ATTESTATION OF CONFORMITY

Issued to:	Hangzhou Livoltek Power Co., Ltd. 1418-35 Moganshan Road, Shangcheng Industrial Zone, 310011 Hangzhou, Zhejiang Province, P.R. China
For the product:	ON-GRID SOLAR INVERTER
Trade name:	LIVOLTEK
Type/Model:	GT1-1K6S1, GT1-2K2S1, GT1-3KS1, GT1-3K3S1, GT1-3K6D1, GT1-4KD1, GT1-4K6D1, GT1-5KD1, GT1-6KD1
Ratings:	See Annex
Manufactured by:	Hangzhou Livoltek Power Co., Ltd. 1418-35 Moganshan Road, Shangcheng Industrial Zone, 310011 Hangzhou, Zhejiang Province, P.R. China
Requirements:	C10/11:2021 (Edition 2.2)

This Attestation is granted on account of an examination by DEKRA, the results of which are laid down in a confidential file no. 6139191.50

The examination has been carried out on one single specimen or several specimens of the product, submitted by the manufacturer. The Attestation does not include an assessment of the manufacturer's production. Conformity of his production with the specimen tested by DEKRA is not the responsibility of DEKRA.

Arnhem, 14 December 2022 Number: 6139191.01AOC

DEKRA Testing and Certification (Shanghai) Ltd.

Kreny Lin
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Annex

Document no. : 6139191.01AOC

Ratings of the test product:

Operating temperature range: - 30°C to + 60°C
Protective class: I
Ingress protection rating: IP65
Power factor range (adjustable): 0.8 leading…0.8 lagging
Over voltage category: III(AC), II(DC)

GT1-1K6S1:
PV input: max 550 Vdc, MPPT voltage range: 50-545 Vdc, max 14 A, Isc PV: 20 A
AC output: 230 Vac, L/N/PE, 50 Hz, max 7.7 A, rated active power 1600 W, max apparent power 1760 VA

GT1-2K2S1:
PV input: max 550 Vdc, MPPT voltage range: 50-545 Vdc, max 14 A, Isc PV: 20 A
AC output: 230 Vac, L/N/PE, 50 Hz, max 10.5 A, rated active power 2200 W, max apparent power 2420 VA

GT1-3KS1:
PV input: max 550 Vdc, MPPT voltage range: 50-545 Vdc, max 14 A, Isc PV: 20 A
AC output: 230 Vac, L/N/PE, 50 Hz, max 14.3 A, rated active power 3000 W, max apparent power 3300 VA

GT1-3K3S1:
PV input: max 550 Vdc, MPPT voltage range: 50-545 Vdc, max 14 A, Isc PV: 20 A
AC output: 230 Vac, L/N/PE, 50 Hz, max 14.3 A, rated active power 3300 W, max apparent power 3300 VA

GT1-3K6D1:
PV input: max 550 Vdc, MPPT voltage range: 70-545 Vdc, max 14/14 A, Isc PV: 20/20 A
AC output: 230 Vac, L/N/PE, 50 Hz, max 17.2 A, rated active power 3600 W, max apparent power 3960 VA

GT1-4KD1:
PV input: max 550 Vdc, MPPT voltage range: 70-545 Vdc, max 14/14 A, Isc PV: 20/20 A
AC output: 230 Vac, L/N/PE, 50 Hz, max 19.1 A, rated active power 4000 W, max apparent power 4400 VA

GT1-4K6D1:
PV input: max 550 Vdc, MPPT voltage range: 70-545 Vdc, max 14/14 A, Isc PV: 20/20 A
AC output: 230 Vac, L/N/PE, 50 Hz, max 20.0 A, rated active power 4600 W, max apparent power 4600 VA

GT1-5KD1:
PV input: max 550 Vdc, MPPT voltage range: 70-545 Vdc, max 14/14 A, Isc PV: 20/20 A
AC output: 230 Vac, L/N/PE, 50 Hz, max 23.9 A, rated active power 5000 W, max apparent power 5500 VA

GT1-6KD1:
PV input: max 550 Vdc, MPPT voltage range: 70-545 Vdc, max 14/14 A, Isc PV: 20/20 A
AC output: 230 Vac, L/N/PE, 50 Hz, max 28.7 A, rated active power 6000 W, max apparent power 6600 VA

End

TEST REPORT

EN 50549-1:2019

Requirements for generating plants to be connected in parallel with distribution networks

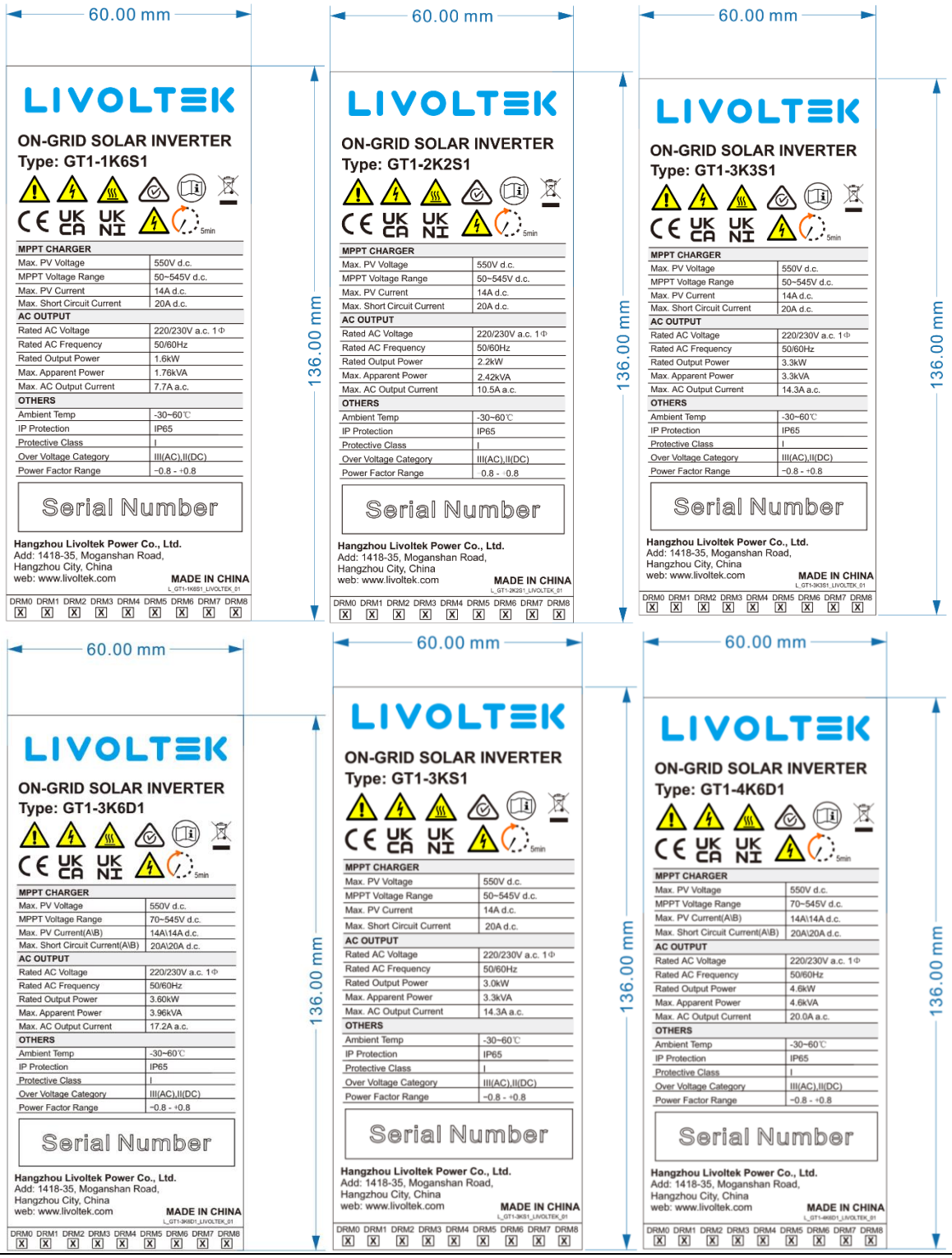
Part 1: Connection to a LV distribution network - Generating plants up to and including type B

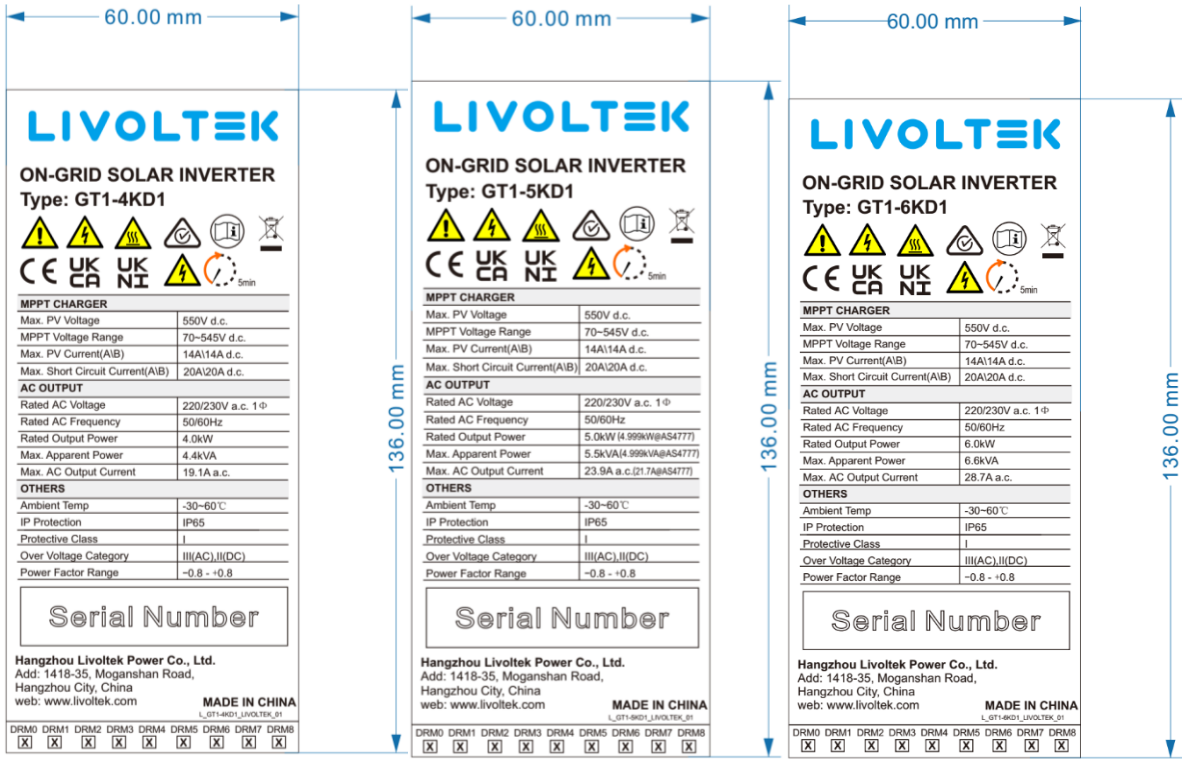
Report	
Report Number.....:	6138994.50
Date of issue.....:	2022-11-21
Total number of pages.....:	152
Testing Laboratory.....:	DEKRA Testing and Certification (Suzhou) Co., Ltd.
Address.....:	No.99, Hongye Road, Suzhou Industrial Park, Suzhou, Jiangsu, P.R. China
Applicant's name.....:	Hangzhou Livoltek Power Co., Ltd.
Address.....:	1418-35 Moganshan Road, Shangcheng Industrial Zone, 310011 Hangzhou, Zhejiang Province, P.R. China
Test specification:	
Standard .....:	EN 50549-1:2019
Test procedure.....:	Type test
Non-standard test method .....:	N/A
Test Report Form No.....:	EN 50549-1_V2.0
Test Report Form(s) Originator.....:	DEKRA Testing and Certification (Suzhou) Co., Ltd.
Master TRF.....:	Dated 2021-10-28
Test item description .....:	Grid-connected PV Inverter
Trade Mark.....:	LIVOLTEK
Manufacturer.....:	Same as applicant
Model/Type reference.....:	GT1-1K6S1, GT1-2K2S1, GT1-3KS1, GT1-3K3S1, GT1-3K6D1, GT1-4KD1, GT1-4K6D1, GT1-5KD1, GT1-6KD1
Ratings.....:	See copy of marking label and model list.

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

List of Attachments (including a total number of pages in each attachment): Appendix: Pictures (18 pages)	
Summary of testing:	
Tests performed (name of test and test clause):	**Testing location:**
All tests (except clause 4.8 EMC tests)	DEKRA Testing and Certification (Suzhou) Co., Ltd. No.99, Hongye Road, Suzhou Industrial Park, Suzhou, Jiangsu, P.R. China
4.8 EMC and power quality – EMC test (The EMC test report No. CN21Y10O 001 provided by the customer)	TÜV Rheinland (Shanghai) Co., Ltd. No.177, 178, Lane 777 West Guangzhong Road, Jing'an District, Shanghai, China

Rating label:





Remark:

According to customer's and market requirement, these models were evaluated under the grid voltage 230Vac and frequency of 50 Hz.

Test item particulars:				
Equipment mobility ..... :	movable fixed	hand-held transportable	stationary for building-in	
Connection to the mains ..... :	pluggable equipment permanent connection		direct plug-in for building-in	
Enviromental category ..... :	outdoor	indoor unconditional	indoor conditional	
Over voltage category Mains..... :	OVC I	OVC II	OVC III	OVC IV
Over voltage category PV ..... :	OVC I	OVC II	OVC III	OVC IV
Mains supply tolerance (%)..... :	±10%			
Tested for power systems..... :	TN, TT			
IT testing, phase-phase voltage (V) ..... :	N/A			
Class of equipment..... :	Class I Not classified	Class II	Class III	
Mass of equipment (kg) ..... :	GT1-1K6S1, GT1-2K2S1, GT1-3KS1, GT1-3K3S1: 6.5 kg GT1-3K6D1, GT1-4KD1, GT1-4K6D1, GT1-5KD1, GT1-6KD1: 12.5 kg			
Pollution degree ..... :	Outside PD3; Inside PD2			
IP protection class ..... :	IP65			
Possible test case verdicts:				
- test case does not apply to the test object ..... :	N/A			
- test object does meet the requirement..... :	P (Pass)			
- test object does not meet the requirement ..... :	F (Fail)			
- this clause is information reference for installation.... :	Info.			
Testing:				
Date of receipt of test item ..... :	2022-04-22 (samples provided by applicant)			
Date (s) of performance of tests ..... :	2022-04-22 to 2022-10-24			

General remarks:

"(see appended table)" refers to a table appended to the report.
"(see Appendix #)" refers to additional information appended to the report.
The test results presented in this report relate only to the object tested.
This report shall not be reproduced, except in full, without the written approval of the Issuing testing laboratory.
The measurement result is considered in conformance with the requirement if it is within the prescribed limit, It is not necessary to account the uncertainty associated with the measurement result.
This report is only for reference and is not used for legal proof function in China market.
Throughout this report a ☐ comma / ☒ point is used as the decimal separator.

The unit under test complies with the following standards and regulations:
EN 50549-1:2019; COMMISSION REGULATION (EU) 2016/631 (NC RfG).

Name and address of factory (ies):

Hangzhou Livoltek Power Co., Ltd.
1418-35 Moganshan Road, Shangcheng Industrial Zone, 310011 Hangzhou, Zhejiang Province, P.R. China

General product information:

The PCEs GT1-1K6S1, GT1-2K2S1, GT1-3KS1, GT1-3K3S1, GT1-3K6D1, GT1-4KD1, GT1-4K6D1, GT1-5KD1, GT1-6KD1 under test (EUTs) are single-phase Grid-connected Photovoltaic Inverter which utilizes the advanced power electronics conversion components such as MOSFET, IGBT to convert the variable DC power generated from the photovoltaic (PV) arrays to the stable utility AC power which can be fed into the commercial electrical grid.

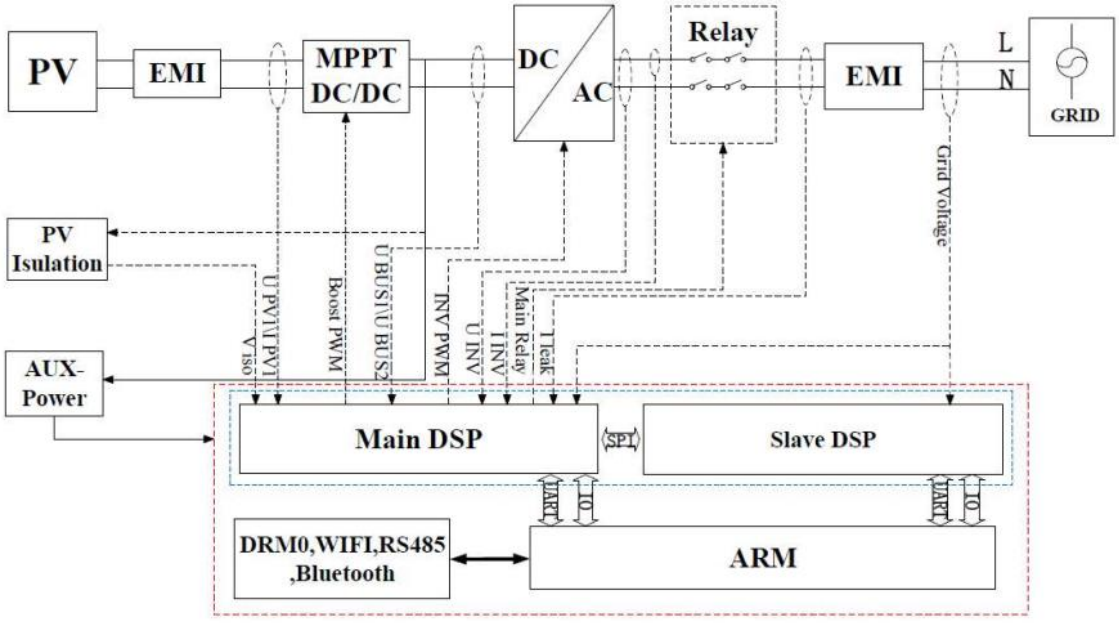
Model Difference:

GT1-1K6S1, GT1-2K2S1, GT1-3KS1, GT1-3K3S1 are same family products identical to each other, except for software settings for different output power and current.

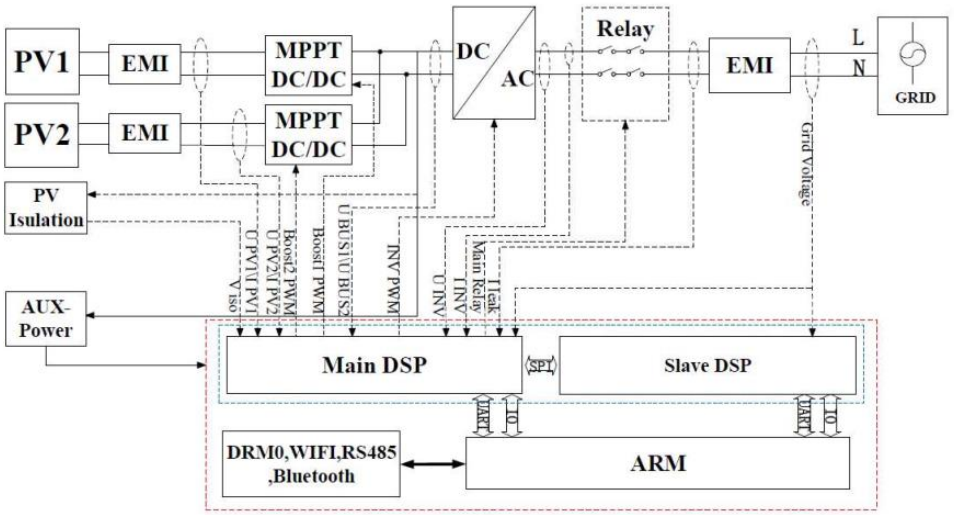
GT1-3K6D1, GT1-4KD1, GT1-4K6D1, GT1-5KD1, GT1-6KD1 are same family products identical to each other, except for software settings for different output power and current.

Unless otherwise specified, all the tests were performed on model GT1-6KD1 and also applicable for all other models stated in this report.

Block diagram for models GT1-1K6S1, GT1-2K2S1, GT1-3KS1, GT1-3K3S1:



Block diagram for models GT1-3K6D1, GT1-4KD1, GT1-4K6D1, GT1-5KD1, GT1-6KD1:



Protective function in PCE:

1. PV array insulation resistance detecting
2. Residual current monitoring
3. Over and under grid voltage / frequency protection
4. Anti-islanding protection
5. DC injection current protection
6. Over current protection
7. Over temperature protection and auto de-rating function
8. Relay self-checking function
9. RCMU self-checking function
10. Relays used in series as grid auto-disconnection devices for redundant NS protection
11. Short-circuit protection relies on external circuit breaks which are specified in the installation manual

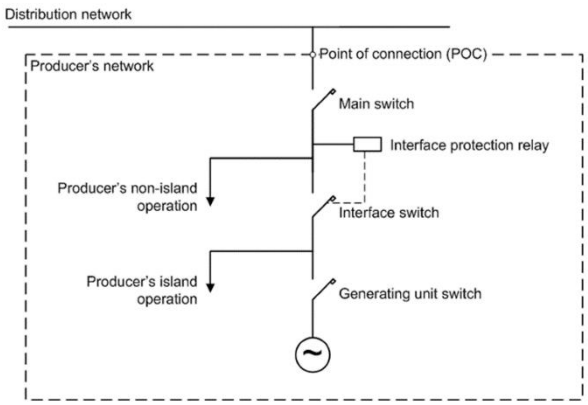
Firmware/software version:

Model	Firmware/software version
GT1-1K6S1	GT11LTK1ACA_Ver1.05; GT11LTK1DCA_Ver1.02
GT1-2K2S1	
GT1-3KS1	
GT1-3K3S1	
GT1-3K6D1	GT12LTK1ACA_Ver1.07; GT12LTK1DCA_Ver1.02
GT1-4KD1	
GT1-4K6D1	
GT1-5KD1	
GT1-6KD1	

Model list:

Technical Data	GT1-1K6S1	GT1-2K2S1	GT1-3KS1	GT1-3K3S1	GT1-3K6D1	GT1-4KD1	GT1-4K6D1	GT1-5KD1	GT1-6KD1
PV Input Data									
Max DC Input Power [W]	2400	3300	4500	4950	5400	6000	6900	7500	9000
Max DC Input Voltage[V]	550				550				
Min PV input voltage[V]	50				70				
Start-up DC Input Voltage[V]	70				90				
Nominal DC Input Voltage[V]	400				400				
MPPT Operating Range[V]	50-545				70-545				
MPPT Operating Range (Full-Load) [V]	120-500	165-500	225-500	250-500	135-500	150-500	170-500	185-500	225-500
Max DC Input Current[A]	14				14+14				
Max Short Circuit current[A]	20				20+20				
AC Output Data									
Nominal Output Power [W]	1600	2200	3000	3300	3600	4000	4600	5000	6000
Max Apparent Power [VA]	1760	2420	3300	3300	3960	4400	4600	5500	6600
Rated AC Grid Output Current[A]	7.0	9.6	13.0	14.3	15.7	17.4	20.0	21.7	26.1
Max AC Output Current[A]	7.7	10.5	14.3	14.3	17.2	19.1	20.0	23.9	28.7
Rated AC Grid Voltage[V]	220V/230V, L+N+PE								
AC Grid Voltage Range[V]	160-300								
Rated Grid Frequency [Hz]	50/60								
Grid Frequency Range [Hz]	45-55/55-65								
Power Factor	> 0.99 Rated power (Adjustable 0.8 Leading - 0.8Lagging)								

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict
4	**TECHNICAL REQUIREMENTS**		P
4.1	**General**		P
	This clause defines the requirements on generating plants to be operated in parallel with the distribution network. Where settings or a range of configurability is provided and respecting the legal framework the configurations and settings may be provided by the DSO. Where no settings are provided by the DSO, the specified default settings shall be used; if no default settings are provided, the producer shall propose settings and inform the DSO.		P
	The requirements of Clause 4 apply during normal operation of the generating units and do not apply in case of maintenance or units out of operation. The provisions apply to EESS in generation mode. In charging mode EESS should have the same characteristics, unless stated otherwise in the clauses of this European Standard.		Info.
	The applicability is independent of the duration the generating unit operates in parallel with the distribution network. It is the responsibility of the DSO to relax, if deemed appropriate, the requirements for an individual generating unit or plant whose operation in parallel only lasts for a short time (temporary operation in parallel). The relaxed requirements shall be agreed between the DSO and the producer, along with the maximum allowable duration of the temporary operation in parallel.		P
	If different requirements on the generating plant interfere with each other, the following hierarchy in descending order shall be applied:		P
	1. Generating unit protection, including regarding the prime mover; 2. interface protection (see 4.9) and protection against faults within the generating plant; 3. voltage support during faults and voltage steps (see 4.7.4); 4. the lower value of: remote control command on active power limitation for distribution grid security (see 4.11) and local response to overfrequency (see 4.6.1); 5. local response to underfrequency if applicable (see 4.6.2); 6. reactive power (see 4.7.2) and active power (P(U) see 4.7.2) controls; 7. other control commands on active power set point for e.g. market, economic reasons, self-consumption optimization.		P
	The system shall be so designed that under foreseeable conditions no self-protection trips prior to the fulfilment of the requirements of this European Standard and all settings provided by the DSO or responsible party.		P

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict
	For cogeneration plants embedded in industrial sites, active power requirements shall be agreed between the responsible party and the producer. In such a case the priority list is adapted accordingly.		P
	Besides the requirements of Clause 4, additional requirements apply for connecting a generating plant to the distribution network, e.g. assessment of the point of connection. However, this is excluded from the scope of this European Standard but some guidance is provided in the informative Annex A.		P
4.2	**Connection scheme**		Info.
	The connection scheme of the generating plant shall be in compliance with the requirements of the DSO. Different requirements may be subject to agreement between the producer and the DSO depending on the power system needs.	It's depended on installer.	Info.
	Inter alia, the generating plant shall ensure the following:		Info.
	• synchronization, operation and disconnection under normal network operating conditions, i.e. in the absence of faults or malfunctions; • faults and malfunctions within the generating plant shall not impair the normal functioning of the distribution network; • coordinated operation of the interface switch with the generating unit switch, the main switch and switches in the distribution network, for faults or malfunctions within the generating plant or the DSO network during operation in parallel with the distribution network; and • disconnection of the generating plant from the distribution network by tripping the interface switch according to 4.9.		Info.
	In order to satisfy the above functions, coordinated but independent switches and protection equipment may be applied in the generating plant, as shown in the example in Figure 2.  **Figure 2 — Example of an generating plant connected to a distribution network (schematic view of switches)**	It's depended on installer.	Info.
4.3	**Choice of switchgear**		P

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict
4.3.1	General		P
	Switches shall be chosen based on the characteristics of the power system in which they are intended to be installed. For this purpose, the short circuit current at the installation point shall be assessed, taking into account, inter alia, the short circuit current contribution of the generating plant.		P
4.3.2	Interface switch		P
	Switches shall be power relays, contactors or mechanical circuit breakers each having a breaking and making capacity corresponding to the rated current of the generating plant and corresponding to the short circuit contribution of the generating plant.	two power relays in series installed both Line and Neutral phase on the mains side of the unit to separate it from the grid.	P
	The short-time withstand current of the switching devices shall be coordinated with rated short circuit power at the point of connection.		P
	In case of loss of auxiliary supply power to the switchgear, a secure disconnection of the switch is required immediately.		P
	Where means of isolation (according to HD 60364-5-551) is not required to be accessible to the DSO at all times, automatic disconnection with single fault tolerance according to 4.13 shall be provided.		P
	The function of the interface switch might be combined with either the main switch or the generating unit switch in a single switching device. In case of a combination, the single switching device shall be compliant to the requirements of both, the interface switch and the combined main switch or generating unit switch. As a consequence, at least two switches in series shall be present between any generating unit and the POC.		P
4.4	**Normal operating range**		P
4.4.1	General		P
	Generating plants when generating power shall have the capability to operate in the operating ranges specified below regardless of the topology and the settings of the interface protection.		P
4.4.2	Operating frequency range		P

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict
	The generating plant shall be capable of operating continuously when the frequency at the point of connection stays within the range of 49 Hz to 51 Hz. In the frequency range from 47 Hz to 52 Hz the generating plant should be capable of operating until the interface protection trips. Therefore, the generating plant shall at least be capable of operating in the frequency ranges, for the duration and for the minimum requirement as indicated in Table 1.	(See appended table)	P
	This permission does not affect the requirements for interface protection according to clause 4.9. In this case over and under frequency machine protection might trip prior to interface protection. If an integrated interface protection device is used, the reduction of the configuration range of the interface protection in clause 4.9 is acceptable.		P
4.4.3	Minimal requirement for active power delivery at underfrequency		P
	A generating plant shall be resilient to the reduction of frequency at the point of connection while reducing the maximum active power as little as possible. The admissible active power reduction due to underfrequency is limited by the full line in Figure 5 and is characterized by a maximum allowed reduction rate of 10% of P_{max} per 1 Hz for frequencies below 49.5 Hz.	(See appended table)	P

Table 1 — Minimum time periods for operation in underfrequency and overfrequency situations

Frequency Range	Time period for operation Minimum requirement	Time period for operation stringent requirement
47,0 Hz – 47,5 Hz	not required	20 s
47,5 Hz – 48,5 Hz	30 min [a]	90 min
48,5 Hz – 49,0 Hz	30 min [a]	90 min [a]
49,0 Hz – 51,0 Hz	Unlimited	Unlimited
51,0 Hz – 51,5 Hz	30 min [a]	90 min
51,5 Hz – 52,0 Hz	not required	15 min

[a] Respecting the legal framework, it is possible that longer time periods are required by the responsible party in some synchronous areas.

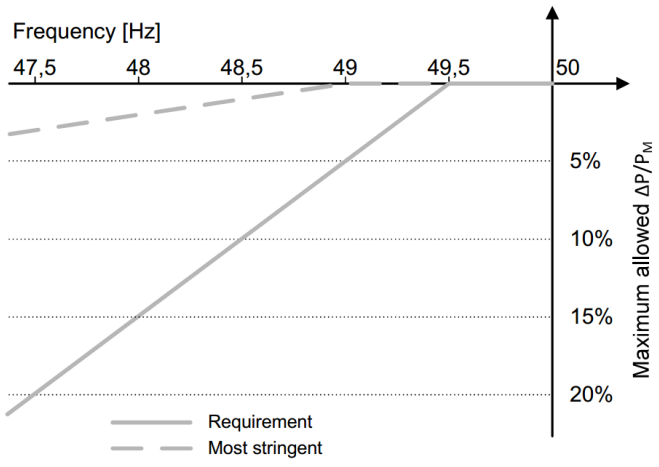
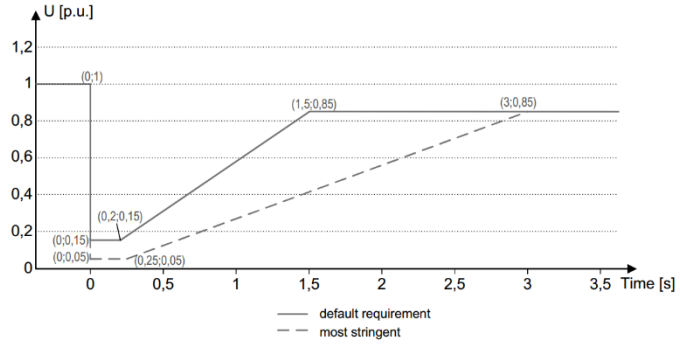
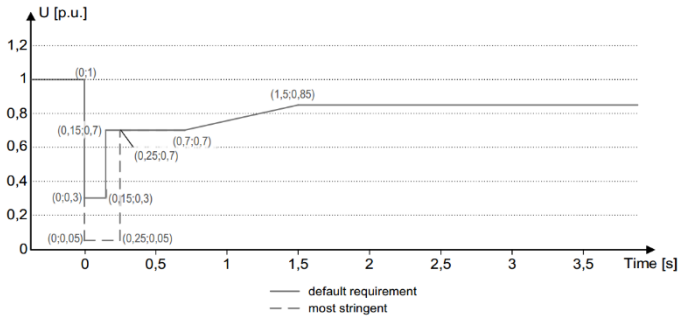
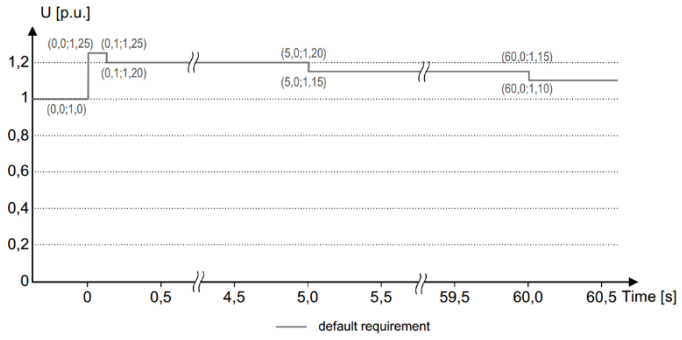


Figure 5 — Maximum allowable power reduction in case of underfrequency

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict
	It is possible that a more stringent power reduction characteristic is required by the responsible party. Nevertheless this requirement is expected to be limited to an admissible active power reduction represented by the dotted line in Figure 5 which is characterised by a reduction rate of 2 % of the maximum power P_{max} per 1 Hz for frequencies below 49 Hz.		P
	If any technologies intrinsic design or ambient conditions have influence on the power reduction behaviour of the system, the manufacturer shall specify at which ambient conditions the requirements can be fulfilled and eventual limitations. The information can be provided in the format of a graph showing the intrinsic behaviour of the generating unit for example at different ambient conditions. The power reduction and the ambient conditions shall comply with the specification given by the responsible party. If the generating unit does not meet the power reduction at the specified ambient conditions, the producer and the responsible party shall agree on acceptable ambient conditions.		P
4.4.4	Continuous operating voltage range		P
	When generating power, the generating plant shall be capable of operating continuously when the voltage at the point of connection stays within the range of 85 % U_n to 110 % U_n. Beyond these values the under and over voltage ride through immunity limits as specified in clause 4.5.3 and 4.5.4 shall apply.	(see appended table)	P
	In case of voltages below U_n, it is allowed to reduce the apparent power to maintain the current limits of the generating plant. The reduction shall be as small as technically feasible.		P
	For this requirement all phase to phase voltages and in case a neutral is connected, additionally all phase to neutral voltages shall be evaluated.		P
	The producer shall take into account the typical voltage rise and voltage drop within the generating plant.		Info.
4.5	**Immunity to disturbances**		P
4.5.1	In general, generating plants should contribute to overall power system stability by providing immunity towards dynamic voltage changes unless safety standards require a disconnection.		P
	The following clauses describe the required immunity for generating plants taking into account the connection technology of the generating modules.		P
	The following withstand capabilities shall be provided regardless of the settings of the interface protection.		P
4.5.2	Rate of change of frequency (ROCOF) immunity	(see appended table)	P

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict
	ROCOF immunity of a power generating plant means that the generating modules in this plant stay connected with the distribution network and are able to operate when the frequency on the distribution network changes with a specified ROCOF. The generating units and all elements in the generating plant that might cause their disconnection or impact their behaviour shall have this same level of immunity.		P
	The generating modules in a generating plant shall have ROCOF immunity for a ROCOF equal or exceeding the value specified by the responsible party. If no ROCOF immunity value is specified, the following ROCOF immunity shall apply, making distinction between generating technologies:		P
	Non-synchronous generating technology: at least 2 Hz/s		P
	Synchronous generating technology: at least 1 Hz/s		N/A
	The ROCOF immunity is defined with a sliding measurement window of 500 ms.		P
4.5.3	Under-voltage ride through (UVRT)		P
	Generating modules classified as type B modules according to COMMISSION REGULATION 2016/631 shall comply with the requirements of 4.5.3.2 and 4.5.3.3.		P
	Generating modules classified as type A and smaller according to COMMISSION REGULATION 2016/631 should comply with these requirements.		P
	The actual behaviour of type A modules and smaller shall be specified in the connection agreement.		P
4.5.3.2	Generating plant with non-synchronous generating technology		P
	Generating modules shall be capable of remaining connected to the distribution network as long as the voltage at the point of connection remains above the voltage-time curve of Figure 6. The voltage is relative to U_n. The smallest phase to neutral voltage, or if no neutral is present, the smallest phase to phase voltage shall be evaluated.  **Figure 6 — Under-voltage ride through capability for non-synchronous generating technology**	(see appended table)	P

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict
	The responsible party may define a different UVRT characteristic. Nevertheless, this requirement is expected to be limited to the most stringent curve as indicated in Figure 6.		P
	This means that the whole generating module has to comply with the UVRT requirement. This includes all elements in a generating plant: the generating units and all elements that might cause their disconnection.		P
	For the generating unit, this requirement is considered to be fulfilled if it stays connected to the distribution grid as long as the voltage at its terminals remains above the defined voltage-time diagram.		P
	After the voltage returns to continuous operating voltage range, 90 % of pre-fault power or available power whichever is the smallest shall be resumed as fast as possible, but at the latest within 1 s unless the DSO and the responsible party requires another value.		P
4.5.3.3	Generating plant with synchronous generating technology	Not synchronous generator.	N/A
	Generating modules shall be capable of staying connected to the distribution network as long as the voltage at the point of connection remains above the voltage-time curve of Figure 7. The voltage is relative to Un. The smallest phase to neutral voltage or if no neutral is present the smallest phase to phase voltage shall be evaluated.  **Figure 7 — Under-voltage ride through capability for synchronous generating technology**		N/A
4.5.4	Over-voltage ride through (OVRT)		P

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict
	Generating modules, except for micro-generating plants, shall be capable of staying connected to the distribution network as long as the voltage at the point of connection remains below the voltage-time curve of Figure 8.  **Figure 8 — Over-voltage ride through capability**	(see appended table)	P
	The highest phase to neutral voltage or if no neutral is present the highest phase to phase voltage shall be evaluated.		P
	This means that not only the generating units shall comply with this OVRT requirement but also all elements in a generating plant that might cause its disconnection.		P
4.6	**Active response to frequency deviation**		P
4.6.1	Power response to over-frequency		P
	Generating plants shall be capable of activating active power response to over-frequency at a programmable frequency threshold f1 at least between and including 50,2 Hz and 52 Hz with a programmable droop in a range of at least s=2 % to s=12 %. The droop reference is P_{ref}. Unless defined differently by the responsible party		P
	• $P_{ref} = P_{max}$, in the case of synchronous generating technology and electrical energy storage systems		N/A
	• $P_{ref} = P_M$, the actual AC output power at the instant when the frequency reaches the threshold f_1, in the case of all other non-synchronous generating technology		P
	The power value calculated according to the droop is a maximum power limit. If e.g. the available primary power decreases during a high frequency period below the power defined by the droop function, lower power values are permitted.		P
	The maximum power limit is: $P_{max-limit} = P_M + \Delta P$ with $\Delta P = \frac{1}{s} \cdot \frac{(f_1 - f)}{f_n} \cdot P_{ref}$ with f the actual frequency		P

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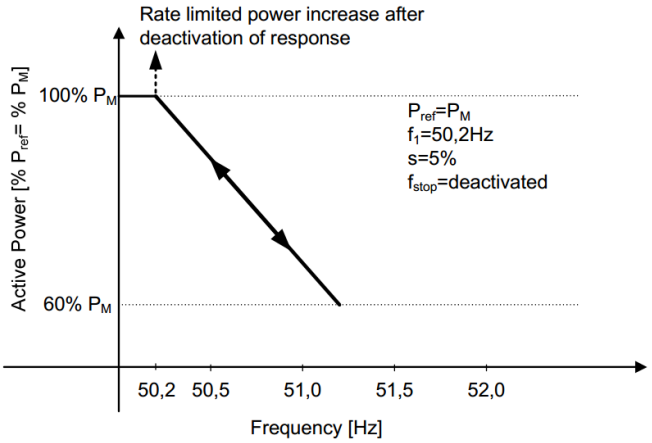
Clause	Requirement - Test	Result - Remark	Verdict
	The generating plant shall be capable of activating active power response to over-frequency as fast as technically feasible with an intrinsic dead time that shall be as short as possible with a maximum of 2 s and with a step response time of maximum 30 s, unless another value is defined by the relevant party. An intentional delay shall be programmable to adjust the dead time to a value between the intrinsic dead time and 2 s.		P
	After activation, the active power frequency response shall use the actual frequency at any time, reacting to any frequency increase or decrease according to the programmed droop with an accuracy of ± 10 % of the nominal power (see Figure 9). The resolution of the frequency measurement shall be ± 10 mHz or less. The accuracy is evaluated with a 1 min average value. At POC, loads if present in the producer's network might interfere with the response of the generating plant. The effect of loads is not considered for the evaluation of the accuracy, only the behaviour of the generating plant is relevant.  **Figure 9 — Example of Active power frequency response to overfrequency**	(see appended table)	P
	Generating plants reaching their minimum regulating level shall, in the event of further frequency increase, maintain this power level constant unless the DSO and the responsible party requires to disconnect the complete plant or if the plant consists of multiple units by disconnecting individual units.		P
	The active power frequency response is only deactivated if the frequency falls below the frequency threshold f_1.		P

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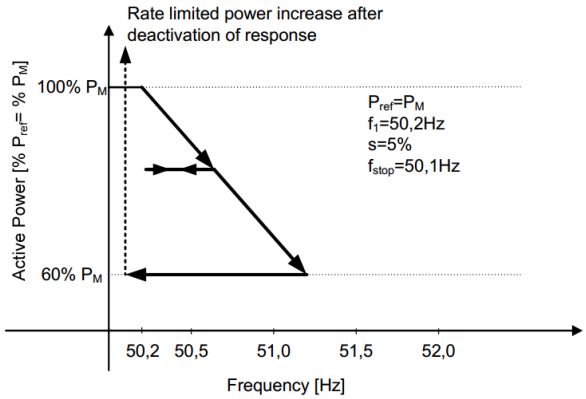
Clause	Requirement - Test	Result - Remark	Verdict
	If required by the DSO and the responsible party an additional deactivation threshold frequency f_{stop} shall be programmable in the range of at least 50 Hz to f_1. If f_{stop} is configured to a frequency below f1 there shall be no response according to the droop in case of a frequency decrease (see Figure 10). The output power is kept constant until the frequency falls below f_{stop} for a configurable time t_{stop}.  **Figure 10 — Example of active power frequency response to overfrequency with configured deactivation threshold**	(see appended table)	P
	If at the time of deactivation of the active power frequency response the momentary active power P_M is below the available active power P_A, the active power increase of the generating plant shall not exceed the gradient defined in 4.10.2.		P
	Settings for the threshold frequency f_1, the droop and the intentional delay are provided by the DSO and the responsible party. If no settings are provided, the default settings in Table 2 should be applied. **Table 2 — Standard settings for frequency response to overfrequency** **Parameter** / **Range** / **Default setting** **Threshold frequency f_1** / **50,2 Hz to 52 Hz** / **50,2 Hz** **Deactivation threshold f_{stop}** / **50,0 Hz to f_1** / **Deactivated** **Deactivation time t_{stop}** / **0 to 600 s** / **30s** **Droop** / **2 % to 12 %** / **5 %** **Intentional delay** / **0 s to 2 s** / **0 s**		P
	The enabling and disabling of the function and its settings shall be field adjustable and means shall be provided to protect these from unpermitted interference (e.g. password or seal) if required by the DSO and the responsible party.		P
	Alternatively for the droop function described above, the following procedure is allowed for generating modules if permitted by the DSO and the responsible party:		P
	• the generating units shall disconnect at randomized frequencies, ideally uniformly distributed between the frequency threshold f_1 and 52 Hz;		P

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Clause	Requirement - Test	Result - Remark	Verdict
	• in case the frequency decreases again, the generating unit shall start its reconnection procedure once the frequency falls below the specific frequency that initiated the disconnection; for this procedure, the connection conditions described in 4.10 do not apply;		P
	• the randomization shall either be at unit level by changing the threshold over time, or on plant level by choosing different values for each unit within a plant, or on distribution system level if the DSO specifies a specific threshold for each plant or unit connected to its distribution system.		P
	EES units that are in charging mode at the time the frequency passes the threshold f_1 shall not reduce the charging power below PM until frequency returns below f_1. Storage units should increase the charging power according to the configured droop. In case the maximum charging capacity is reached or to prevent any other risk of injury or damage of equipment, a reduction of charging power is permitted.		N/A
4.6.2	Power response to underfrequency		N/A
	EES units shall be capable of activating active power response to underfrequency. Other generating units/plants should be capable of activating active power response to underfrequency. If active power to underfrequency is provided by a generating plant/unit, the function shall comply with the requirements below.	Not EES unit.	N/A
	Active power response to under-frequency shall be provided when all of the following conditions are met:		N/A
	• when generating, the generating unit is operating at active power below its maximum active power P_{max};		N/A
	• when generating, the generating unit is operating at active power below the available active power P_A;		N/A
	• the voltages at the point of connection of the generating plant are within the continuous operating voltage range; and		N/A
	• when generating, the generating unit is operating with currents lower than its current limit.		N/A
	In the case of EES units, active power frequency response to under-frequency shall be provided in charging and generating mode.		N/A

