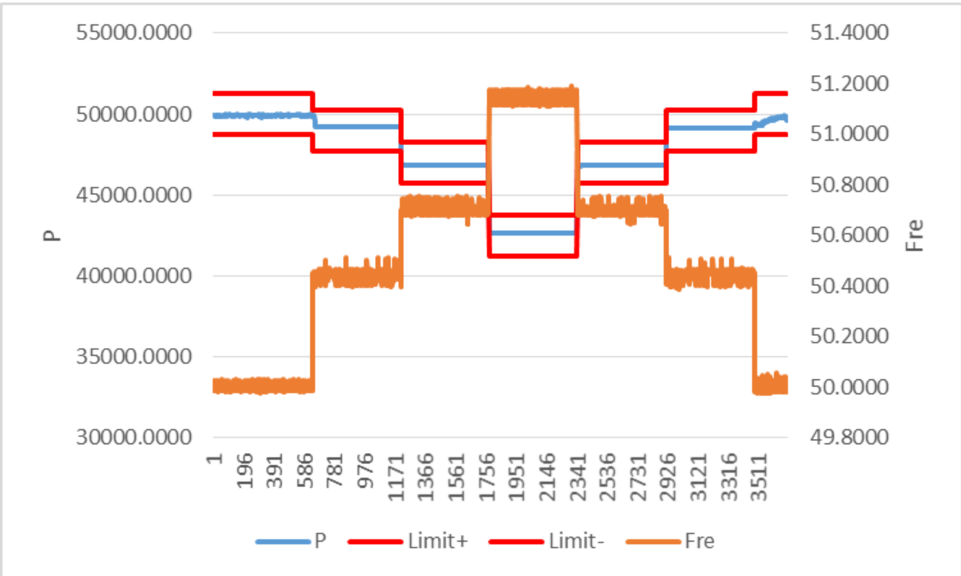
Figure 13.12 Reactive Power capability requirements (Power Park Modules operating at Registered Capacity, voltage at or below 33 kV)



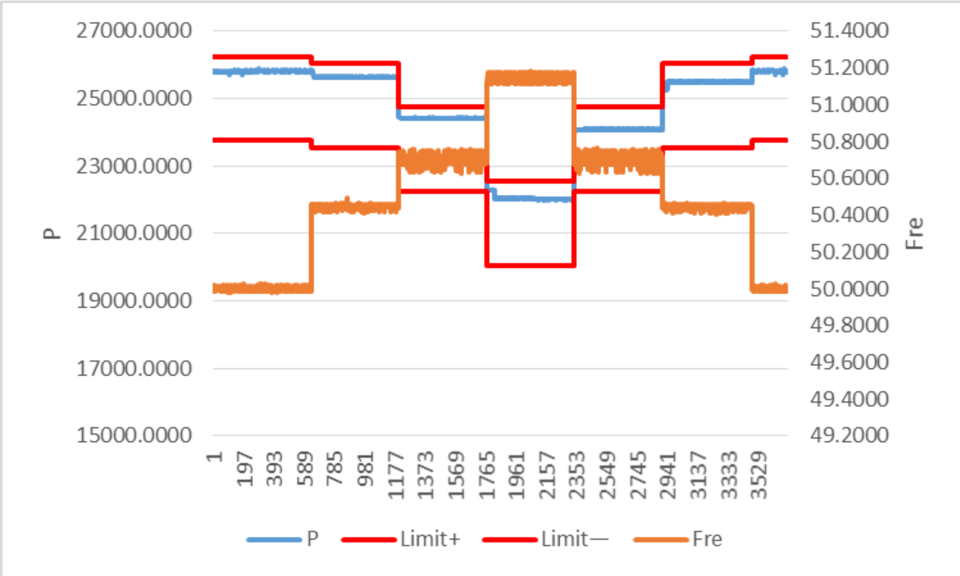
*The rated output voltage of the unit is 230V, and the setting value of PF in this test item can cover the limit value of reactive power for Type B, Type C and Type D.

9.5. 12.2.4/13.2.4 Limited Frequency Sensitive Mode – Over frequency) (For type B/C/D)							**P**
1-min mean value [Hz]:	a) 50,00	b) 50,45	c) 50,70	d) 51,15	e) 50,70	f) 50,45	g) 50,00
1. Measurement a) to g): Active power output > 80% P_n							
Frequency [Hz]:	50,00	50,45	50,70	51,15	50,70	50,45	50,00
$P_{expected}$ [kW]:	50,0	49,0	47,0	42,5	47,0	49,0	50,0
$P_{measured}$ [kW]:	49,9	49,2	46,9	42,6	46,8	49,1	49,6
$\Delta P_{E60}/P_{Setpoint}$ [%]:	0,2	0,4	0,2	0,2	0,4	0,2	0,8
2. Measurement a) to g): Active power output 40% and 60% after freezing > 80% P_n							
Frequency [Hz]:	50,00	50,45	50,70	51,15	50,70	50,45	50,00
$P_{expected}$ [kW]:	25,0	24,8	23,5	21,3	23,5	24,8	25,0
$P_{measured}$ [kW]:	25,8	25,6	24,4	22,1	24,1	25,5	25,8
$\Delta P_{E60}/P_{Setpoint}$ [%]:	1,6	1,6	1,8	1,6	1,2	1,4	1,6
Limit $\Delta P_{E60}/P_{Setpoint}$:	± 2,5% % of P_{Emax}						
Graph of power gradient:							

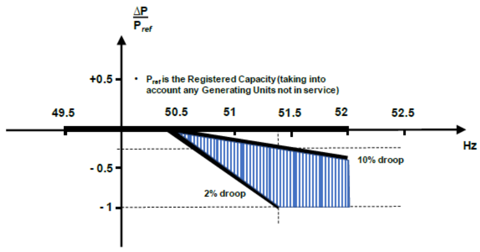
Graph of Measurement 1,: Active power output reduction 100% P_{nom}



Graph of Measurement 2,: Active power output reduction 50% Pnom



Test.



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 12.2 Active Power Frequency Response capability when operating in LFSM-O

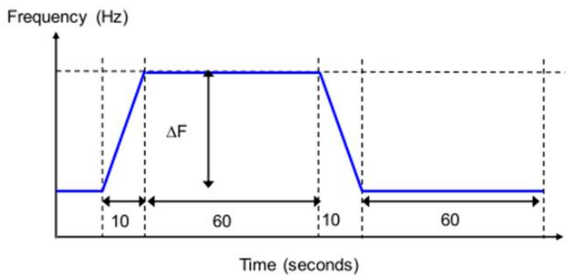


Figure B.4.1 – LFSM-O frequency step response simulation

The test is conducted for two powers. First, the test must start at a power > 80% Pn ("Measurement 1"), and in a second test, for a power between 40% to 60% Pn ("Measurement 2"). In the second test, after freezing of the P_M, the available active power output must be increased to a value > 80% Pn, and after the network frequency of 50,4 Hz is fallen below, the rise of the active power gradient must be recorded.

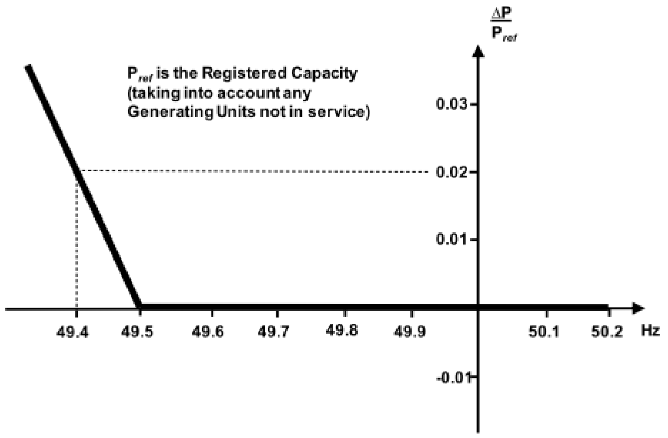
Point g) must be held until the micro-generator is again feeding in with the active power output available.

Note.

The test was performed with a droop of 2% (20%Pn/Hz).