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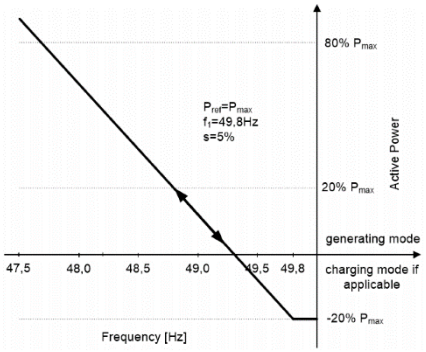
Clause	Requirement - Test	Result - Remark	Verdict
	The active power response to underfrequency shall be delivered at a programmable frequency threshold f1 at least between and including 49,8 Hz and 46,0 Hz with a programmable droop in a range of at least 2 % to 12 %. The droop reference P_{ref} is P_{max}. If the available primary power or a local set value increases during an underfrequency period above the power defined by the droop function, higher power values are permitted. The power value calculated according to the droop is therefore a minimum limit. The minimum power limit is, $P_{min-limit} = P_M + \Delta P$ with $\Delta P = \frac{1}{s} \times \frac{(f1 - f)}{fn} \times Pref$ with f the actual frequency.		N/A
	The generating unit shall be capable of activating active power response to underfrequency as fast as technically feasible with an intrinsic dead time that shall be as short as possible with a maximum of 2 s and with a step response time of maximum 30 s unless another value is defined by the relevant party.		N/A
	An intentional initial delay shall be programmable to adjust the dead time to a value between the intrinsic dead time and 2 s.  **Figure 11 — Example of active power frequency response to underfrequency in case of storage device with 20 % power charging at passing of threshold frequency f_1**		N/A
	After activation, the active power frequency response shall use the actual frequency at any time, reacting to any frequency increase or decrease according to the programmed droop with an accuracy of ± 10 % of the nominal power. The accuracy is evaluated with a 1 min average value. The resolution of the frequency measurement shall be ± 10 mHz or less. At POC loads, if present in the producer's network, might interfere with the response of the generating plant. The effect of loads is not considered for the evaluation of the accuracy, only the behaviour of the generating plant is relevant.		N/A
	Generating modules reaching any of the conditions above during the provision of active power frequency response shall, in the event of further frequency decrease, maintain this power level constant.		N/A

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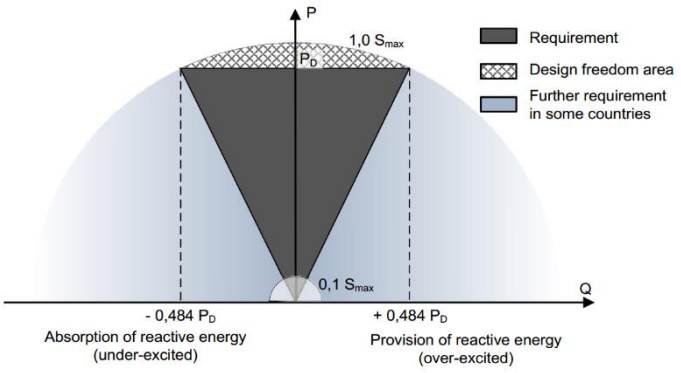
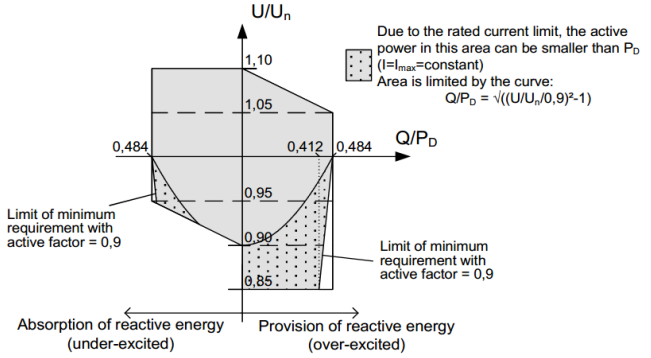
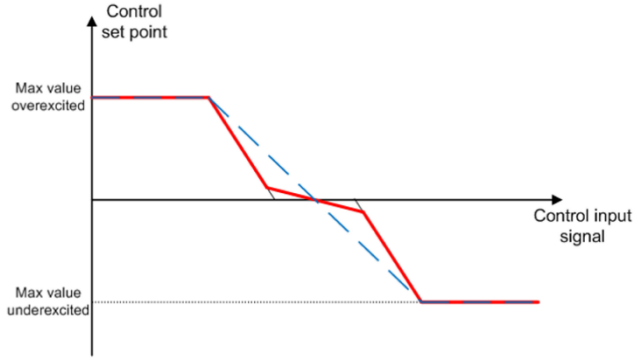
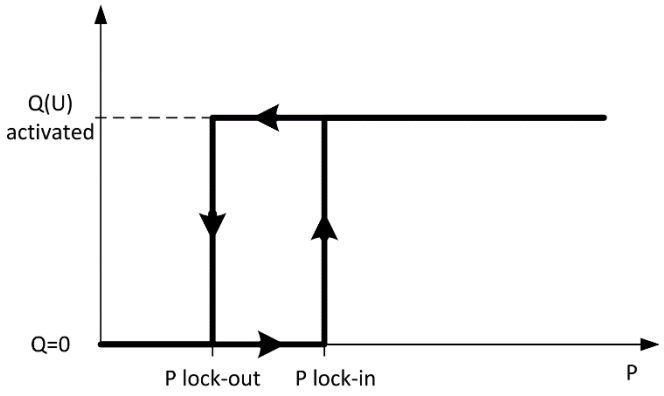
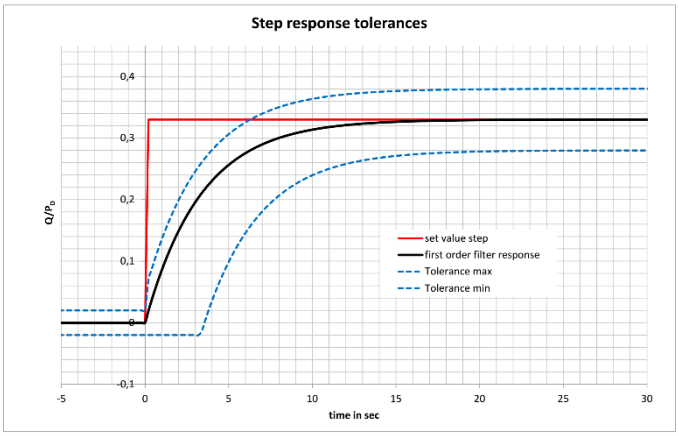
Clause	Requirement - Test	Result - Remark	Verdict
	The active power frequency response is only deactivated if the frequency increases above the frequency threshold f_1.		N/A
	Settings for the threshold frequency f_1, the droop and the intentional delay are defined by the DSO and the responsible party, if no settings are provided, the function shall be disabled.		N/A
	The activation and deactivation of the function and its settings shall be field adjustable and means shall be provided to protect these from unpermitted interference (e.g. password or seal) if required by the DSO and the responsible party.		N/A
4.7	**Power response to voltage changes**		P
4.7.1	General		P
	When the contribution to voltage support is required by the DSO and the responsible party, the generating plant shall be designed to have the capability of managing reactive and/or active power generation according to the requirements of this clause.		P
4.7.2	Voltage support by reactive power		P
4.7.2.1	General		P
	Generating plants shall not lead to voltage changes out of acceptable limits. These limits should be defined by national regulation. Generating units and plants shall be able to contribute to meet this requirement during normal network operation.		P
	Throughout the continuous operating frequency (see 4.4.2) and voltage (see 4.4.4) range, the generating plant shall be capable to deliver the requirements stipulated below. Outside these ranges, the generating plant shall follow the requirements as good as technically feasible although there is no specified accuracy required.		P
4.7.2.2	Capabilities		P
	 **Figure 12 — Reactive power capability at nominal voltage**	(see appended table)	P
	Figure 12 gives a graphical representation of the minimum and optional capabilities at nominal voltage.		P

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict
	Unless specified differently below, for specific generating technologies, generating plants shall be able to operate with active factors as defined by the DSO and the responsible party from active factor = $0,90_{underexcited}$ to active factor = $0,90_{overexcited}$		P
	The reactive power capability shall be evaluated at the terminals of the / each generating unit.		P
	CHP generating units with a capacity < 150 kVA shall be able to operate with active factors as defined by DSO from cos φ = $0,95_{underexcited}$ to cos φ = $0,95_{underexcited}$ to cos φ = $0,95_{overexcited}$		N/A
	Generating units with an induction generator coupled directly to the grid and used in generating plants above micro generating level, shall be able to operate with active factors as defined by the DSO from cos φ = $0,95_{underexcited}$ to cos = 1 at the terminals of the unit. Deviating from 4.7.2.3 point mode is required. Deviating from the accuracy requirements below, the accuracy is only required at active power P_D.		N/A
	Generating units with an induction generator coupled directly to the grid and used in micro generating plants shall operate with an active factor above 0,95 at the terminals of the generating unit. A controlled voltage support by reactive power is not required from this technology.		N/A
	Generating units with linear generators, coupled directly and synchronously to the grid shall operate with an active factor above 0,95 at the terminals of the generating unit, and therefore a controlled voltage support by reactive power is not required from this technology.		N/A
	In case of different generating technologies with different requirements in one generating plant, each unit shall provide voltage support by reactive power as required for its specific technology. A compensation of one technology to reach the general plant requirement is not expected.		P
	The DSO and the responsible party may relax the above requirements. This relaxation might be general or specific for a certain generating plant or generating technology.		P
	All involved parties can expect to have access to information documenting the actual choices regarding active power capabilities relative to reactive power requirements and related to the power rating in the operating voltage range (see further in this clause). A P-Q Diagram shall be included in the product documentation of a generating unit.		P

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict
	When operating above the apparent power threshold S_{min} equal to 10 % of the maximum apparent power S_{max} or the minimum regulating level of the generating plant, whichever is the higher value, the reactive power capability shall be provided with an accuracy of ± 2 % S_{max}. Up to this apparent power threshold S_{min}, deviations above 2 % are permissible; nevertheless the accuracy shall always be as good as technically feasible and the exchange of uncontrolled reactive power in this low-power operation mode shall not exceed 10 % of the maximum apparent power S_{max}. At POC loads, if present in the producer's network might interfere with the response of the generating plant. The effect of loads is not considered for the evaluation of the accuracy, only the behaviour of the generating plant is relevant.		P
	For generating units with a reactive power capability according Figure 12 the reactive power capability at active power P_D shall be at least according Figure 13. For generating units with a reduced reactive power capability Figure 13 is only applicable up to the maximum reactive power capability.  **Figure 13 — Reactive power capability at active power P_D in the voltage range (positive sequence component of the fundamental)**		P
	For voltages below U_n it is allowed to reduce apparent power according to 4.4.4.		P
4.7.2.3	Control modes		P
4.7.2.3.1	General		P
	The control shall refer to the terminals of the generating units The generating plant/unit shall be capable of operating in the control modes specified below within the limits specified in 4.7.2.2. The control modes are exclusive; only one mode may be active at a time.		P
	• Q setpoint mode	(see appended table)	P
	• Q (U)	(see appended table)	P
	• Cos φ setpoint mode	(see appended table)	P
	• Cos (P)	(see appended table)	P

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict
	For mass market products, it is recommended to implement all control modes. In case of site specific generating plant design, only the control modes required by the DSO need to be implemented.		P
	The configuration, activation and deactivation of the control modes shall be field adjustable. For field adjustable configurations and activation of the active control mode, means shall be provided to protect the settings from unpermitted interference (e.g. password or seal) if required by the DSO. Which control modes are available in a product and how they are configured shall be stated in the product documentation.		P
4.7.2.3.2	Setpoint control modes	(see appended table)	P
	Q setpoint mode and cos φ setpoint mode control the reactive power output and the cos φ of the output respectively, according to a set point set in the control of the generating plant/unit. In the case of change of the set point local or by remote control the settling time for the new set point shall be less than one minute.		P
4.7.2.3.3	Voltage related control mode	(see appended table)	P
	The voltage related control mode Q (U) controls the reactive power output as a function of the voltage.		P
	There is no preferred state of the art for evaluating the voltage. Therefore it is the responsibility of the generating plant designer to choose a method. One of the following methods should be used:		P
	• the positive sequence component of the fundamental;		P
	• the average of the voltages measured independently for each phase to neutral or phase to phase;		P
	• phase independently the voltage of every phase to determine the reactive power for every phase.		P
	For voltage related control modes, a characteristic with a minimum and maximum value and three connected lines according to Figure 16 shall be configurable.  **Figure 16 — Example characteristics for Q respectively cos φ control mode**		P

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict
	In addition to the characteristic, further parameters shall be configurable:		P
	• The dynamics of the control shall correspond with a first order filter having a time constant that is configurable in the range of 3 s to 60 s.		P
	To limit the reactive power at low active power two methods shall be configurable:		P
	• a minimal cos φ shall be configurable in the range of 0-0.95;		P
	• two active power levels shall be configurable both at least in the range of 0 % to 100 % of P_D. The lock-in value turns the Q(U) mode on, the lock-out value turns Q(U) off. If lock-in is larger than lock-out a hysteresis is given. See also Figure 14.  **Figure 14 – Example of lock-in and lock-out values for Q(U) mode**		P
	The static accuracy shall be in accordance with 4.7.2.2. The dynamic accuracy shall be in accordance with Figure 15 with a maximum tolerance of +/- 5% of P_D plus a time delay of up to 3 seconds deviating from an ideal first order filter response.  **Figure 15 — Example of dynamic control response and tolerance band for a step from Q=0 to Q= 33%P_D with τ=3,33s**		P
4.7.2.3.4	Power related control mode	(see appended table)	P

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict
	The power related control mode cos φ (P) controls the output as a function of the active power output.		P
	For power related control modes, a characteristic with a minimum and maximum value and three connected lines shall be configurable in accordance with Figure 16.		P
	Resulting from a change in active power output a new cos φ set point is defined according to the set characteristic .The response to a new cos φ set value shall be as fast as technically feasible to allow the change in reactive power, The new reactive power set value shall be reached at the latest within 10 s after the end value of the active power is reached, the static accuracy of each cos set point shall be according to 4.7.2.2		P
4.7.3	Voltage related active power reduction		P
	In order to avoid disconnection due to overvoltage protection, generating plants/units are allowed to reduce active power output as a function of this rising voltage. The final implemented logic can be chosen by the manufacturer. Nevertheless, this logic shall not cause steps or oscillations in the output power. The power reduction caused by such a function may not be faster than an equivalent of a time constant tau = 3 s (= 33%/s at a 100% change). The enabling and disabling of the function shall be field adjustable and means have to be provided to protect the setting from unpermitted interference (e.g. password or seal) if required by the DSO.	(see appended table)	P
4.7.4	Short circuit current requirements on generating plants		P
4.7.4.1	General		P
	The following clauses describe the required short circuit current contribution for generating plants taking into account the connection technology of the generating modules.	Type A generator	P
	Generating modules classified as type B modules according to COMMISSION REGULATION 2016/631 shall comply with the requirements of 4.7.4.2 and 4.7.4.3.		N/A
	Generating modules classified as type A according to COMMISSION REGULATION 2016/631 should comply with these requirements. The actual behaviour of type A modules shall be specified in the connection agreement.		P
4.7.4.2	Generating plant with non-synchronous generating technology		P
4.7.4.2.1	Voltage support during faults and voltage steps		N/A

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict
	In general no voltage support during faults and voltage steps is required from generating plants connected in LV distribution networks as the additional reactive current is expected to interfere with grid protection equipment. If the responsible party requires voltage support during faults and voltage steps for generating plants of type B connected to LV distribution grids, the clause 4.7.4 of EN 50549-2 applies		N/A
4.7.4.2.2	Zero current mode for converter connected generating technology		P
	If UVRT capability (see 4.5.3) is provided additional to the requirements of 4.5, generating units connected to the grid by a converter shall have the capability to reduce their current as fast as technically feasible down to or below 10 % of the rated current when the voltage is outside of a static voltage range. Generating units based on a doubly fed induction machine can only reduce the positive sequence current below 10 % of the rated current. Negative sequence current shall be tolerated during unbalanced faults. In case this current reduction is not sufficient, the DSO should choose suitable interface protection settings.		P
	The static voltage range shall be adjustable from 20 % to 100 % of U_n for the under-voltage boundary and from 100 % to 130 % of U_n for the overvoltage boundary. The default setting shall be 50% of U_n for the under-voltage boundary and 120% of U_n for the overvoltage boundary. Each phase to neutral voltage or if no neutral is present each phase to phase voltage shall be evaluated. At voltage re-entry into the voltage range, 90% of pre-fault power or available power, whichever is the smallest, shall be resumed as fast as possible, but at the latest according to 4.5.3 and 4.5.4.		P
	All described settings are defined by the DSO and the responsible party. If no settings are provided, the function shall be disabled. The enabling and disabling and the settings shall be field adjustable and means have to be provided to protect these from unpermitted interference (e.g. password or seal) if required by the DSO.		P
4.7.4.2.3	Induction generator based units	The inverter was not induction generator.	N/A
	In general no voltage support during faults and voltage steps is required from generating plants connected in LV distribution networks as the additional reactive current is expected to interfere with grid protection equipment. If the responsible party requires voltage support during faults and voltage steps for generating plants of type B connected to LV distribution grids, the clause 4.7.4 of EN50549-2 applies.		N/A
4.7.4.3	Generating plant with synchronous generating technology - Synchronous generator based units	The inverter is not belonged synchronous generating technology.	N/A

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict
	In general no voltage support during faults and voltage steps is required from generating plants connected in LV distribution networks as the additional reactive current is expected to interfere with grid protection equipment. If the responsible party requires voltage support during faults and voltage steps for generating plants of type B connected to LV distribution grids, the clause 4.7.4 of EN50549-2 applies.		N/A
4.8	**EMC and power quality**		P
	Similar to any other apparatus or fixed installation, generating units shall comply with the requirements on electromagnetic compatibility established in Directive 2014/30/EU or 2014/53/EU, whichever applies.	Refer EMC test report No. CN21Y10O 001 issued by TÜV Rheinland (Shanghai) Co., Ltd.	P
	EMC limits and tests, described in EN 61000 series, have been traditionally developed for loads, without taking into account the particularities of generating units, such as their capability to create overvoltages or high frequency disturbances due to the presence of power converters, which were either impossible or less frequent in case of loads.		Info.
	NOTE 1 Currently, IEC SC 77A are reviewing all their existing standards to include, where necessary, specific requirements for generating units/plants. For dispersed generating units in LV networks, the Technical Report IEC/TR 61000–3-15 is addressing gaps in the existing EMC standards making recommendations on the following aspects: • Harmonic emissions; • Flicker and voltage fluctuations; • DC injection; • Short and long duration overvoltages emission; • Switching frequency emission; • Immunity to voltage dips and short interruptions; • Immunity to frequency variation; • Immunity to harmonics and inter-harmonics; • Unbalance.		Info.
	As long as specific tests for generating units are not available for immunity and/or emission, generic EMC standards and/or any relevant EU harmonized EMC standard should be applied.	Refer EMC test report No. CN21Y10O 001 issued by TÜV Rheinland (Shanghai) Co., Ltd.	P
	NOTE 2 Besides the compliance with EN 61000 Series, in most countries power quality characteristic according to standards such as for example EN 61400-21 or VDE V 0124-100 are required as part of the connection agreement.		P
	Additional phenomena need to be addressed specifically to generating plants and their integration in the power system.		P

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict
	• ROCOF: See 4.5.2	(see appended table)	P
	• UVRT: See 4.5.3		P
	• OVRT: See 4.5.4		P
	• DC injection: Generating plants shall not inject direct currents.	(see appended table)	P
	NOTE 3 The DC injection clause is considered to be passed when for all generating units within the generating plant the measured DC injection of a type-tested unit is below the testing threshold.		P
	Generating plants can also disturb mains signalling (ripple control or power line carrier systems). EMC requirements on inter-harmonics and on conducted disturbances in the frequency range between 2 kHz and 150 kHz are under development. In case of electromagnetic interferences to mains signalling systems due to the connection of a generating plant, mitigation measures should be taken and national requirements may apply.		P
	Generating units are also expected to be compatible with voltage characteristics at the point of connection, as described in EN 50160 or in national regulations; however no compliance test is required due to the scope of EN 50160.		P
4.9	**Interface protection**		P
4.9.1	General		P
	According to HD 60364-5-551:2010, 551.7.4, means of automatic switching shall be provided to disconnect the generating plant from the distribution network in the event of loss of that supply or deviation of the voltage or frequency at the supply terminals from values declared for normal supply.		P
	This automatic means of disconnection has following main objectives:		P
	• prevent the power production of the generating plant to cause an overvoltage situation in the distribution network it is connected to. Such over-voltages could result in damages to the equipment connected to the distribution network as well as the distribution network itself;		P
	• detect unintentional island situations and disconnect the generating plant in this case. This is contributing to prevent damage to other equipment, both in the producers' installations and the distribution network due to out of phase re-closing and to allow for maintenance work after an intentional disconnection of a section of the distribution network;		P
	• assist in bringing the distribution network to a controlled state in case of voltage or frequency deviations beyond corresponding regulation values.		P

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Clause	Requirement - Test	Result - Remark	Verdict
	It is not the purpose of the interface protection system to:		P
	• disconnect the generating plant from the distribution network in case of faults internal to the power generating plant. Protection against internal faults (short-circuits) shall be coordinated with network protection, according to DSO protection criteria. Protection against e.g. overload, electric shock and against fire hazards shall be implemented additionally according to HD 60364-1 and local requirements;		P
	• prevent damages to the generating unit due to incidents (e.g. short circuits) on the distribution network		P
	Interface protections may contribute to preventing damage to the generating units due to out-of-phase reclosing of automatic reclosing which may happen after some hundreds of ms. However, in some countries some technologies of generating units are explicitly required to have an appropriate immunity level against the consequences of out-of-phase reclosing.		P
	The type of protection and the sensitivity and operating times depend upon the protection and the characteristics of the distribution network.		P
	A wide variety of approaches to achieve the above mentioned objectives is used throughout Europe. Besides the passive observation of voltage and frequency other active and passive methods are available and used to detect island situations. The requirements given in this clause are intended to provide the necessary functions for all known approaches as well as to give guidance in their use. Which functions are available in a product shall be stated in the product documentation.		P
	The interface protection system shall comply with the requirements of this European Standard, the available functions and configured settings shall comply with the requirements of the DSO and the responsible party. In any case, the settings defined shall be understood as the values for the interface protection system, i.e. where there is a wider technical capability of the generation module, it shall not be withheld by the settings of the protections (other than the interface protection).		P
	For micro generating plants, the interface protection system and the point of measurement might be integrated into the generating units. For generating plants with nominal current above 16 A the DSO may define a threshold above which the interface protection system shall be realized as a dedicated device and not integrated into the generating units.		P
	• to place the protection system as close to the point of connection as possible, to avoid tripping due to overvoltages resulting from the voltage rise within the producer's network;		P

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Clause	Requirement - Test	Result - Remark	Verdict
	• to allow for periodic field tests. In some countries periodic field tests are not required if the protection system meets the requirements of single fault safety.		P
	The interface protection relay acts on the interface switch. The DSO may require that the interface protection relay acts additionally on another switch with a proper delay in case the interface switch fails to operate.		P
	In case of failure of the power supply of the interface protection, the interface protection shall trigger the interface switch without delay. An uninterruptible power supply may be required by the DSO, for instance in case of UVRT capability, delay in protection etc.		P
	In case of field adjustable settings of threshold and operation time, means shall be provided to protect the settings from unpermitted interference (e.g. password or seal) if required by the DSO.		P
4.9.2	Void		N/A
4.9.3	Requirements on voltage and frequency protection		P
4.9.3.1	General		P
	Part or all of the following described functions may be required by the DSO and the responsible party.		P
	The protection functions shall evaluate at least all phases where generating units, covered by this protection system, are connected to.		P
	In case of three phase generating units/plants and in all cases when the protection system is implemented as an external protection system in a three phase power supply system, all phase to phase voltages and, if a neutral conductor is present, all phase to neutral voltages shall be evaluated.		P
	The frequency shall be evaluated on at least one of the voltages.		P
	If multiple signals (e.g. 3 phase to phase voltages) are to be evaluated by one protection function, this function shall evaluate all of the signals separately. The output of each evaluation shall be OR connected, so that if one signal passes the threshold of a function, the function shall trip the protection in the specified time.		P
	The minimum required accuracy for protection is:		P
	• for frequency measurement ± 0,05 Hz;		P
	• for voltage measurement ± 1 % of U_n.		P
	• The reset time shall be ≤ 50 ms		P

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Clause	Requirement - Test	Result - Remark	Verdict
	• The interface protection relay shall not conduct continuous starting and disengaging operations of the interface protection relay. Therefore a reasonable reset ratio shall be implemented which shall not be zero but be below 2% of nominal value for voltage and below 0,2 Hz for frequency.		P
4.9.3.2	Under-voltage protection [27]	(see appended table)	P
	The protection shall comply with EN 60255-127. The evaluation of the r.m.s. or the fundamental value is allowed.		P
	Undervoltage protection may be implemented with two completely independent protection thresholds, each one able to be activated or not. The standard adjustment ranges are as follows.		P
	Undervoltage threshold stage 1 [27 <]:		P
	• Threshold (0,2 – 1) U_n adjustable by steps of 0,01 U_n		P
	• Operate time (0,1 – 100) s adjustable in steps of 0,1 s		P
	Undervoltage threshold stage 2 [27 < <]:		P
	• Threshold (0,2 – 1) U_n adjustable by steps of 0,01 U_n		P
	• Operate time (0,1 – 5) s adjustable in steps of 0,05 s		P
	The undervoltage threshold stage 2 is not applicable for micro-generating plants		P
4.9.3.3	Overvoltage protection	(see appended table)	P
	The protection shall comply with EN 60255-127. The evaluation of the r.m.s. or the fundamental value is allowed.		P
	Overvoltage protection may be implemented with two completely independent protection thresholds, each one able to be activated or not. The standard adjustment ranges are as follows.		P
	Overvoltage threshold stage 1 [59 >]:		P
	• Threshold (1,0 – 1,2) U_n adjustable by steps of 0,01 U_n		P
	• Operate time (0,1 – 100) s adjustable in steps of 0,1 s		P
	Overvoltage threshold stage 2 [59 > >]:		P
	• Threshold (1,0 – 1,30) U_n adjustable by steps of 0,01 U_n		P
	• Operate time (0,1 – 5) s adjustable in steps of 0,05 s		P
4.9.3.4	Overvoltage 10 min mean protection	(see appended table)	P

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Clause	Requirement - Test	Result - Remark	Verdict
	The calculation of the 10 min value shall comply with the 10 min aggregation of EN 61000-4-30 Class S, but deviating from EN 61000-4-30 as a moving window is used. Therefore the function shall be based on the calculation of the square root of the arithmetic mean of the squared input values over 10 min. The calculation of a new 10 min value at least every 3 s is sufficient, which is then to be compared with the threshold value.		P
	• Threshold (1,0 – 1,15) U_n adjustable by steps of 0,01 U_n		P
	• Start time 3s not adjustable		P
	• Time delay setting = 0 ms		P
4.9.3.5	Under-frequency protection [81 <]	(see appended table)	P
	Under frequency protection may be implemented with two completely independent protection thresholds, each one able to be activated or not. The standard adjustment ranges are as follows.		P
	Under-frequency threshold stage 1 [81 <]:		P
	• Threshold (47,0 – 50,0) Hz adjustment by steps of 0,1 Hz		P
	• Operate time (0,1 – 100) s adjustable in steps of 0,1 s		P
	Under-frequency threshold stage 2 [81 < <]:		P
	• Threshold (47,0 – 50,0) Hz adjustment by steps of 0,1 Hz		P
	• Operate time (0,1 – 5) s adjustable in steps of 0,05 s		P
	In order to use narrow frequency thresholds for islanding detection (see 4.9.3.3) it may be required to have the ability to activate and deactivate a stage by an external signal.		P
	The frequency protection shall function correctly in the input voltage range between 20 % U_n and 120 % U_n and shall be inhibited for input voltages of less than 20 % U_n. Under 0,2 U_n the frequency protection is inhibited. Disconnection may only happen based on under-voltage protection.		P
4.9.3.6	Over-frequency protection [81 >]	(see appended table)	P
	Overfrequency protection may be implemented with two completely independent protection thresholds, each one able to be activated or not. The standard adjustment ranges are as follows.		P
	Overfrequency threshold stage 1 [81 >]:		P
	• Threshold (50,0 - 52,0) Hz adjustment by steps of 0,1 Hz		P
	• Operate time (0,1 – 100) s adjustable in steps of 0,1 s		P

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Clause	Requirement - Test	Result - Remark	Verdict
	Overfrequency threshold stage 2 [81 > >]:		P
	• Threshold (50,0 - 52,0) Hz adjustment by steps of 0,1 Hz		P
	• Operate time (0,1 - 5) s adjustable in steps of 0,05 s		P
	In order to use narrow frequency thresholds for islanding detection (see 4.9.3.3) it may be required to have the ability to activate and deactivate a stage by an external signal.		P
	The frequency protection shall function correctly in the input voltage range between 20 % U_n and 120 % U_n and shall be inhibited for input voltages of less than 20 % U_n.		P
4.9.4	Means to detect island situation		P
4.9.4.1	General		P
	Besides the passive observation of voltage and frequency further means to detect an island may be required by the DSO. Detecting islanding situations shall not be contradictory to the immunity requirements of 4.5.		P
	Commonly used functions include: • Active methods tested with a resonant circuit; • ROCOF tripping; • Switch to narrow frequency band; • Vector shift; • Transfer trip.	Active methods tested with a resonant circuit	P
	Only some of the methods above rely on standards. Namely for ROCOF tripping and for the detection of a vector shift, also called a vector jump, currently no European Standard is available.		P
4.9.4.2	Active methods tested with a resonant circuit		P
	These are methods which pass the resonant circuit test for PV inverters according to EN 62116.		P
4.9.4.3	Switch to narrow frequency band (see Annex E and Annex F)		P
	In case of local phenomena (e.g. a fault or the opening of circuit breaker along the line) the DSO in coordination with the responsible party may require a switch to a narrow frequency band to increase the interface protection relay sensitivity. In the event of a local fault it is possible to enable activation of the restrictive frequency window (using the two under-frequency / over-frequency thresholds described in 4.9.2.5 and 4.9.2.6) correlating its activation with another additional protection function.		P
	If required by the DSO, a digital input according to 4.9.4 shall be available to allow the DSO the activation of a restrictive frequency window by communication. NOTE An additional gateway to ensure communication with the DSO communication system might be required.		P

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Clause	Requirement - Test	Result - Remark	Verdict
4.9.5	Digital input to the interface protection		P
	If required by the DSO, the interface protection shall have at least two configurable digital inputs. These inputs can for example be used to allow transfer trip or the switching to the narrow frequency band.		P
4.10	**Connection and starting to generate electrical power**		P
4.10.1	General		P
	Connection and starting to generate electrical power is only allowed after voltage and frequency are within the allowed voltage and frequency ranges for at least the specified observation time. It shall not be possible to overrule these conditions.		P
	Within these voltage and frequency ranges, the generating plant shall be capable of connecting and starting to generate electrical power.		P
	The setting of the conditions depends on whether the connection is due to a normal operational startup or an automatic reconnection after tripping of the interface protection. In case the settings for automatic reconnection after tripping and starting to generate power are not distinct in a generating plant, the tighter range and the start-up gradient shall be used.		P
	The frequency range, the voltage range, the observation time and the power gradient shall be field adjustable.		P
	For field adjustable settings, means shall be provided to protect the settings from unpermitted interference (e.g. password or seal) if required by the DSO.		P
4.10.2	Automatic reconnection after tripping		P
	The frequency range, the voltage range, the observation time shall be adjustable in the range according to Table 3 column 2. If no settings are specified by the DSO and the responsible party, the default settings for the reconnection after tripping of the interface protection are according to Table 3 column 3.	(see appended table)	P

Table 3 — Automatic reconnection after tripping

Parameter	Range	Default setting
Lower frequency	47,0Hz – 50,0Hz	49,5Hz
Upper frequency	50,0Hz – 52,0Hz	50,2Hz
Lower voltage	50% – 100%U_n	85 % U_n
Upper voltage	100% – 120% U_n	110 % U_n
Observation time	10s – 600s	60s
Active power increase gradient	6% – 3000%/min	10%/min

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Clause	Requirement - Test	Result - Remark	Verdict
	After reconnection, the active power generated by the generating plant shall not exceed a specified gradient expressed as a percentage of the active nominal power of the unit per minute. If no gradient is specified by the DSO and the responsible party, the default setting is 10 % P_n /min. Generating modules for which it is technically not feasible to increase the power respecting the specified gradient over the full power range may connect after 1 min to 10 min (randomized value, uniformly distributed) or later.		P
4.10.3	Starting to generate electrical power		P
	The frequency range, the voltage range, the observation time shall be adjustable in the range according to Table 4 column 2. If no settings are specified by the DSO and the responsible party, the default settings for connection or starting to generate electrical power due to normal operational startup or activity are according to Table 4 column 3. **Table 4 — Starting to generate electrical power** **Parameter** / **Range** / **Default setting** Lower frequency / 47,0Hz – 50,0Hz / 49,5Hz Upper frequency / 50,0Hz – 52,0Hz / 50,1Hz Lower voltage / 50% – 100% U_n / 85 % U_n Upper voltage / 100% – 120% U_n / 110 % U_n Observation time / 10s – 600s / 60s Active power increase gradient / 6% – 3000%/min / disabled	(see appended table)	P
	If applicable, the power gradient shall not exceed the maximum gradient specified by the DSO and the responsible party. Heat driven CHP generating units do not need to keep a maximum gradient, since the start up is randomized by the nature of the heat demand.		P
	For manual operations performed on site (e.g. for the purpose of initial start-up or maintenance) it is permitted to deviate from the observation time and ramp rate.		P
4.10.4	Synchronization		P
	Synchronizing a generating plant/unit with the distribution network shall be fully automatic i.e. it shall not be possible to manually close the switch between the two systems to carry out synchronization.		P
4.11	**Ceasing and reduction of active power on set point**		P
4.11.1	Ceasing active power		P
	Generating plants with a maximum capacity of 0,8 kW or more shall be equipped with a logic interface (input port) in order to cease active power output within five seconds following an instruction being received at the input port. If required by the DSO and the responsible party, this includes remote operation.	(see appended table)	P
4.11.2	Reduction of active power on set point		P

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Clause	Requirement - Test	Result - Remark	Verdict
	For generating modules of type B, a generating plant shall be capable of reducing its active power to a limit value provided remotely by the DSO. The limit value shall be adjustable in the complete operating range from the maximum active power to minimum regulating level.		P
	The adjustment of the limit value shall be possible with a maximum increment of 10% of nominal power.		P
	A generation unit/plant shall be capable of carrying out the power output reduction to the respective limit within an envelope of not faster than 0,66 % P_n / s and not slower than 0,33 % P_n / s with an accuracy of 5 % of nominal power. Generating plants are permitted to disconnect from the network at a limit value below it minimum regulating level. If required by the DSO, this includes remote operation.	(see appended table)	P
4.12	**Remote information exchange**		P
	Generating plants whose power is above a threshold to be determined by the DSO and the responsible party shall have the capacity to be monitored by the DSO or TSO control centre or control centres as well as receive operation parameter settings for the functions specified in this European Standard from the DSO or TSO control centre or control centres.		P
	It should not interact directly with the power generation equipment and the switching devices of the generating plant. It should interact with the operation and control system of the generating plant.		P
	In principle, standardized communication should be used. It is recommended that in case of using protocols for signal transmission used between the DSO or TSO control centre or control centres and the generating plant, relevant technical standards (e.g. EN 60870-5-101, EN 60870-5-104, EN 61850 and in particular EN 61850-7-4, EN 61850-7-420, IEC/TR 61850-90-7, as well as EN 61400-25 for wind turbines and relevant parts of IEC 62351 for relevant security measures) are recognized.		P
	Alternative protocols can be agreed between the DSO and the producer. These protocols include hardwired digital input/output and analogue input/output provided locally by DSO. The information needed for remote monitoring and the setting of configurable parameters are specific to each distribution network and to the way it is operated.		P
4.13	**Requirements regarding single fault tolerance of interface protection system and interface switch**		P
	If required in 4.3.2, the interface protection system and the interface switch shall meet the requirements of single fault tolerance.	(see appended table)	P
	A single fault shall not lead to a loss of the safety functions.		P

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Clause	Requirement - Test	Result - Remark	Verdict
	Series-connected switches shall each have a independent breaking capacity corresponding to the rated current of the generating unit and corresponding to the short circuit contribution of the generating unit.		P
	The short-time withstand current of the switching devices shall be coordinated with maximum short circuit power at the connection point.		P
	At least one of the switches shall be a switch-disconnector suitable for overvoltage category 2. For single-phase generating units, the switch shall have one contact of this overvoltage category for both the neutral conductor and the line conductor. For poly-phase generating units, it is required to have one contact of this overvoltage category for all active conductors. The second switch may be formed of electronic switching components from an inverter bridge or another circuit provided that the electronic switching components can be switched off by control signals and that it is ensured that a failure is detected and leads to prevention of the operation at the latest at the next reconnection.		P
	For PV-inverters without simple separation between the network and the PV generating unit (e.g. PV Inverter without transformer) both switches mentioned in the paragraph above shall be switch disconnectors with the requirements described therein, although one switching device is permitted to be located between PV array and PV inverter.	Two power relays in series installed each both line neutral on the mains side of the unit to separate it from the grid.	P
Annex A	Interconnection guidance		P
Annex B	Void		N/A
Annex C	Parameter Table		P
Annex D	List of national requirements applicable for generating plants		Info.
Annex E	Loss of Mains and overall power system security		P
Annex F	Examples of protection strategies		Info.
Annex G	Abbreviations		Info.
Annex H	Relationship between this European standard and the COMMISSION REGULATION (EU) 2016/631		P
	Generating plants compliant with the clauses of this European Standard are considered to be compliant with the relevant Article of COMMISSION REGULATION (EU) 2016/631, provided, that all settings as provided by the DSO and the responsible party are complied with.		P

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Clause	Requirement - Test	Result - Remark	Verdict

Table H.1 – Correspondence between this European standard and the COMMISSION REGULATION (EU) 2016/631

Article	Clause(s) / subclause(s) of this EN
13.1(a)	4.4.2 Operating frequency range
13.1(b)	4.5.2 Rate of change of frequency (ROCOF) immunity
13.2	4.6.1 Power response to overfrequency
13.3	4.4.3 Minimal requirement for active power delivery at underfrequency
13.4	4.4.3 Minimal requirement for active power delivery at underfrequency
13.5	4.4.3 Minimal requirement for active power delivery at underfrequency
13.6	4.11.1 Ceasing active power
13.7	4.10 Connection and starting to generate electrical power
14.1	4.4.2, 4.5.2, 4.6.1, 4.4.3, 4.11.1 and 4.10
14.2(a)	4.11.2 Reduction of active power on set point
14.2(b)	4.12 Remote information exchange
14.3	4.5.3 Under-voltage ride through (UVRT)
14.4.	4.10 Connection and starting to generate electrical power
14.5(a)	4.6, 4.7, 4.9, 4.10, 4.11, 4.12
14.5(b)	4.9 Interface protection,
14.5(c)	4.1 General
14.5(d)	4.12 Remote information exchange
17.1	4. as applicable above
17.2	4.7.2 Voltage support by reactive power
17.3	4.5.3 Under-voltage ride through (UVRT)
20.1	4. as applicable above
20.2 (a)	4.7.2 Voltage support by reactive power
20.2 (b) (c)	4.7.4.2 Short circuit current requirements on generating plants
20.3	4.5.3 Under-voltage ride through (UVRT)

P

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Clause	Requirement - Test	Result - Remark	Verdict

Test overview:		
EN 50549-1:2019		
4.4.2	Operating frequency range	P
4.4.3	Minimal requirement for active power delivery at under-frequency	P
4.4.4	Continuous operating voltage range	P
4.5.2	Rate of change of frequency (ROCOF) immunity	P
4.5.3	Under-voltage ride through (UVRT)	P
4.5.4	Over-voltage ride through (OVRT)	P
4.6.1	Power response to over-frequency	P
4.6.2	Power response to under-frequency	N/A
4.7.2	Voltage support by reactive power	P
4.7.2.3.2	Setpoint control modes – Q setpoint mode	P
4.7.2.3.2	Setpoint control modes – Cos φ setpoint mode	P
4.7.2.3.3	Voltage related control mode – Q(U)	P
4.7.2.3.4	Power related control mode – cos φ (P)	P
4.7.3	Voltage related active power reduction	P
4.7.4	Short circuit current requirements on generating plants	P
4.8	EMC and power quality	P
4.9.3	Requirements on voltage and frequency protection	P
4.9.3.2	Under-voltage protection	P
4.9.3.3	Overvoltage protection	P
4.9.3.4	Overvoltage 10 min mean protection	P
4.9.3.5	Underfrequency protection	P
4.9.3.6	Overfrequency protection	P
4.9.4	Means to detect island situation	P
4.9.5	Digital input to the interface protection	P
4.10.2	Automatic reconnection after tripping	P
4.10.3	Starting to generate electrical power	P
4.11.1	Ceasing active power	P
4.11.2	Reduction of active power on set point	P
4.13	Requirements regarding single fault tolerance of interface protection system	P

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Clause	Requirement - Test	Result - Remark	Verdict

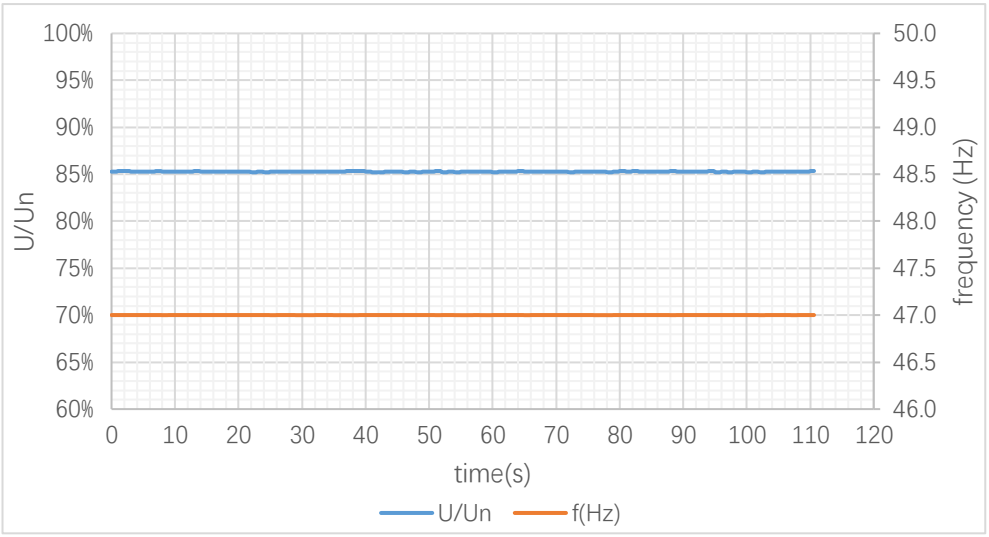
4.4.2 & 4.4.4	**TABLE: Operating frequency range and voltage range**							**P**
Model	GT1-6KD1							
Test sequence	Test condition		Measurement					Limits
	U/U_n	f (Hz)	U/U_n	f (Hz)	P/P_n	Cos φ	Duration T (s)	Cont. T*
1	85%	47.0	85.3%	47.00	95.3%	0.999	110S	≥ 20 s*
2	85%	47.5	85.3%	47.00	95.3%	0.999	6000S	≥ 5400s*
3	110%	51.5	110.2%	51.50	100.2%	0.999	5690S	≥ 5400s*
4	110%	52.0	110.2%	52.00	100.1%	0.999	950S	≥ 900 s*

Note:

* Stringent requirement

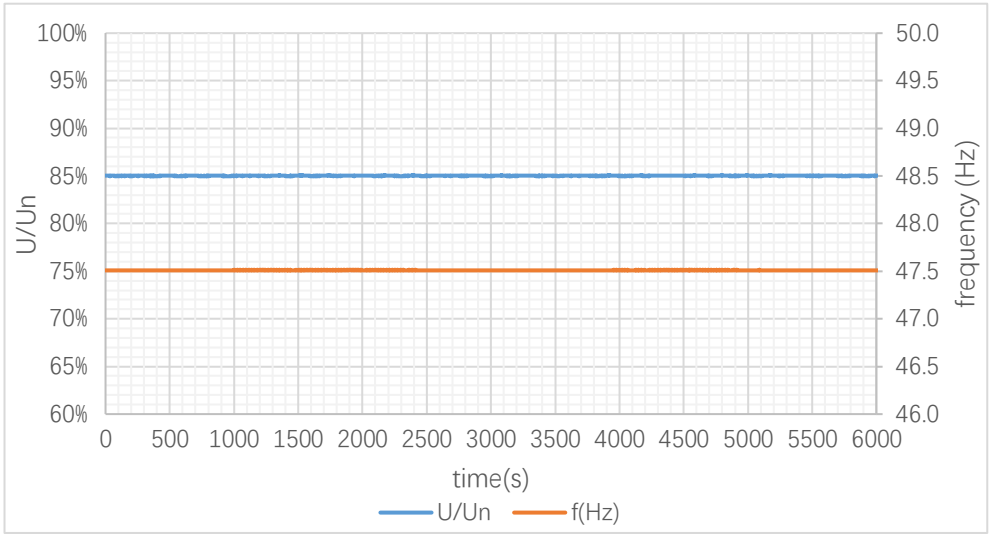
If the grid voltage is lower than the nominal voltage U_n, the output power will not be fully loaded due to the lower voltage and the limitation of inverter max output current.