9.6. 13.2.5 Limited Frequency Sensitive Mode – Under frequency (LFSM-U) (For type C/D)							**P**
1-min mean value [Hz]:	a)50,00 Hz	b)49,35 Hz	c)48,80 Hz	d)47,60 Hz	e)48,80 Hz	f)49,35 Hz	g)50,00 Hz
1**.** Measurement a) to g): Active power output =60% P_n							
Frequency [Hz]:	50,00	49,35	48,80	47,60	48,80	49,35	50,00
$P_{expected}$ [kW]:	30,0	31,5	37,0	49,0	37,0	31,5	30,0
$P_{measured}$ [kW]:	29,8	31,0	37,0	49,1	37,0	31,3	30,0
$\Delta P_{E60}/P_{Setpoint}$ [%]:	0,4	1,0	0,0	0,2	0,0	0,4	0,2
2. Measurement a) to g): Active power output = 10% P_n							
Frequency [Hz]:	50,00	49,35	48,80	47,60	48,80	49,35	50,00
$P_{expected}$ [kW]:	5,00	6,50	12,00	24,00	12,00	6,50	5,00
$P_{measured}$ [kW]:	4,97	6,51	12,00	23,90	12,00	6,50	5,40
$\Delta P_{E60}/P_{Setpoint}$ [%]:	0,06	0,02	0,00	0,20	0,00	0,00	0,20
Limit $\Delta P_{E60}/P_{Setpoint}$:	± 2,5% % of P_{Emax}						
Graph of power gradient:							

Test.



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 13.3 - Limited Frequency Sensitive Mode – Under frequency capability of Power Generating Modules

Note.

The test was performed with a droop of 10% (20%Pn/Hz).

12.3 & 12.6/13.3 & 13.6 Fault Ride Through and Fast Fault Current Injection (type B/C/D)	P

General:

12.3.1.5

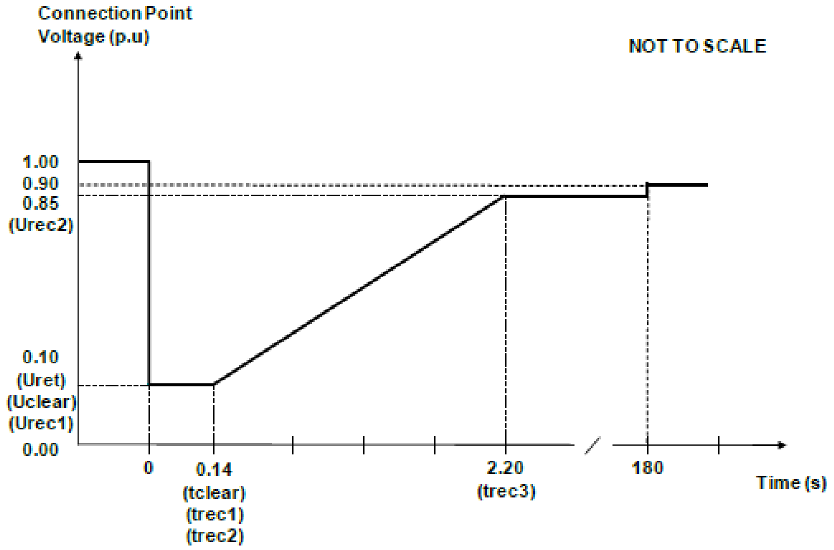


Figure 12.4 - Voltage against time curve applicable to Type B Power Park Modules

13.3.1.7

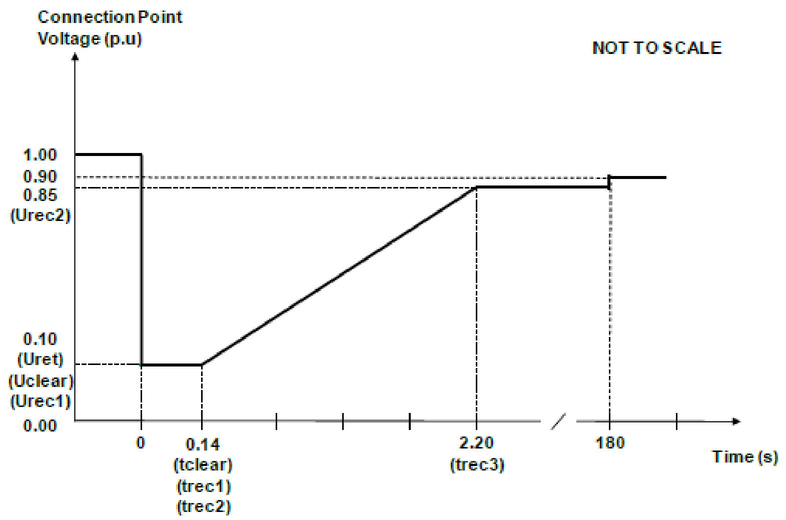


Figure 13.8 - Voltage against time curve applicable to Type C and Type D Power Park Modules connected below 110 kV

13.3.1.9

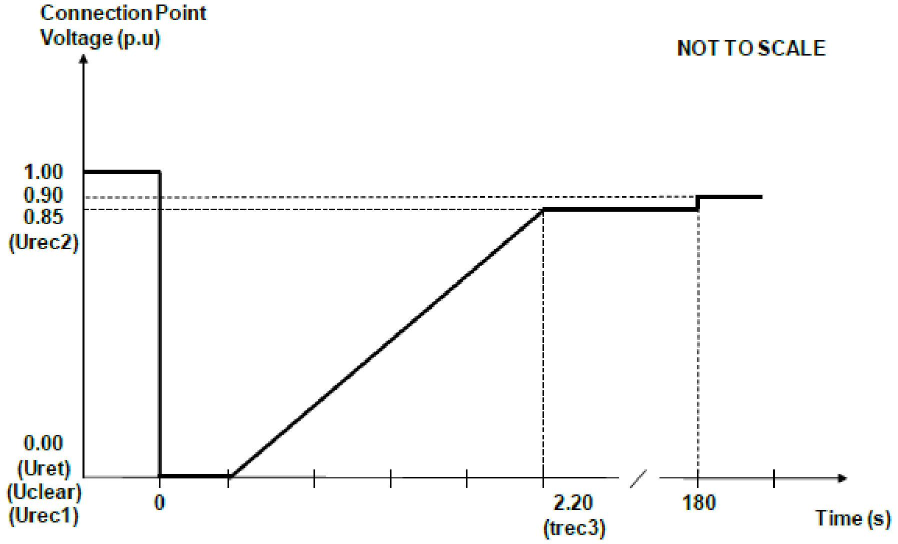


Figure 13.9 - Voltage against time curve applicable to Type D Power Park Modules connected at or above 110 kV