Graph of Test 1: 85% U_n / 47.0 Hz

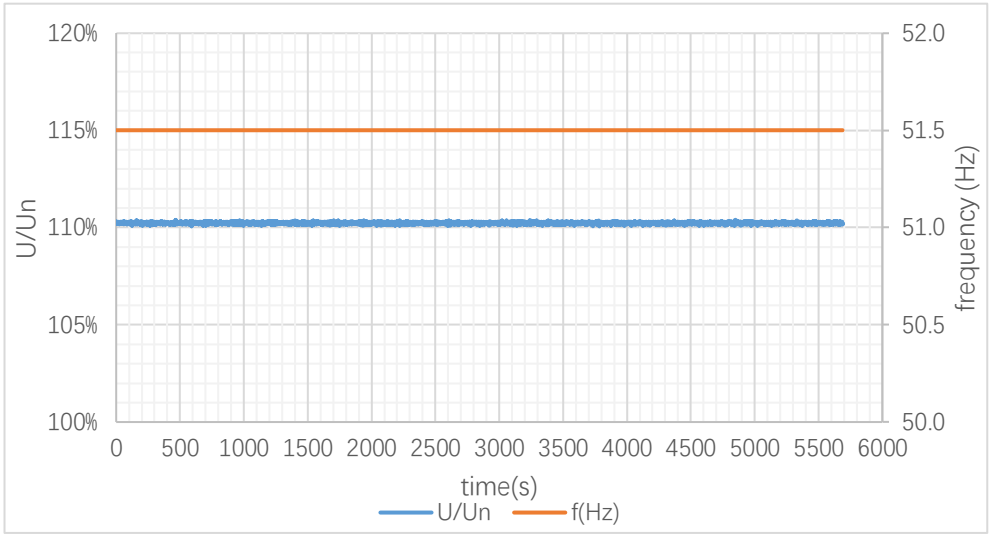


Graph of Test 2: 85% U_n / 47.5 Hz

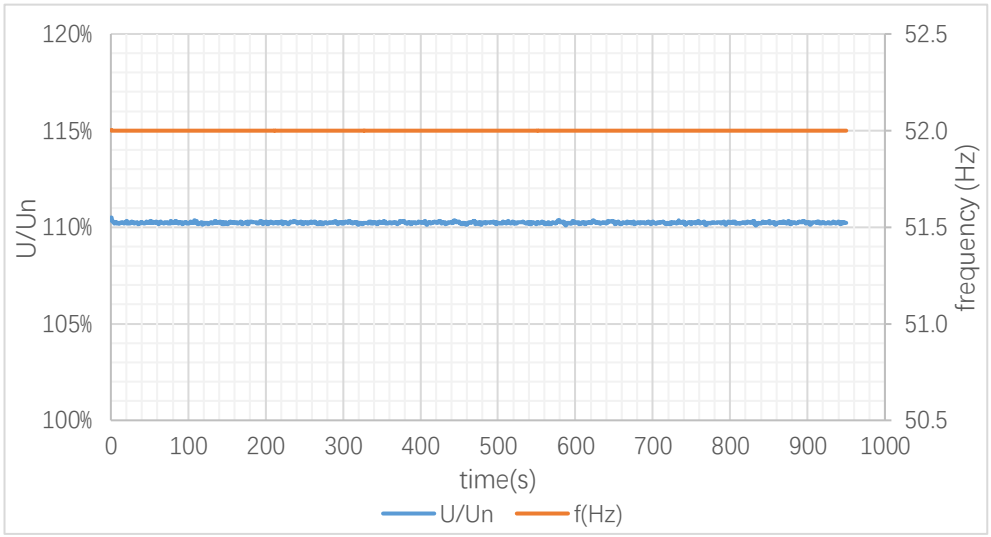
EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict



Graph of Test 3: 110% U_n / 51.0 Hz



Graph of Test 4: 110% U_n / 52.0 Hz



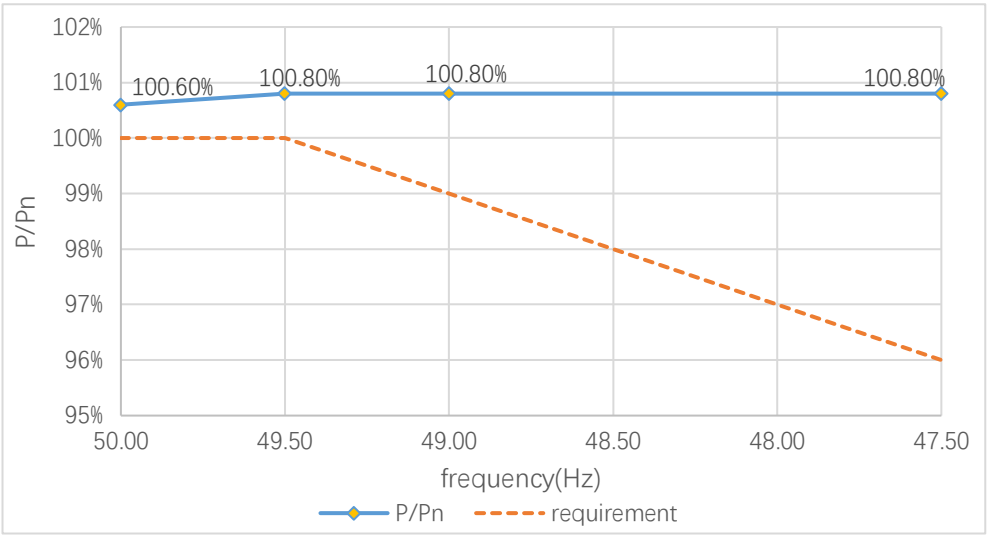
EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

4.4.3	**TABLE: Minimal requirement for active power delivery at under-frequency**	**P**
Model	GT1-6KD1	

Test sequence	Test condition		Measurement						Limits
	U/U_n	f (Hz)	U/U_n	f (Hz)	P/P_n	Cosφ (PF)	$\Delta P/P_n$	$\Delta P/P_n$ per 1 Hz	$\Delta P/P_n$ per 1 Hz
1	100%	50.0	100.30%	50.00	100.60%	-0.999	--	--	--
2	100%	49.5	100.30%	49.50	100.80%	-0.999	--	--	≥ -2%*
3	100%	49.0	100.30%	49.00	100.80%	-0.999	--	--	
4	100%	47.5	100.30%	47.50	100.80%	-0.999	--	--	

Note:
* Stringent requirement

P-f Diagram

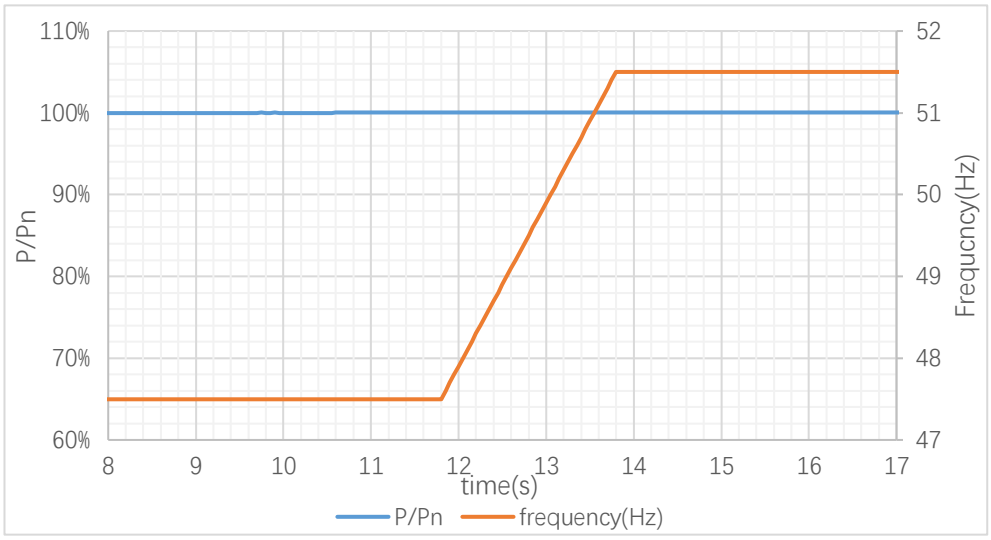


EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

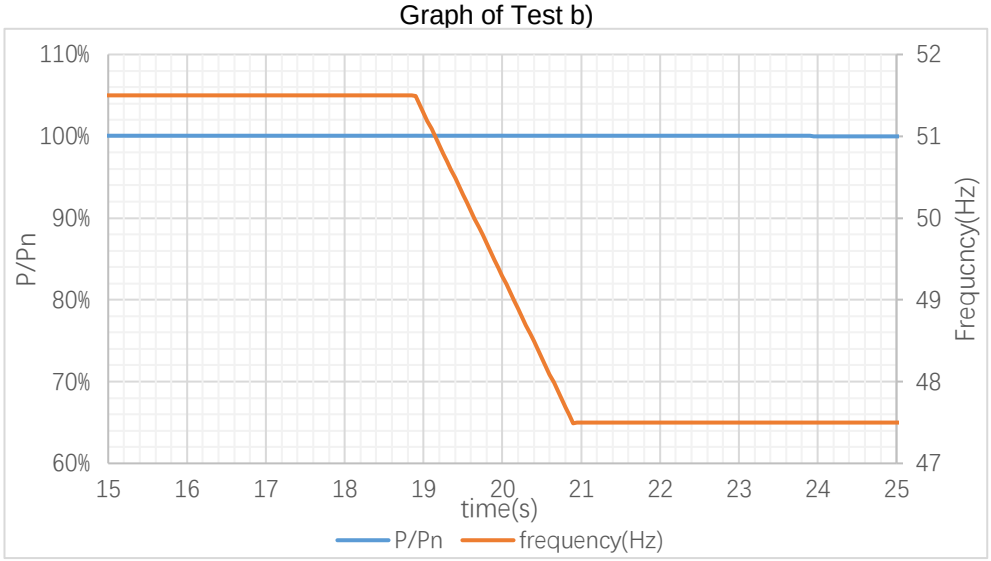
4.5.2	**TABLE: Rate of change of frequency (ROCOF) immunity**					**P**
Model	GT1-6KD1					
Voltage (Vac)	230					
Output power (W)	6000					
	Frequency		Change time	Result	Requirement	
	Begin	End				
a)	47.50 Hz	51.5 Hz	2.0 s	Not disconnect	Stay connected	
b)	51.50 Hz	47.5 Hz	2.0 s	Not disconnect	Stay connected	

Note:
The ROCOF immunity is defined with a sliding measurement window of 500 ms.

Graph of Test a)



Graph of Test b)



EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

4.5.3, 4.5.4, 4.7.4	TABLE: Under and Over Voltage Ride-Through (UVRT / OVRT)	P

Test	Voltage dip U/Un (p.u.)	VRT fault type	Fault duration (t2-t1) (ms)	P/Pn (p.u.)	Q/Pn (p.u.)	Test No.
1	0.05* or 0.15	A	≥250* or ≥200	0.98 to 1.02	0 to ± 0.1	1.1
				0.1 to 0.5		1.2
		D1		0.98 to 1.02		N/A
				0.1 to 0.5		N/A
		D2		0.98 to 1.02		N/A
				0.1 to 0.5		N/A
2	0.3	A	≥1110* or ≥480	0.98 to 1.02	0 to ± 0.1	2.1
				0.1 to 0.5		2.2
		D1		0.98 to 1.02		N/A
				0.1 to 0.5		N/A
3	0.7	A	≥2500* or ≥1230	0.98 to 1.02	0 to ± 0.1	3.1
				0.1 to 0.5		3.2
		D1		0.98 to 1.02		N/A
				0.1 to 0.5		N/A
4	0.85	A	≥3000	0.98 to 1.02	0 to ± 0.1	4.1
				0.1 to 0.5		4.2
		D1		0.98 to 1.02		N/A
				0.1 to 0.5		N/A
5	1.25	A	≥100	0.98 to 1.02	0 to ± 0.1	5.1
				0.1 to 0.5		5.2
		D1		0.98 to 1.02		N/A
				0.1 to 0.5		N/A
		D2		0.98 to 1.02		N/A
				0.1 to 0.5		N/A
6	1.20	A	≥5000	0.98 to 1.02	0 to ± 0.1	6.1
				0.1 to 0.5		6.2
		D1		0.98 to 1.02		N/A
				0.1 to 0.5		N/A
7	1.15	A	≥60000	0.98 to 1.02	0 to ± 0.1	7.1
				0.1 to 0.5		7.2
		D1		0.98 to 1.02		N/A
				0.1 to 0.5		N/A

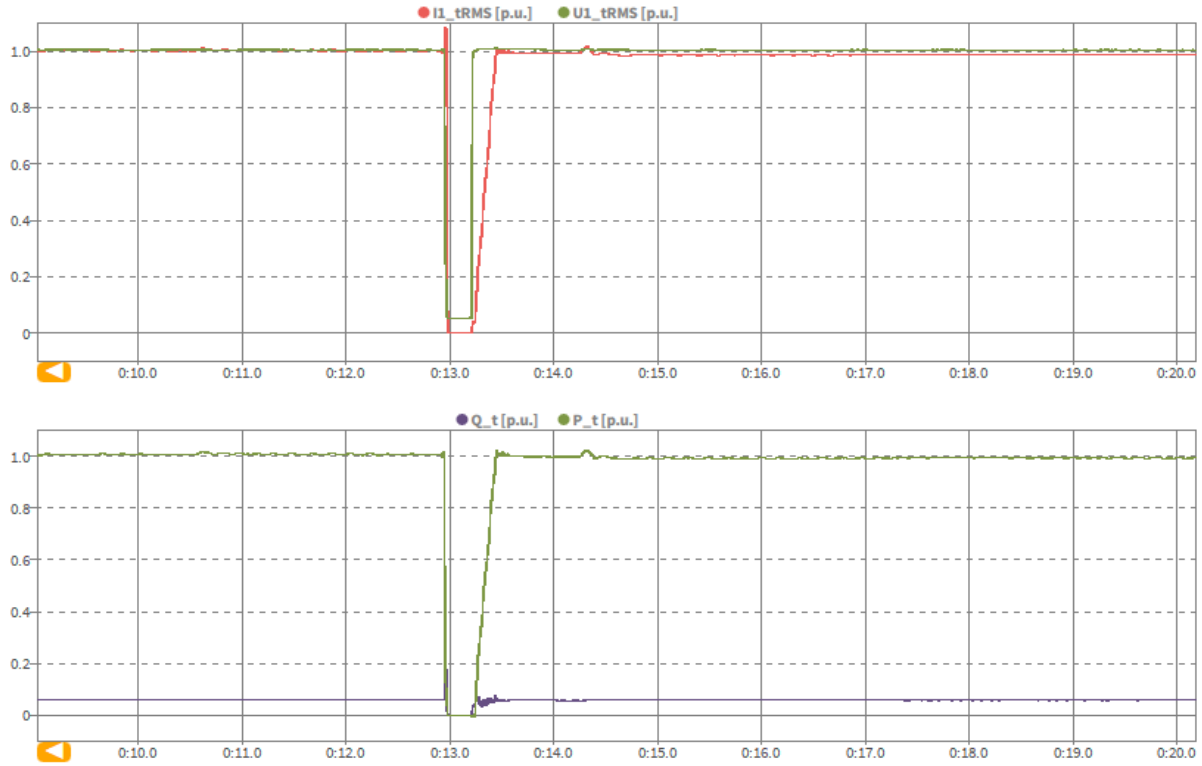
Note(s):
*Most stringent.
Before EUT test, AC grid shall be measured and recorded test data in empty load test at each condition of test numbers (1.x to 7.x) and VRT fault types (A/D1/D2).
Each case two consecutive tests must be completed successfully.

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

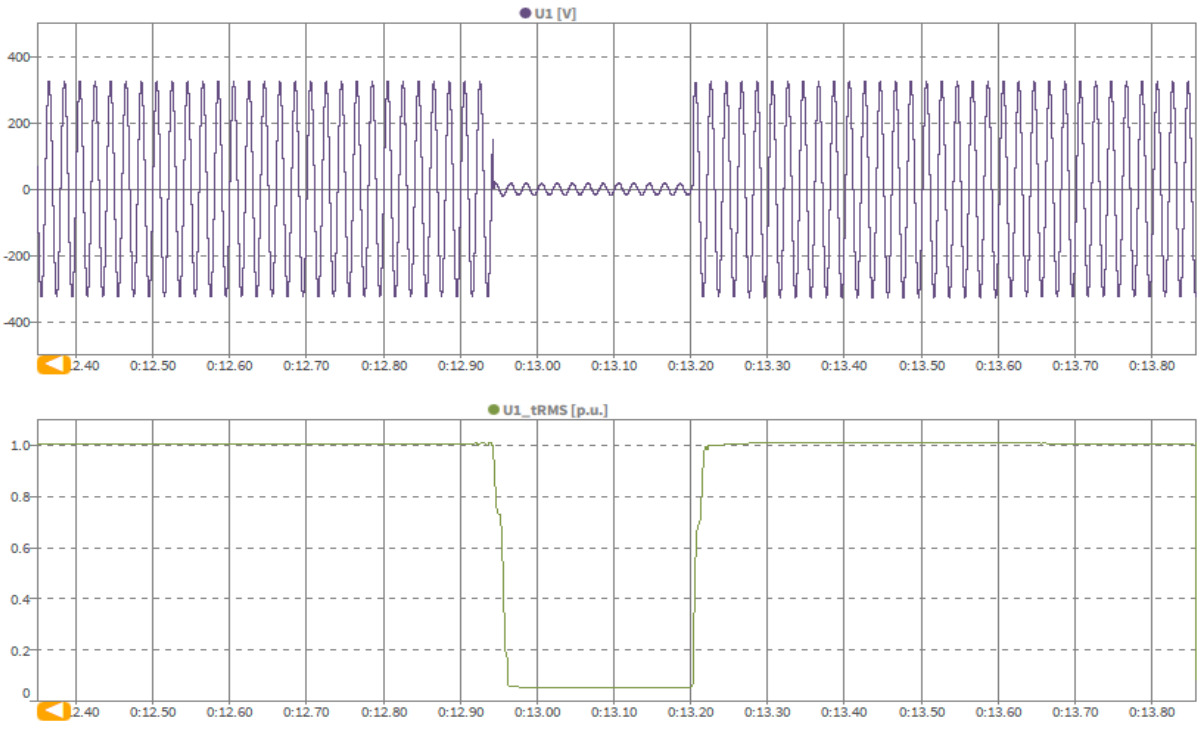
Condition						Measured value	
Item	No.	Parameter	Phase ref.	Time ref.	unit		
General Info.	0	Test number	--	--	--	1.1	1.2
	1	Date	--	--	yyyy.mm.dd	2022.10.24	2022.10.24
	2	Time (start of test)	--	--	hh:mm:ss.f	15:31:42	15:54:11
	3	Fault type (phase)	--	--	--	Type A	Type A
	4	Setting voltage depth	Phase conductor	--	p.u.	0.05	0.05
	5	Setting dip duration		--	--	260	260
	6	Point of fault entry(t_1)	Total	--	ms	12942	12023
	7	Point of fault clearance(t_2)	Total	--	ms	13203	12285
	8	Fault duration in empty load test	Total	--	ms	261	262
	9	Voltage depth/height in empty load test	Total	t1+100ms to t2 and t1-10s to t1	p.u.	0.05	0.05
	10		Pos.			N/A	N/A
Before dip <t1	11	Voltage	Line to neutral	t1-100s to t1	p.u.	1	1
	12	Current	Pos.	t1-500ms to t1-100ms	p.u.	N/A	N/A
	13	Active power	Total	t1-10s to t1	p.u.	1	0.2
	14		Pos.			N/A	N/A
	15	Reactive power	Total	t1-10s to t1	p.u.	0.07	0.03
	16		Pos.			N/A	N/A
	17	Cosφ	--	t1-10s to t1	--	0.99	0.99
During dip t1 to t2	18	Voltage	Line to neutral	t1+100ms to t2-20ms	p.u.	0.05	0.05
	19	Line current	Phase 1	t1+60ms	p.u.	0.01	0.01
	20		Phase 2			N/A	N/A
	21		Phase 3			N/A	N/A
	22	Line current	Phase 1	t1+100ms	p.u.	0.01	0.01
	23		Phase 2			N/A	N/A
	24		Phase 3			N/A	N/A
	25	Active power	Total	t1+100ms to t2-20ms	p.u.	0	0
	26		Pos.			N/A	N/A
After dip > t2	27	Voltage	Line to neutral	t2+3s to t2+10s	p.u.	1	1
	28	Active power	Total	t2+3s to t2+10s	p.u.	1	0.2
	29		Pos.			N/A	N/A
	30	Response time reactive power	Pos.	--	s	0.435	0.243
	31	Reactive power	Total	t2+3s to t2+10s	p.u.	0.07	0.03
	32		Pos.			N/A	N/A
	33	Reactive power rising time	Pos.	--	s	N/A	N/A
	34	PGU does not disconnect from grid till 60s after fault	--	t2 to t2+60s	Yes / No	Yes	Yes

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 1.1 Depth of fault phase: 0.05 p.u., three-phase SC (type A), 100% load
Test overview (voltage, current, active and reactive power)



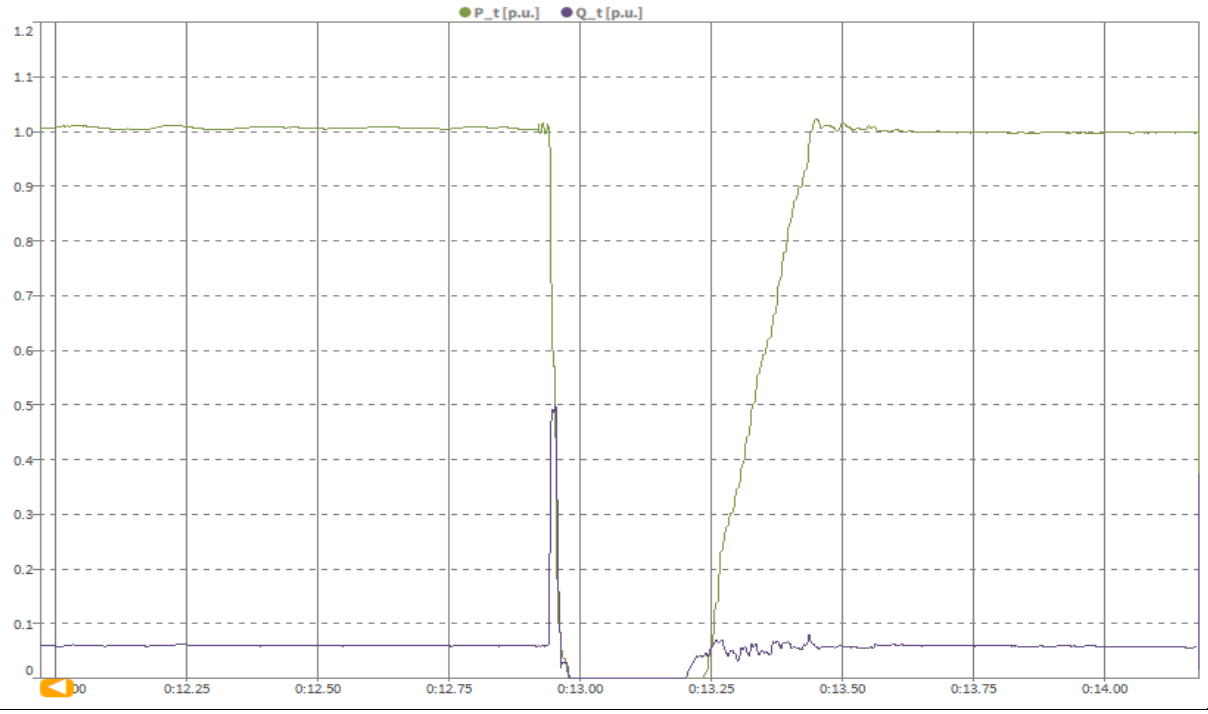
Test 1.1 Depth of fault phase: 0.05 p.u., three-phase SC (type A), 100% load
Instantaneous curve and RMS values of phase-to-neutral voltages



EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

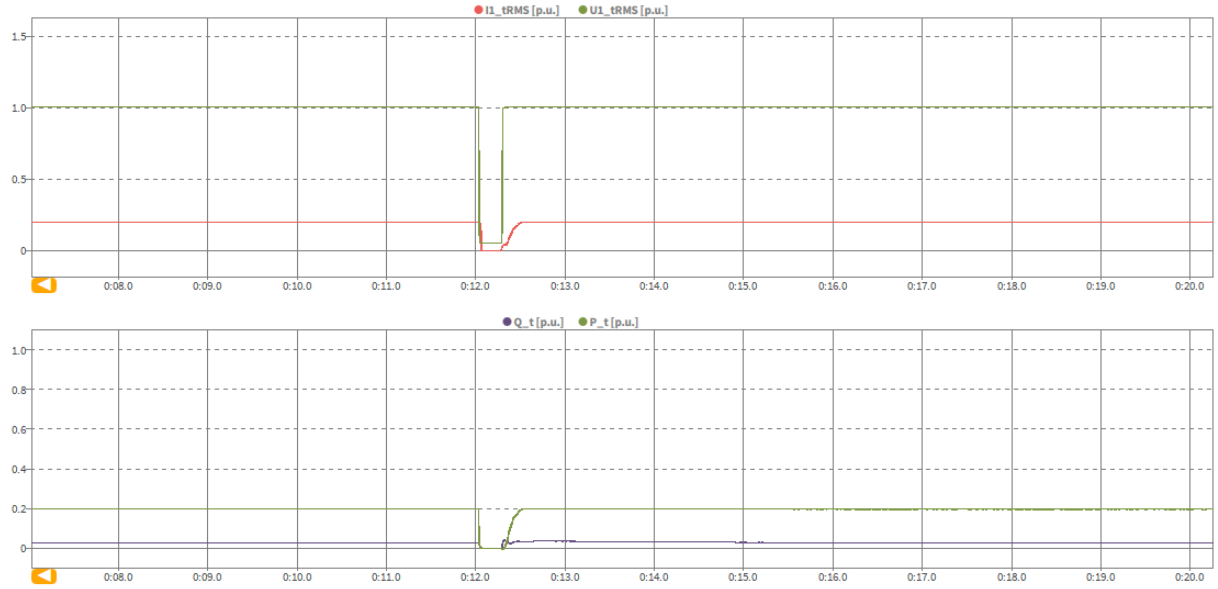
Test 1.1 Depth of fault phase: 0.05 p.u., three-phase SC (type A), 100% load
Instantaneous curve and RMS values of phase currents

Test 1.1 Depth of fault phase: 0.05 p.u., three-phase SC (type A), 100% load
Positive sequence active and reactive power



EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

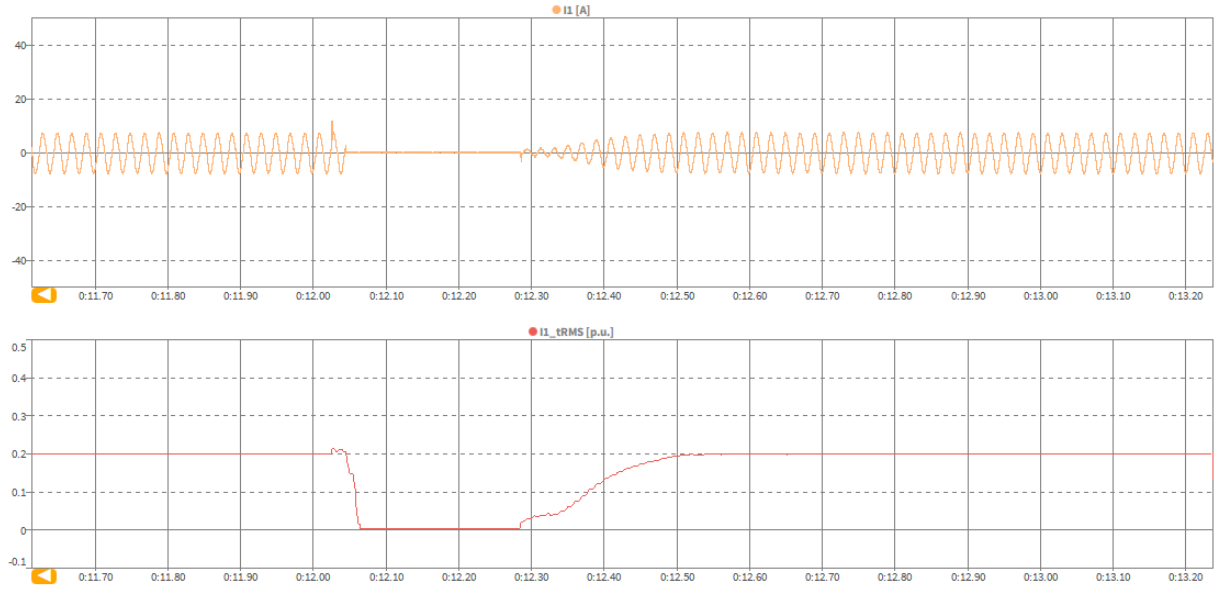
Test 1.2 Depth of fault phase: 0.05 p.u., three-phase SC (type A), 20% load
Test overview (voltage, current, active and reactive power)



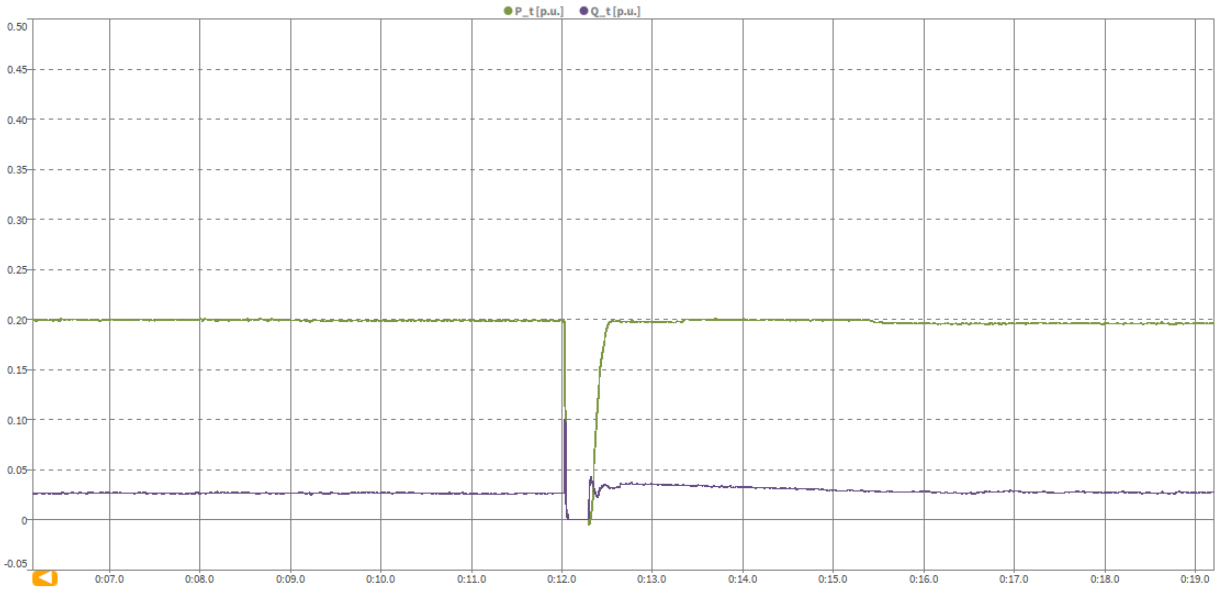
Test 1.2 Depth of fault phase: 0.05 p.u., three-phase SC (type A), 20% load
Instantaneous curve and RMS values of phase-to-neutral voltages

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 1.2 Depth of fault phase: 0.05 p.u., three-phase SC (type A), 20% load
Instantaneous curve and RMS values of phase currents



Test 1.2 Depth of fault phase: 0.05 p.u., three-phase SC (type A), 20% load
Positive sequence active and reactive power

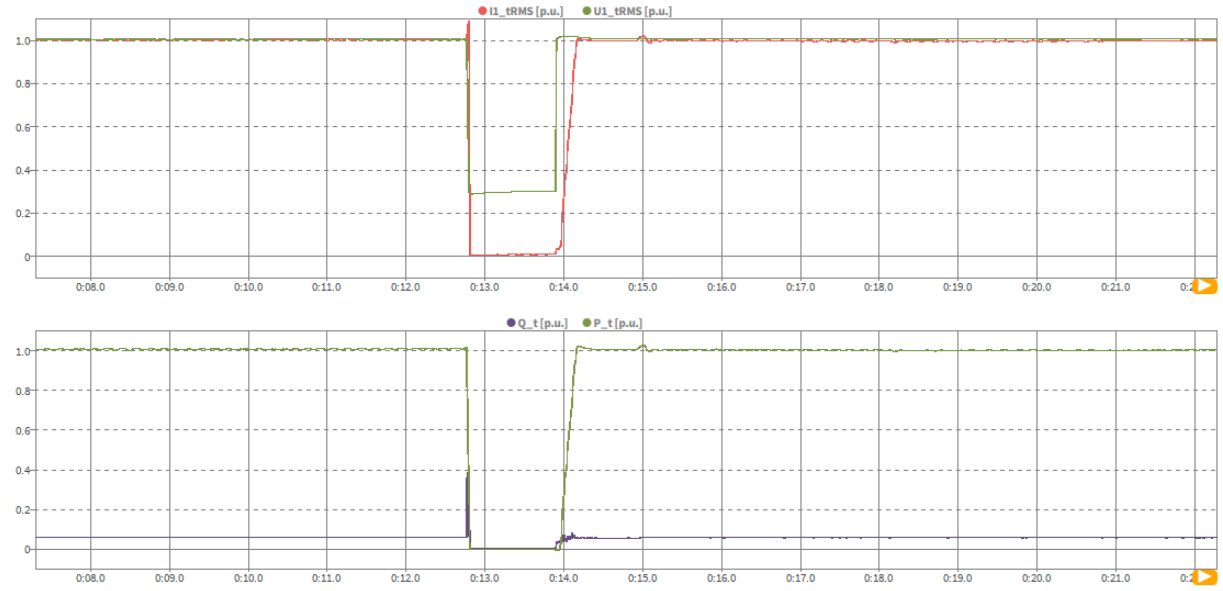


EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

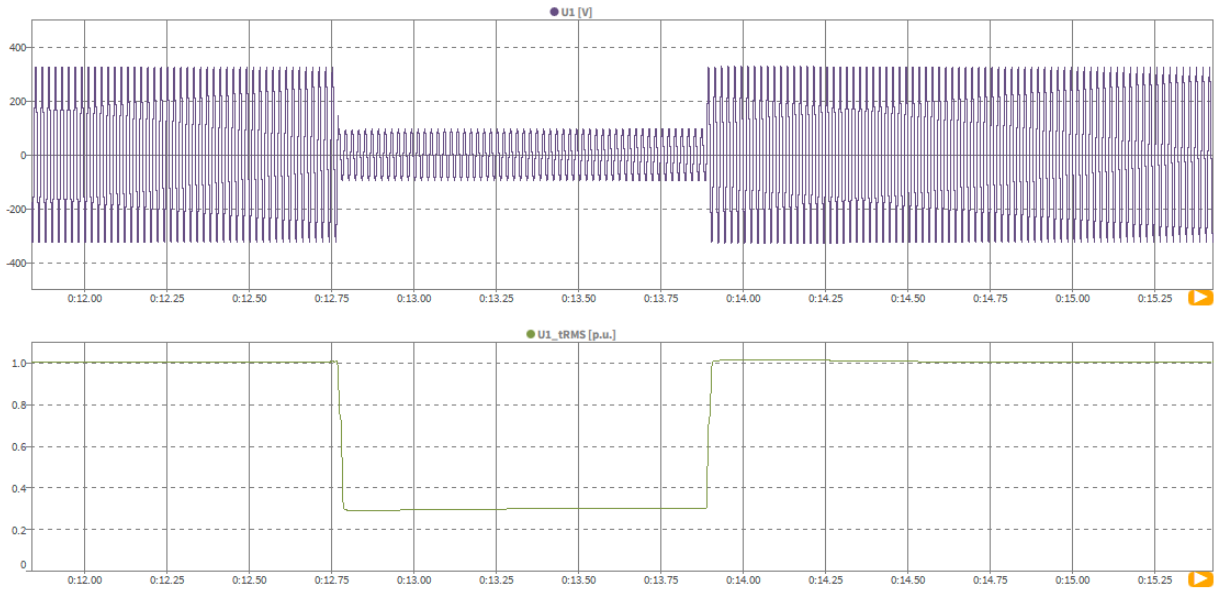
Condition						Measured value	
Item	No.	Parameter	Phase ref.	Time ref.	unit		
General Info.	0	Test number	--	--	--	2.1	2.2
	1	Date	--	--	yyyy.mm.dd	2022.10.24	2022.10.24
	2	Time (start of test)	--	--	hh:mm:ss.f	15:34:27	16:24:18
	3	Fault type (phase)	--	--	--	Type A	Type A
	4	Setting voltage depth	Phase conductor	--	p.u.	0.3	0.3
	5	Setting dip duration		--	--	1125	1125
	6	Point of fault entry(t_1)	Total	--	ms	12764	12197
	7	Point of fault clearance(t_2)	Total	--	ms	13889	13321
	8	Fault duration in empty load test	Total	--	ms	1125	1124
	9	Voltage depth/height in empty load test	Total	t1+100ms to t2 and t1-10s to t1	p.u.	0.3	0.3
	10		Pos.			N/A	N/A
Before dip <t1	11	Voltage	Line to neutral	t1-100s to t1	p.u.	1	1
	12	Current	Pos.	t1-500ms to t1-100ms	p.u.	N/A	N/A
	13	Active power	Total	t1-10s to t1	p.u.	1	0.2
	14		Pos.			N/A	N/A
	15	Reactive power	Total	t1-10s to t1	p.u.	0.06	0.03
	16		Pos.			N/A	N/A
	17	Cosφ	--	t1-10s to t1	--	0.99	0.99
During dip t1 to t2	18	Voltage	Line to neutral	t1+100ms to t2-20ms	p.u.	0.3	0.3
	19	Line current	Phase 1	t1+60ms	p.u.	0.01	0.01
	20		Phase 2			N/A	N/A
	21		Phase 3			N/A	N/A
	22	Line current	Phase 1	t1+100ms	p.u.	0.01	0.01
	23		Phase 2			N/A	N/A
	24		Phase 3			N/A	N/A
	25	Active power	Total	t1+100ms to t2-20ms	p.u.	0	0
	26		Pos.			N/A	N/A
After dip > t2	27	Voltage	Line to neutral	t2+3s to t2+10s	p.u.	1	1
	28	Active power	Total	t2+3s to t2+10s	p.u.	1	0.2
	29		Pos.			N/A	N/A
	30	Response time reactive power	Pos.	--	s	0.462	0.181
	31	Reactive power	Total	t2+3s to t2+10s	p.u.	0.07	0.04
	32		Pos.			N/A	N/A
	33	Reactive power rising time	Pos.	--	s	N/A	N/A
	34	PGU does not disconnect from grid till 60s after fault	--	t2 to t2+60s	Yes / No	Yes	Yes

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 2.1 Depth of fault phase: 0.3p.u., three-phase SC (type A), 100% load
Test overview (voltage, current, active and reactive power)

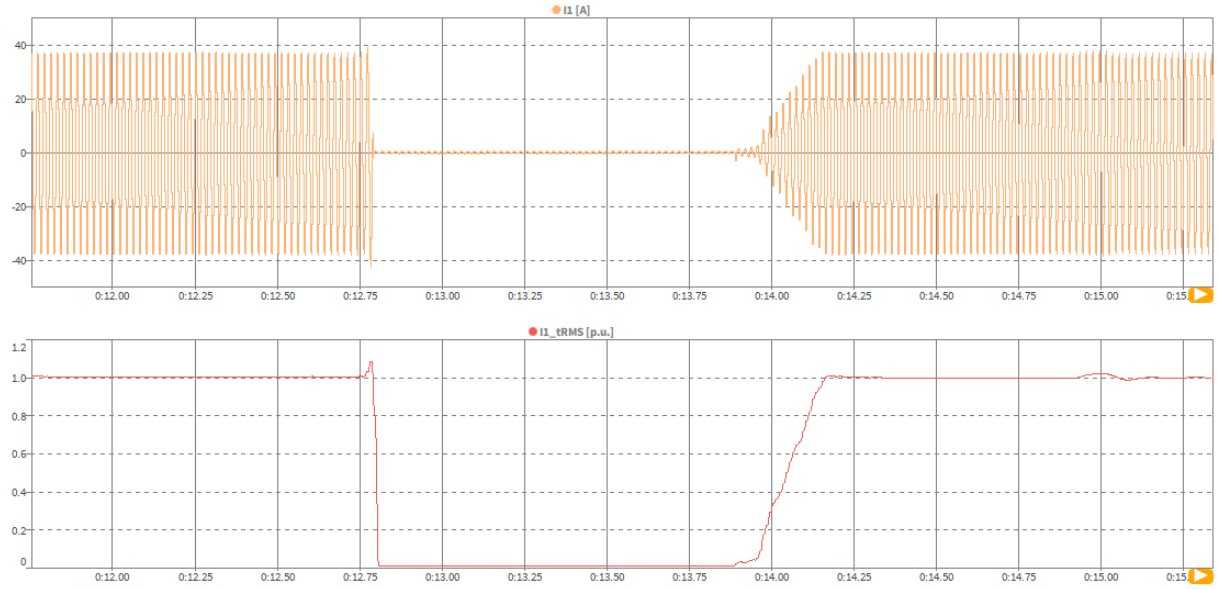


Test 2.1 Depth of fault phase: 0.3p.u., three-phase SC (type A), 100% load
Instantaneous curve and RMS values of phase-to-neutral voltages

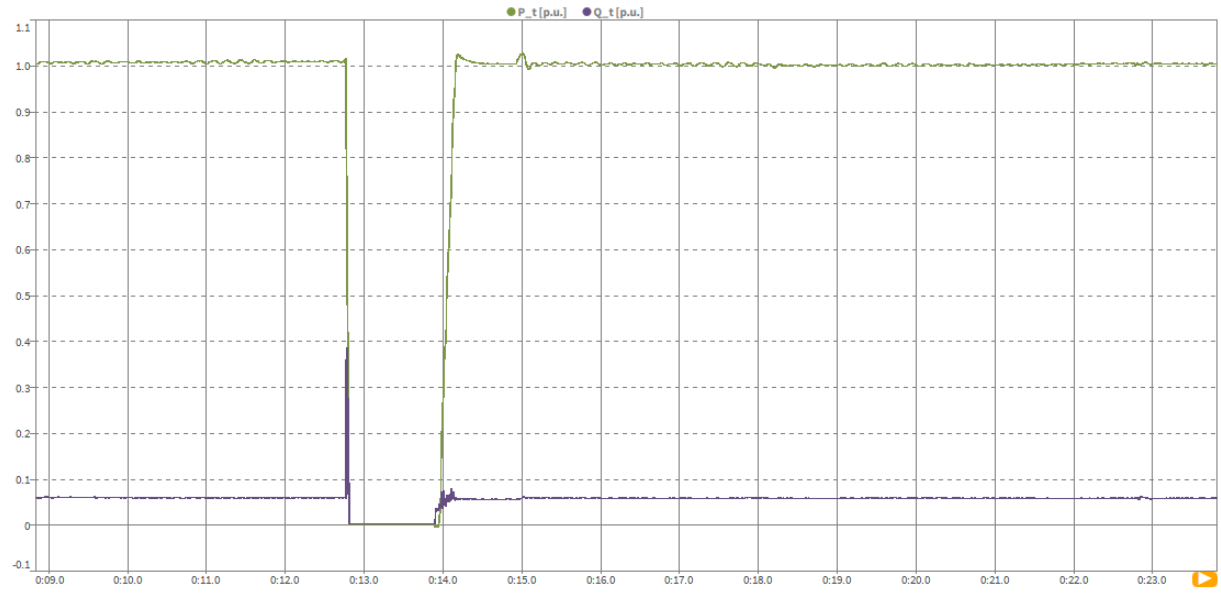


EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 2.1 Depth of fault phase: 0.3p.u., three-phase SC (type A), 100% load
Instantaneous curve and RMS values of phase currents