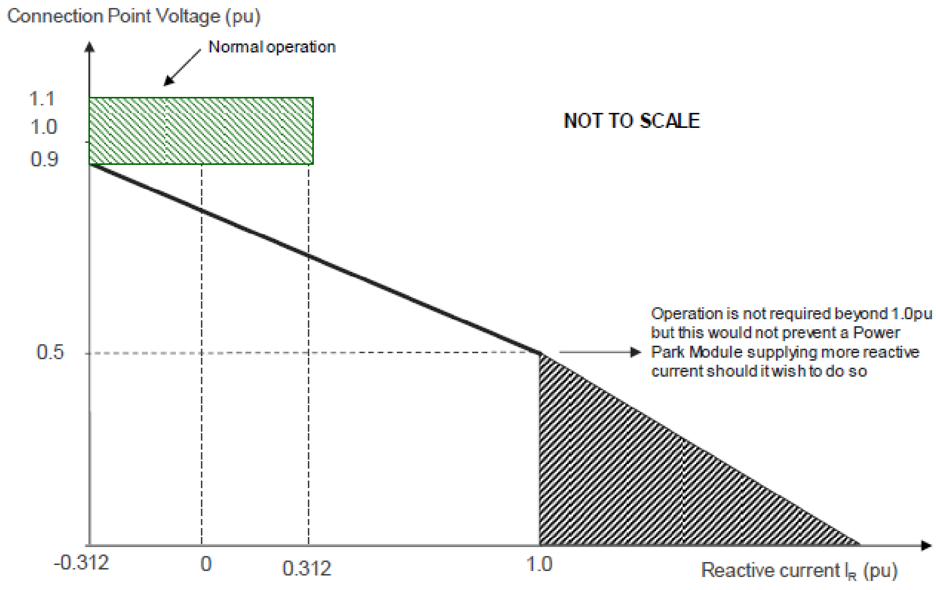


Figure 13.14 – locus of magnitude of injected reactive current

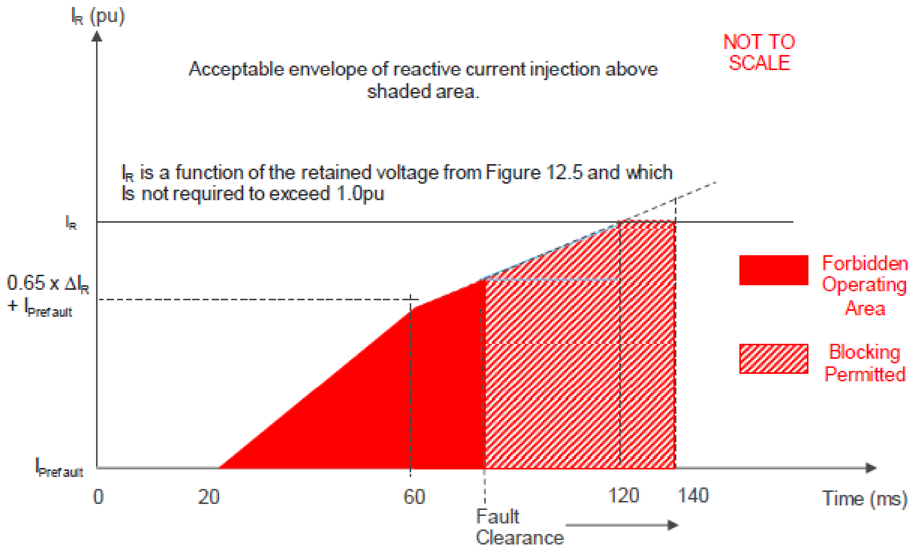


Figure 13.15(a) Chart showing area of Reactive Current injections for voltage depressions of ≤ 140 ms duration

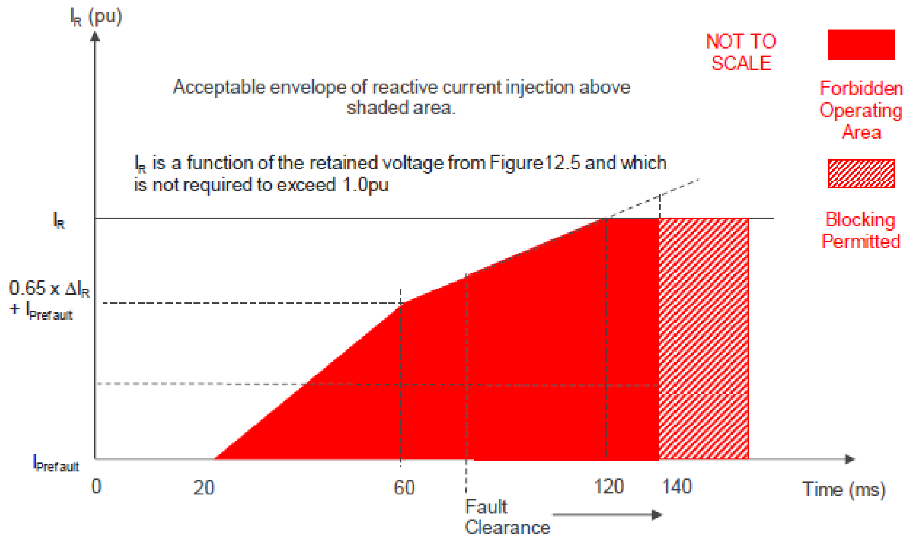
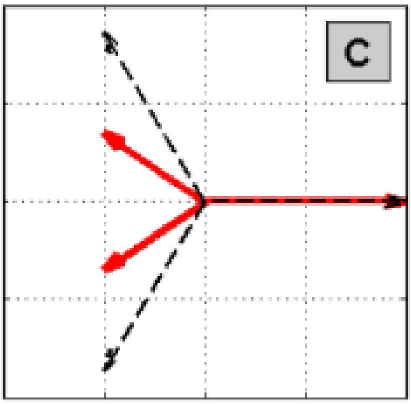


Figure 13.15(b) Chart showing area of Reactive Current injections for voltage depressions of > 140 ms duration

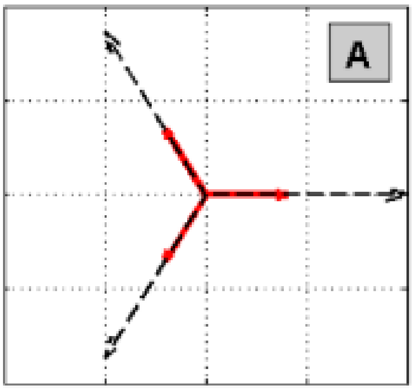
Test	Drop depth requirement [p.u. U_n]	Symmetry	Fault duration [ms]	Output power level			k-factor	Test no.
				P requirement	set P [P/P_n]	set Q [Q/P_n]		
2.1	0,10	Symmetry (Three phase fault)	≥383	P ≥0,9 P_{Emax}	1,0	0,0	0	2.1
2.2	0,10		≥383	0,1 P_{Emax} ≤ P ≤ 0,3 P_{Emax}	0,2	0,0	0	2.2
3.1	0,50		≥1352	P ≥0,9 P_{Emax}	1,0	0,0	0	3.1
3.2	0,50		≥1352	0,1 P_{Emax} ≤ P ≤ 0,3 P_{Emax}	0,2	0,0	0	3.2
4.1	0,85		≥2200	P ≥0,9 P_{Emax}	1,0	0,0	0	4.1
4.2	0,85		≥2200	0,1 P_{Emax} ≤ P ≤ 0,3 P_{Emax}	0,2	0,0	0	4.2
6.1	0,10	Asymmetric(two pahse fault)	≥383	P ≥0,9 P_{Emax}	1,0	0,0	0	6.1
6.2	0,10		≥383	0,1 P_{Emax} ≤ P ≤ 0,3 P_{Emax}	0,2	0,0	0	6.2
7.1	0,50		≥1352	P ≥0,9 P_{Emax}	1,0	0,0	0	7.1
7.2	0,50		≥1352	0,1 P_{Emax} ≤ P ≤ 0,3 P_{Emax}	0,2	0,0	0	7.2
8.1	0,85		≥2200	P ≥0,9 P_{Emax}	1,0	0,0	0	8.1
8.2	0,85		≥2200	0,1 P_{Emax} ≤ P ≤ 0,3 P_{Emax}	0,2	0,0	0	8.2

Note:

Phase to phase fault:



3-phase fault:



Graph of FRT test one

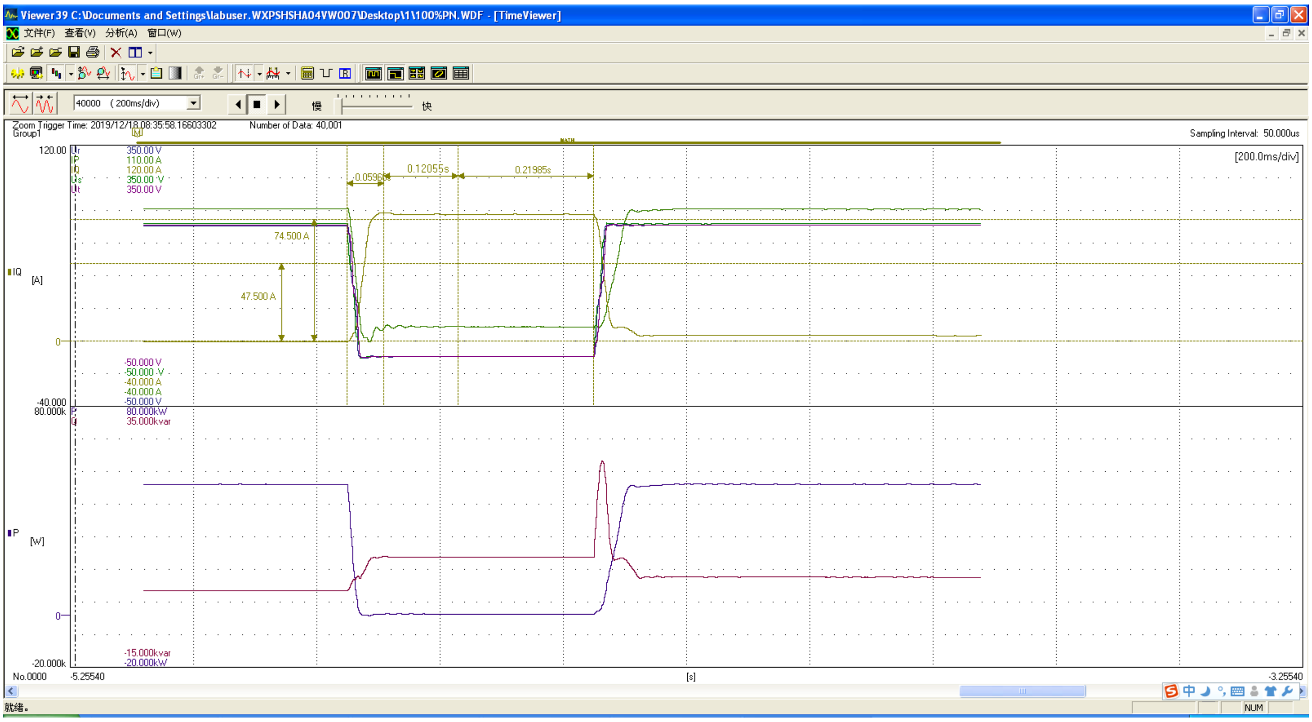
Test Result:

Test no.	Residual amplitude of phase-to-phase voltage [p.u.]	Limit for fault duration [ms]	Duration fault [ms]	Limit percentage of Injected current after 60ms [p.u. In]	Percentage of Injected current after 60ms [p.u. In]*	Limit percentage of Injected current after 120ms [p.u. In]*	Percentage of Injected current after 120ms [p.u. In]*	Result
2.1	0,10	≥383	400	≥0,650 p.u	1,048	≥1,000 p.u	1,028	P
2.2	0,10	≥383	400	≥0,650 p.u	1,072	≥1,000 p.u	1,050	P
3.1	0,50	≥1352	1362	≥0,650 p.u	1,087	≥1,000 p.u	1,089	P
3.2	0,50	≥1352	1362	≥0,650 p.u	1,084	≥1,000 p.u	1,008	P
4.1	0,85	≥2200	2201	≥-0,100 p.u	-0,150	≥-0,148 p.u	-0,150	P
4.2	0,85	≥2200	2201	≥-0,100 p.u	-0,150	≥-0,148 p.u	-0,150	P
6.1	0,10	≥383	403	≥0,650 p.u	1,000	≥1,000 p.u	1,000	P
6.2	0,10	≥383	403	≥0,650 p.u	1,000	≥1,000 p.u	1,000	P
7.1	0,50	≥1352	1358	≥0,650 p.u	1,010	≥1,000 p.u	1,010	P
7.2	0,50	≥1352	1358	≥0,650 p.u	1,001	≥1,000 p.u	1,001	P
8.1	0,85	≥2200	2738	≥-0,100 p.u	-0,150	≥-0,148 p.u	-0,150	P
8.2	0,85	≥2200	2738	≥-0,100 p.u	-0,150	≥-0,148 p.u	-0,150	P

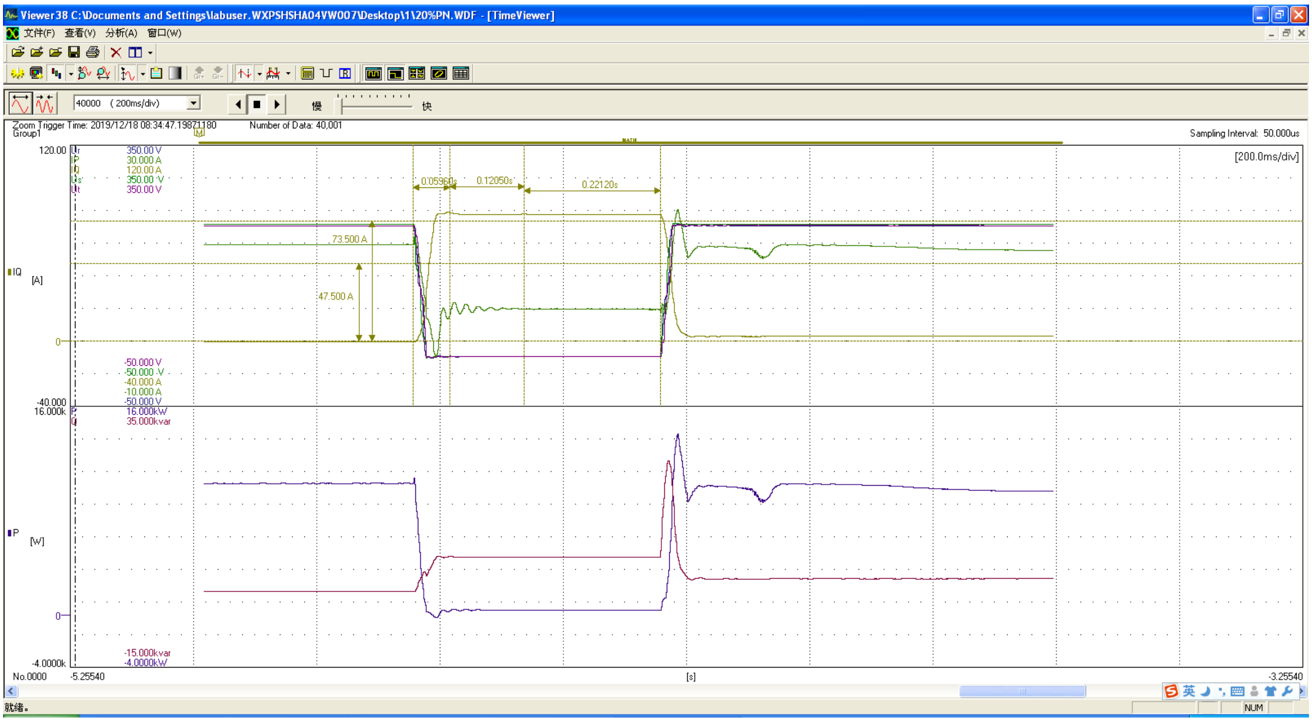
Note:

***The rate output current is 74,5A**

Test no. 2.1 – three-phase symmetrical fault (U/U_{nom} = 0,10)
P > 0,9 P_{Emax}

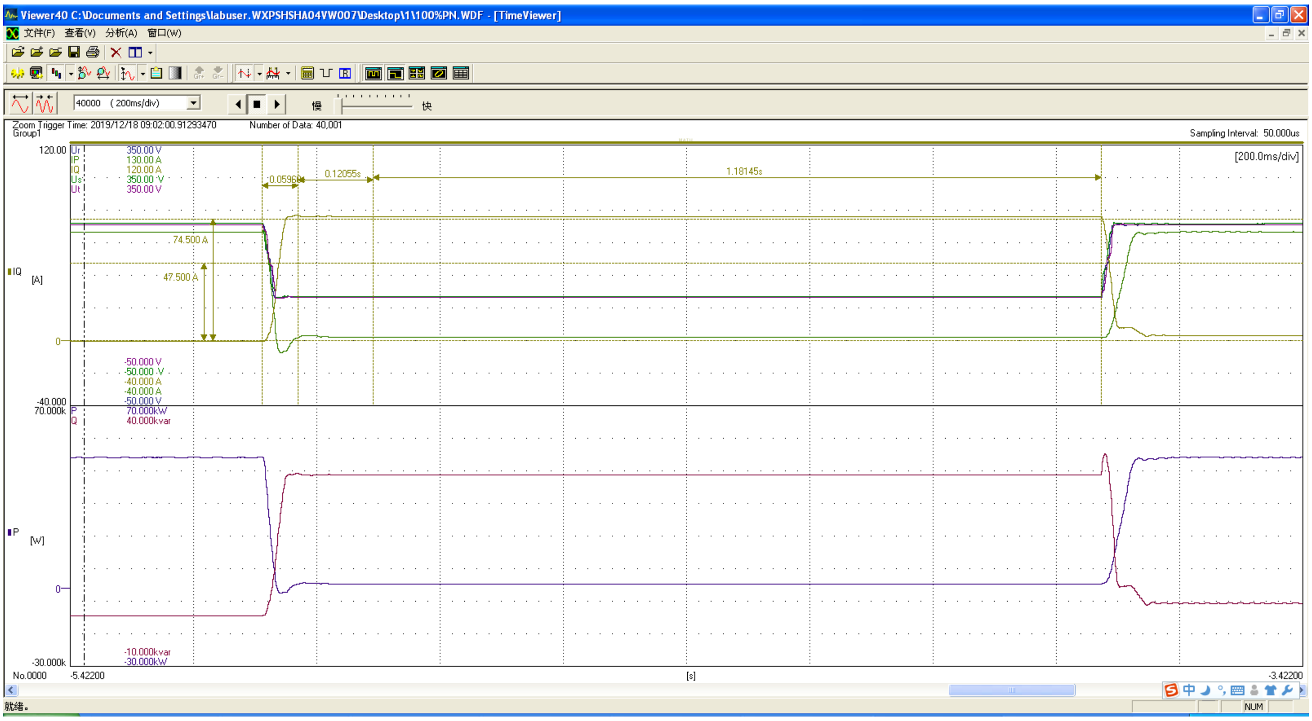


Test no. 2.2 – three-phase symmetrical fault (U/U_{nom} = 0,10)
0,**1** P_{Emax} **≤ P ≤ 0,3** P_{Emax}



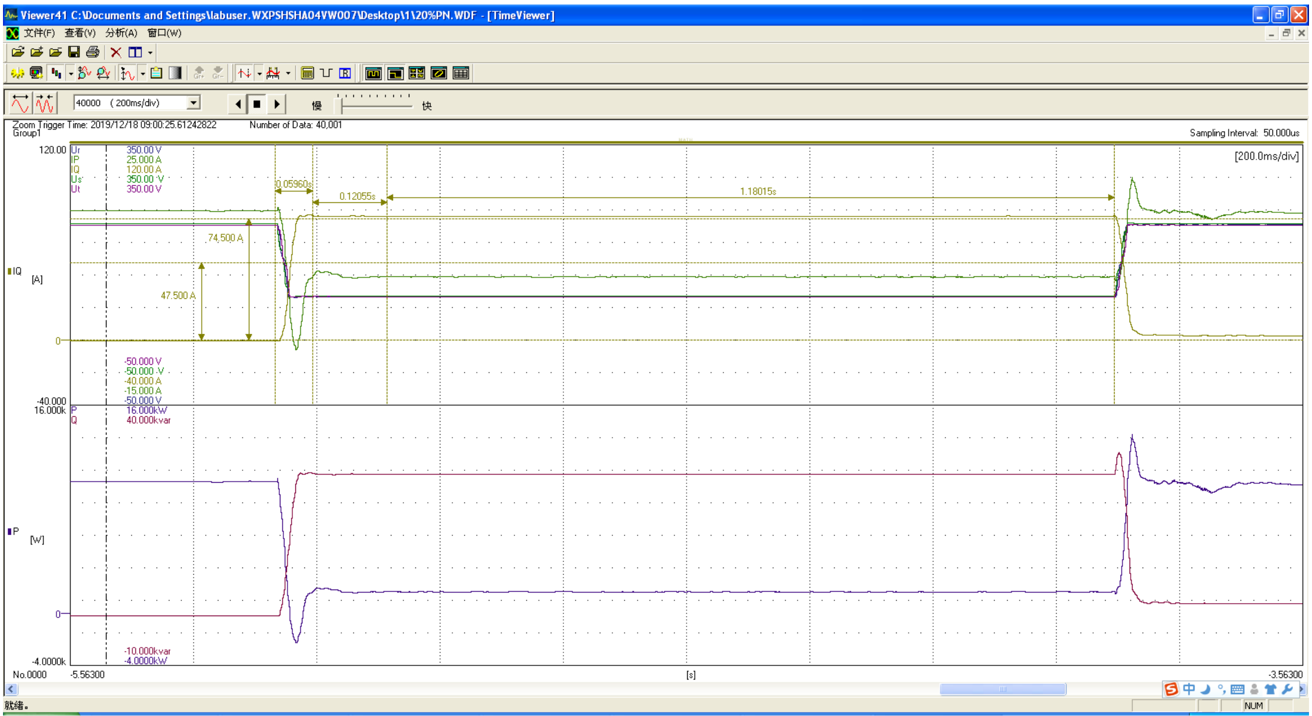
Test no. 3.1 – three-phase symmetrical fault (U/U_{nom} = 0,50)

P > 0,9 P_{Emax}



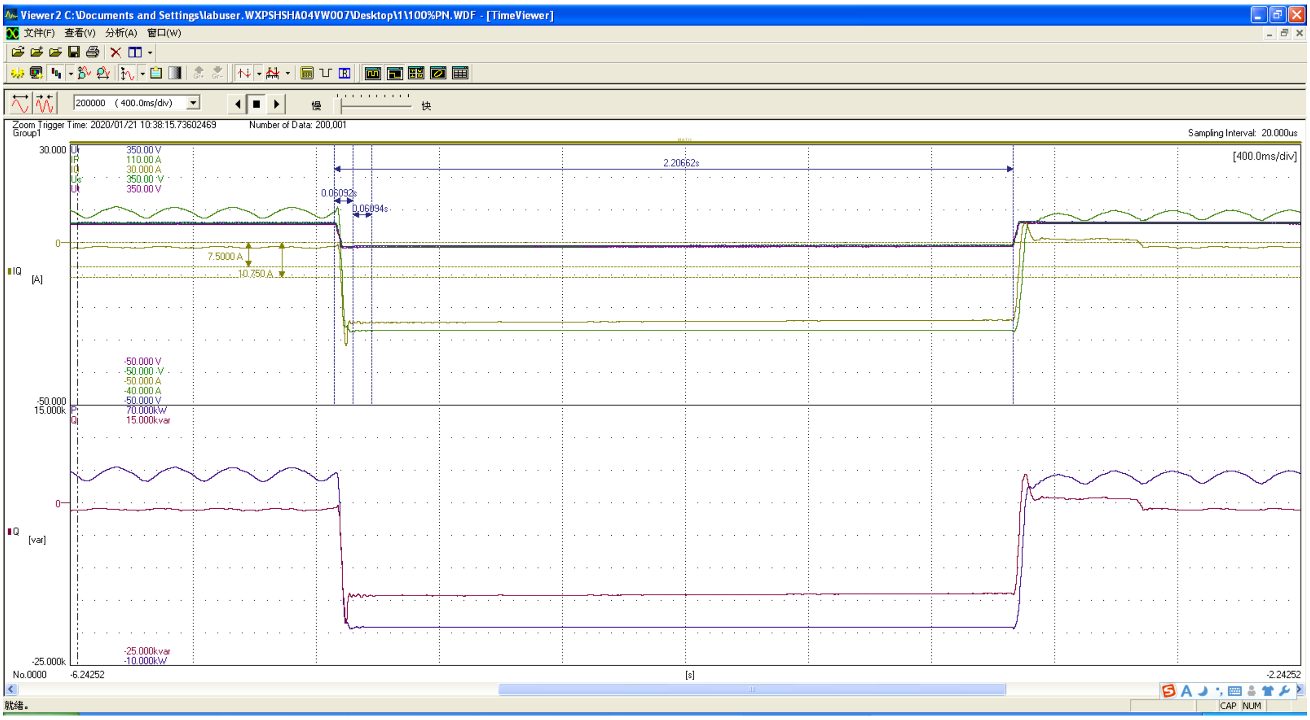
Test no. 3.2 – three-phase symmetrical fault (U/U_{nom} = 0,50)

0,**1** P_{Emax} **≤ P ≤ 0,3** P_{Emax}



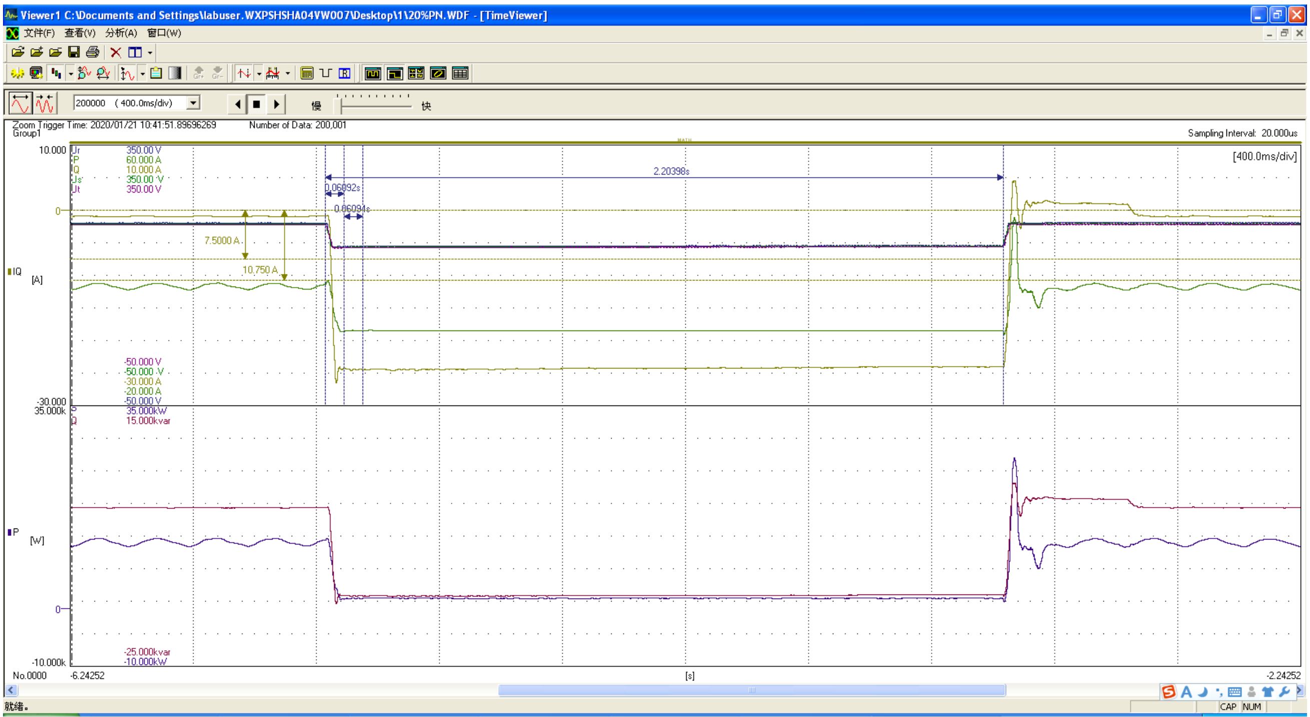
Test no. 4.1 – three-phase symmetrical fault (U/U_{nom} = 0,85)