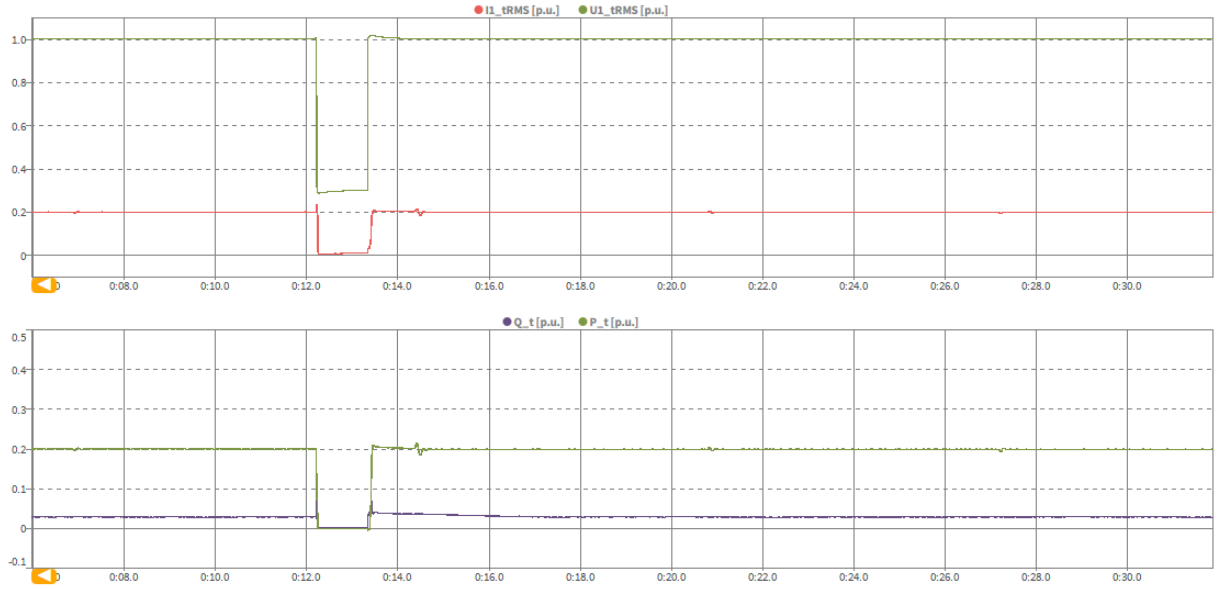


Test 2.1epth of fault phase: 0.3p.u., three-phase SC (type A), 100% load
Positive sequence active and reactive power



EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

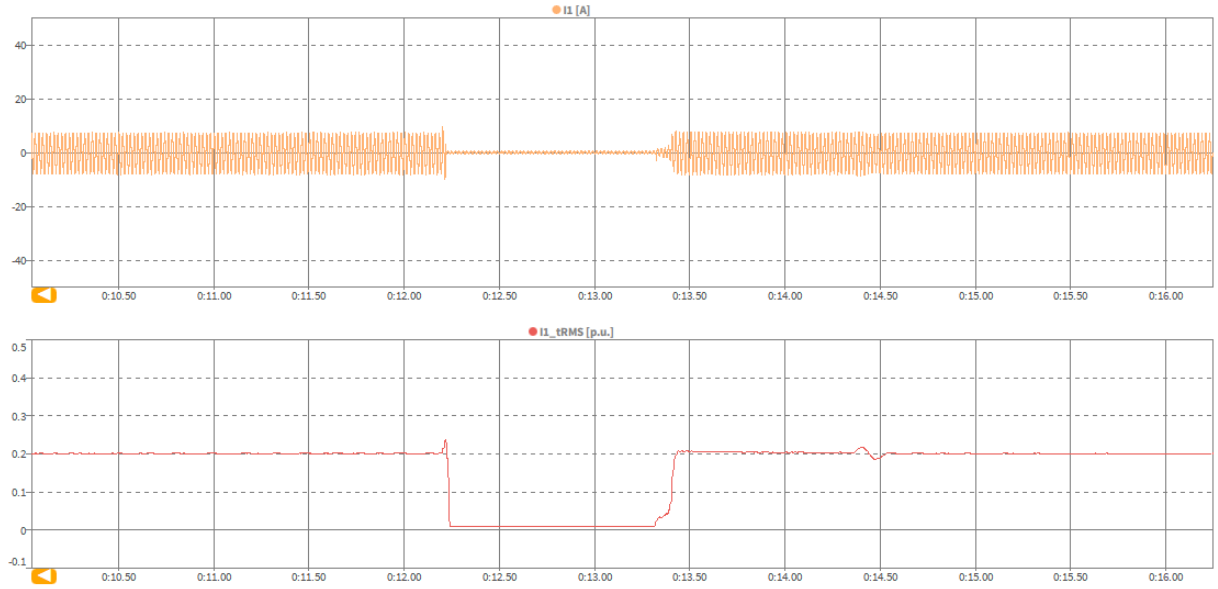
Test 2.2 Depth of fault phase: 0.3 p.u., three-phase SC (type A), 20% load
Test overview (voltage, current, active and reactive power)



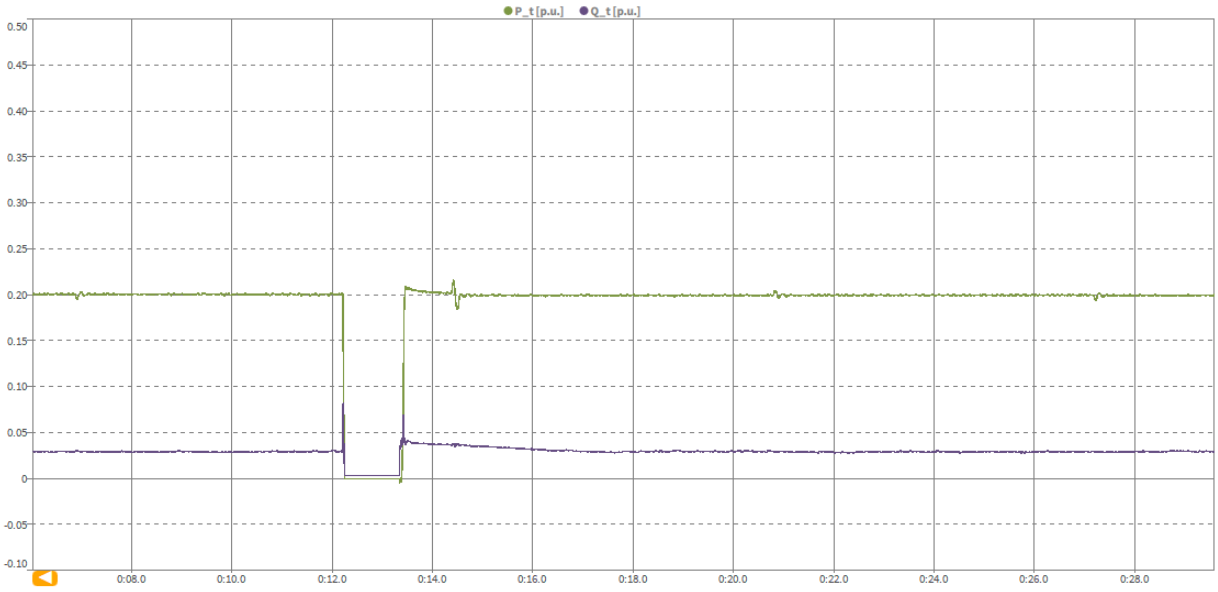
Test 2.2 Depth of fault phase: 0.3 p.u., three-phase SC (type A), 20% load
Instantaneous curve and RMS values of phase-to-neutral voltages

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 2.2 Depth of fault phase: 0.3 p.u., three-phase SC (type A), 20% load
Instantaneous curve and RMS values of phase currents



Test 2.2 Depth of fault phase: 0.3 p.u., three-phase SC (type A), 20% load
Positive sequence active and reactive power

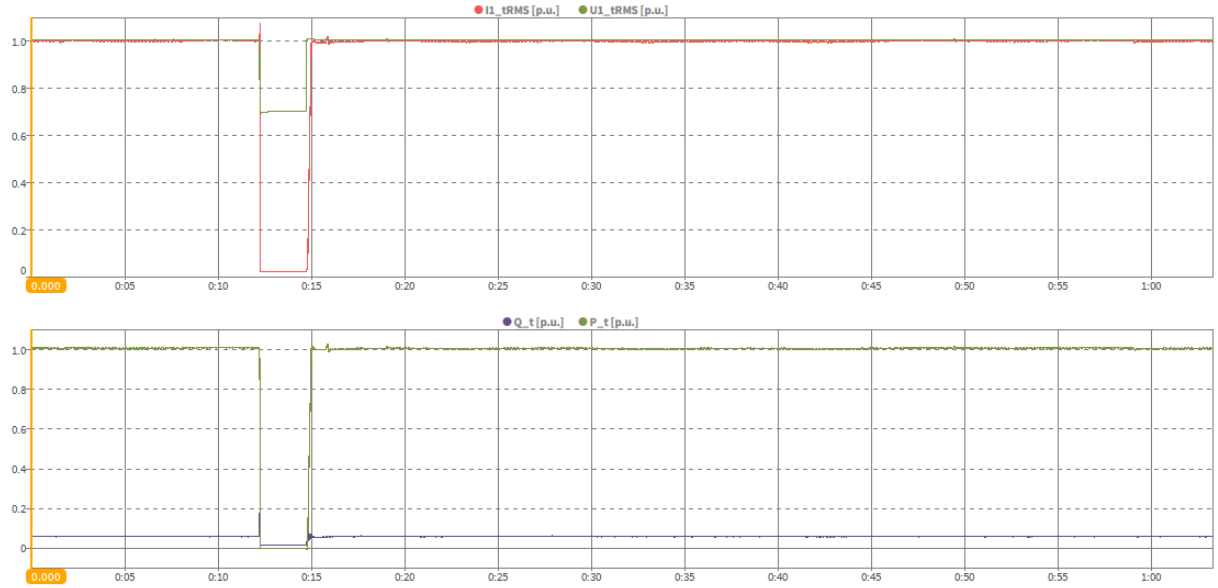


EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

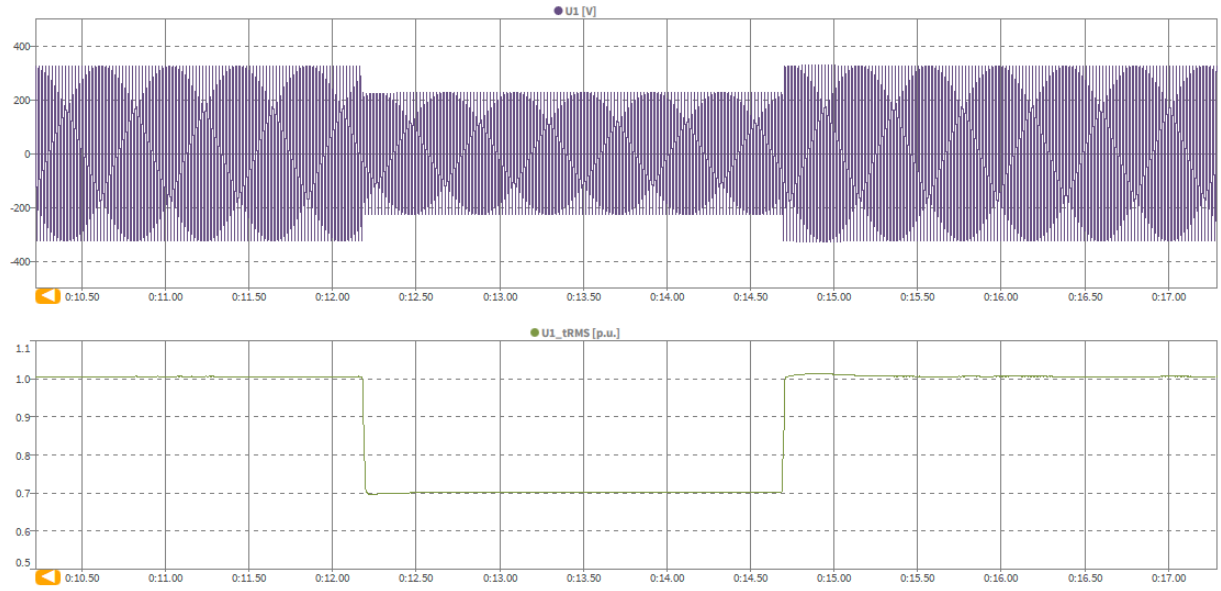
Condition						Measured value	
Item	No.	Parameter	Phase ref.	Time ref.	unit		
General Info.	0	Test number	--	--	--	3.1	3.2
	1	Date	--	--	yyyy.mm.dd	2022.10.24	2022.10.24
	2	Time (start of test)	--	--	hh:mm:ss.f	15:35:57	11:13:52
	3	Fault type (phase)	--	--	--	Type A	Type A
	4	Setting voltage depth	Phase conductor	--	p.u.	0.7	0.7
	5	Setting dip duration		--	--	2510	2510
	6	Point of fault entry(t_1)	Total	--	ms	12177	13357
	7	Point of fault clearance(t_2)	Total	--	ms	14682	15876
	8	Fault duration in empty load test	Total	--	ms	2505	2519
	9	Voltage depth/height in empty load test	Total	t1+100ms to t2 and t1-10s to t1	p.u.	0.7	0.7
	10		Pos.			N/A	N/A
Before dip <t1	11	Voltage	Line to neutral	t1-100s to t1	p.u.	1	1
	12	Current	Pos.	t1-500ms to t1-100ms	p.u.	N/A	N/A
	13	Active power	Total	t1-10s to t1	p.u.	1	0.2
	14		Pos.			N/A	N/A
	15	Reactive power	Total	t1-10s to t1	p.u.	0.06	0.03
	16		Pos.			N/A	N/A
	17	Cosφ	--	t1-10s to t1	--	0.99	0.99
During dip t1 to t2	18	Voltage	Line to neutral	t1+100ms to t2-20ms	p.u.	0.7	0.7
	19	Line current	Phase 1	t1+60ms	p.u.	0.02	0.02
	20		Phase 2			N/A	N/A
	21		Phase 3			N/A	N/A
	22	Line current	Phase 1	t1+100ms	p.u.	0.02	0.02
	23		Phase 2			N/A	N/A
	24		Phase 3			N/A	N/A
	25	Active power	Total	t1+100ms to t2-20ms	p.u.	0	0
	26		Pos.			N/A	N/A
After dip > t2	27	Voltage	Line to neutral	t2+3s to t2+10s	p.u.	1	1
	28	Active power	Total	t2+3s to t2+10s	p.u.	1	0.2
	29		Pos.			N/A	N/A
	30	Response time reactive power	Pos.	--	s	0.301	0.147
	31	Reactive power	Total	t2+3s to t2+10s	p.u.	0.06	0.03
	32		Pos.			N/A	N/A
	33	Reactive power rising time	Pos.	--	s	N/A	N/A
	34	PGU does not disconnect from grid till 60s after fault	--	t2 to t2+60s	Yes / No	Yes	Yes

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 3.1 Depth of fault phase: 0.7 p.u., three-phase SC (type A), 100% load
Test overview (voltage, current, active and reactive power)

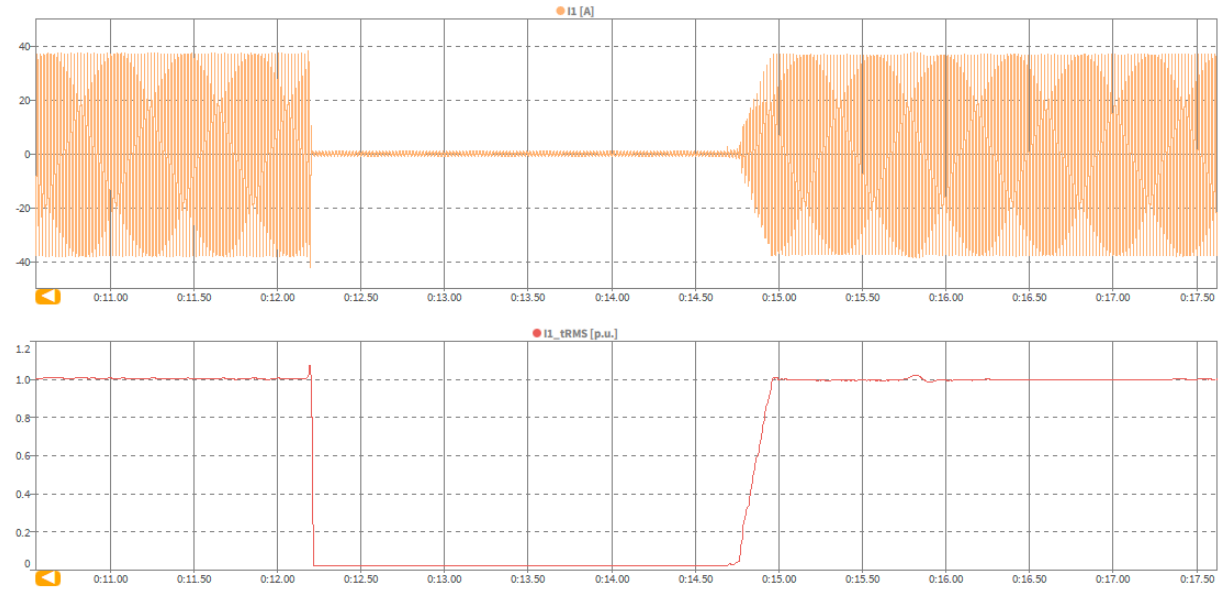


Test 3.1 Depth of fault phase: 0.7 p.u., three-phase SC (type A), 100% load
Instantaneous curve and RMS values of phase-to-neutral voltages

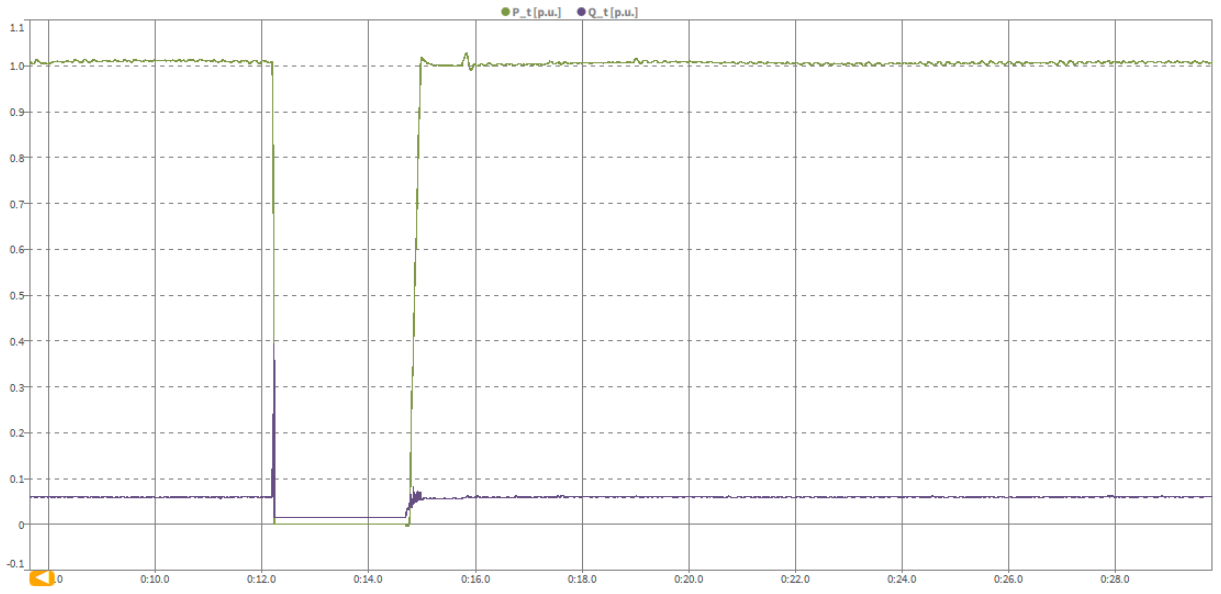


EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 3.1 Depth of fault phase: 0.7 p.u., three-phase SC (type A), 100% load
Instantaneous curve and RMS values of phase currents

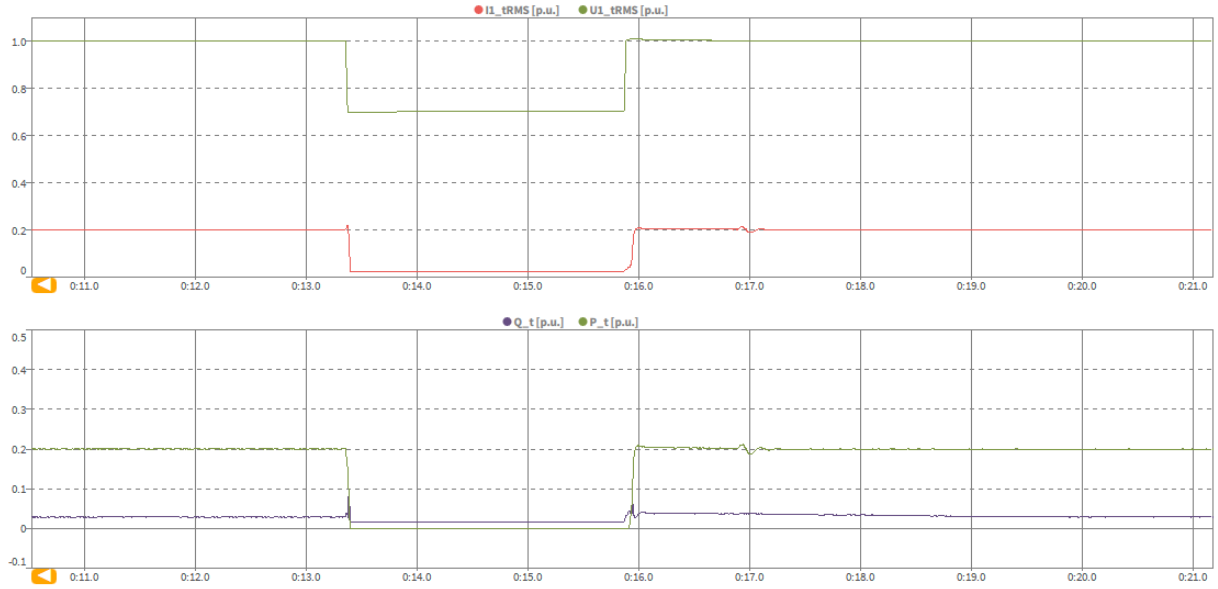


Test 3.1 Depth of fault phase: 0.7 p.u., three-phase SC (type A), 100% load
Positive sequence active and reactive power

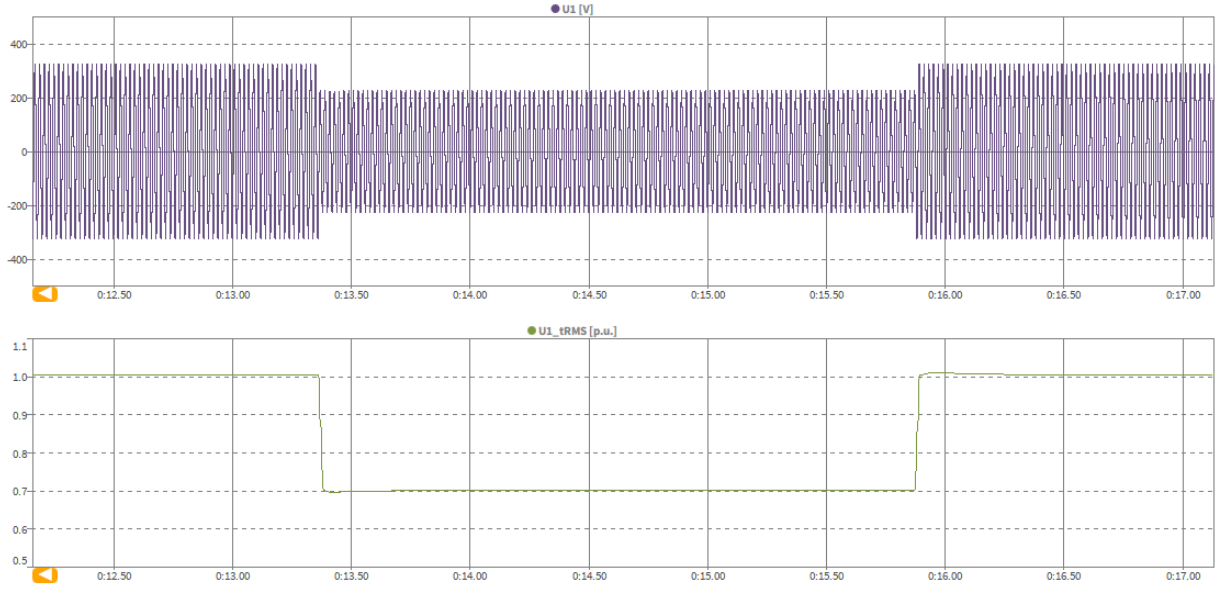


EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 3.2 Depth of fault phase: 0.7 p.u., three-phase SC (type A), 20% load
Test overview (voltage, current, active and reactive power)

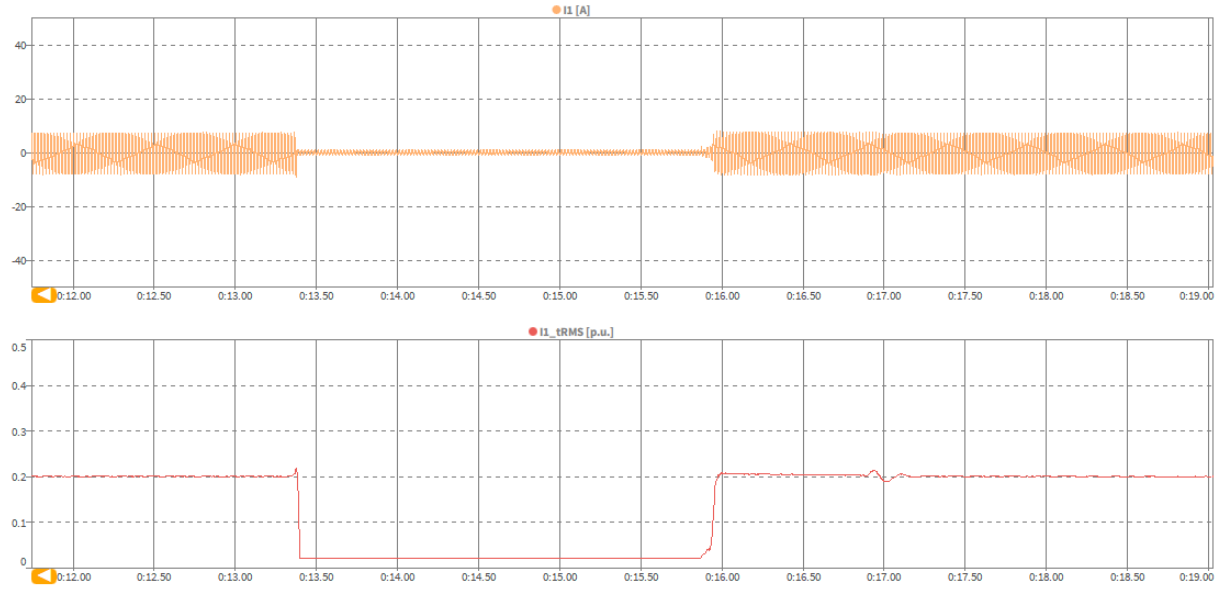


Test 3.2 Depth of fault phase: 0.7 p.u., three-phase SC (type A), 20% load
Instantaneous curve and RMS values of phase-to-neutral voltages

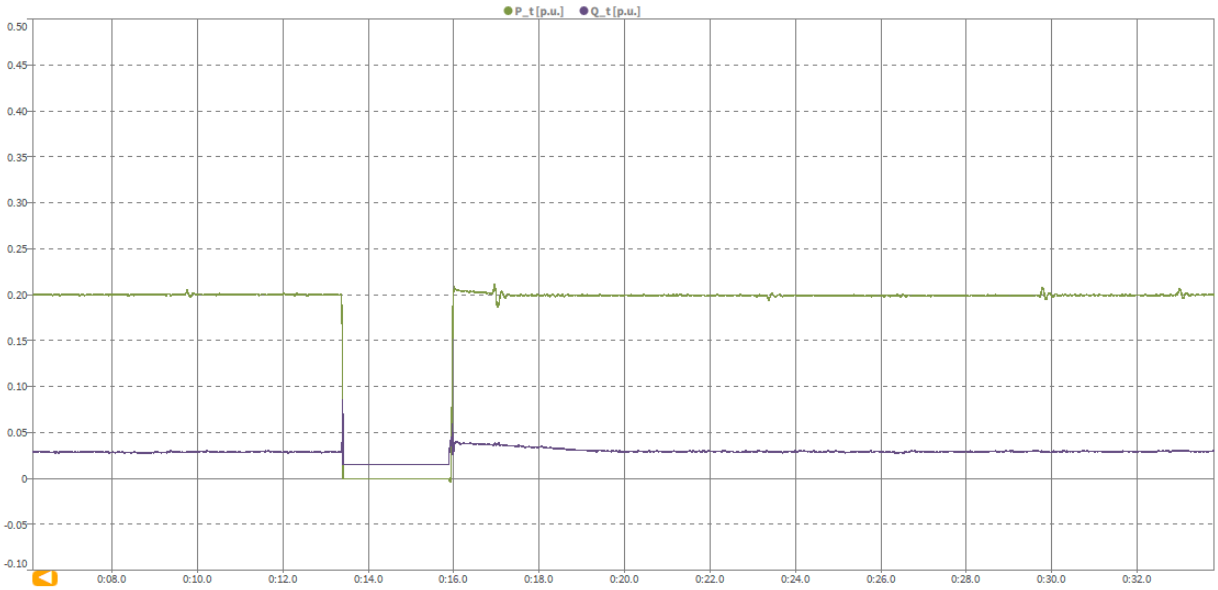


EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 3.2 Depth of fault phase: 0.7 p.u., three-phase SC (type A), 20% load
Instantaneous curve and RMS values of phase currents



Test 3.2 Depth of fault phase: 0.7 p.u., three-phase SC (type A), 20% load
Positive sequence active and reactive power

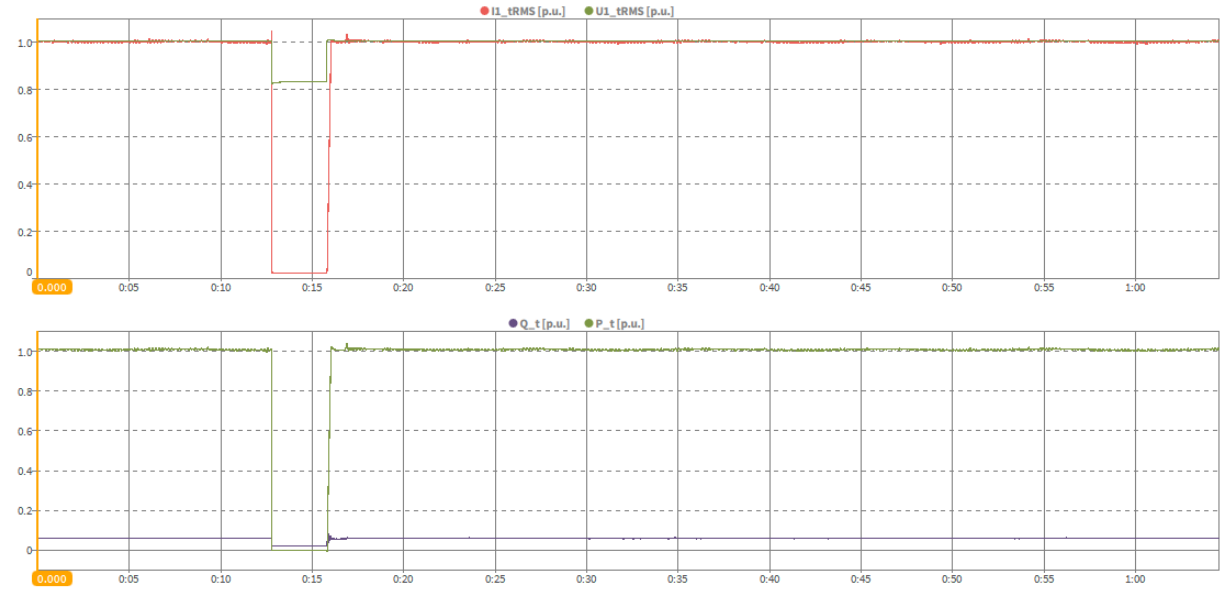


EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

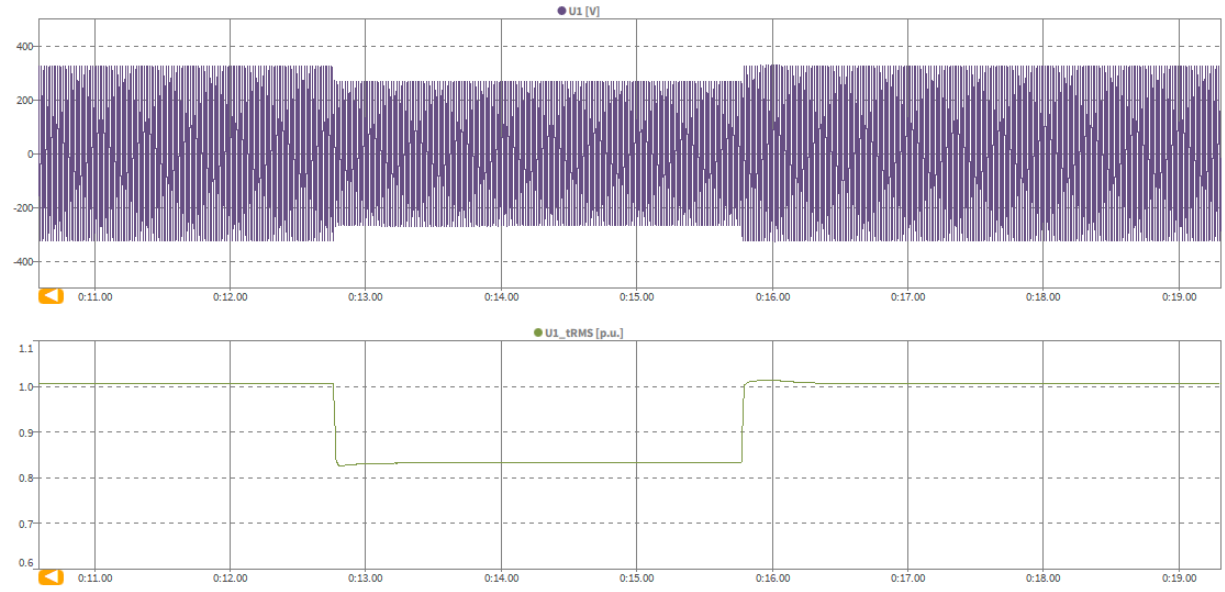
Condition						Measured value	
Item	No.	Parameter	Phase ref.	Time ref.	unit		
General Info.	0	Test number	--	--	--	4.1	4.2
	1	Date	--	--	yyyy.mm.dd	2022.10.24	2022.10.24
	2	Time (start of test)	--	--	hh:mm:ss.f	15:36:16	16:21:05
	3	Fault type (phase)	--	--	--	Type A	Type A
	4	Setting voltage depth	Phase conductor	--	p.u.	0.83	0.83
	5	Setting dip duration		--	--	3020	3020
	6	Point of fault entry(t_1)	Total	--	ms	12768	11975
	7	Point of fault clearance(t_2)	Total	--	ms	15781	14997
	8	Fault duration in empty load test	Total	--	ms	3013	3022
	9	Voltage depth/height in empty load test	Total	t1+100ms to t2 and t1-10s to t1	p.u.	0.83	0.83
	10		Pos.			N/A	N/A
Before dip <t1	11	Voltage	Line to neutral	t1-100s to t1	p.u.	1	1
	12	Current	Pos.	t1-500ms to t1-100ms	p.u.	N/A	N/A
	13	Active power	Total	t1-10s to t1	p.u.	1	0.2
	14		Pos.			N/A	N/A
	15	Reactive power	Total	t1-10s to t1	p.u.	0.06	0.03
	16		Pos.			N/A	N/A
	17	Cosφ	--	t1-10s to t1	--	0.99	0.99
During dip t1 to t2	18	Voltage	Line to neutral	t1+100ms to t2-20ms	p.u.	0.83	0.83
	19	Line current	Phase 1	t1+60ms	p.u.	0.02	0.026
	20		Phase 2			N/A	N/A
	21		Phase 3			N/A	N/A
	22	Line current	Phase 1	t1+100ms	p.u.	0.02	0.03
	23		Phase 2			N/A	N/A
	24		Phase 3			N/A	N/A
	25	Active power	Total	t1+100ms to t2-20ms	p.u.	0	0
	26		Pos.			N/A	N/A
After dip > t2	27	Voltage	Line to neutral	t2+3s to t2+10s	p.u.	1.01	1.00
	28	Active power	Total	t2+3s to t2+10s	p.u.	1.01	0.20
	29		Pos.			N/A	N/A
	30	Response time reactive power	Pos.	--	s	0.299	0.153
	31	Reactive power	Total	t2+3s to t2+10s	p.u.	0.06	0.4
	32		Pos.			N/A	N/A
	33	Reactive power rising time	Pos.	--	s	N/A	N/A
	34	PGU does not disconnect from grid till 60s after fault	--	t2 to t2+60s	Yes / No	Yes	Yes

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 4.1 Depth of fault phase: 0.83 p.u., three-phase SC (type A), 100% load
Test overview (voltage, current, active and reactive power)

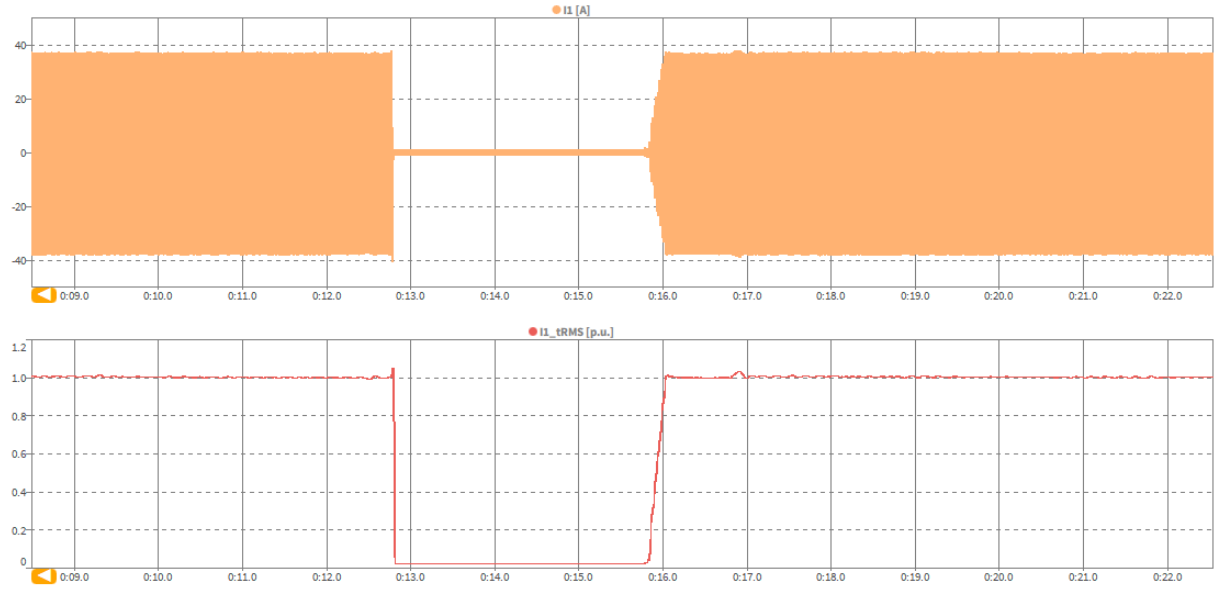


Test 4.1 Depth of fault phase: 0.83 p.u., three-phase SC (type A), 100% load
Instantaneous curve and RMS values of phase-to-neutral voltages

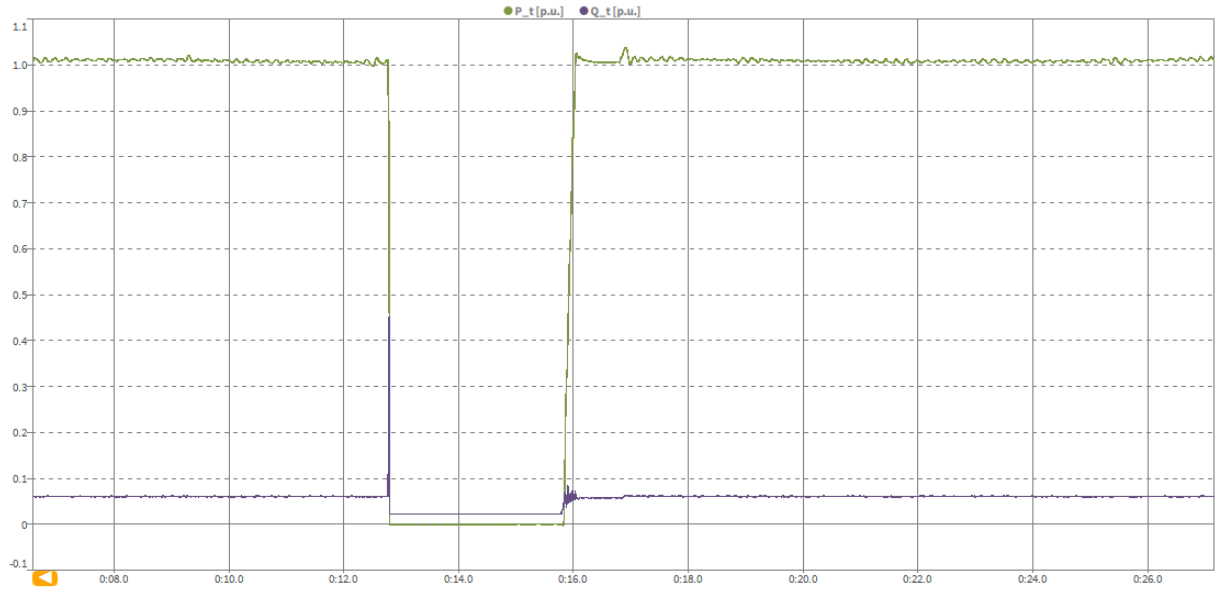


EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 4.1 Depth of fault phase: 0.83 p.u., three-phase SC (type A), 100% load
Instantaneous curve and RMS values of phase currents

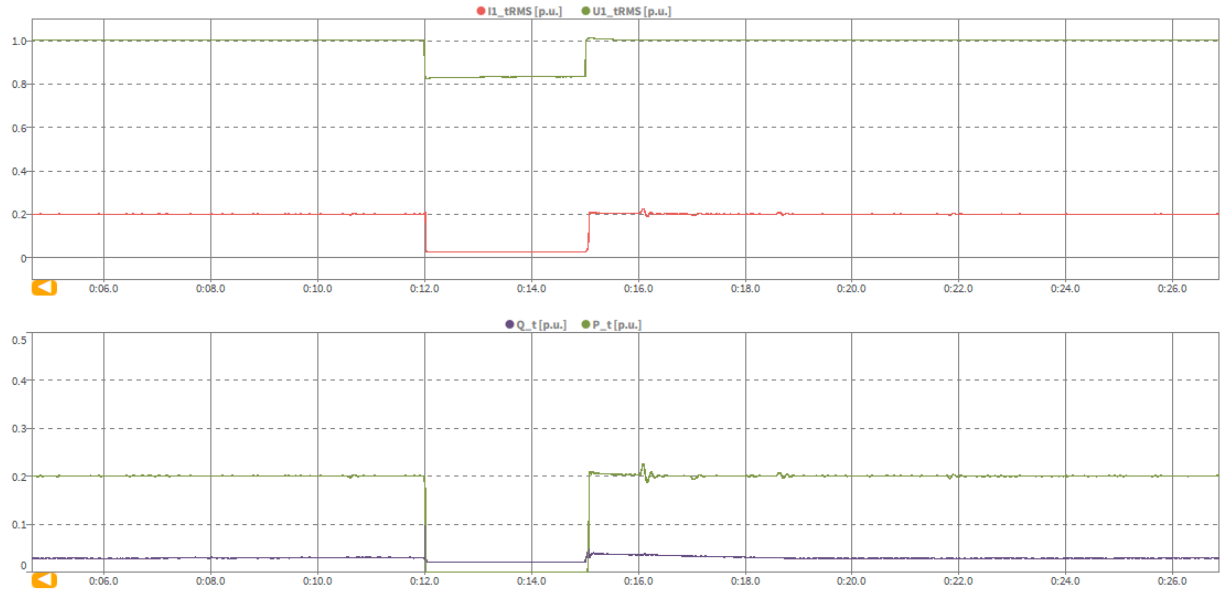


Test 4.1 Depth of fault phase: 0.83 p.u., three-phase SC (type A), 100% load
Positive sequence active and reactive power