P > 0,9 P_{Emax}



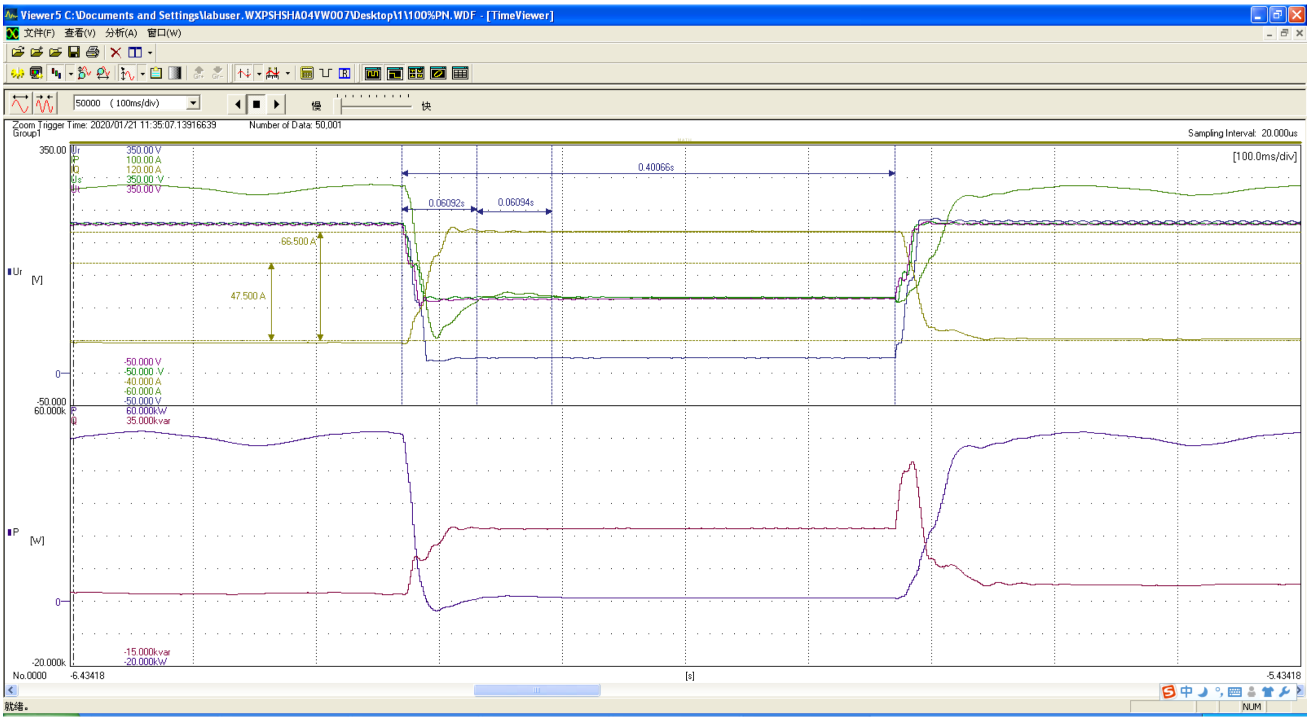
Test no. 4.2 – three-phase symmetrical fault (U/U_{nom} = 0,85)

0,**1** P_{Emax} **≤ P ≤ 0,3** P_{Emax}



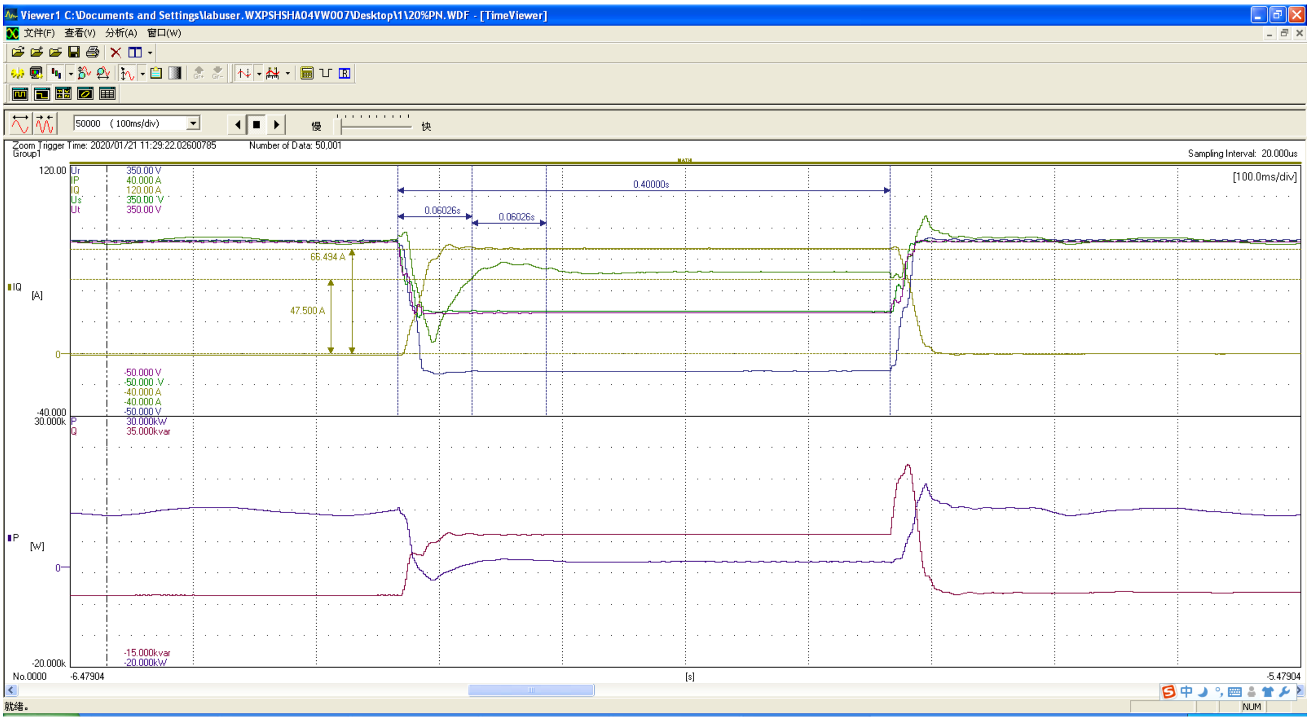
Test no. 6.1 – two-phase asymetrical fault (U/U_{nom} = 0,10)

P > 0,9 P_{Emax}

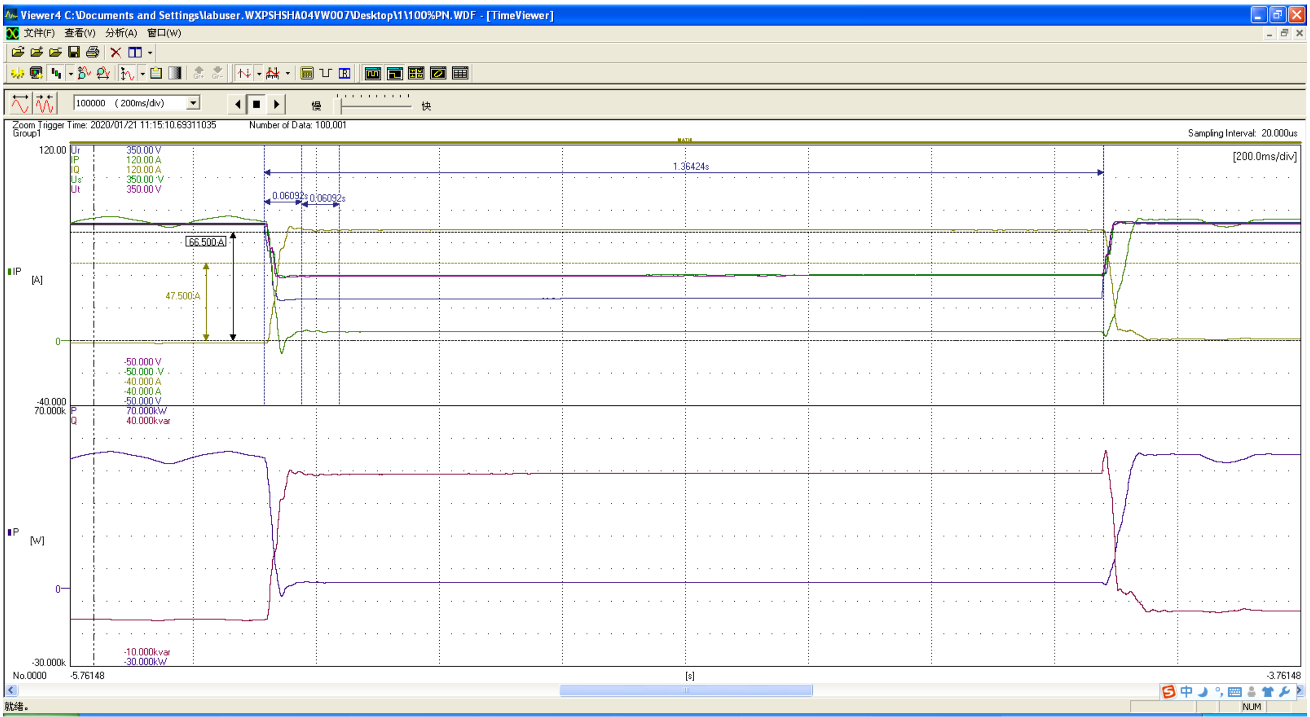


Test no. 6.2 – two-phase asymetrical fault (U/U_{nom} = 0,10)

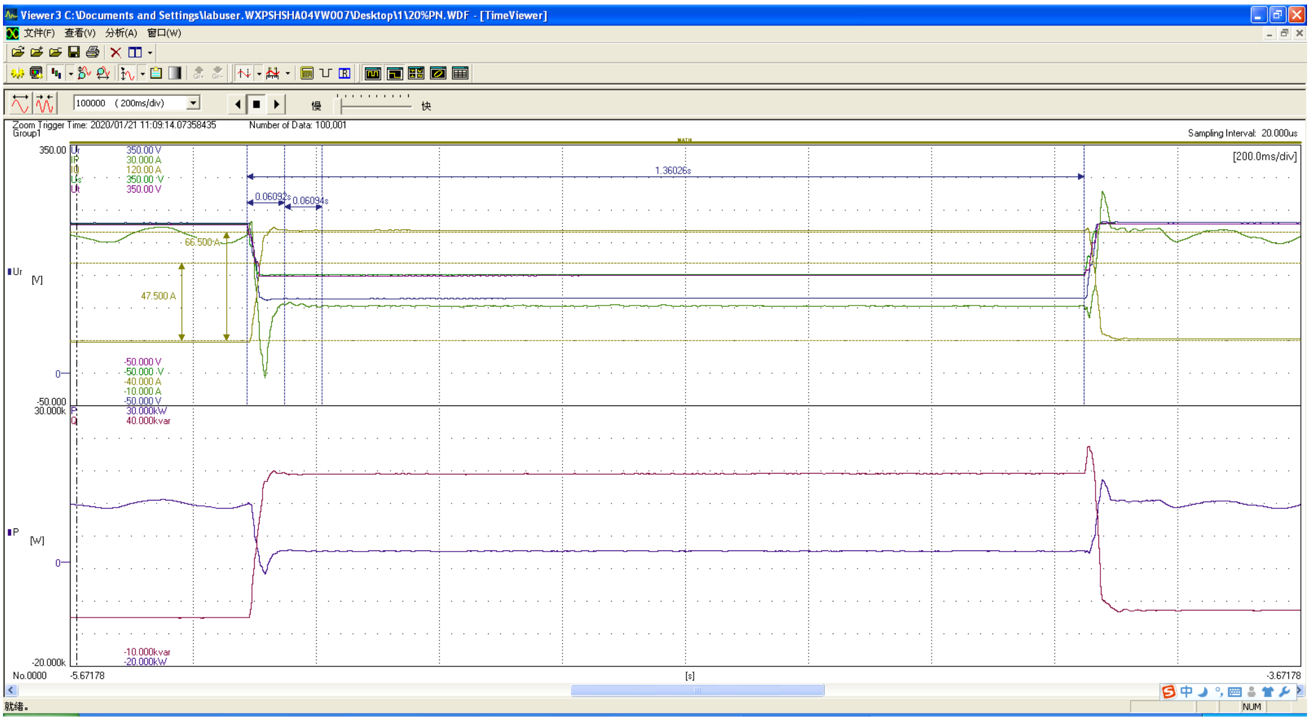
0,**1** P_{Emax} **≤ P ≤ 0,3** P_{Emax}



Test no. 7.1 – two-phase asymetrical fault (U/U_{nom} = 0,50)
P > 0,9 P_{Emax}

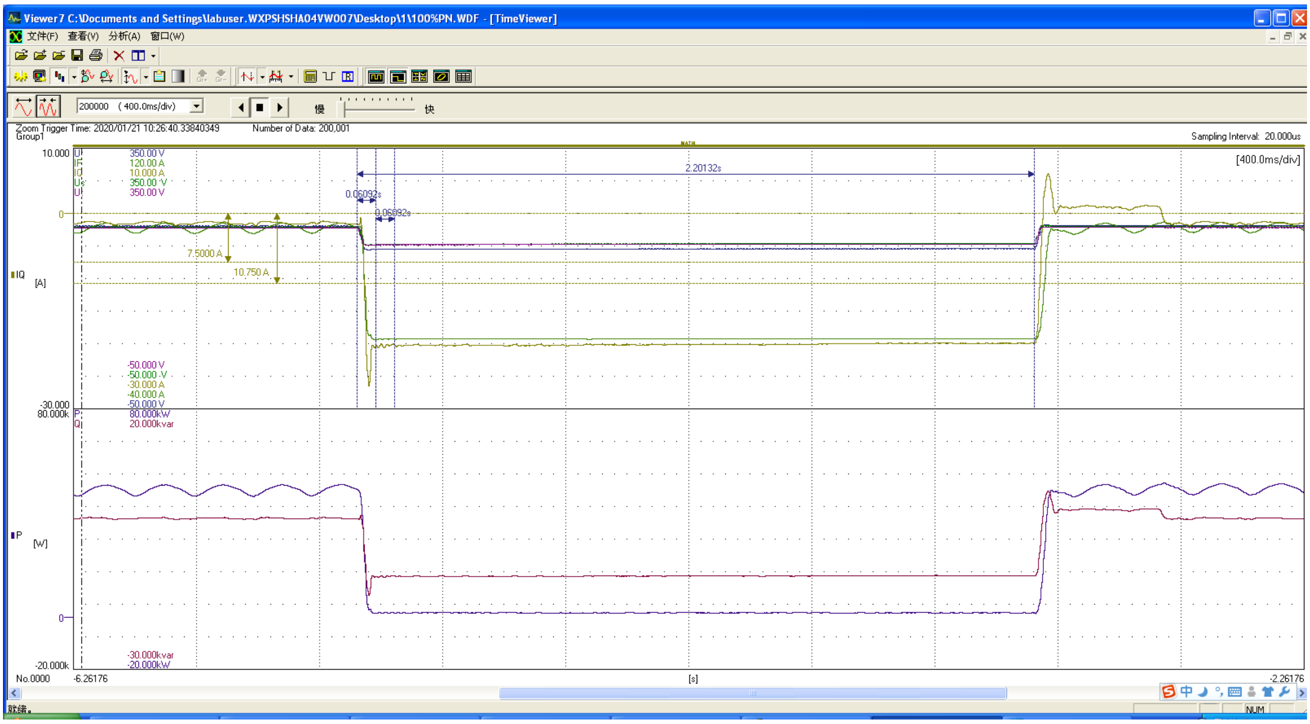


Test no. 7.2 – two-phase asymetrical fault (U/U_{nom} = 0,50)
0,1 P_{Emax} ≤ P ≤ 0,3 P_{Emax}