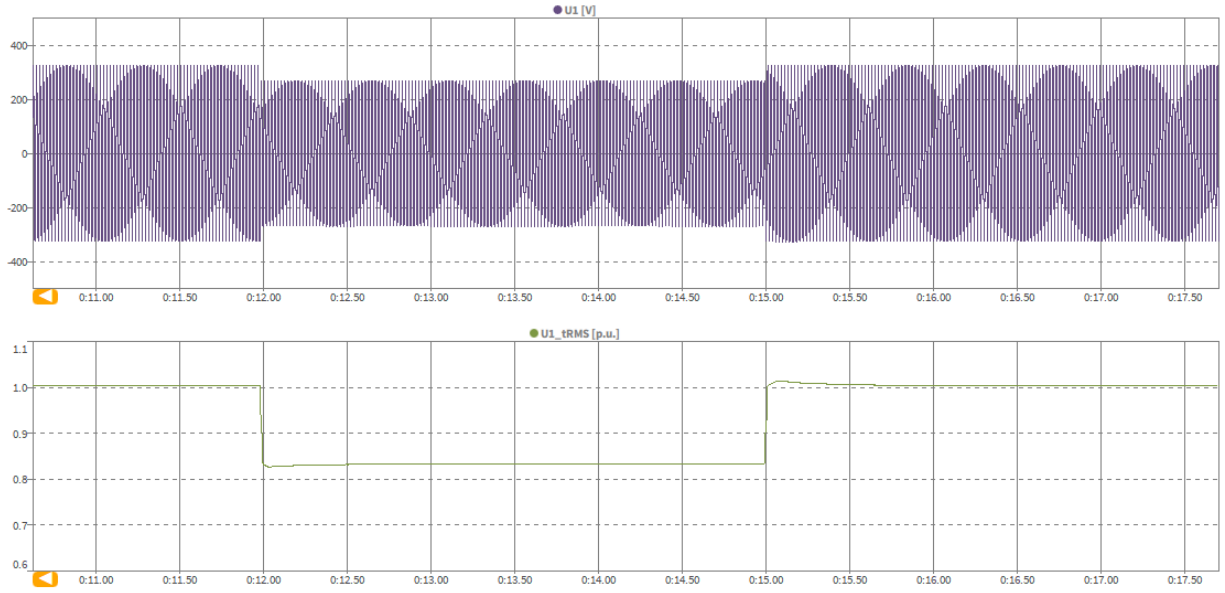


EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 4.2 Depth of fault phase: 0.83 p.u., three-phase SC (type A), 20% load
Test overview (voltage, current, active and reactive power)

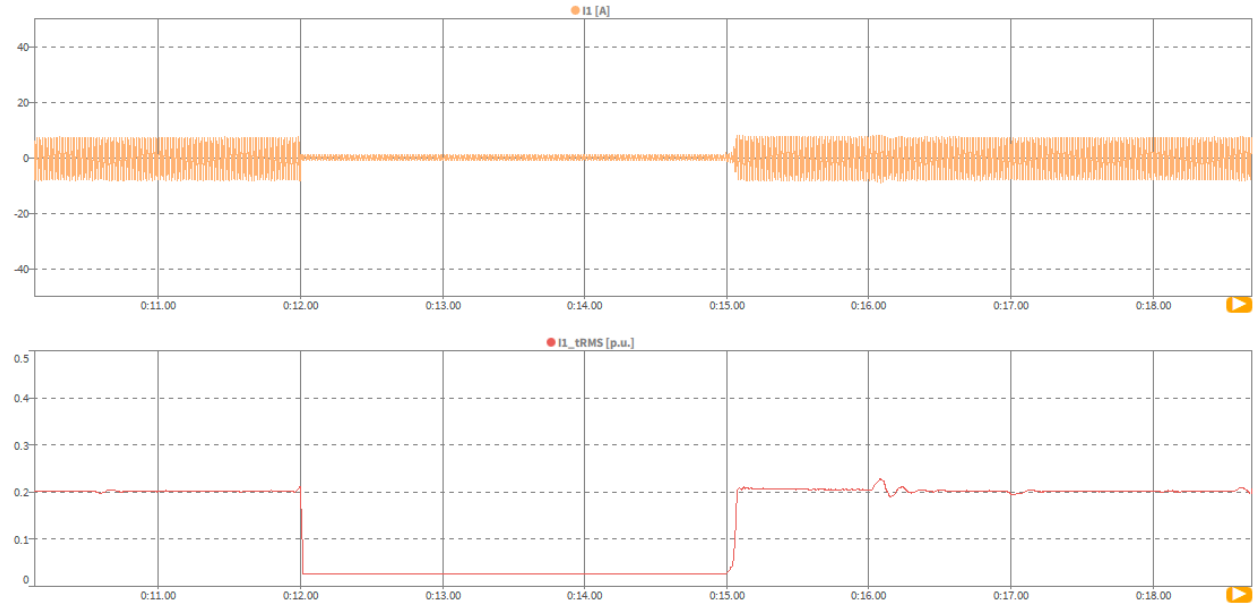


Test 4.2 Depth of fault phase: 0.83 p.u., three-phase SC (type A), 20% load
Instantaneous curve and RMS values of phase-to-neutral voltages

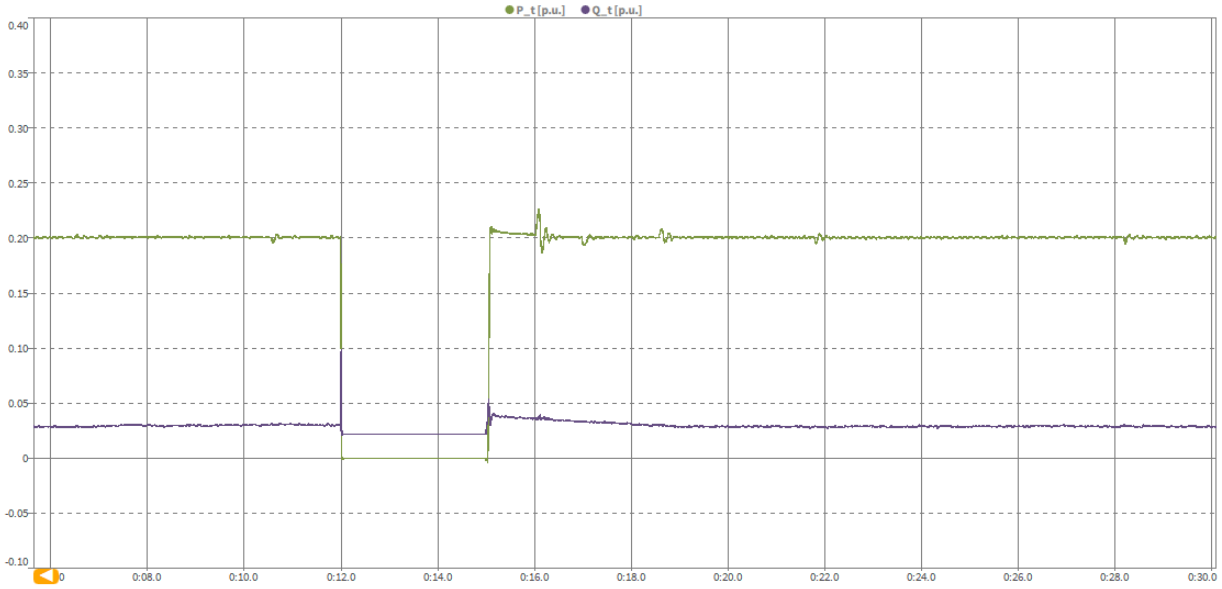


EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 4.2 Depth of fault phase: 0.83 p.u., three-phase SC (type A), 20% load
Instantaneous curve and RMS values of phase currents



Test 4.2 Depth of fault phase: 0.83 p.u., three-phase SC (type A), 20% load
Positive sequence active and reactive power

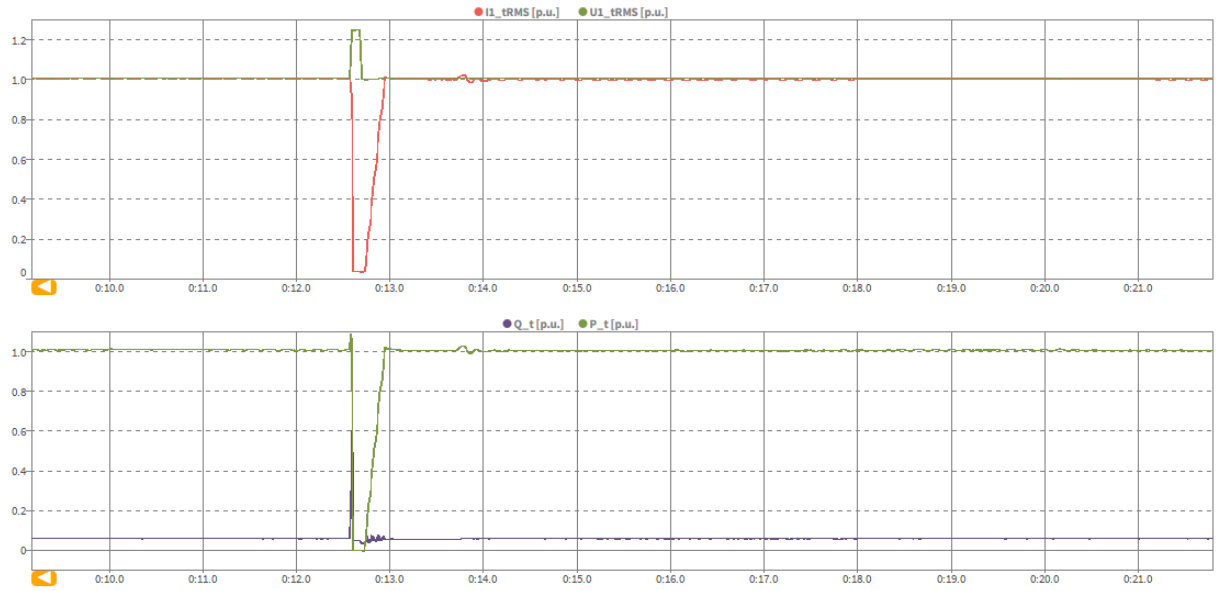


EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Condition						Measured value	
Item	No.	Parameter	Phase ref.	Time ref.	unit		
General Info.	0	Test number	--	--	--	5.1	5.2
	1	Date	--	--	yyyy.mm.dd	2022.10.24	2022.10.24
	2	Time (start of test)	--	--	hh:mm:ss.f	15:15:19	16:19:28
	3	Fault type (phase)	--	--	--	Type A	Type A
	4	Setting voltage depth	Phase conductor	--	p.u.	1.25	1.25
	5	Setting dip duration		--	--	110	110
	6	Point of fault entry(t_1)	Total	--	ms	12576	12402
	7	Point of fault clearance(t_2)	Total	--	ms	12684	12511
	8	Fault duration in empty load test	Total	--	ms	108	109
	9	Voltage depth/height in empty load test	Total	t1+100ms to t2 and t1-10s to t1	p.u.	1.25	1.25
	10		Pos.			N/A	N/A
Before dip <t1	11	Voltage	Line to neutral	t1-100s to t1	p.u.	1	1
	12	Current	Pos.	t1-500ms to t1-100ms	p.u.	N/A	N/A
	13	Active power	Total	t1-10s to t1	p.u.	1	0.2
	14		Pos.			N/A	N/A
	15	Reactive power	Total	t1-10s to t1	p.u.	0.06	0.03
	16		Pos.			N/A	N/A
	17	Cosφ	--	t1-10s to t1	--	0.99	0.99
During dip t1 to t2	18	Voltage	Line to neutral	t1+100ms to t2-20ms	p.u.	1.25	1.25
	19	Line current	Phase 1	t1+60ms	p.u.	0.04	0.04
	20		Phase 2			N/A	N/A
	21		Phase 3			N/A	N/A
	22	Line current	Phase 1	t1+100ms	p.u.	0.04	0.04
	23		Phase 2			N/A	N/A
	24		Phase 3			N/A	N/A
	25	Active power	Total	t1+100ms to t2-20ms	p.u.	0	0
	26		Pos.			N/A	N/A
After dip > t2	27	Voltage	Line to neutral	t2+3s to t2+10s	p.u.	1	1.00
	28	Active power	Total	t2+3s to t2+10s	p.u.	1	0.20
	29		Pos.			N/A	N/A
	30	Response time reactive power	Pos.	--	s	0.279	0.12
	31	Reactive power	Total	t2+3s to t2+10s	p.u.	0.06	0.04
	32		Pos.			N/A	N/A
	33	Reactive power rising time	Pos.	--	s	N/A	N/A
	34	PGU does not disconnect from grid till 60s after fault	--	t2 to t2+60s	Yes / No	Yes	Yes

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 5.1 Depth of fault phase: 1.25 p.u., three-phase SC (type A),100% load
Test overview (voltage, current, active and reactive power)



Test 5.1 Depth of fault phase: 1.25 p.u., three-phase SC (type A),100% load
Instantaneous curve and RMS values of phase-to-neutral voltages

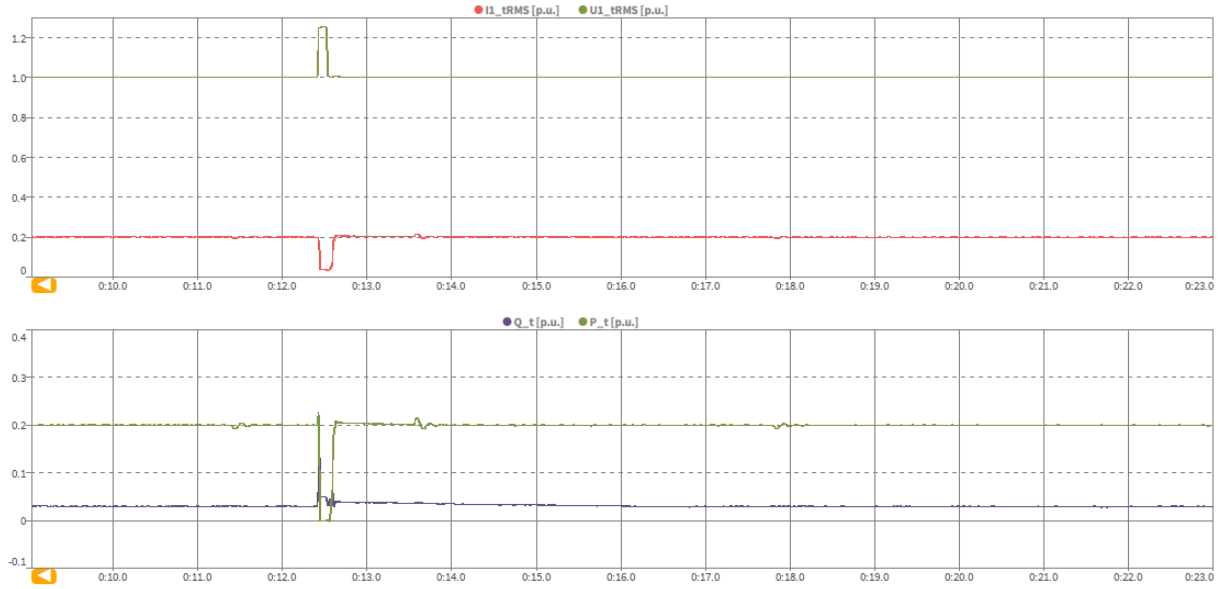
EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 5.1 Depth of fault phase: 1.25 p.u., three-phase SC (type A),100% load
Instantaneous curve and RMS values of phase currents

Test 5.1 Depth of fault phase: 1.25 p.u., three-phase SC (type A),100% load
Positive sequence active and reactive power

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

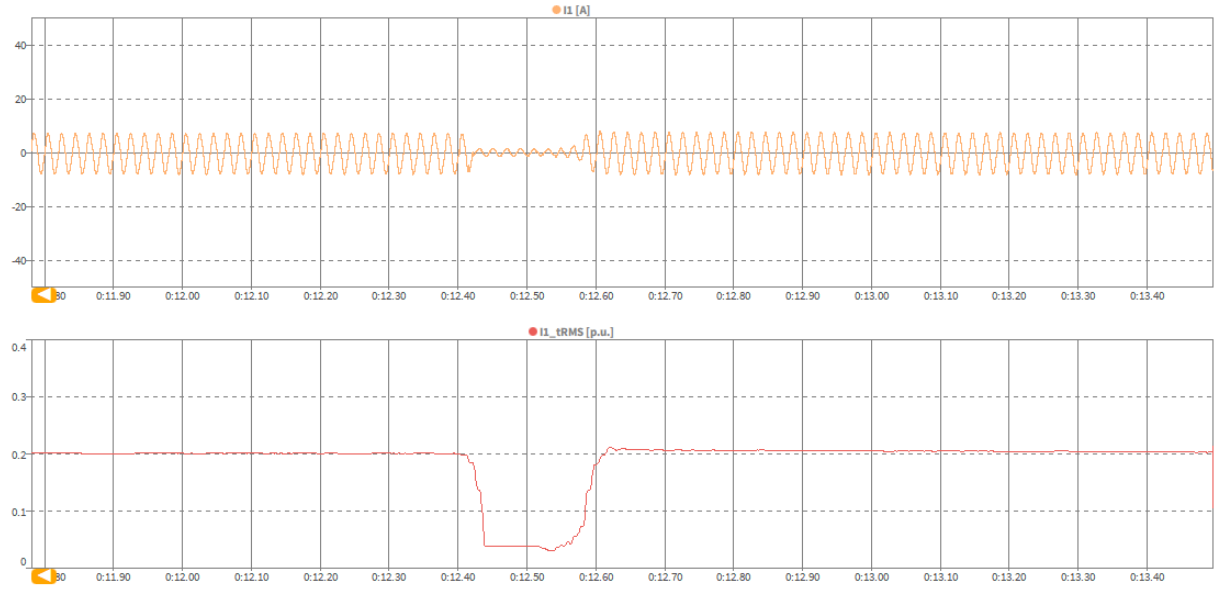
Test 5.2 Depth of fault phase: 1.25 p.u., three-phase SC (type A),20% load
Test overview (voltage, current, active and reactive power)



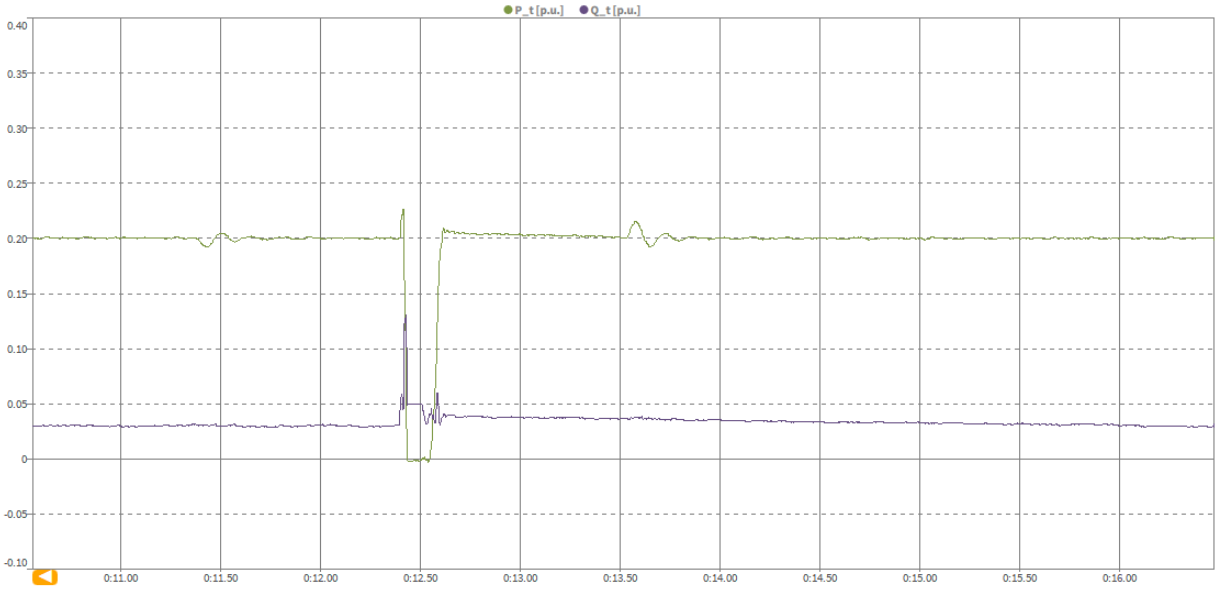
Test 5.2 Depth of fault phase: 1.25 p.u., three-phase SC (type A),20% load
Instantaneous curve and RMS values of phase-to-neutral voltages

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 5.2 Depth of fault phase: 1.25 p.u., three-phase SC (type A),20% load
Instantaneous curve and RMS values of phase currents



Test 5.2 Depth of fault phase: 1.25 p.u., three-phase SC (type A),20% load
Positive sequence active and reactive power

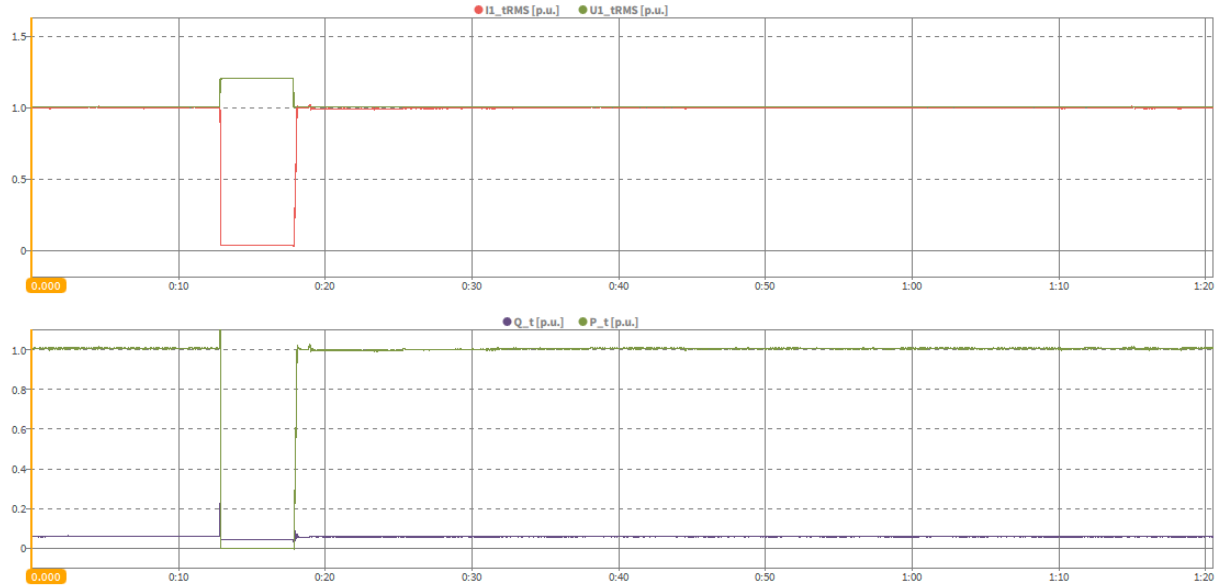


EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

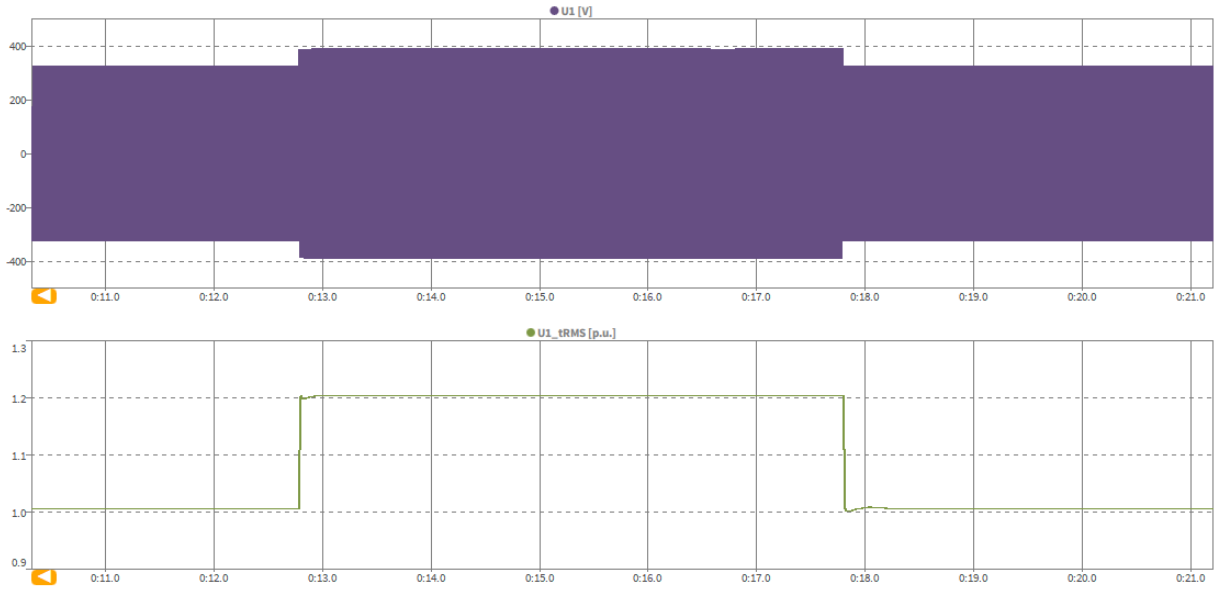
Condition						Measured value	
.tem	No.	Parameter	Phase ref.	Time ref.	unit		
General Info.	0	Test number	--	--	--	6.1	6.2
	1	Date	--	--	yyyy.mm.dd	2022.10.24	2022.10.24
	2	Time (start of test)	--	--	hh:mm:ss.f	15:19:22	16:17:42
	3	Fault type (phase)	--	--	--	Type A	Type A
	4	Setting voltage depth	Phase conductor	--	p.u.	1.2	1.2
	5	Setting dip duration		--	--	5000	5000
	6	Point of fault entry(t_1)	Total	--	ms	12776	13555
	7	Point of fault clearance(t_2)	Total	--	ms	17784	18565
	8	Fault duration in empty load test	Total	--	ms	5008	5010
	9	Voltage depth/height in empty load test	Total	t1+100ms to t2 and t1-10s to t1	p.u.	1.2	1.2
	10		Pos.			N/A	N/A
Before dip <t1	11	Voltage	Line to neutral	t1-100s to t1	p.u.	1	1
	12	Current	Pos.	t1-500ms to t1-100ms	p.u.	N/A	N/A
	13	Active power	Total	t1-10s to t1	p.u.	1	0.2
	14		Pos.			N/A	N/A
	15	Reactive power	Total	t1-10s to t1	p.u.	0.06	0.03
	16		Pos.			N/A	N/A
	17	Cosφ	--	t1-10s to t1	--	0.99	0.99
During dip t1 to t2	18	Voltage	Line to neutral	t1+100ms to t2-20ms	p.u.	1.2	1.25
	19	Line current	Phase 1	t1+60ms	p.u.	0.04	0.04
	20		Phase 2			N/A	N/A
	21		Phase 3			N/A	N/A
	22	Line current	Phase 1	t1+100ms	p.u.	0.04	0.04
	23		Phase 2			N/A	N/A
	24		Phase 3			N/A	N/A
	25	Active power	Total	t1+100ms to t2-20ms	p.u.	0	0
	26		Pos.			N/A	N/A
After dip > t2	27	Voltage	Line to neutral	t2+3s to t2+10s	p.u.	1	1.00
	28	Active power	Total	t2+3s to t2+10s	p.u.	1	0.20
	29		Pos.			N/A	N/A
	30	Response time reactive power	Pos.	--	s	0.349	0.153
	31	Reactive power	Total	t2+3s to t2+10s	p.u.	0.05	0.03
	32		Pos.			N/A	N/A
	33	Reactive power rising time	Pos.	--	s	N/A	N/A
	34	PGU does not disconnect from grid till 60s after fault	--	t2 to t2+60s	Yes / No	Yes	Yes

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 6.1 Depth of fault phase: 1.2 p.u., three-phase SC (type A), 100% load
Test overview (voltage, current, active and reactive power)

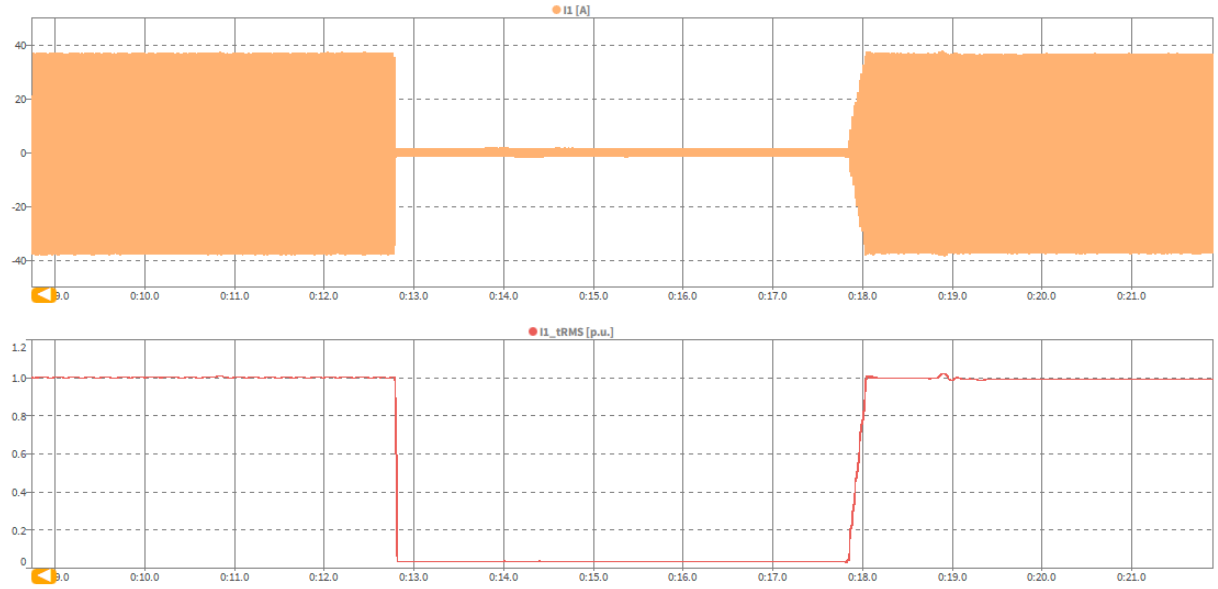


Test 6.1 Depth of fault phase: 1.2 p.u., three-phase SC (type A), 100% load
Instantaneous curve and RMS values of phase-to-neutral voltages

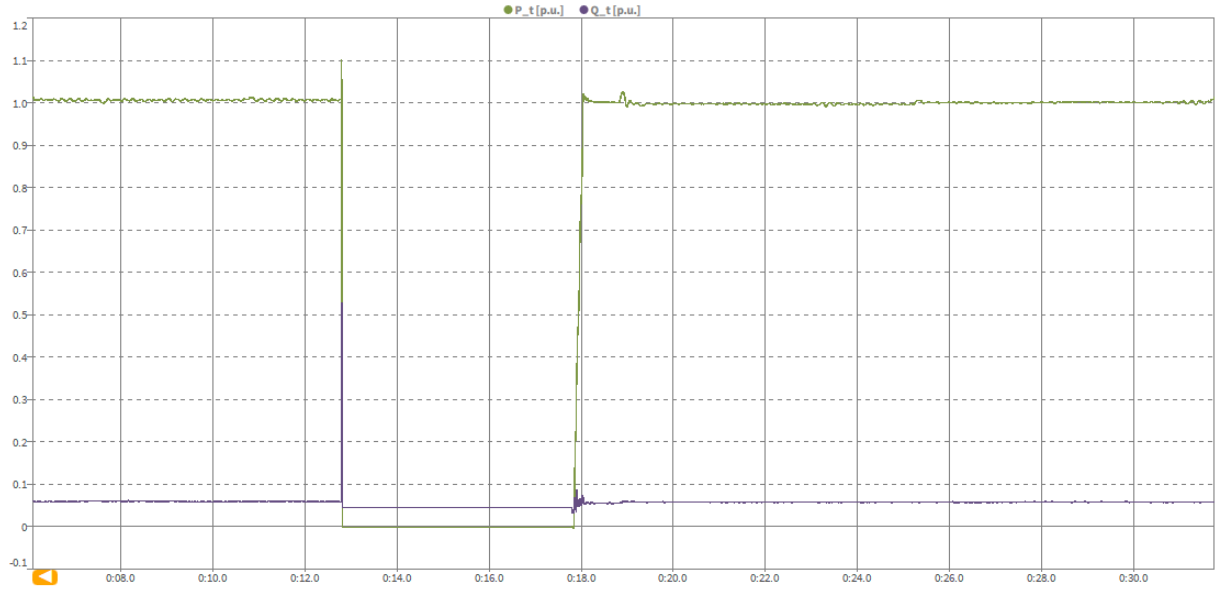


EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 6.1 Depth of fault phase: 1.2 p.u., three-phase SC (type A), 100% load
Instantaneous curve and RMS values of phase currents

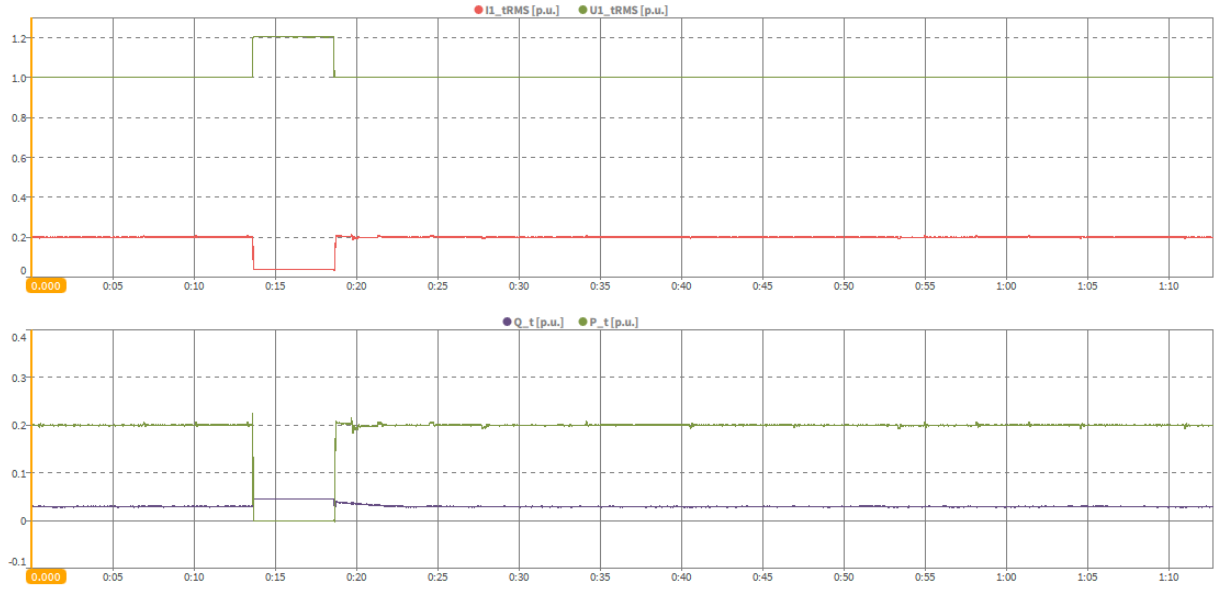


Test 6.1 Depth of fault phase: 1.2 p.u., three-phase SC (type A), 100% load
Positive sequence active and reactive power

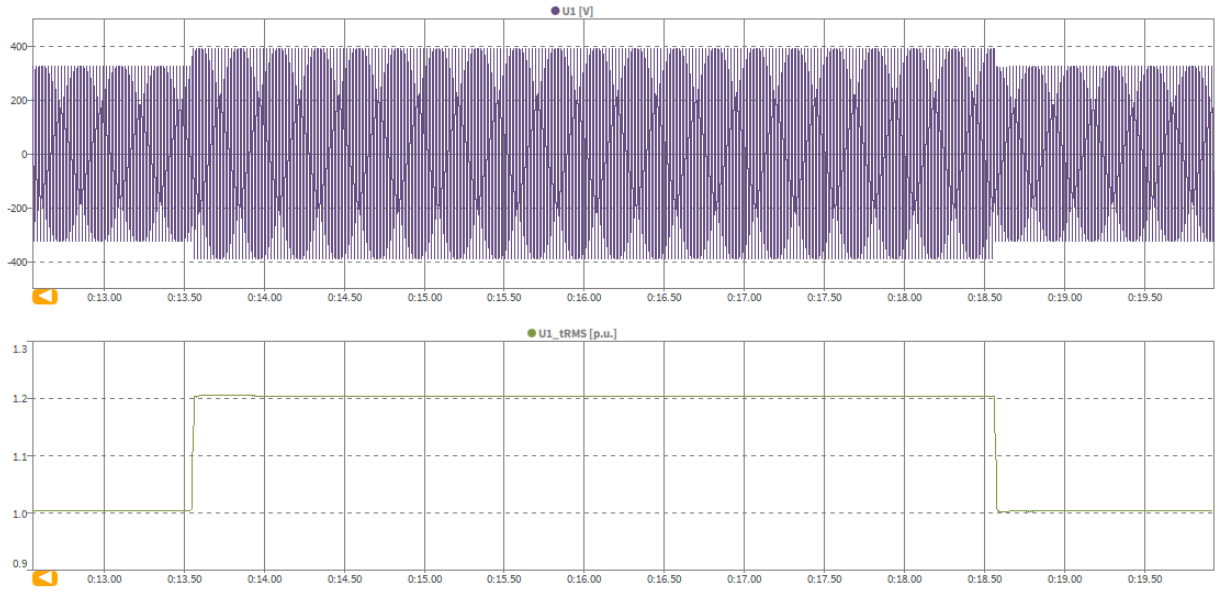


EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 6.2 Depth of fault phase: 1.2 p.u., three-phase SC (type A), 20% load
Test overview (voltage, current, active and reactive power)

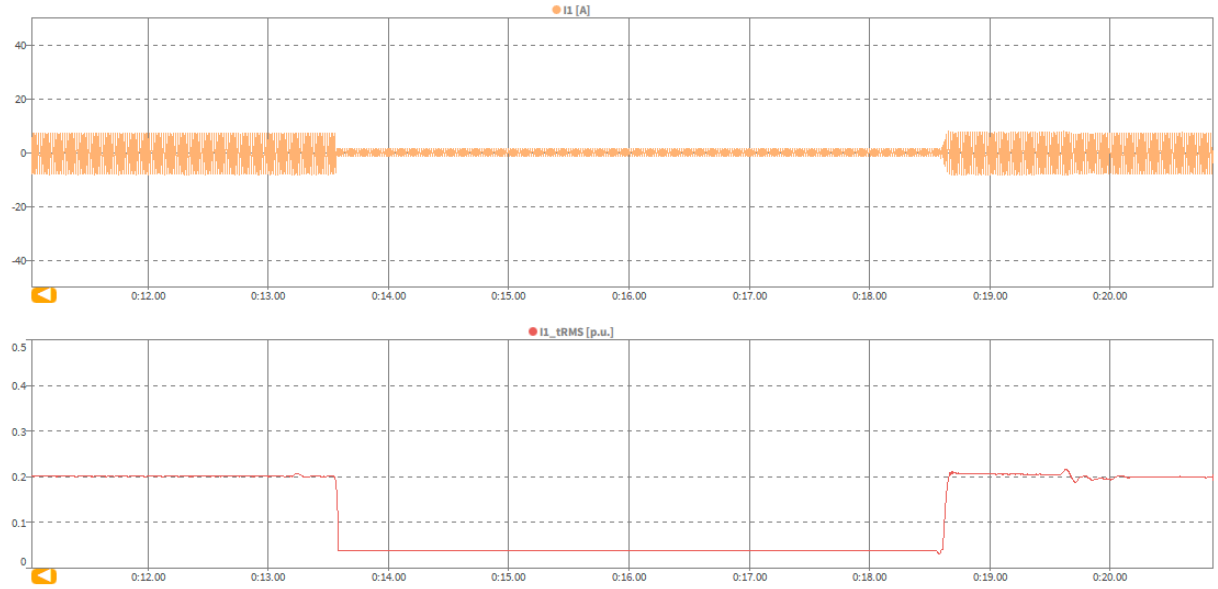


Test 6.2 Depth of fault phase: 1.2 p.u., three-phase SC (type A), 20% load
Instantaneous curve and RMS values of phase-to-neutral voltages

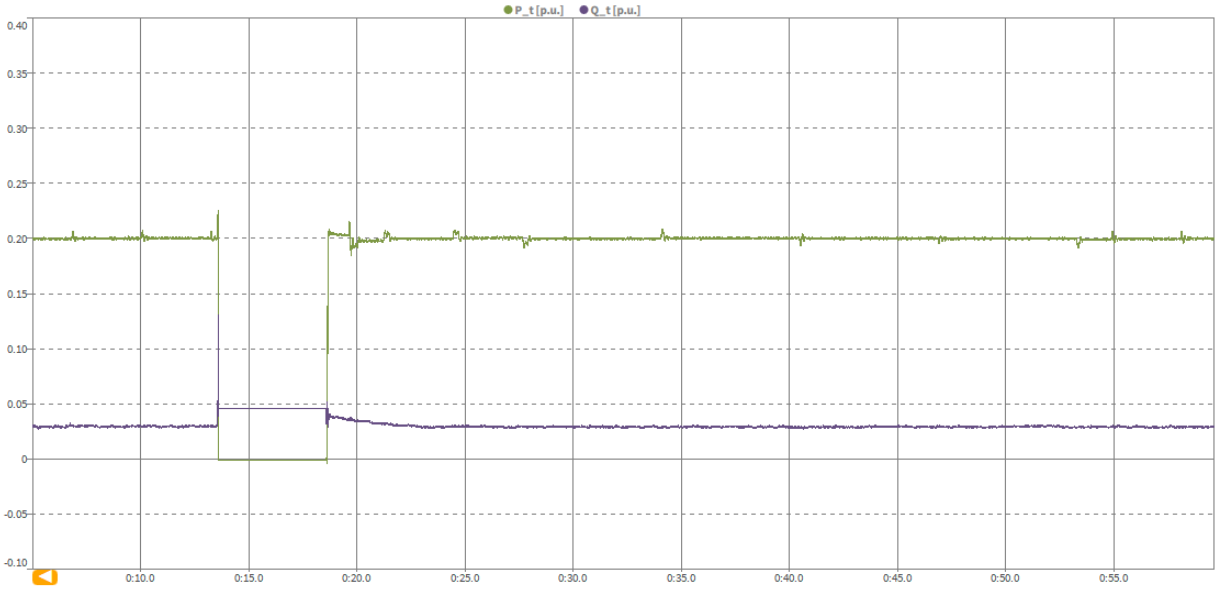


EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 6.2 Depth of fault phase: 1.2 p.u., three-phase SC (type A), 20% load
Instantaneous curve and RMS values of phase currents



Test 6.2 Depth of fault phase: 1.2 p.u., three-phase SC (type A), 20% load
Positive sequence active and reactive power