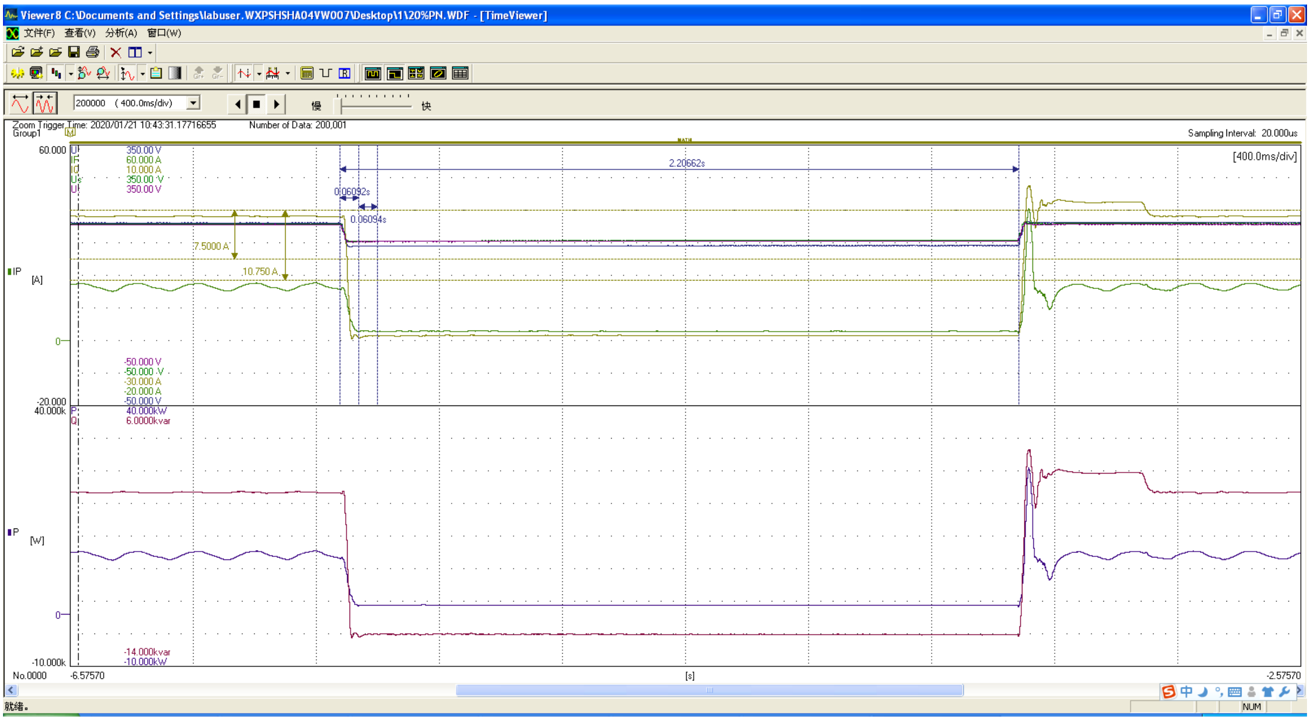
Test no. 8.1 – two-phase asymetrical fault (U/U_{nom} = 0,85)

P > 0,9 P_{Emax}



Test no. 8.2 – two-phase asymetrical fault (U/U_{nom} = 0,85)

0,1 P_{Emax} **≤ P ≤ 0,3** P_{Emax}



Annex No. 1
EMC Test Report

The complete EMC test report is stored at Bureau Veritas LCIE China.

CERTIFICATE

of Conformity
EC Council Directive 2014/30/EU
Electromagnetic Compatibility

Registration No.: AE 50435999 0001

Report No.: 50239652 001

Holder: Sungrow Power Supply Co., Ltd.
No.1699 Xiyou Rd.,New & High
Technology Industrial
Development Zone,
Hefei 230088
P. R. China

Product: PV-Inverter
(Grid-connected PV Inverter)

Identification: SG30CX SG33CX SG40CX SG50CX
Serial No.: n.a.
Remark: Refer to test report 50239652 001 for details.

Tested acc. to:
EN 61000-6-1:2007
EN 61000-6-2:2005
EN 61000-6-3:2007+A1
EN 61000-6-4:2007+A1
IEC 61000-6-1:2005
IEC 61000-6-2:2005
IEC 61000-6-3:2006+A1
IEC 61000-6-4:2006+A1

This certificate of conformity is based on an evaluation of a sample of the above mentioned product. Technical Report and documentation are at the Licence Holder's disposal. This is to certify that the tested sample is in conformity with all provisions of Annex I of Council Directive 2014/30/EU.
This certificate does not imply assessment of the production of the product and does not permit the use of a TÜV Rheinland mark of conformity. The holder of the certificate is authorized to use this certificate in connection with the EC declaration of conformity according to the a.m. Directive.

Certification Body

Date 10.05.2019

Xinhua Lu

TÜV Rheinland LGA Products GmbH - Tillystraße 2 - 90431 Nürnberg

CE The CE marking may only be used if all relevant and effective EC Directives are complied with. CE

TÜV Rheinland (China) Ltd.
Member of TÜV Rheinland Group

TÜVRheinland®
Precisely Right.

Sungrow Power Supply Co., Ltd.
Shandong Cao
-
No.1699 Xiyou Rd.,New & High
Technology Industrial
Development Zone,
Hefei 230088
P. R. China

Date : 10.05.2019
Our ref. : LHX 01
Your ref.: C.S.D.

Ref : AE Certificate of Conformity EMC

Type of Equipment : Grid-connected PV Inverter
Model Designation : See Certificate
Certificate No. : AE 50435999 0001
Report No. : 50239652 001

Dear Shandong Cao,

We herewith confirm that a sample of the above mentioned technical equipment has been tested and was found to be in accordance with the relevant requirements.

Enclosed please find your Certificate of Conformity.

We appreciate your kind support and would like to offer our assistance and continuous services in the future.

With kind regards,

Certification Body

Xinhua Lu

CC: Sungrow Power Supply Co., Ltd.

Enclosure

证书的详细资料请登陆www.tuvdotcom.com查阅,或拨打我司客服热线800 999 3668 / 400 883 1300咨询

TÜV Rheinland (China) Ltd.
莱茵检测认证服务(中国)有限公司

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e-mail: info@bj.chn.tuv.com
Internet: http://www.chn.tuv.com

Annex No. 2

Pictures of the unit

The complete Pictures of the unit is stored at Bureau Veritas LCIE China.

Figure 1. Overview

Figure 2.Right side view

Figure 3.Left side view

Figure 4.Top side view


Figure 5. Bottom side view


Figure 6.Rear view

Annex No. 3
Test Equipment list

No,	Equipment	Internal No,	Type/characteristics	Manufacturer	Last Calibration	Due Data
1	AC programmable power supply	ES20-69	RS810i	Ametek	2019-9-24	2020-9-24
2	Programmable DC power supply	ES21-167	TC.128.1500.160	TOPOCON	2019-9-24	2020-9-24
3	The RF power analyzer	EV21-11	WT3000	YOKOGAWA	2019-11-1	2020-10-31
4	Oscilloscope	RU21-01	DL850	YOKOGAWA	2019-9-23	2020-9-23
5	Anti-islanding test device	EI21-01	ACLT-3830H	Beijing Qunling	2019-9-24	2020-9-24
6	Voltage probe	ES21-174	P5200A	Tektromix	2019-9-24	2020-9-24
7	Voltage probe	ES21-176	P5200A	Tektromix	2019-9-24	2020-9-24
8	Voltage probe	ES21-177	P5200A	Tektromix	2019-9-24	2020-9-24
9	Voltage probe	ES21-144	P5200A	Tektromix	2019-9-24	2020-9-24
10	Current transformer	ES21-253	701930	YOKOGAWA	2019-9-23	2020-9-23
11	Current transformer	ES21-254	701930	YOKOGAWA	2019-9-23	2020-9-23
12	Current transformer	ES21-255	701930	YOKOGAWA	2019-9-23	2020-9-23
13	Current transformer	EH21-06	CT1000	YOKOGAWA	2019-9-24	2020-9-24