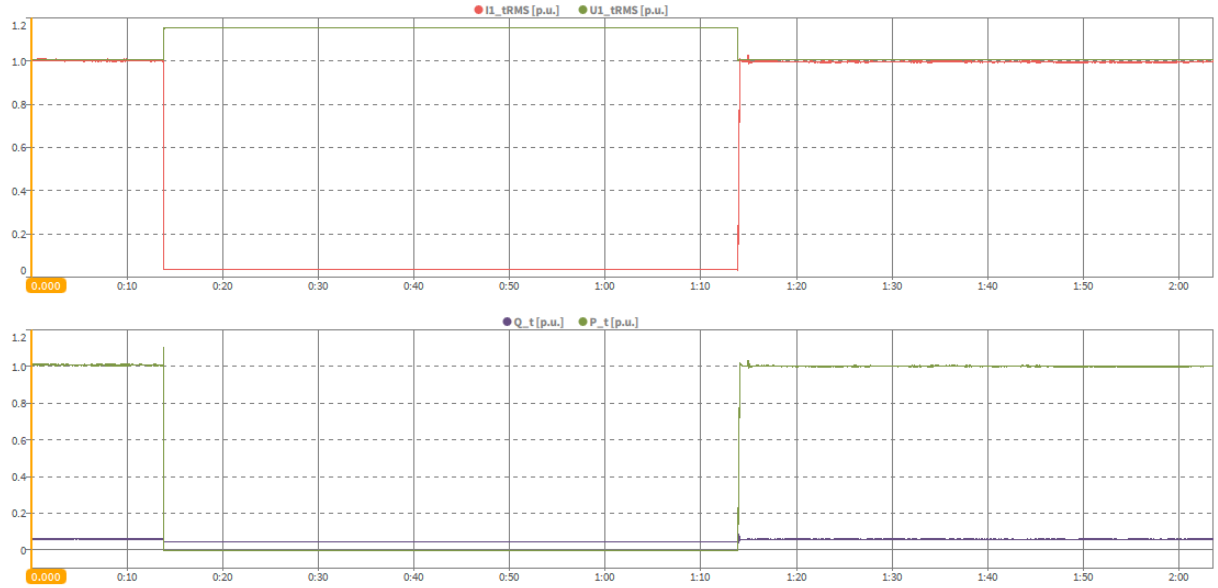


EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

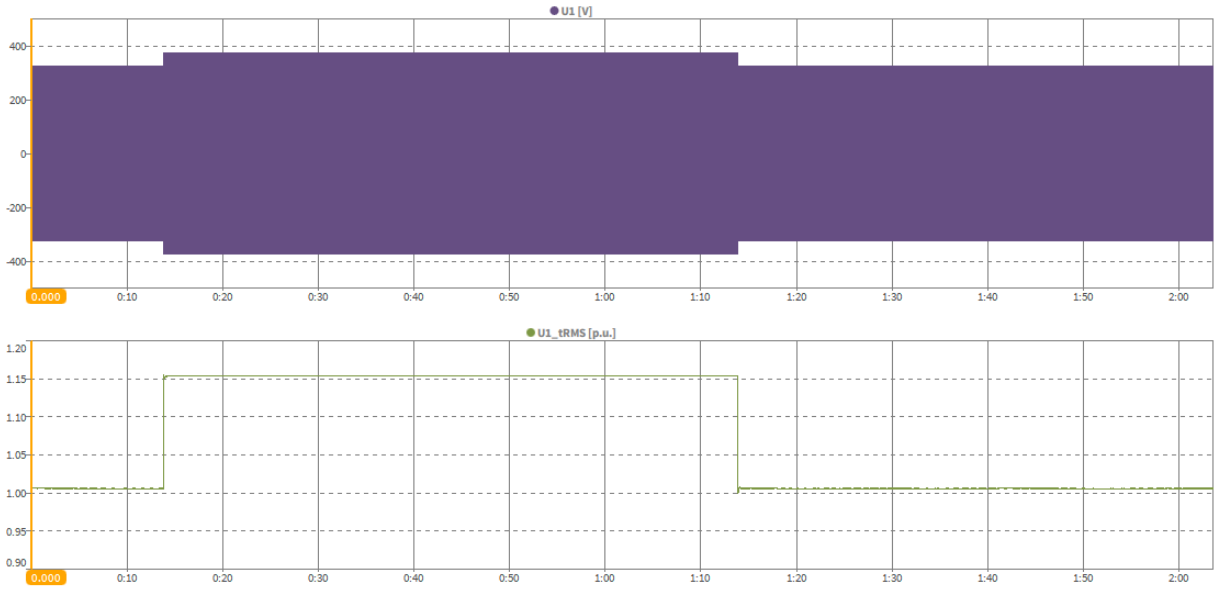
Condition						Measured value	
Item	No.	Parameter	Phase ref.	Time ref.	unit		
General Info.	0	Test number	--	--	--	7.1	7.2
	1	Date	--	--	yyyy.mm.dd	2022.10.24	2022.10.24
	2	Time (start of test)	--	--	hh:mm:ss.f	15:24:36	16:15:17
	3	Fault type (phase)	--	--	--	Type A	Type A
	4	Setting voltage depth	Phase conductor	--	p.u.	1.15	1.15
	5	Setting dip duration		--	--	60000	60000
	6	Point of fault entry(t_1)	Total	--	ms	13719	12473
	7	Point of fault clearance(t_2)	Total	--	ms	73750	72486
	8	Fault duration in empty load test	Total	--	ms	60031	60013
	9	Voltage depth/height in empty load test	Total	t1+100ms to t2 and t1-10s to t1	p.u.	1.15	1.15
	10		Pos.			N/A	N/A
Before dip <t1	11	Voltage	Line to neutral	t1-100s to t1	p.u.	1	1
	12	Current	Pos.	t1-500ms to t1-100ms	p.u.	N/A	N/A
	13	Active power	Total	t1-10s to t1	p.u.	1	0.2
	14		Pos.			N/A	N/A
	15	Reactive power	Total	t1-10s to t1	p.u.	0.06	0.03
	16		Pos.			N/A	N/A
	17	Cosφ	--	t1-10s to t1	--	0.99	0.99
During dip t1 to t2	18	Voltage	Line to neutral	t1+100ms to t2-20ms	p.u.	1.15	1.15
	19	Line current	Phase 1	t1+60ms	p.u.	0.04	0.04
	20		Phase 2			N/A	N/A
	21		Phase 3			N/A	N/A
	22	Line current	Phase 1	t1+100ms	p.u.	0.04	0.04
	23		Phase 2			N/A	N/A
	24		Phase 3			N/A	N/A
	25	Active power	Total	t1+100ms to t2-20ms	p.u.	0	0
	26		Pos.			N/A	N/A
After dip > t2	27	Voltage	Line to neutral	t2+3s to t2+10s	p.u.	1	1.00
	28	Active power	Total	t2+3s to t2+10s	p.u.	1	0.20
	29		Pos.			N/A	N/A
	30	Response time reactive power	Pos.	--	s	0.387	0.191
	31	Reactive power	Total	t2+3s to t2+10s	p.u.	0.05	0.04
	32		Pos.			N/A	N/A
	33	Reactive power rising time	Pos.	--	s	N/A	N/A
	34	PGU does not disconnect from grid till 60s after fault	--	t2 to t2+60s	Yes / No	Yes	Yes

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 7.1 Depth of fault phase: 1.15 p.u., three-phase SC (type A), 100% load
Test overview (voltage, current, active and reactive power)

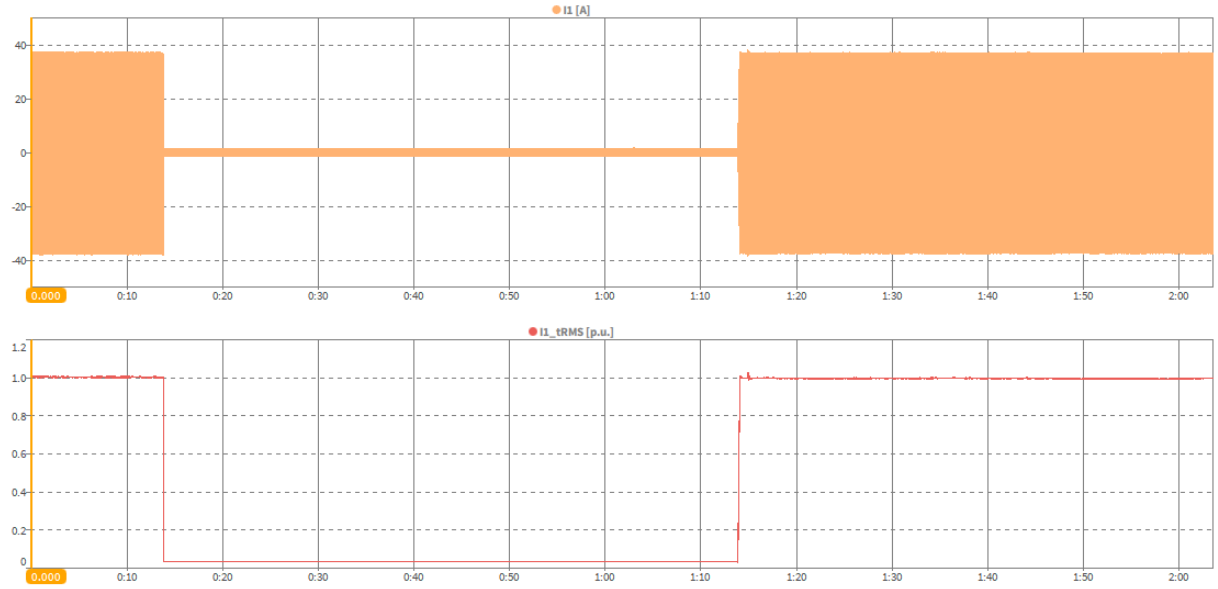


Test 7.1 Depth of fault phase: 1.15 p.u., three-phase SC (type A), 100% load
Instantaneous curve and RMS values of phase-to-neutral voltages

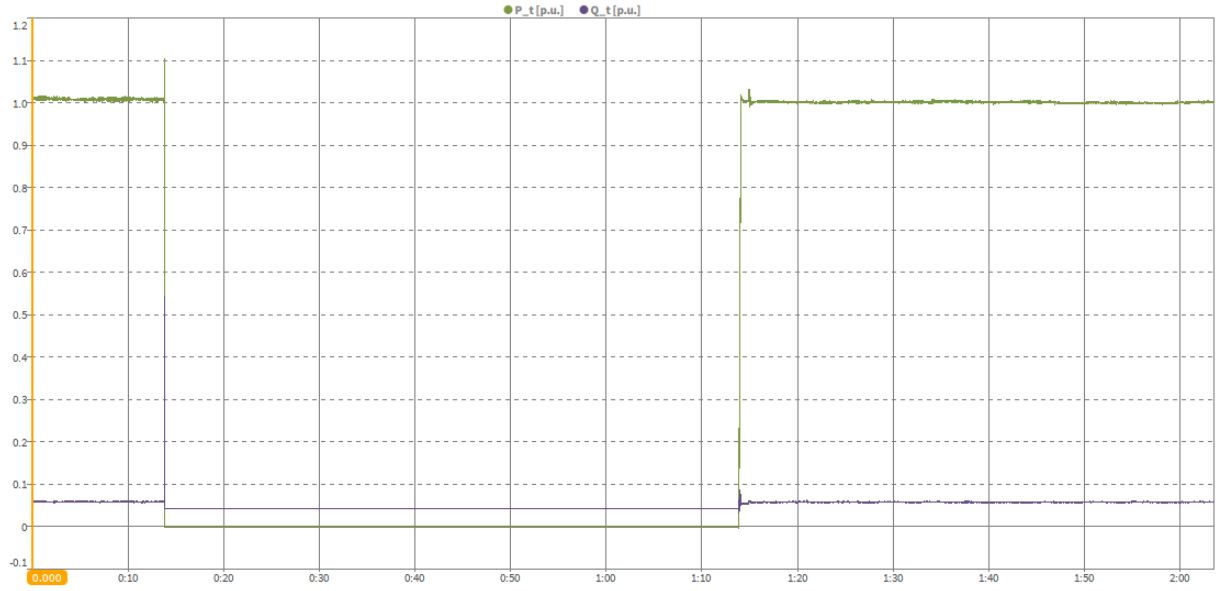


EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 7.1 Depth of fault phase: 1.15 p.u., three-phase SC (type A), 100% load
Instantaneous curve and RMS values of phase currents

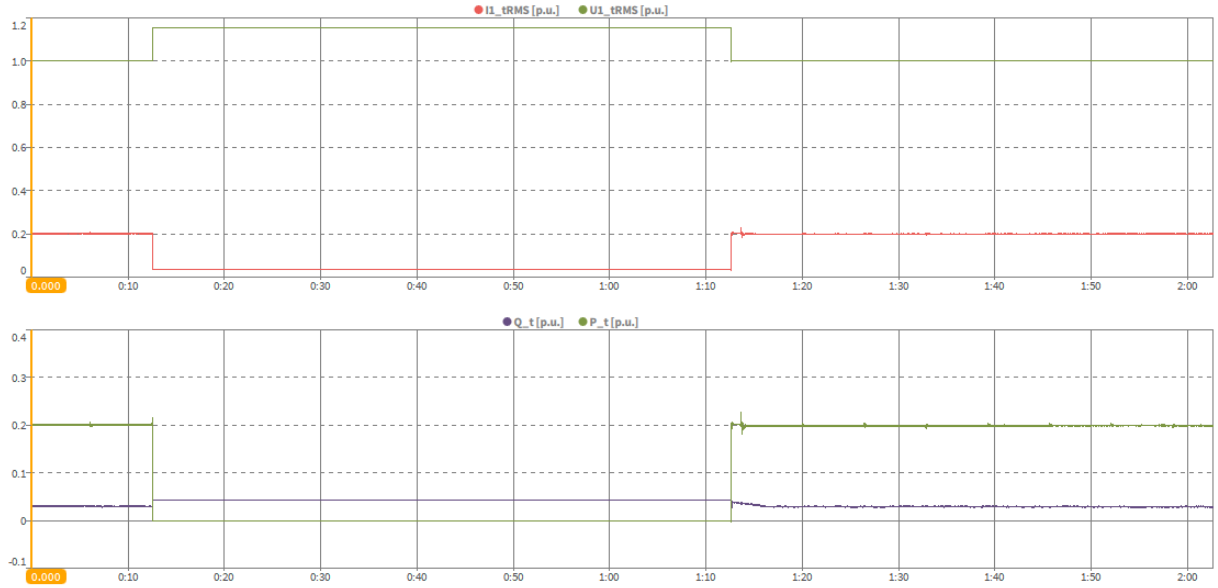


Test 7.1 Depth of fault phase: 1.15 p.u., three-phase SC (type A), 100% load
Positive sequence active and reactive power

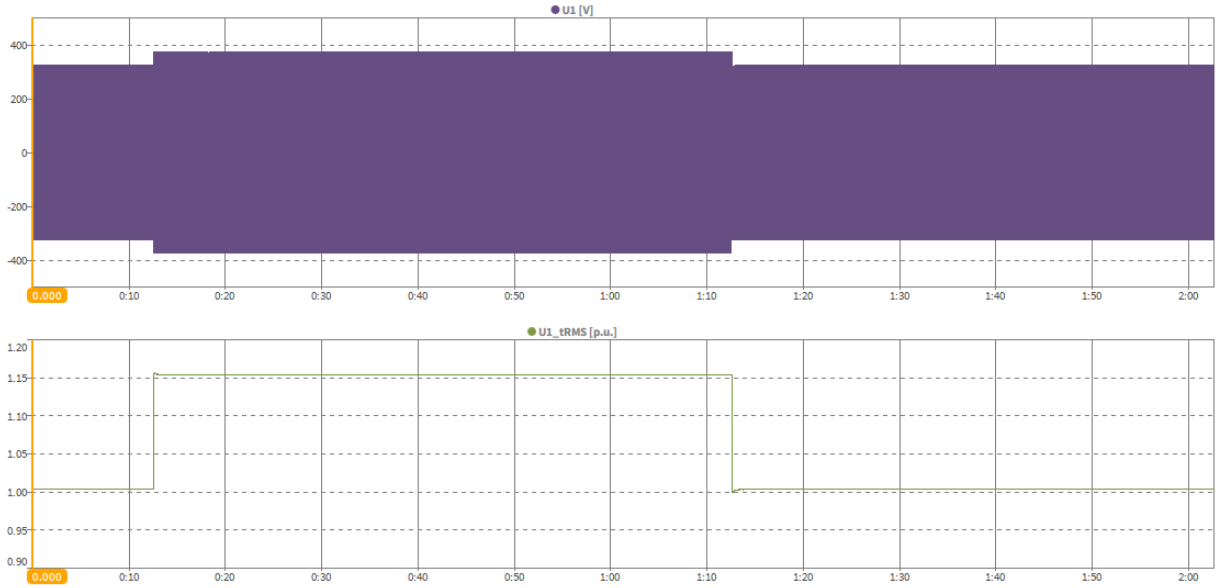


EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 7.2 Depth of fault phase: 1.15 p.u., three-phase SC (type A), 20% load
Test overview (voltage, current, active and reactive power)

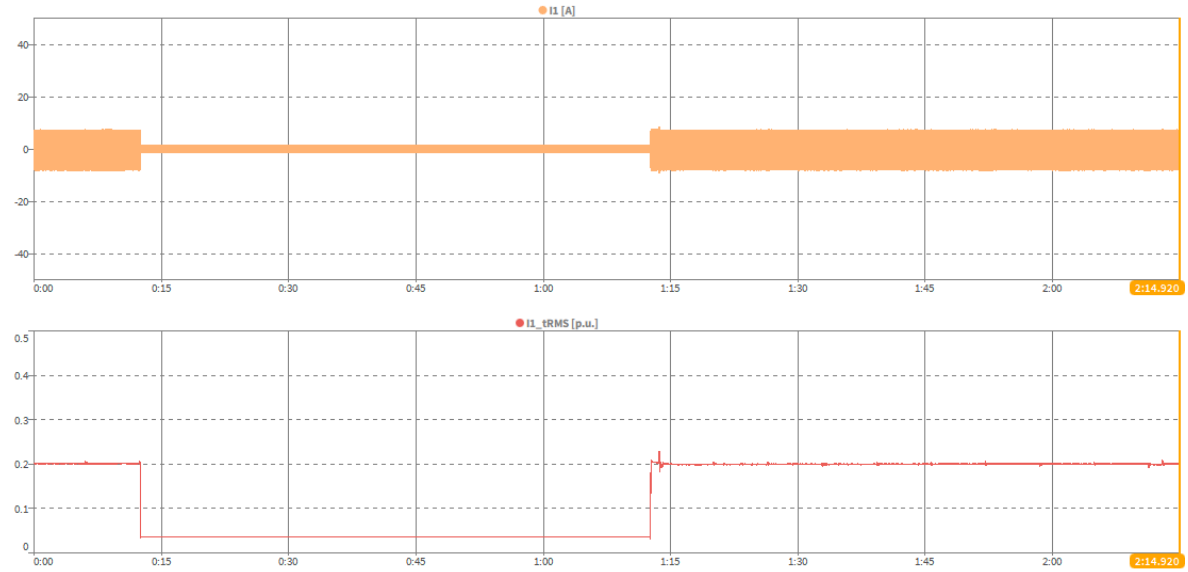


Test 7.2 Depth of fault phase: 1.15 p.u., three-phase SC (type A), 20% load
Instantaneous curve and RMS values of phase-to-neutral voltages

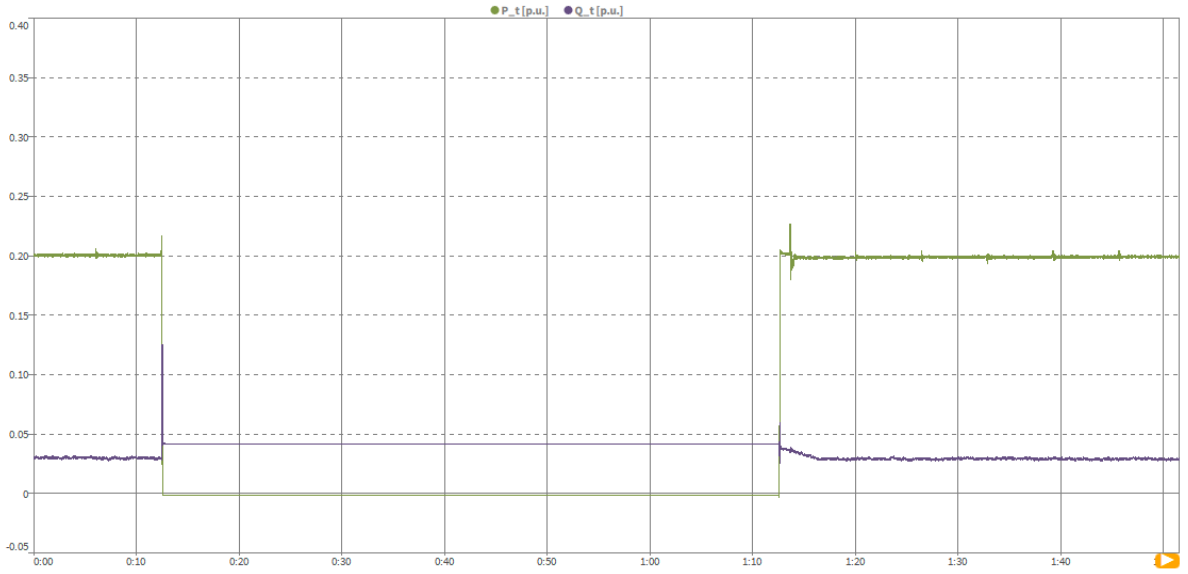


EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 7.2 Depth of fault phase: 1.15 p.u., three-phase SC (type A), 20% load
Instantaneous curve and RMS values of phase currents



Test 7.2 Depth of fault phase: 1.15 p.u., three-phase SC (type A), 20% load
Positive sequence active and reactive power



EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

4.6.1	**TABLE: Power response to over-frequency (LFSM-O)**	**P**

Option 1: For other generating unit, Available P adjust to follow droop during the over-frequency transient

Test No. 1:

Power output:	100% P_n
Starting frequency f_1:	50.2Hz
Deactivation threshold f_{stop}:	50.2Hz (Deactivated)
Droop:	5% (40%P_{ref} / Hz)

Test condition		Measurement						Limit $\Delta P/P_n$
f (Hz)	Target P/P_n	f (Hz)	P/P_n	$T_{sr\_90\%}$ (s)	$T_{settling}$ (s)	T_d (s)	$\Delta P/P_n$	
a) 50.0	100%	50.00	100.8%	--	--	--	0.8%	± 10%
b) 50.25	98%	50.25	97.7%	--	1.1	--	-0.3%	
c) 50.7	80%	50.70	80.1%	--	1.1	--	0.1%	
d) 51.4	52%	51.40	51.7%	--	1.2	--	-0.3%	
e) 50.7	80%	50.70	80.1%	--	1.1	--	0.1%	
f) 50.25	98%	50.25	97.3%	--	1.1	--	-0.7%	
g) 50.0	100%	50.00	100.1%	--	0.1	--	0.1%	

Test condition	Measurement		Limit
g) 50 to h) 51.65	Disconnection Time (ms):	177.2ms	200ms
h) 51.65 to i) 50.25	Reconnection:	No reconnection	No reconnection
i) 50.25 to j) 50	Reconnection time (s):	63.1	≥ 60s
	Max. power gradient (%P_n/min):	10%	≤10% P_n/min

Test No. 2:

Power output:	60% P_n
Starting frequency f_1:	50.5Hz
Deactivation threshold f_{stop}:	50.5Hz (Deactivated)
Droop:	12% (16.67%P_{ref} / Hz)

Test condition		Measurement						Limit $\Delta P/P_n$
f (Hz)	Target P/P_n	f (Hz)	P/P_n	$T_{sr\_90\%}$ (s)	$T_{settling}$ (s)	T_d (s)	$\Delta P/P_n$	
a) 50	60%	50.00	60.2%	--	--	--	0.2%	± 10%
b) 50.4	60%	50.40	60.2%	--	--	--	0.2%	
c) 50.7	58%	50.70	57.8%	--	7.3	0	-0.2%	
d) 51.4	51%	51.40	51.5%	--	1.1	0	0.5%	

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

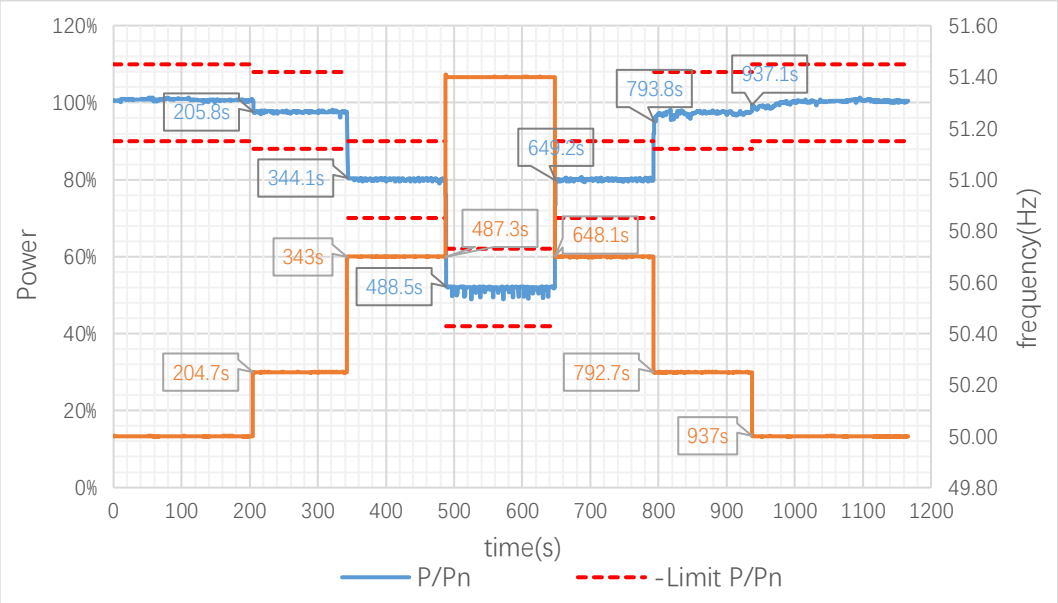
e) 50.7	58%	50.70	57.7%	--	0.7	0	-0.3%	
f) 50.4	60% to 100%	50.40	--	--	--	--	--	
g) 50	100%	50.00	100.6%	--	--	--	0.6%	

Test condition	Measurement		Limit
e) 50.7 to f) 50.4	Max. power gradient (%P_n/min):	9.9	≤10% P_n/min

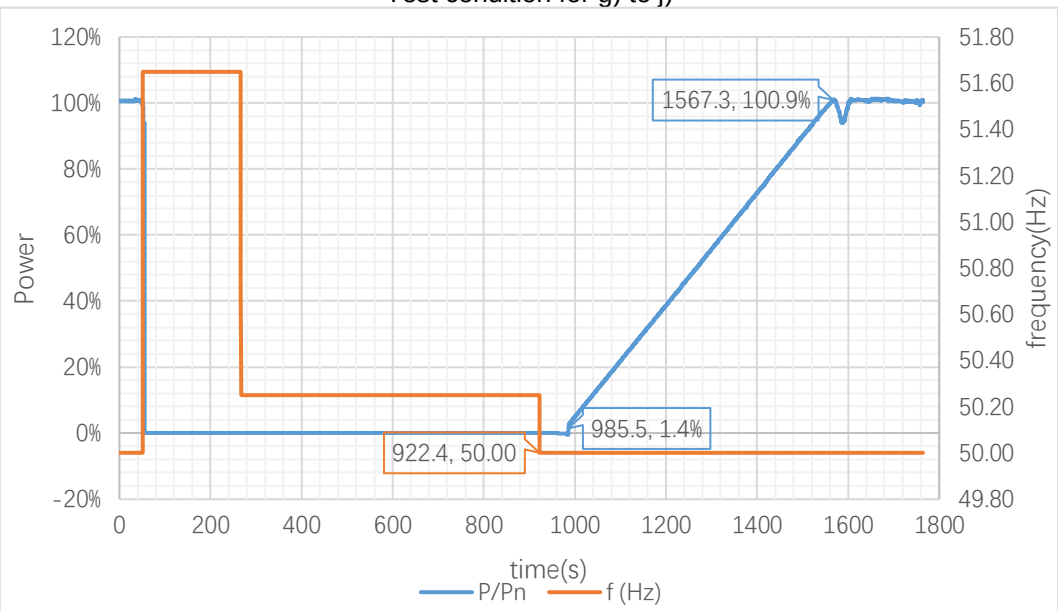
Note: The test method refer to VDE V 0124-100:2020.

Graph of Measurement test 1.: Active power output 100% P_{Emax}

Test condition for a) to g)

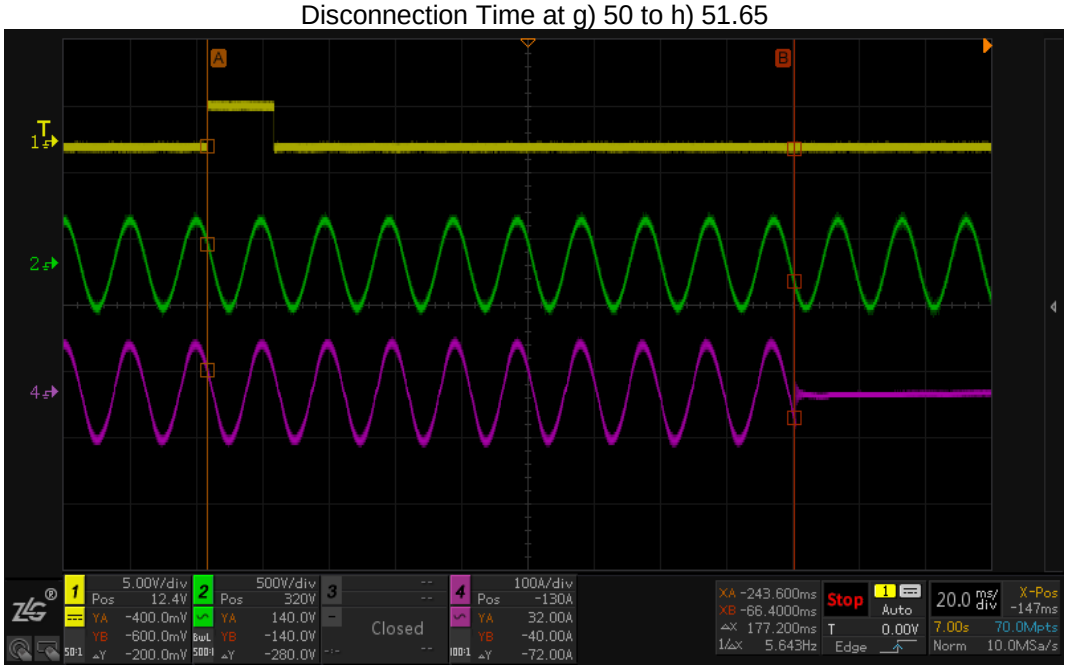


Test condition for g) to j)

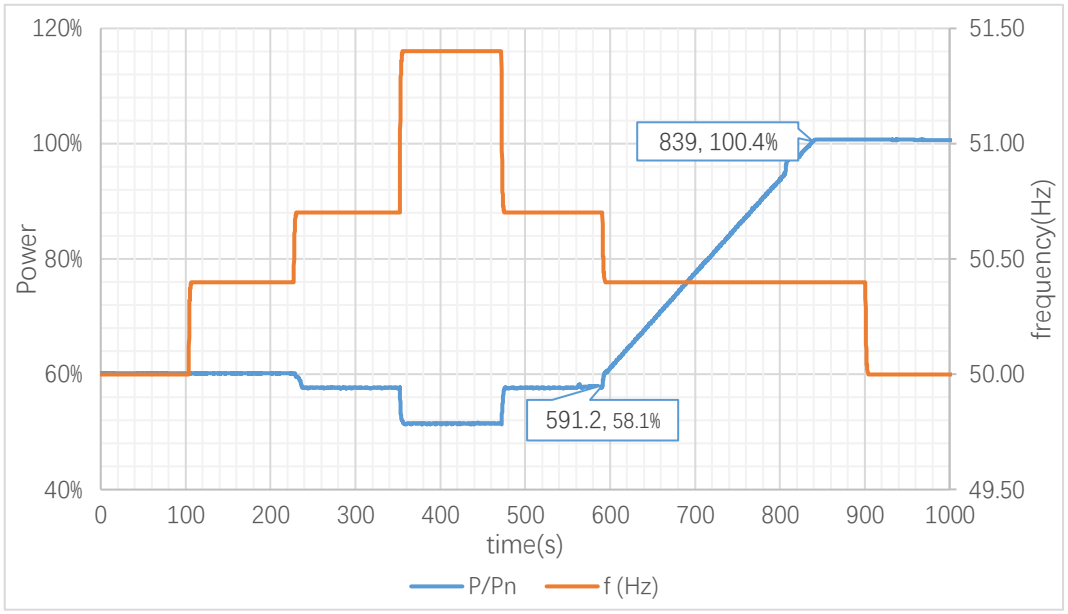


EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Disconnection Time at g) 50 to h) 51.65



Graph of Measurement test 2.: Active power output 60% P_{Emax}



EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

4.6.1	**TABLE: Power response to over-frequency (LFSM-O)**	**P**

Option 2: For other generating unit, Available P limit to reach the minimum value during the over-frequency transient

Test No. 1:

Power output:	100% P_n
Starting frequency f_1:	50.2Hz
Deactivation threshold f_{stop}:	50.1Hz (Activated)
Deactivation threshold t_{stop}:	30s
Droop:	5% (40%P_{ref} / Hz)

Test condition		Measurement						Limit $\Delta P/P_n$
f (Hz)	Target P/P_n	f (Hz)	P/P_n	$T_{sr\_90\%}$ (s)	$T_{settling}$ (s)	T_d (s)	$\Delta P/P_n$	
a) 50	100%	50.00	100%	--	--	--	0	± 10%
b) 50.25	98%	50.25	97.03%	0	6.3	--	0.97%	
c) 50.7	80%	50.70	79.28%	0	0.7	--	0.72%	
d) 50.25	80%	50.25	79.15%	--	--	--	0.85%	
e) 51.4	52%	51.40	51.13%	0	0.3	--	0.27%	
f) 50.15	52%	50.15	51.12%	0	0	--	0.88%	
g) 50	52% to 100%	50.00	100.75%	--	--	--	0.75%	

Test condition	Measurement		Limit
f) 50.15 to g) 50	Max. power gradient (%P_n/min):	9.8	≤10% P_n/min

Test No. 2:

Power output:	60% P_n
Starting frequency f_1:	50.5Hz
Deactivation threshold f_{stop}:	50.1Hz (Activated)
Deactivation threshold t_{stop}:	30s
Droop:	12% (16.67%P_{ref} / Hz)

Test condition		Measurement						Limit $\Delta P/P_n$
f (Hz)	Target P/P_n	f (Hz)	P/P_n	$T_{sr\_90\%}$ (s)	$T_{settling}$ (s)	T_d (s)	$\Delta P/P_n$	
a) 50	60%	50.00	59.63%	--	--	--	0.37%	± 10%
b) 50.4	60%	50.40	59.59%	--	--	--	0.41%	
c) 50.7	58%	50.70	56.72%	--	3	--	0.28%	

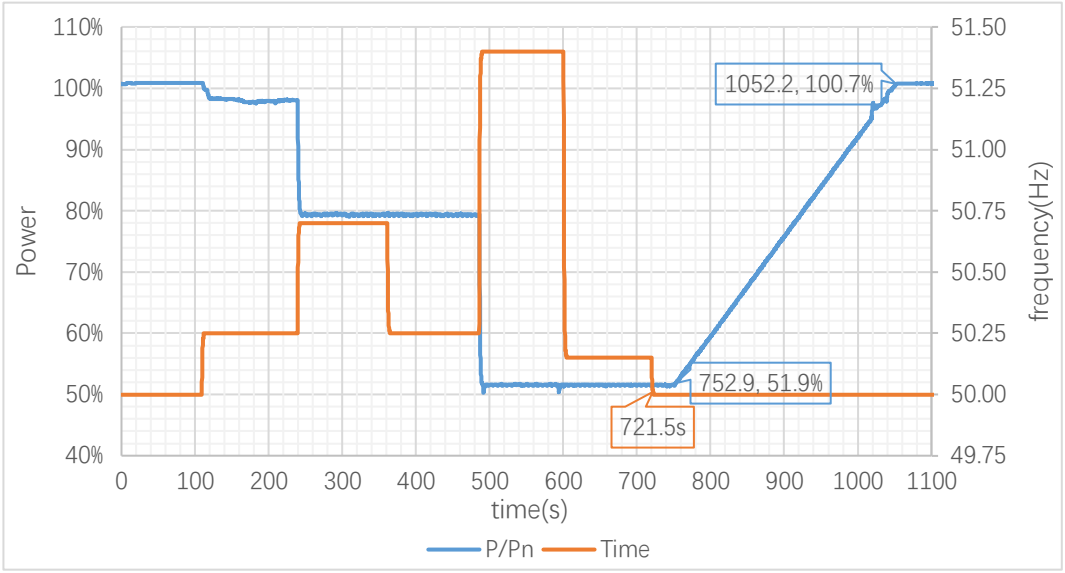
EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

d) 50.4	58%	50.40	56.69%	--	--	--	0.31%	
e) 51.4	51%	51.40	50.26%	--	1	--	0.74%	
f) 50.15	51%	50.15	50.25%	--	--	--	0.75%	
g) 50	51% to 100%	50.00	100.75%	--	--	--	0.75%	

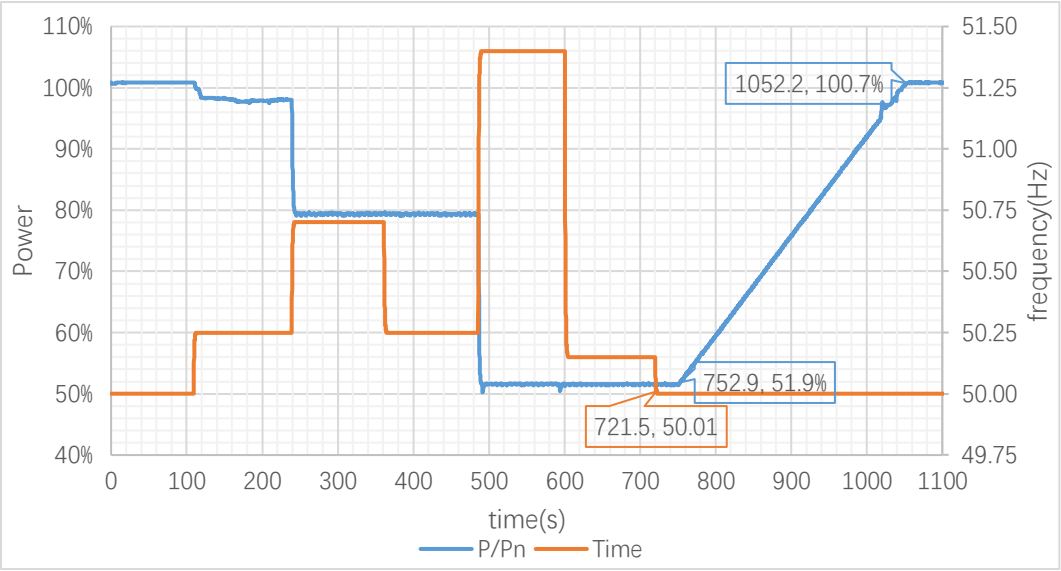
Test condition	Measurement		Limit
f) 50.15 to g) 50	Max. power gradient (%P_n/min):	10	≤10% P_n/min

Note(s): The test method refer to VDE V 0124-100:2020.

Graph of Measurement Test 1: Active power output 100% P_{Emax}



Graph of Measurement Test No. 2: Active power output 60% P_{Emax}



EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

4.7.2.2	**TABLE: Capabilities (Cos φ setpoint mode)**	**P**
Model	GT1-6KD1	

Opinion 1: Cos φ setpoint mode

setpoint for constant Cos φ	under-excited	over-excited
	$0.90_{\text{under-excite}}$	$0.90_{\text{over-excited}}$

Test 1:

Test condition			Measurement						Limit $\Delta Q/S_n$
P/S_n	Target Cos φ	Target Q/S_n	U/U_n	P/S_n	S/S_n	cos φ	Q/S_n	$\Delta Q/S_n$	
0-5%	1	0	99.91%	5.97%	5.98%	0.932	-0.06%	0.06%	± 10%
10%			99.94%	10.69%	10.70%	0.992	-0.23%	0.23%	± 2%
20%			100.01%	20.22%	20.23%	0.999	-0.19%	0.19%	
30%			100.07%	29.53%	29.54%	0.999	-0.22%	0.22%	
40%			100.07%	39.84%	39.85%	0.999	-0.69%	0.69%	
50%			100.13%	49.99%	50.01%	0.999	-1.02%	1.02%	
60%			100.18%	60.55%	60.56%	1.000	-1.08%	1.08%	
70%			100.21%	70.25%	70.26%	1.000	-1.13%	1.13%	
80%			100.26%	79.53%	79.55%	1.000	-1.53%	1.53%	
90%			100.30%	90.27%	90.29%	1.000	-1.51%	1.51%	
100%			100.35%	99.50%	99.52%	0.999	-1.23%	1.23%	
0-5%	0.90 under-excited	--	99.90%	5.88%	6.57%	0.894	-2.24%	2.24%	± 10%
10%		-4.8%	99.91%	10.68%	11.86%	0.900	-5.16%	0.36%	± 2%
20%		-9.7%	100.00%	19.81%	22.02%	0.900	-9.62%	-0.08%	
30%		-14.5%	100.02%	29.56%	32.88%	0.899	-14.38%	-0.12%	
40%		-19.4%	100.07%	38.59%	42.92%	0.899	-18.80%	-0.60%	
50%		-24.2%	100.10%	49.77%	55.38%	0.899	-24.29%	0.09%	
60%		-29.0%	100.14%	60.41%	67.24%	0.898	-29.52%	0.52%	
70%		-33.9%	100.20%	69.89%	77.81%	0.898	-34.21%	0.31%	
80%		-38.7%	100.23%	79.15%	88.13%	0.898	-38.76%	0.06%	
90%		-43.6%	100.28%	90.03%	100.26%	0.898	-44.12%	0.52%	
95%	0.95 under-excited	-31.2%	100.30%	94.64%	99.56%	0.951	-30.93%	-0.27%	
100%		-31.2%	100.33%	95.63%	100.24%	0.954	-30.04%	-1.16%	

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 1:

Test condition			Measurement						Limit $\Delta Q/S_n$
P/S_n	Target Cos φ	Target Q/S_n	U/U_n	P/S_n	S/S_n	cos φ	Q/S_n	$\Delta Q/S_n$	
0-5%	0.90 over-excited	--	99.88%	5.15%	5.72%	0.900	2.50%	-2.50%	± 10%
10%		4.8%	99.92%	10.71%	11.94%	0.897	5.29%	-0.49%	± 2%
20%		9.7%	99.99%	20.22%	22.44%	0.901	9.73%	-0.03%	
30%		14.5%	100.06%	29.58%	32.85%	0.900	14.30%	0.20%	
40%		19.4%	100.09%	40.56%	45.07%	0.900	19.65%	-0.25%	
50%		24.2%	100.12%	49.92%	55.48%	0.900	24.21%	-0.01%	
60%		29.0%	100.17%	60.32%	67.05%	0.900	29.29%	-0.29%	
70%		33.9%	100.19%	70.06%	77.89%	0.899	34.04%	-0.14%	
80%		38.7%	100.26%	79.24%	88.10%	0.899	38.50%	0.20%	
90%		43.6%	100.30%	89.48%	99.44%	0.900	43.38%	0.22%	
95%	0.95 over-excited	31.2%	100.32%	94.34%	99.61%	0.947	31.97%	-0.77%	
100%		31.2%	100.32%	94.79%	100.09%	0.947	32.15%	-0.95%	

Note(s): The limitation capacity of reactive power shall be met to Figure 12 or better.

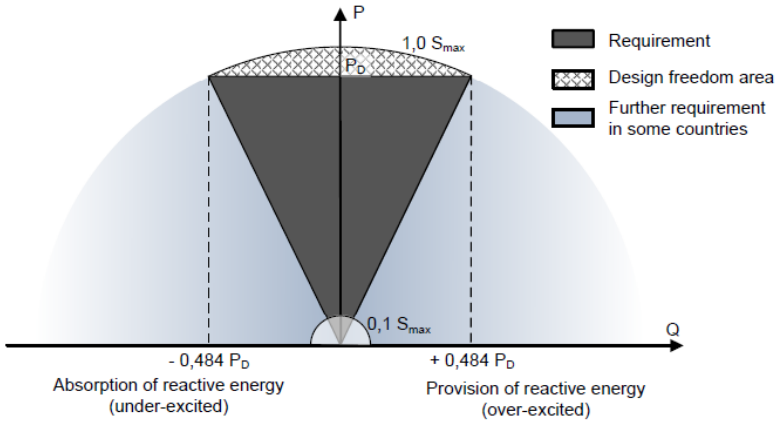
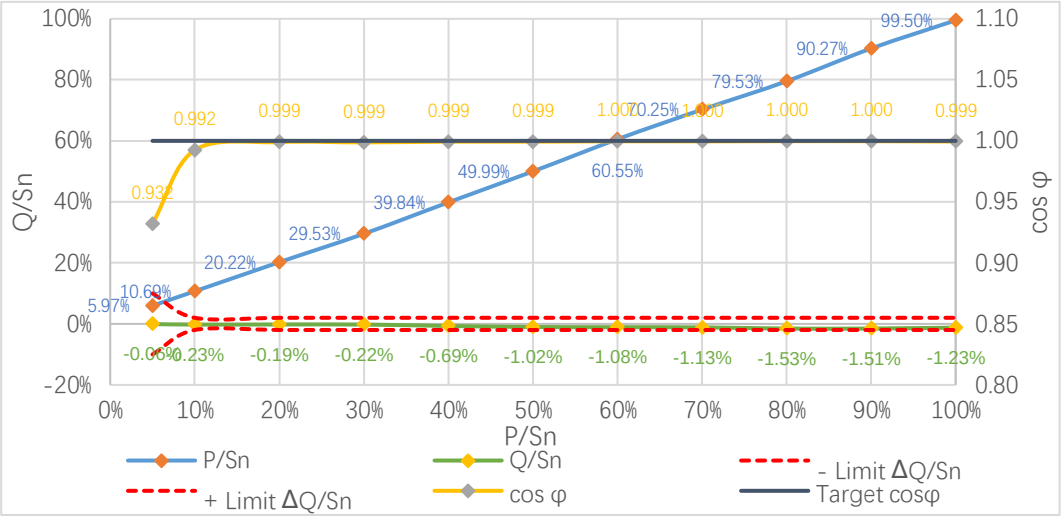


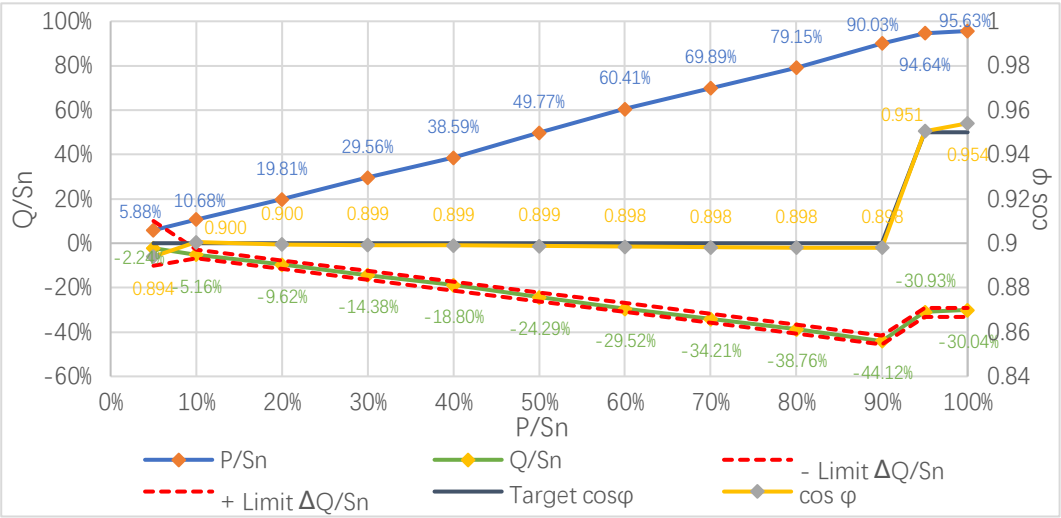
Figure 12 — Reactive power capability at nominal voltage

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

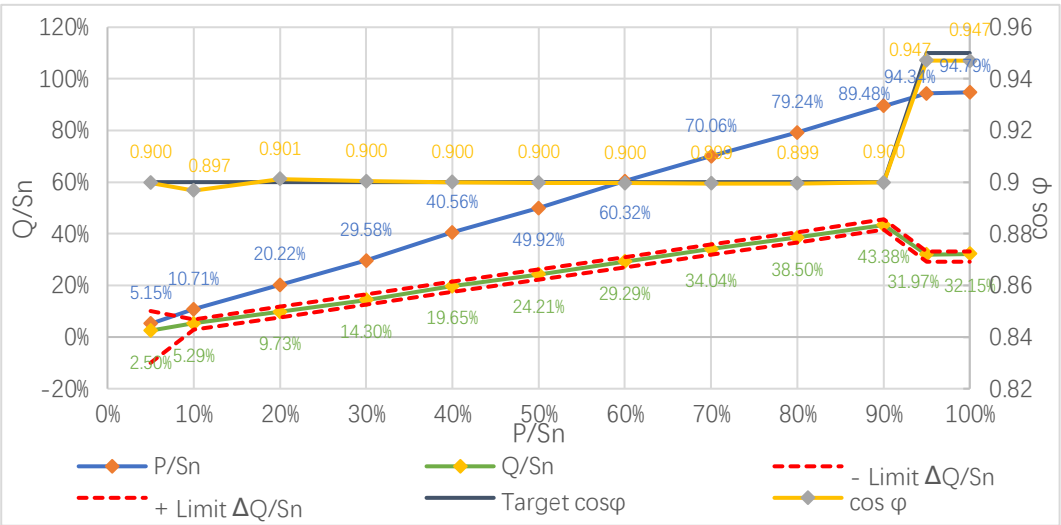
Graph of Measurement Test 1: setpoint for constant Cos φ = 1



Graph of Measurement Test 1: setpoint for constant Cos φ = 0.90$_{\text{under-excited}}$



Graph of Measurement Test 1: setpoint for constant Cos φ=0.90$_{\text{over-excited}}$



EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 2:

Test condition			Measurement						Limit $\Delta Q/S_n$
U/U_n	Target Cos φ	Target Q/S_n	U/U_n	P/S_n	S/S_n	cos φ	Q/S_n	$\Delta Q/S_n$	
85%	1	0	85.40%	94.90%	94.93%	0.932	-0.79%	0.79%	± 2%
90%			90.40%	99.01%	99.03%	0.992	-1.58%	1.58%	
95%			95.16%	99.13%	99.15%	0.999	-1.79%	1.79%	
100%			100.32%	99.41%	99.43%	0.999	-1.78%	1.78%	
105%			105.11%	99.53%	99.55%	0.999	-1.24%	1.24%	
110%			109.86%	99.12%	99.14%	0.999	-0.34%	0.34%	
85%	≤0.90 under-excited	≤-43.6%	85.32%	85.79%	95.20%	0.901	-41.26%	-2.34%	--
90%			90.33%	90.57%	100.48%	0.901	-43.53%	-0.07%	
95%			95.10%	90.79%	100.72%	0.901	-43.60%	0.00%	± 2%
100%			100.08%	90.71%	100.57%	0.902	-43.41%	-0.19%	
105%			105.06%	90.36%	100.13%	0.902	-43.14%	-0.46%	
110%			110.24%	89.86%	99.54%	0.903	-42.82%	-0.78%	
85%	≤0.90 over-excited	≥37.2%	85.38%	85.41%	94.56%	0.903	40.59%	3.39%	--
90%		≥43.6%	90.36%	90.28%	100.05%	0.902	43.14%	0.46%	± 2%
95%			95.13%	90.45%	100.34%	0.901	43.45%	0.15%	
100%			100.31%	90.10%	100.05%	0.900	43.51%	0.09%	
105%			105.07%	89.62%	99.62%	0.900	43.48%	0.12%	
110%			110.28%	89.23%	99.30%	0.899	43.59%	0.01%	--

Note(s): The limitation capacity of reactive power shall be met to Figure 13 or better

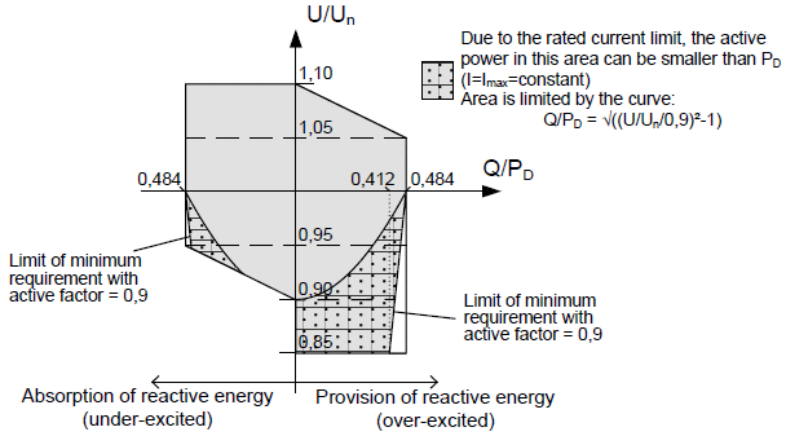
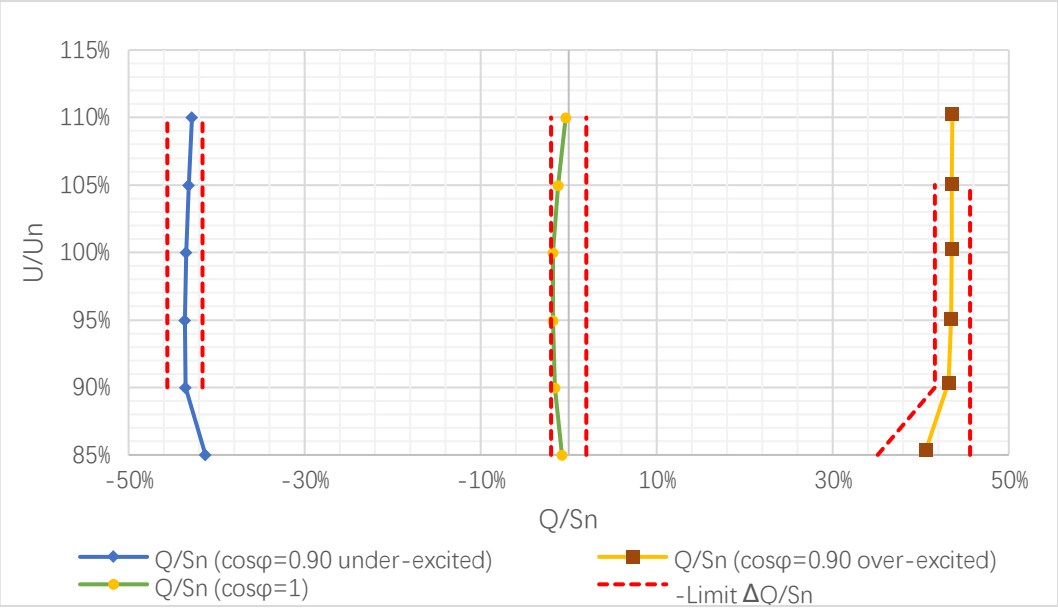


Figure 13 — Reactive power capability at active power P_D in the voltage range (positive sequence component of the fundamental)

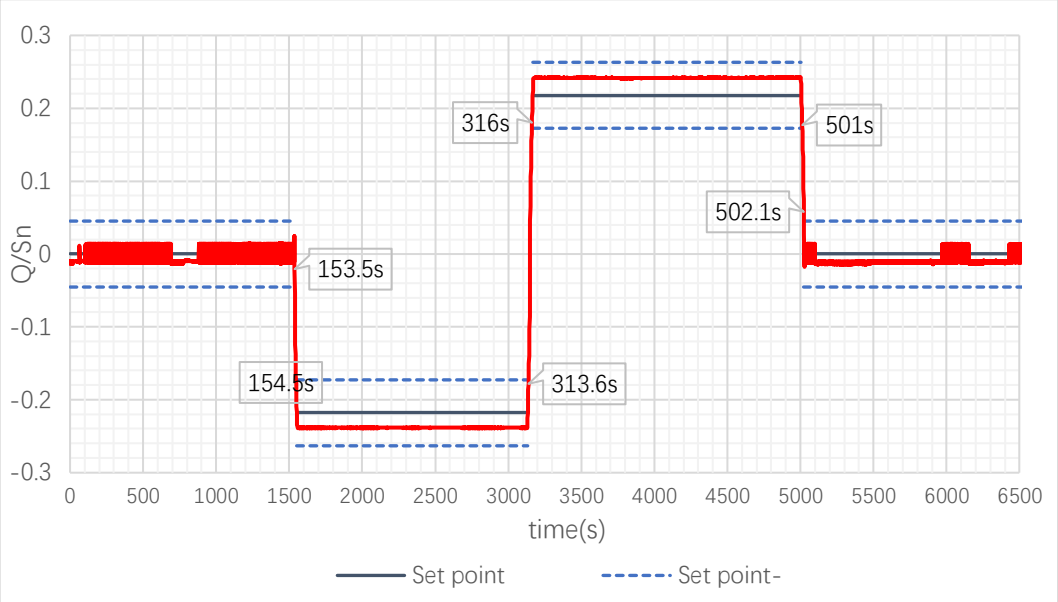
EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Diagram for Measurement of Reactive power Q/Sn



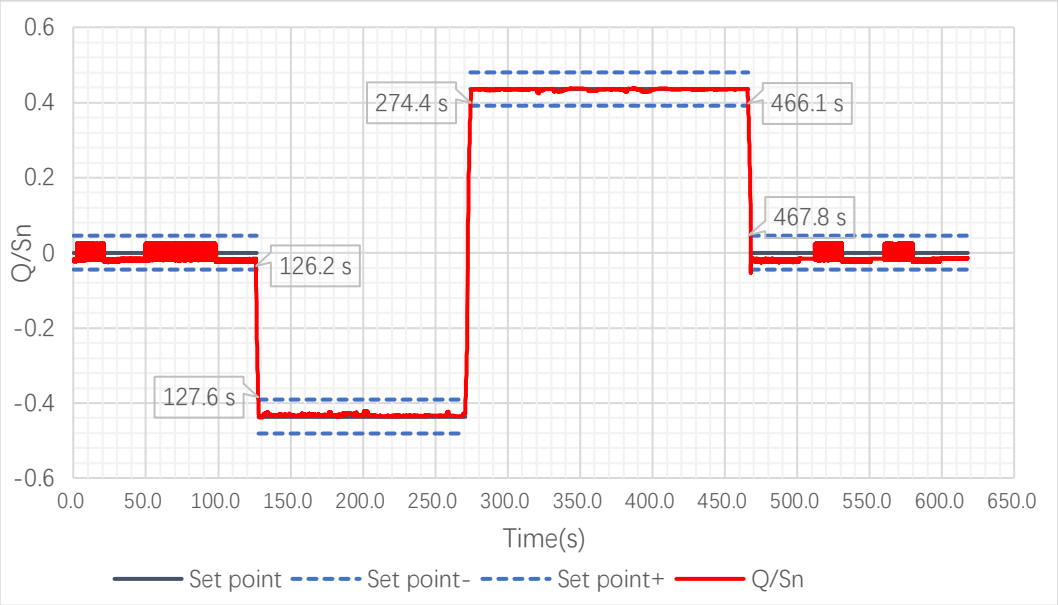
EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

4.7.2.3.2	**TABLE: Setpoint control modes (cos φ setpoint mode)**								**P**
Model	GT1-6KD1								
Test 1:									
Test condition		Measurement						Limit	
P/S_n	Target Q/S_n	U/U_n	P/P_n	cos φ	Q/S_n	$\Delta Q/S_n$	$\Delta T_{settling}$	$\Delta Q/S_n$	$\Delta T_{settling}$
50%	0	100.12%	49.99%	1.000	-0.41%	-0.41%	--	±4.5%	≤ 60s
	- 21.8%	100.11%	49.79%	0.902	-23.87%	-2.07%	1s		
	+ 21.8%	100.13%	49.88%	0.900	24.19%	2.39%	2.4s		
	0	100.12%	49.99%	1.000	-0.92%	-0.92%	1.1s		
Test 2:									
100%	0	100.32%	99.43%	1.000	-1.07%	-1.07%	--	±4.5%	≤ 60s
	- 43.6%	100.27%	90.28%	0.902	-43.23%	0.37%	1.4s		
	+ 43.6%	100.30%	89.99%	0.900	43.47%	-0.13%	3.5s		
	0	100.33%	98.94%	1.000	-1.46%	-1.46%	1.7s		
Note(s): The test was conducted at 50% P_n (Test 1) and 100% P_n (Test 2) of output power.									
Diagram for Q setpoint mode at 50% Pn									



EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Diagram for Q setpoint mode at 100% Pn



EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

4.7.2.3.3	**TABLE: Voltage related control mode (Q(U) curve)**	**P**
Model	GT1-6KD1	

Q(U) curve ralated reactive power for Q

Set point	**X_1**	**X_2**	**X_3**	**X_4**	**Set point**	P Lock-in	P Lock-out
U/U_n	93%	97%	103%	107%	Q activated	20%P_n	5%P_n
Q/P_n	43.6%	0	0	-43.6%			

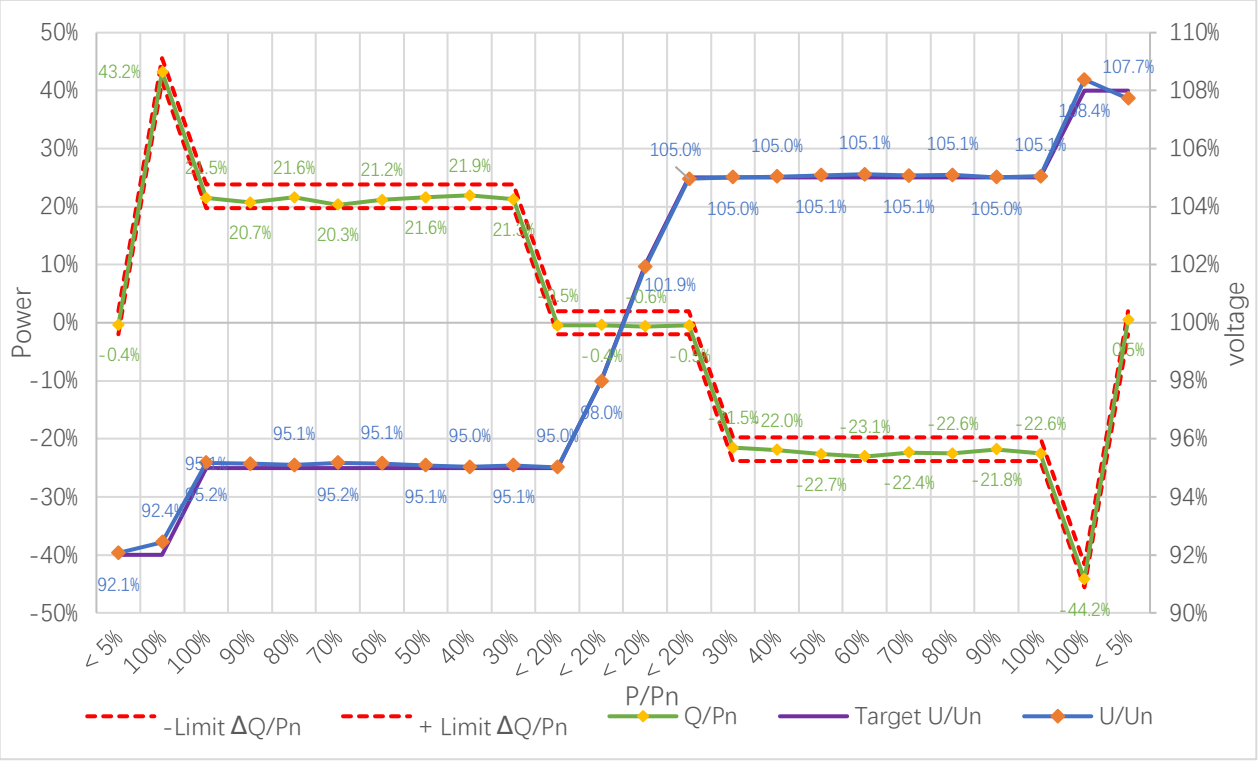
Test 1: Static test for accuracy

Test Conditions		Measurements				Target value	Limits
U/U_n	P/P_n	U/U_n	P/P_n	Q/P_n	$\Delta Q/P_n$	Q/P_n	$\Delta Q/P_n$
102%	< 20%	101.92%	18.62%	-0.64%	-0.64%	0.6%	±2%
105%	< 20%	104.96%	18.43%	-0.47%	-0.47%	0.5%	
105%	30%	105.01%	29.51%	-21.54%	0.26%	-21.8%	
105%	40%	105.03%	39.73%	-21.95%	-0.15%	-21.8%	
105%	50%	105.08%	49.78%	-22.67%	-0.87%	-21.8%	
105%	60%	105.12%	60.03%	-23.06%	-1.26%	-21.8%	
105%	70%	105.07%	70.24%	-22.36%	-0.56%	-21.8%	
105%	80%	105.09%	79.61%	-22.56%	-0.76%	-21.8%	
105%	90%	105.02%	89.73%	-21.82%	-0.02%	-21.8%	
105%	100%	105.05%	97.21%	-22.56%	-0.76%	-21.8%	
108%	100%	108.38%	100.83%	-44.24%	-0.64%	-43.6%	
108%	< 5%	107.73%	4.29%	0.47%	0.47%	0%	
98%	< 20%	97.98%	18.63%	-0.43%	-0.43%	0%	±2%
95%	< 20%	95.02%	18.62%	-0.49%	-0.49%	0%	
95%	30%	95.08%	29.53%	21.28%	-0.52%	21.8%	
95%	40%	95.03%	40.41%	21.93%	0.13%	21.8%	
95%	50%	95.09%	49.74%	21.62%	-0.18%	21.8%	
95%	60%	95.15%	60.42%	21.17%	-0.63%	21.8%	
95%	70%	95.18%	70.01%	20.31%	-1.49%	21.8%	
95%	80%	95.09%	79.37%	21.61%	-0.19%	21.8%	
95%	90%	95.14%	90.13%	20.74%	-1.06%	21.8%	
95%	100%	95.17%	98.10%	21.51%	-0.29%	21.8%	
92%	100%	92.43%	99.89%	43.24%	-0.36%	43.6%	
92%	< 5%	92.07%	4.23%	-0.39%	-0.39%	0%	

Note(s):

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Diagram of Q(U) Static test



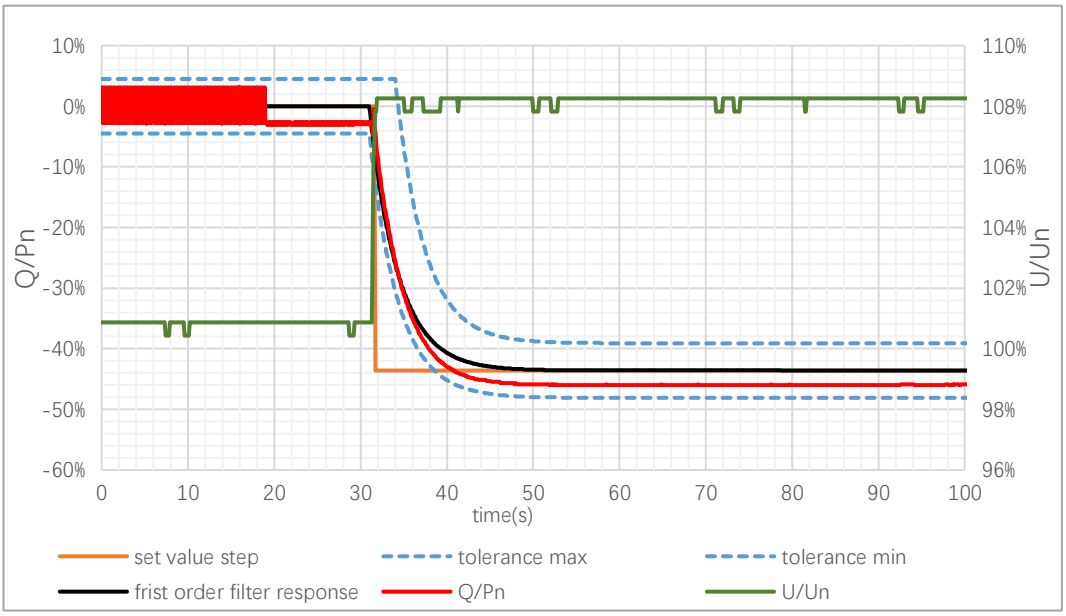
EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test 2: Dynamic test

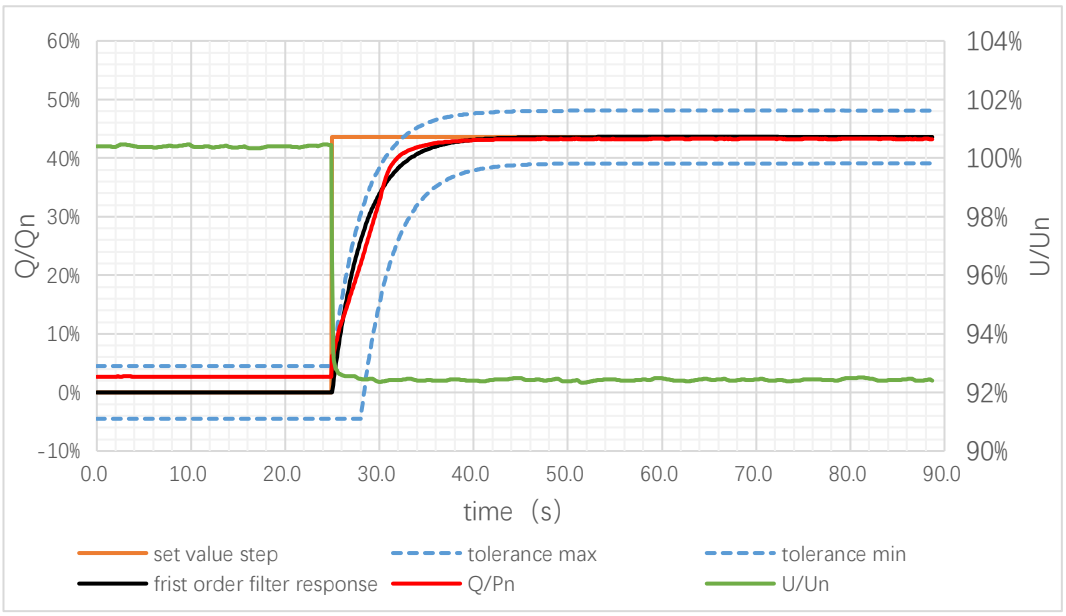
Test Conditions		Measurements					Target value	Limits	
U/U_n	P/P_n	U/U_n	P/P_n	Q/P_n	$T_{sr\_95\%}$	$\Delta Q/P_n$	Q/P_n	$\Delta Q/P_n$	$T_{sr\_95\%}$
100% → 108%	100%	108%	100%	47.1%	8 s	3.5%	-43.6%	±4.5%	≤ 10s
		108%	99.4%	47%	8 s	3.4%			
100% → 92%	100%	92%	98.7%	47.8%	8 s	4.2%	+43.6%		
		92%	98.7%	47.8%	8 s	4.2%			

Diagram of Q(U) dynamic test

100% Un → 108% Un



100% Un → 92% Un



EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

4.7.2.3.4	**TABLE: Power related control mode (Cos φ (P) curve)**	**P**
Model	GT1-6KD1	

Set point	**P_1**	**P_2**	**P_3**	**P_4**
P/P_n	20%	40%	50%	100%
cos φ	$0.9_{over\text{-}excited}$	$0.98_{over\text{-}excited}$	1	$0.9_{under\text{-}excited}$

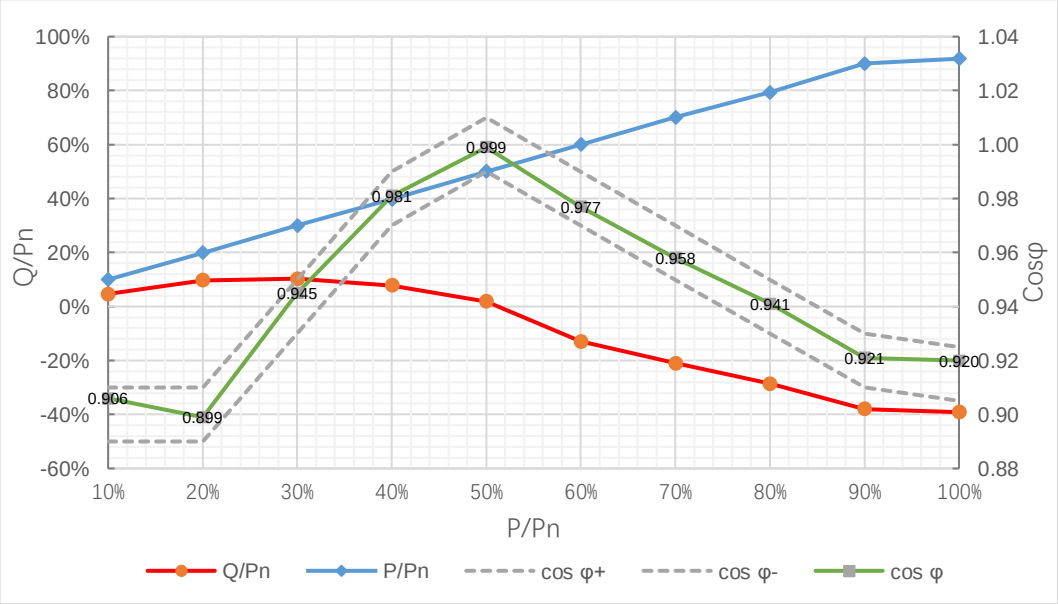
Test 1: Static test for accuracy of Power related control mode

Test Conditions	Measurements					Target value		Limits
P/P_n	U/U_n	P/P_n	Q/P_n	cos φ	Δ Cos φ	Q/P_n	cos φ	Δ Cos φ
10%	100.03%	9.98%	4.66%	0.906	-0.18%	+4.84%	0.900	±0.01
20%	100.08%	19.96%	9.71%	0.899	0.02%	+9.69%	0.900	
30%	100.03%	29.96%	10.33%	0.945	-0.56%	+10.89%	0.940	
40%	100.08%	39.75%	7.86%	0.981	-0.35%	+8.21%	0.980	
50%	100.13%	49.99%	1.85%	0.999	1.85%	0%	1.000	
60%	100.17%	59.99%	-12.98%	0.977	-0.80%	-12.18%	0.980	
70%	100.20%	70.13%	-21.04%	0.958	-0.62%	-20.42%	0.960	
80%	100.25%	79.32%	-28.54%	0.941	0.50%	-29.04%	0.940	
90%	100.28%	90.00%	-37.95%	0.921	0.39%	-38.34%	0.920	
100%	100.30%	91.82%	-39.14%	0.920	1.20%	-40.34%*	0.915*	

Note(s):

* Actual active power (P) output de-rating while rated P_n equal to S_n.

Static test for accuracy of Power related control mode



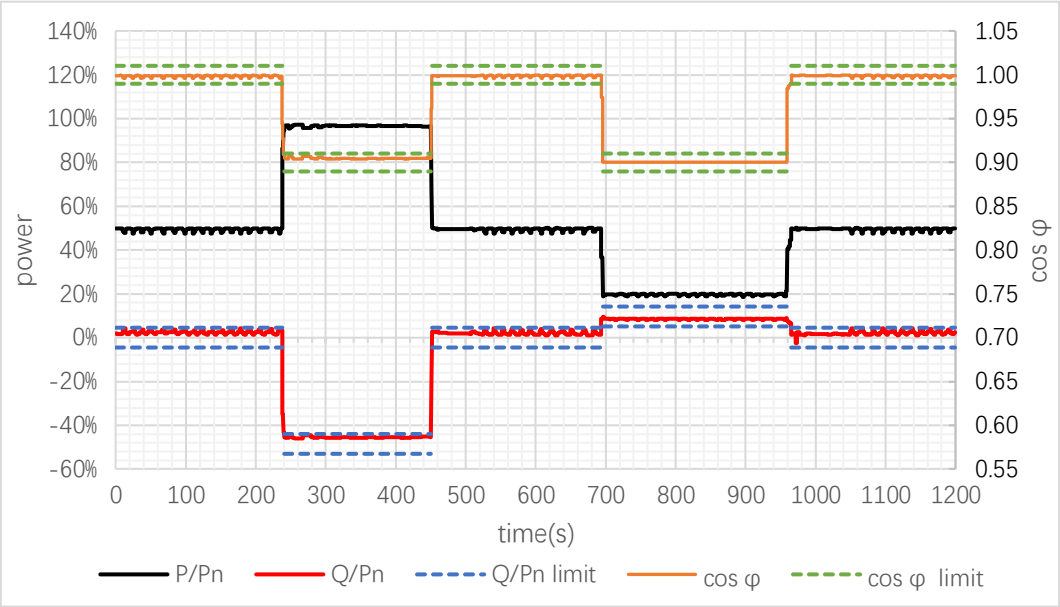
Test 2: Dynamic test of Power related control mode

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Test Conditions	Measurements					Target value		Limits	
P/P_n	U/U_n	P/P_n	Q/P_n	cos φ	$T_{sr\_95\%}$	Q/P_n	cos φ	$\Delta Q/P_n$	$T_{sr\_95\%}$
50%→100 %	100%	91.8%	-39.3%	1.04%	1s	-48.4%	0.900	±4.5%	≤ 10s
100%→50 %	100%	49.9%	1.9%	1.9%	1s	0%	1.000		
50%→20%	100%	20.2%	9.2%	-0.49%	1s	+9.69%	0.900		
20%→50%	100%	50%	1.7%	1.7%	1s	0%	1.000		

Note(s): * Actual active power (P) output de-rating while rated P_n equal to S_n.

Diagram of dynamic test for Power related control mode



EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

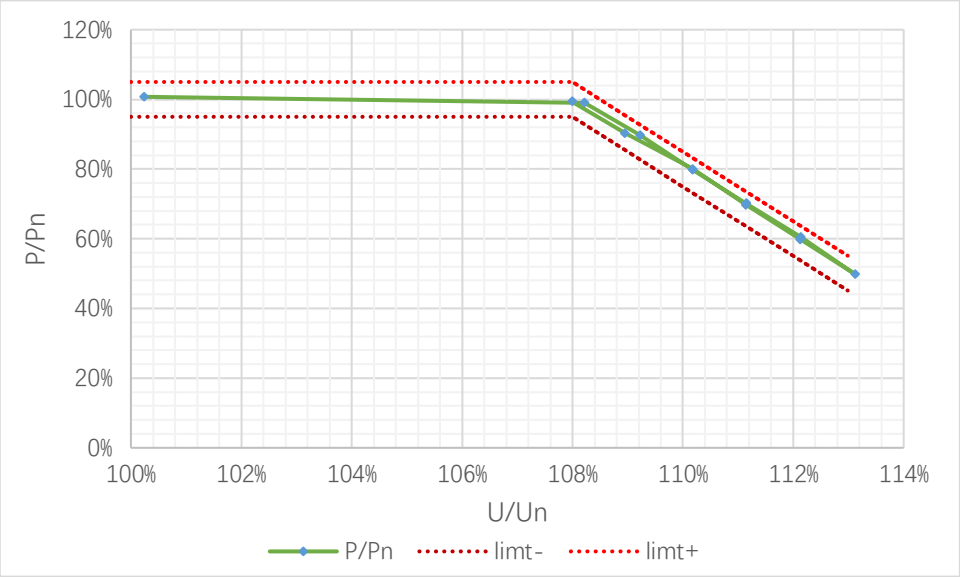
4.7.3	**Voltage related active power reduction (P(U) curve)**	**P**
Model	GT1-6KD1	

Set point	**Starting voltage U_1 (U/U_n)**	**Deactivation threshold U_{stop}:**	**Power reduction (P/P_n)**
	110%	110%	≤ 20%

Test 1: Static test for accuracy of Voltage related active power reduction

Test Conditions		Measurements			Target value	Limits
U/U_n	P/P_n	U/U_n	P/P_n	$\Delta P/P_n$	P/P_n	$\Delta P/P_n$
100%	100%	100.2%	100.74%	0.74%	100%	±5%
108%		108.2%	99.07%	-0.93%	100%	
109%		109.2%	89.79%	-0.21%	90%	
110%		110.2%	79.84%	-0.16%	80%	
111%		111.1%	70.23%	0.23%	70%	
112%		112.1%	60.53%	0.53%	60%	
113%		113.1%	49.87%	-0.13%	50%	
112%		112.1%	59.85%	-0.15%	60%	
111%		111.1%	69.73%	-0.27%	70%	
110%		110.2%	79.98%	-0.02%	80%	
109%		108.9%	90.33%	0.33%	90%	
108%		108.0%	99.36%	-0.64%	100%	

Diagram



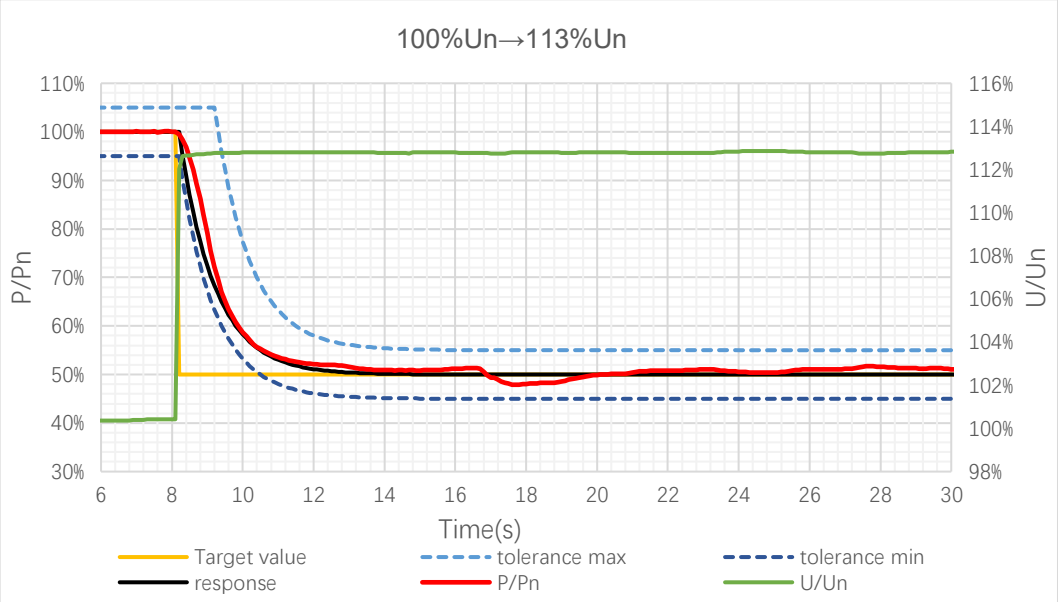
EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

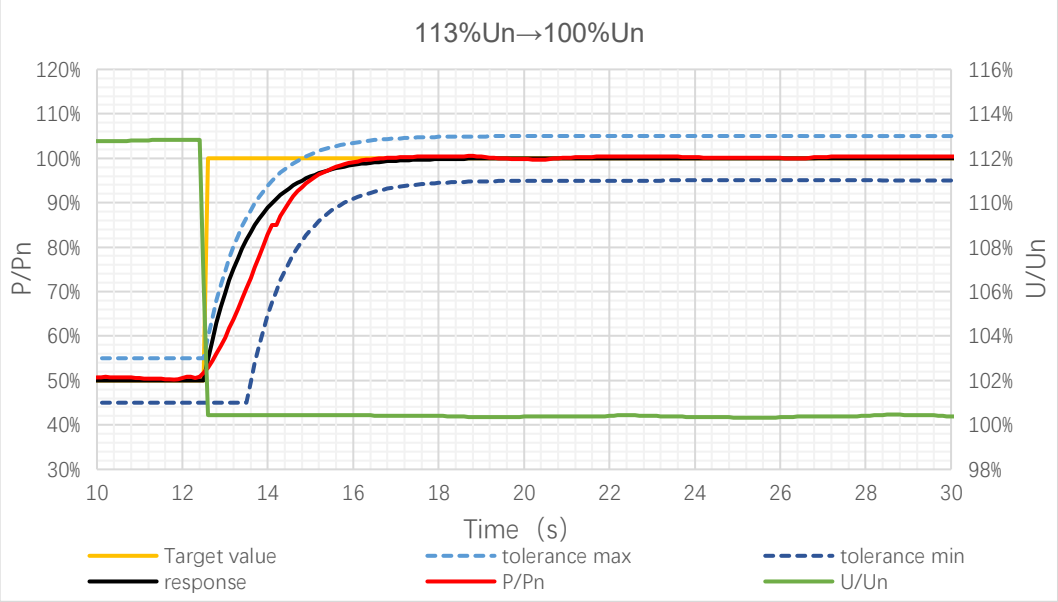
Test 2: Dynamic test of Power related control mode

Test Conditions		Measurements				Target value	Limits	
U/U_n	P/P_n	U/U_n	P/P_n	$\Delta P/P_n$	$T_{sr\_90\%}$ (s)	P/P_n	$\Delta P/P_n$	$T_{sr\_90\%}$
100%→113%	100%	112.8%	50.6%	0.6%	3	50%	≤ ±5%	≥ 3s
113%→100%	50%	100.4%	100.2%	0.2%	3	100%		

Note(s):

Diagram





EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

4.8	**TABLE: Power quality - Harmonic and inter-harmonics**	**P**

Power generating unit (individual device) and power generating system which is $I_n \leq 75A$

Harmonics

Model	GT1-6KD1	Current (A)	26.26
Active power (W)	6052.26	Power Factor	-0.999
Voltage (V)	230.62	Frequency (Hz)	50.00

Harmonics	Current Magnitude (A)	Current % of fundamental	Phase	Harmonic Current Limits (%)	
				Single-phase	Three-phase
1st	26.220	--	single phase	--	--
2nd	0.086	0.33	single phase	8	8
3rd	0.526	2.01	single phase	21,6	N/A
4th	0.072	0.27	single phase	4	4
5th	0.192	0.73	single phase	10,7	10,7
6th	0.036	0.14	single phase	2,7	2,7
7th	0.100	0.38	single phase	7,2	7,2
8th	0.013	0.05	single phase	2	2
9th	0.064	0.24	single phase	3,8	N/A
10th	0.025	0.10	single phase	1,6	1,6
11th	0.060	0.23	single phase	3,1	3,1
12th	0.018	0.07	single phase	1,3	1,3
13th	0.073	0.28	single phase	2	2
14th	0.011	0.04	single phase	N/A	N/A
15th	0.063	0.24	single phase	N/A	N/A
16th	0.010	0.04	single phase	N/A	N/A
17th	0.044	0.17	single phase	N/A	N/A
18th	0.012	0.05	single phase	N/A	N/A
19th	0.024	0.09	single phase	N/A	N/A
20th	0.010	0.04	single phase	N/A	N/A
21st	0.020	0.08	single phase	N/A	N/A
22nd	0.006	0.02	single phase	N/A	N/A
23rd	0.027	0.10	single phase	N/A	N/A
24th	0.009	0.03	single phase	N/A	N/A
25th	0.024	0.09	single phase	N/A	N/A
26th	0.011	0.04	single phase	N/A	N/A
27th	0.014	0.05	single phase	N/A	N/A
28th	0.009	0.03	single phase	N/A	N/A
29th	0.008	0.03	single phase	N/A	N/A
30th	0.007	0.03	single phase	N/A	N/A
31st	0.009	0.03	single phase	N/A	N/A
32nd	0.009	0.03	single phase	N/A	N/A
33rd	0.011	0.04	single phase	N/A	N/A
34th	0.009	0.03	single phase	N/A	N/A
35th	0.010	0.04	single phase	N/A	N/A
36th	0.007	0.03	single phase	N/A	N/A
37th	0.008	0.03	single phase	N/A	N/A
38th	0.007	0.03	single phase	N/A	N/A
39th	0.009	0.03	single phase	N/A	N/A
40th	0.009	0.03	single phase	N/A	N/A
THD	--	2.29	single phase	23	13
PWHD	--	1.69	single phase	23	22

Note(s): output current > 16A and ≤ 75A, it shall be complied with EN 61000-3-12.

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

4.8	**TABLE: Power quality - Harmonic and inter-harmonics**	**P**

Power generating unit (individual device) and power generating system which is $I_n \leq 75A$

Harmonics

Model	GT1-3K6D1	Current (A)	15.68
Active power (W)	3614.42	Power Factor	-0.999
Voltage (V)	230.58	Frequency (Hz)	50.00

Harmonics	Current Magnitude (A)	Phase	Harmonic Current Limits (A)
1st	15.683	single phase	--
2nd	0.037	single phase	1.08
3rd	0.253	single phase	2.3
4th	0.022	single phase	0.43
5th	0.088	single phase	1.14
6th	0.012	single phase	0.3
7th	0.057	single phase	0.77
8th	0.006	single phase	0.23
9th	0.038	single phase	0.4
10th	0.008	single phase	0.184
11th	0.029	single phase	0.33
12th	0.008	single phase	0.153
13th	0.021	single phase	0.21
14th	0.005	single phase	0.131
15th	0.016	single phase	0.15
16th	0.005	single phase	0.115
17th	0.012	single phase	0.132
18th	0.006	single phase	0.102
19th	0.009	single phase	0.118
20th	0.006	single phase	0.092
21st	0.007	single phase	0.107
22nd	0.005	single phase	0.084
23rd	0.006	single phase	0.098
24th	0.006	single phase	0.077
25th	0.006	single phase	0.09
26th	0.007	single phase	0.071
27th	0.007	single phase	0.083
28th	0.006	single phase	0.066
29th	0.008	single phase	0.078
30th	0.005	single phase	0.061
31st	0.009	single phase	0.073
32nd	0.007	single phase	0.058
33rd	0.011	single phase	0.068
34th	0.007	single phase	0.054
35th	0.010	single phase	0.064
36th	0.009	single phase	0.051
37th	0.010	single phase	0.061
38th	0.011	single phase	0.048
39th	0.012	single phase	0.058
40th	0.017	single phase	0.046
THD	1.83%	single phase	5%

Note(s): output current < 16A and ≤ 75A, it shall be complied with EN 61000-3-2.

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

4.8	**TABLE: Power quality - Harmonic and inter-harmonics**	**P**

Power generating unit (individual device) and power generating system which is $I_n \leq 75A$

Harmonics

Model	GT1-3K3S1	Current (A)	14.42
Active power (W)	3327.33	Power Factor	0.999
Voltage (V)	230.86	Frequency (Hz)	50.00

Harmonics	Current Magnitude (A)	Phase	Harmonic Current Limits (A)
1st	14.422	single phase	--
2nd	0.073	single phase	1.08
3rd	0.257	single phase	2.3
4th	0.027	single phase	0.43
5th	0.024	single phase	1.14
6th	0.019	single phase	0.3
7th	0.019	single phase	0.77
8th	0.013	single phase	0.23
9th	0.025	single phase	0.4
10th	0.018	single phase	0.184
11th	0.023	single phase	0.33
12th	0.013	single phase	0.153
13th	0.027	single phase	0.21
14th	0.016	single phase	0.131
15th	0.022	single phase	0.15
16th	0.016	single phase	0.115
17th	0.018	single phase	0.132
18th	0.028	single phase	0.102
19th	0.026	single phase	0.118
20th	0.017	single phase	0.092
21st	0.021	single phase	0.107
22nd	0.008	single phase	0.084
23rd	0.018	single phase	0.098
24th	0.018	single phase	0.077
25th	0.018	single phase	0.09
26th	0.009	single phase	0.071
27th	0.021	single phase	0.083
28th	0.007	single phase	0.066
29th	0.015	single phase	0.078
30th	0.010	single phase	0.061
31st	0.016	single phase	0.073
32nd	0.010	single phase	0.058
33rd	0.015	single phase	0.068
34th	0.008	single phase	0.054
35th	0.014	single phase	0.064
36th	0.014	single phase	0.051
37th	0.011	single phase	0.061
38th	0.010	single phase	0.048
39th	0.012	single phase	0.058
40th	0.020	single phase	0.046
THD	2.00%	single phase	5%

Note(s): output current < 16A and ≤ 75A, it shall be complied with EN 61000-3-2.

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

4.8	**TABLE: Power quality - Harmonic and inter-harmonics**	**P**

Power generating unit (individual device) and power generating system which is $I_n \leq 75A$

Harmonics

Model	GT1-1K6S1	Current (A)	7.048
Active power (W)	1620.00	Power Factor	0.999
Voltage (V)	230.00	Frequency (Hz)	50.00

Harmonics	Current Magnitude (A)	Phase	Harmonic Current Limits (A)
1st	7.048	single phase	--
2nd	0.038	single phase	1.08
3rd	0.084	single phase	2.3
4th	0.012	single phase	0.43
5th	0.027	single phase	1.14
6th	0.010	single phase	0.3
7th	0.031	single phase	0.77
8th	0.006	single phase	0.23
9th	0.033	single phase	0.4
10th	0.006	single phase	0.184
11th	0.032	single phase	0.33
12th	0.006	single phase	0.153
13th	0.029	single phase	0.21
14th	0.005	single phase	0.131
15th	0.034	single phase	0.15
16th	0.005	single phase	0.115
17th	0.025	single phase	0.132
18th	0.004	single phase	0.102
19th	0.028	single phase	0.118
20th	0.004	single phase	0.092
21st	0.031	single phase	0.107
22nd	0.005	single phase	0.084
23rd	0.026	single phase	0.098
24th	0.005	single phase	0.077
25th	0.021	single phase	0.09
26th	0.005	single phase	0.071
27th	0.025	single phase	0.083
28th	0.005	single phase	0.066
29th	0.022	single phase	0.078
30th	0.006	single phase	0.061
31st	0.020	single phase	0.073
32nd	0.006	single phase	0.058
33rd	0.022	single phase	0.068
34th	0.006	single phase	0.054
35th	0.018	single phase	0.064
36th	0.011	single phase	0.051
37th	0.018	single phase	0.061
38th	0.009	single phase	0.048
39th	0.023	single phase	0.058
40th	0.015	single phase	0.046
THD	2.11%	single phase	5%

Note(s): output current < 16A and ≤ 75A, it shall be complied with EN 61000-3-2.

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

4.8	**Power quality - Voltage fluctuations (Flicker)**	P
Model	GT1-6KD1	

Measurements

Parameter	P_{st}			d(t) (%)			d_c (%)			d_{max} (%)		
	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
1	0.189	--	--	0	--	--	0.184	--	--	0.381	--	--
2	0.187	--	--	0	--	--	0.176	--	--	0.345	--	--
3	0.183	--	--	0	--	--	0.171	--	--	0.326	--	--
4	0.186	--	--	0	--	--	0.220	--	--	0.367	--	--
5	0.183	--	--	0	--	--	0.227	--	--	0.328	--	--
6	0.185	--	--	0	--	--	0.200	--	--	0.375	--	--
7	0.182	--	--	0	--	--	0.156	--	--	0.359	--	--
8	0.183	--	--	0	--	--	0.170	--	--	0.364	--	--
9	0.183	--	--	0	--	--	0.188	--	--	0.332	--	--
10	0.183	--	--	0	--	--	0.185	--	--	0.336	--	--
11	0.184	--	--	0	--	--	0.173	--	--	0.387	--	--
12	0.185	--	--	0	--	--	0.178	--	--	0.310	--	--

Parameter	Measurements					Limit				
	P_{st}	P_{lt}	d(t) (%)	d_c (%)	d_{max} (%)	P_{st}	P_{lt}	d(t) (%)	d_c (%)	d_{max} (%)
L1	0.189	0.184	0	0.227	0.387	≤ 1.0	≤ 0.65	≤ 3.3	≤ 3.3	≤ 4.0
L2	--	--	--	--	--					
L3	--	--	--	--	--					

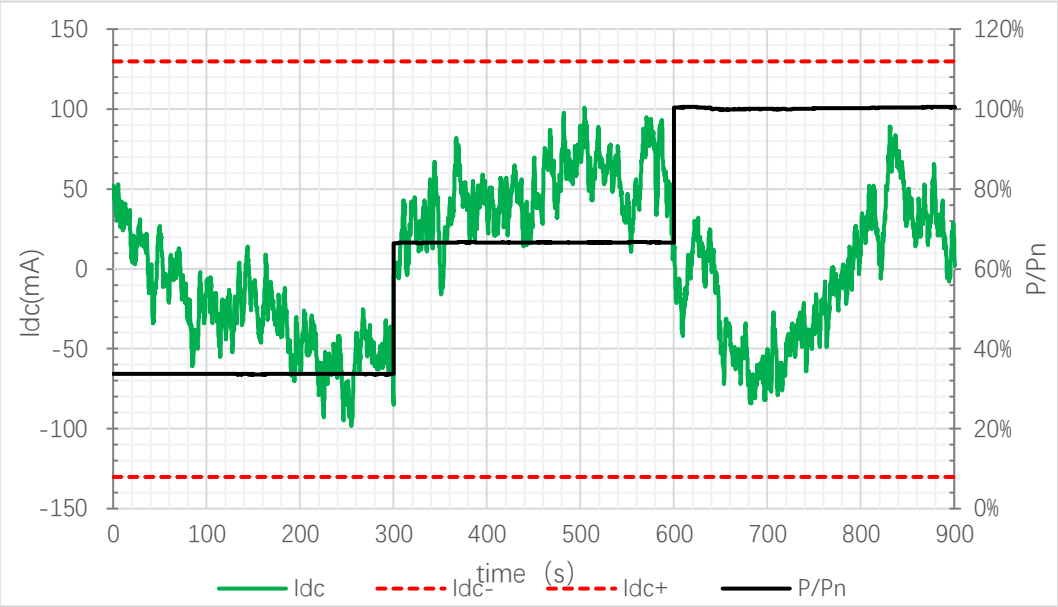
Note:
Each phase output current > 16A and ≤75A, it shall be complied with EN 61000-3-11.

4.8	**TABLE: Power quality - Voltage fluctuations (K_{imax})**	P
Model	GT1-6KD1	

Test Conditions	Measurements		Limit	
	U/U_n	I/I_n	K_i	K_i
Starting to 50%P_n	1.01	0.25	1.01	≤ 1.2
Starting to 100% P_n	1.01	0.28	1.01	≤ 1.2
Stopping at 100% P_n	1.01	0.54	1.01	≤ 1.2

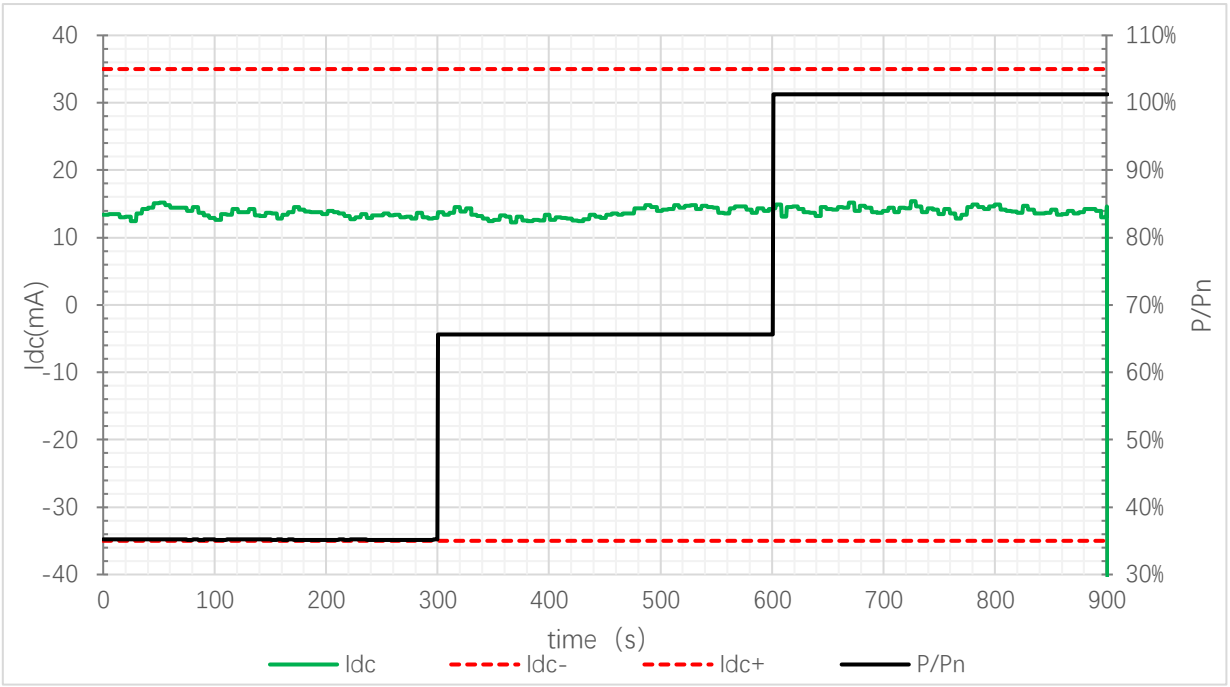
EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

4.8	**TABLE: Power quality - DC Injection**								P
Model	GT1-6KD1								
Test Conditions	Measurements							Target value	Limits
P/P_n	U/U_n	I/I_n	P/P_n	cos φ	I_{dc}/I_n			I_{dc}/I_n	I_{dc}/I_n
					L1	L2	L3		
30-40%	100.1%	33.8%	33.7%	0.999	0.33%	-	-	0%	≤ ±0.5%
60-70%	100.3%	66.7%	66.7%	1.000	0.37%	-	-	0%	
≥ 95%	100.4%	100.0%	100.0%	1.000	0.25%	-	-	0%	



EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

4.8	**TABLE: Power quality - DC Injection**								P
Model	GT1-1K6S1								
Test Conditions	Measurements							Target value	Limits
P/P_n	U/U_n	I/I_n	P/P_n	cos φ	I_{dc}/I_n			I_{dc}/I_n	I_{dc}/I_n
					L1	L2	L3		
30-40%	100.0%	35.3%	35.2%	98.9%	0.33%	-	-	0%	≤ ±0.5%
60-70%	100.0%	65.3%	65.6%	99.8%	0.21%	-	-	0%	
≥ 95%	100.0%	100.8%	101.3%	99.9%	0.22%	-	-	0%	



EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

4.9.3	**Table: Requirements on voltage and frequency protection**								**P**
All thresholds must be adjustable									
Voltage values									
Threshold	(27<)	t_{min} (27<)	(27<<)	t_{min} (27<<)	59>	t_{max} (59>)	59>>	t_{max} (59.S1)	59 10 min-mean
Range	0.2-1.0 U_n	0.1-100s	0.2-1.0 U_n	0.1-5s	1.0-1.2 U_n	0.1-100s	1.0-1.3 U_n	0.1-5s	1.0-1.15 U_n
Adjustable in Step	0.01 U_n	0.1s	0.01 U_n	0.05s	0.01 U_n	0.1s	0.01 U_n	0.05s	0.01 U_n

Frequency values								
Threshold	81<	tmin (81<)	81<<	tmin (81<<)	81>	tmax (81>)	81>>	tmax (81>>)
Range	47.0-50.0Hz	0.1-100s	47.0-50.0Hz	0.1-5s	50.0-52.0Hz	0.1-100s	50.0-52.0Hz	0.1-5s
Steps	0.1 Hz	0.1s	0.1 Hz	0.05s	0.1 Hz	0.1s	0.1 Hz	0.05s

Note 1:	External SPI stays in operation conditions for 5s after disconnecting the mains voltage
Note 2:	The frequency protection shall function correctly in the input voltage range between 20%U_n and 120%U_n and shall be inhibited for input voltages of less than 20%U_n. Under 20% U_n the frequency protection is inhibited. Disconnection may only happen based on undervoltage protection.

Note(s):

The trip values were evaluated by varying the applied voltage from Un down to $U_{th\text{-}low}$ - 2% of Un in steps of 0,5% of Un for under-voltage testing as well as from Un up to $U_{th\text{-}high}$ + 2% of Un in steps of 0,5% of Un for overvoltage testing. Lower and upper threshold voltage shall not fall or rise below or above 2,3V of the trip value itself. The disconnection time was measured by application of a negative voltage step from Un to the operate value -5% of Un as well as positive voltage step from Un to the operate value +5% of Un.

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

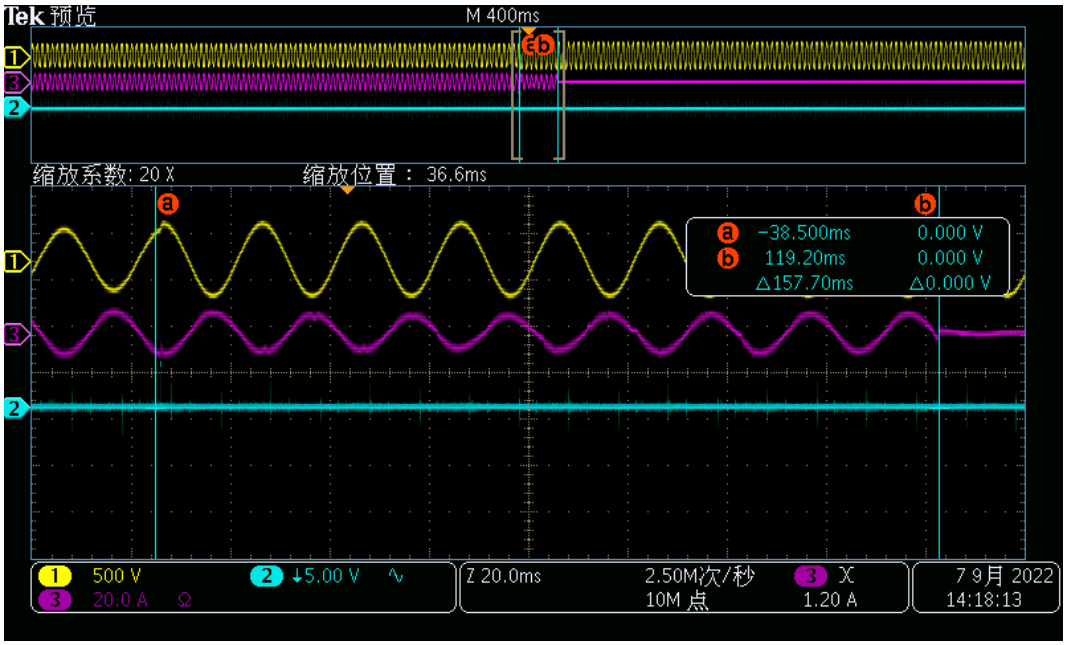
4.9.3.2	**TABLE: Under-voltage protection**	**P**
Model	GT1-6KD1	
Test condition:	Output level: 50 ± 5% of its rated current output Frequency: 50 Hz	

Test condition		Measurement			Limit
Threshold	Setting U/U_n	Tripped value (V)			
		L1 to N	L2 to N	L3 to N	
U > (59 >)	115%	264.7	--	--	±1%U_n
		264.7	--	--	
		264.7	--	--	
U >> (59 >>)	125%	286.6	--	--	
		286.6	--	--	
		286.6	--	--	
U < (27 <)	85%	195.3	--	--	
		195.3	--	--	
		195.3	--	--	
U << (27 <<)	40%	91.9	--	--	
		92.0	--	--	
		91.9	--	--	

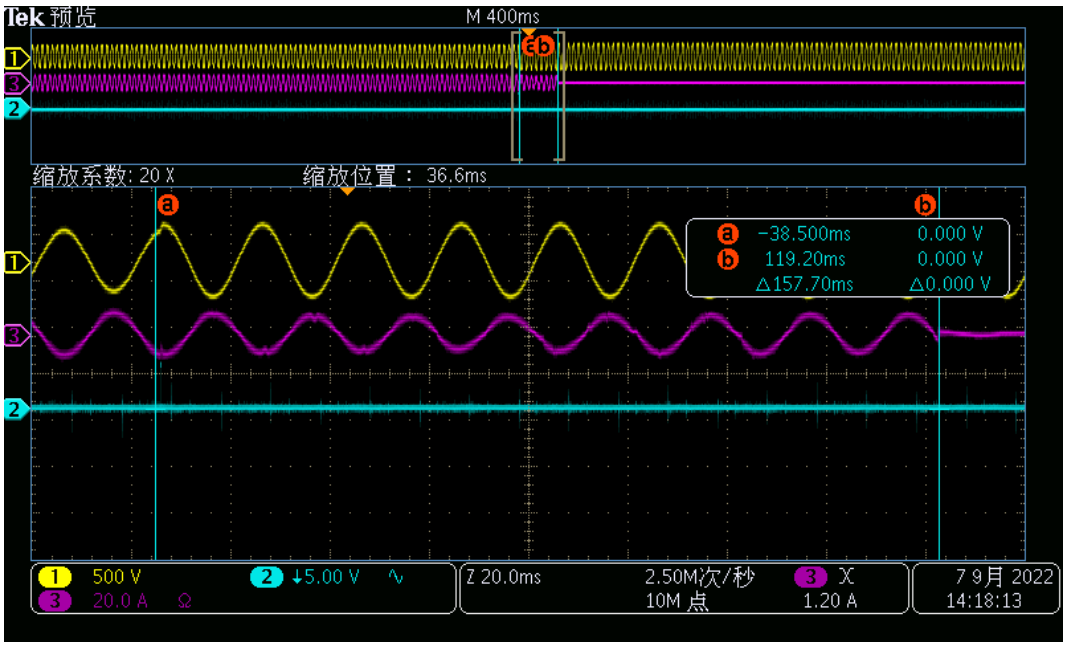
Test condition			Measurement			Limit (ms)
Threshold	Setting time (ms)	Step to Step (%)	Tripping time (ms)			
			L1 to N	L2 to N	L3 to N	
U > (59 >)	100	100% to 117%	154.8	--	--	100-200
			154.9	--	--	
			157.7	--	--	
U >> (59 >>)	100	100% to 127%	109.6	--	--	100-200
			116.8	--	--	
			127.2	--	--	
U < (27 <)	3000	100% to 83%	3020	--	--	3000-3100
			3040	--	--	
			3040	--	--	
U << (27 <<)	1500	100 % to 38%	1520	--	--	1500-1600
			1512	--	--	
			1216	--	--	

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Graph of disconnection at U > (59 >)

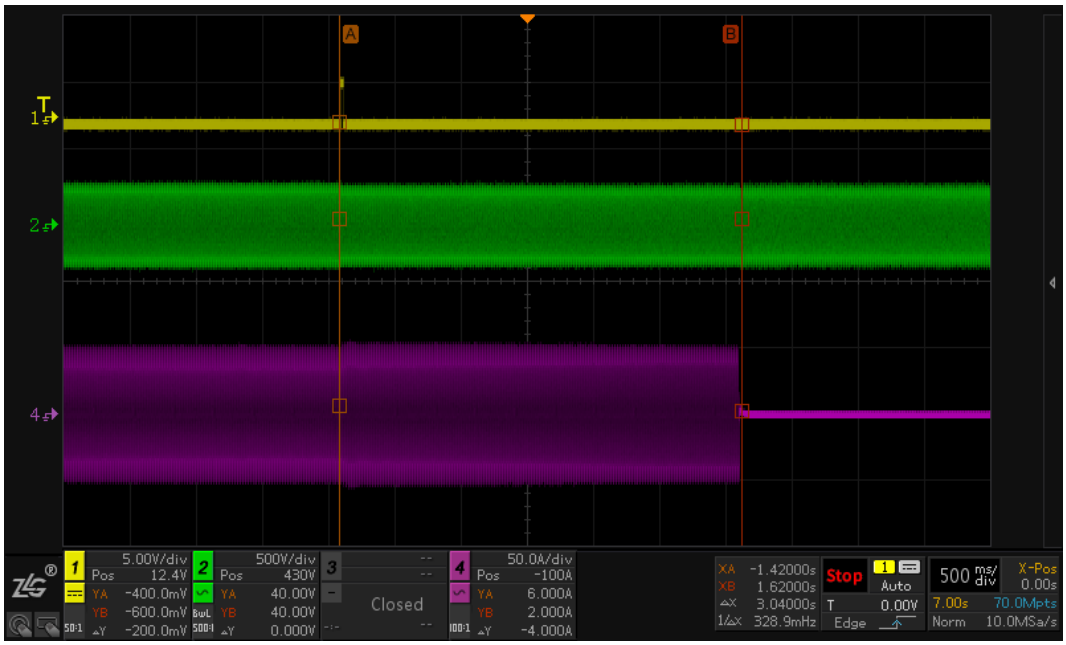


Graph of disconnection at U >> (59 >>)

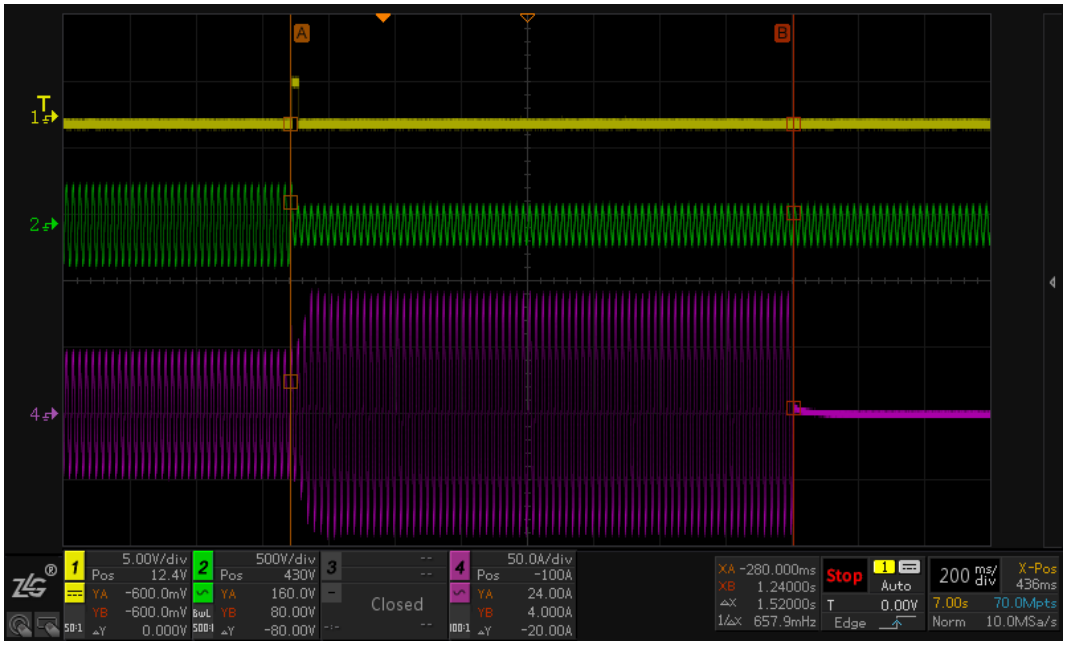


EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Graph of disconnection at U < (27 <)



Graph of disconnection at U << (27 <<)



EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

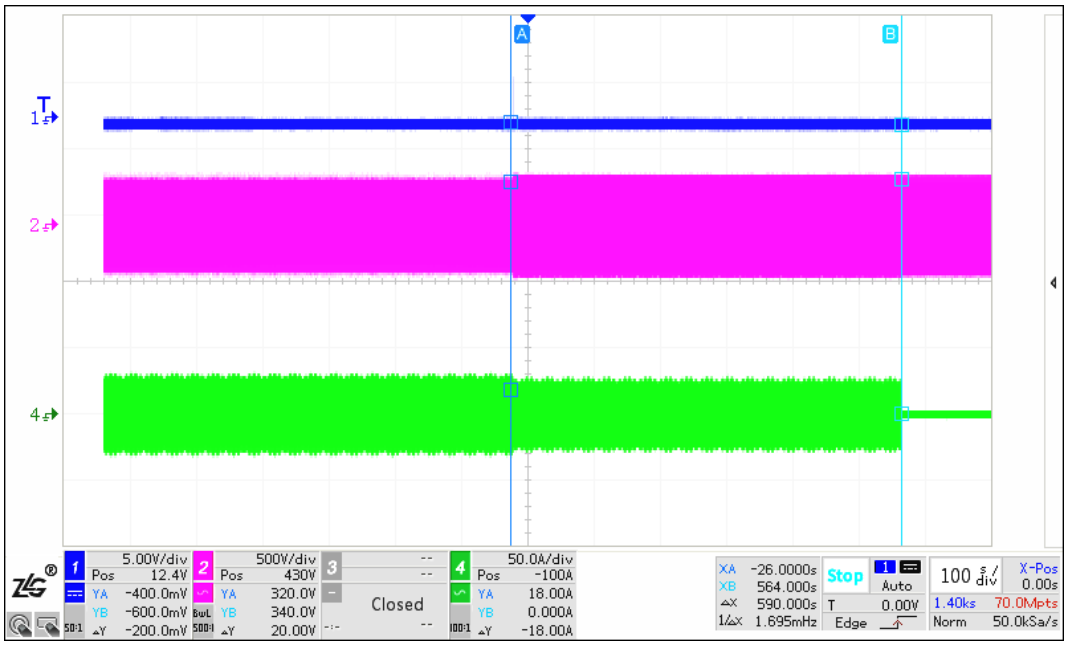
4.9.3.4	**Table: Overvoltage 10 min mean protection (OV)**		P
Setting values: U > (59 >)		Setting U > (V):	253
		Setting $T_{disconnection}$ (s):	600
Parameter		Measurement (V)	Limit:
Phase 1		253	± 1% of Un
Phase 2		--	
Phase 3		--	
Parameter		Disconnection time: [s]	Limit:
a)	The voltage is set to 100% U_n and held for 600 s. Thereafter the voltage is set to 112% U_n. Disconnection must take place within 600 s.		
	Phase 1	590s	≤ 600 s
	Phase 2	--	
	Phase 3	--	
b)	The voltage is set to U_n for 600 s and then to 108% U_n for 600 s. No disconnection should take place.		
	Phase 1	No disconnection	Disconnection should not take place.
	Phase 2	--	
	Phase 3	--	
c)	The voltage is set to 106% U_n and held for 600 s. Thereafter the voltage is set to 114% U_n. Disconnection must take place within 300 s or about 50% of the disconnection time measured in point a).*		
	Phase 1	294s	The disconnection time should be about 50% of the value measured in a). *
	Phase 2	--	
	Phase 3	--	

Note(s):

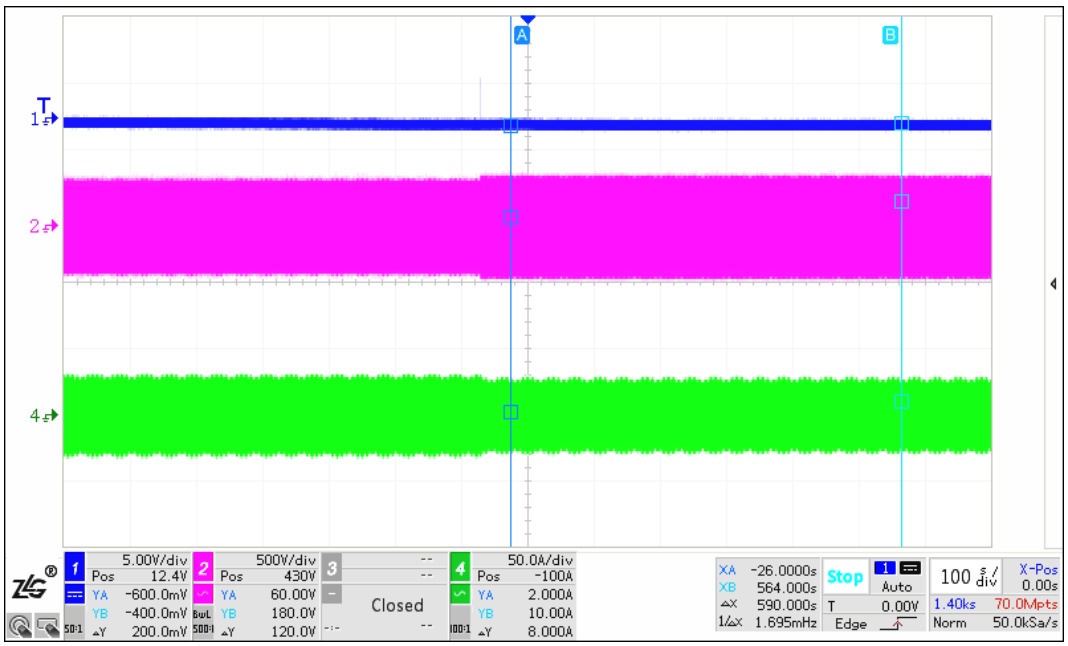
*If the setting value is set to 600 s, then the disconnection time can be in the range between 225 s and 375 s.

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Graph of disconnection at (a):

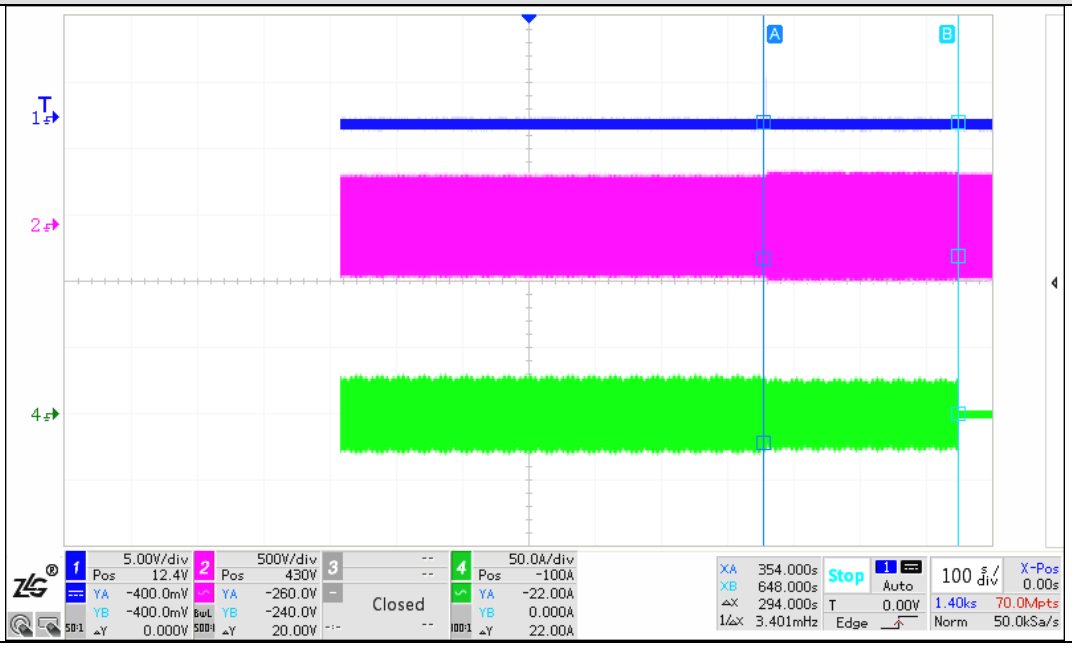


Graph of disconnection at (b):



EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Graph of disconnection at (c):



EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

4.9.3.5 4.9.3.6	**TABLE: Underfrequency/Overfrequency protection (OF/UF)**	P

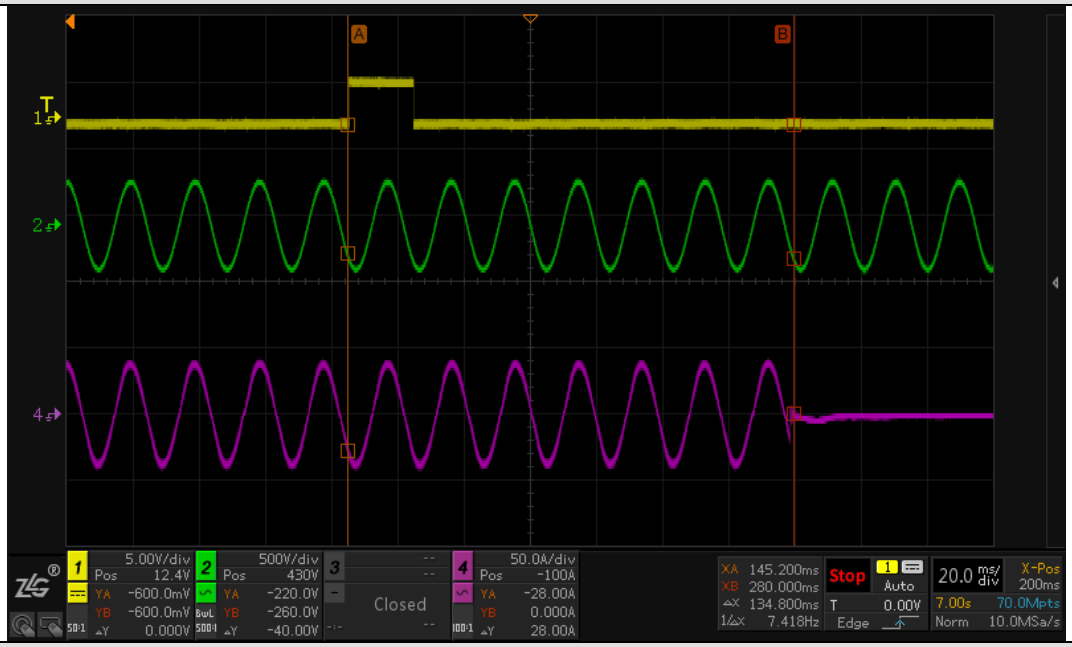
Test condition		Measurement			Limit
Threshold	Setting f (Hz)	Tripped value (Hz)			
F >> (81 >>)	52.0	52.02	52.02	52.01	±0.1%f_n
F > (81 >)	51.5	51.52	51.52	51.52	
F < (81 <)	47.5	47.48	47.49	47.49	
F << (81 <<)	47.0	47	47	47	

Test condition			Measurement			Limit(ms)
Threshold	Setting time (ms)	Step to Step (Hz)	Tripping time (ms)			
F >> (81 >>)	100	51.4 to 52.1	115.2	114.4	134.8	100-200
F > (81 >)	5000	51.4 to 51.6	5030	5030	5010	5000-5100
F < (81 <)	5000	47.6 to 47.4	5030	5010	5000	5000-5100
F << (81 <<)	100	47.6 to 46.9	107.6	119.6	119.2	100-200

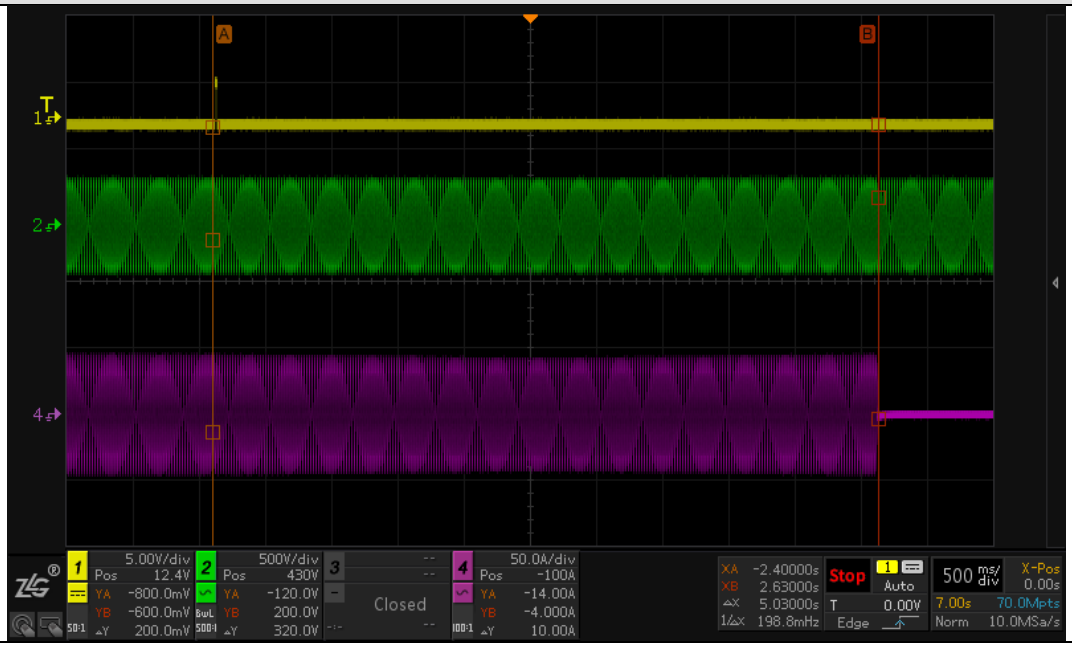
Note(s):

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Graph of disconnection at F >> (81 >>)

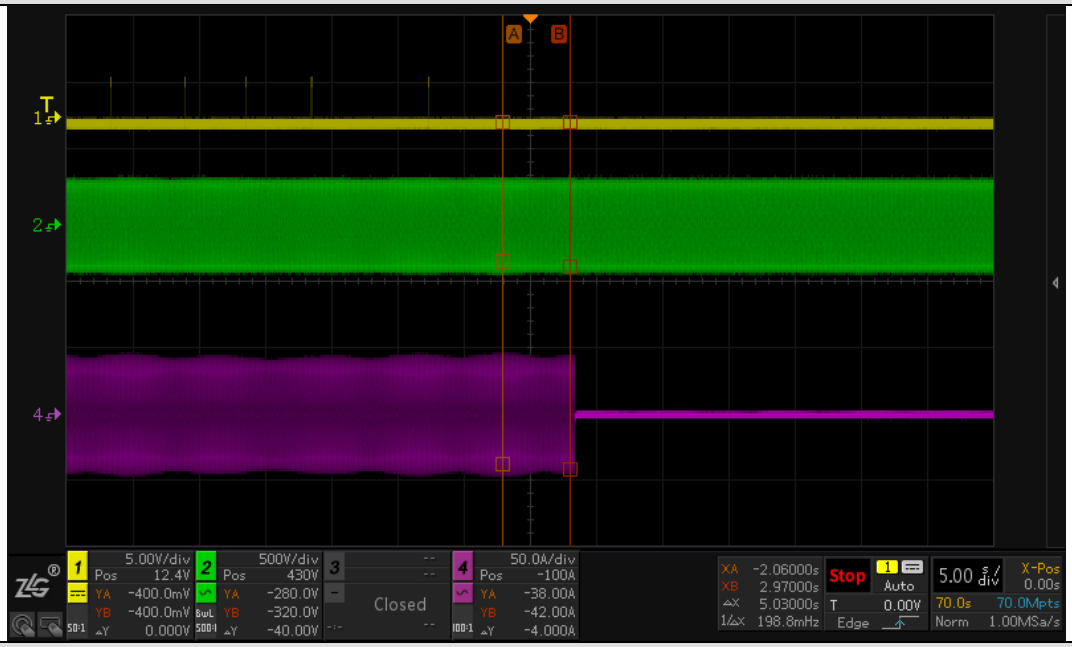


Graph of disconnection at F > (81 >)

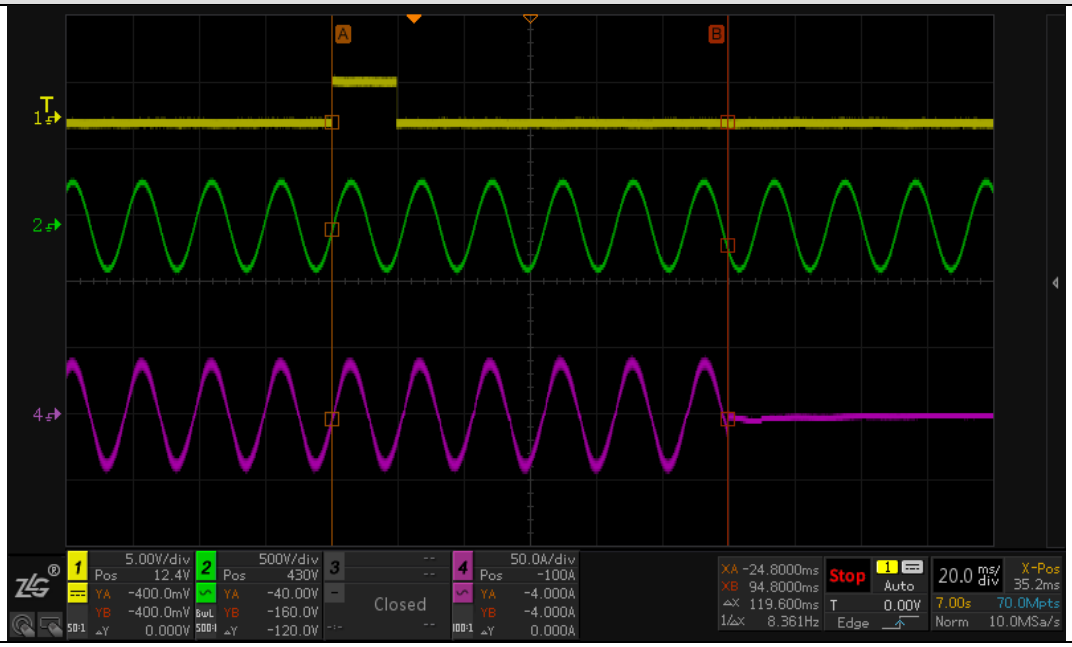


EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Graph of disconnection at F < (81 <)



Graph of disconnection at F << (81 <<)



EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

4.9.4.2	**Active methods tested with a resonant circuit in accordance with EN 62116 - test condition A (EUT output = 100%)**	**P**
Model	GT1-6KD1	

Test conditions A

Disconnection limit			2 s						
No	P_{EUT} [a] (% of EUT rating)	Reactive load (% of Q_L in 6.1.d)	P_{ac} [b] (% of nominal)	Q_{ac} [c] (% of nominal)	Run on Time (ms)	P_{EUT} (W)	Actual Q_f	V_{DC}	Remarks [d]
1	100	100	0	0	830	6000	1.01	450	Test A at BL
2	100	100	0	- 5	556	6000	1.00	450	Test A at IB
3	100	100	0	+ 5	548	6000	0.99	450	Test A at IB
4	100	100	- 5	- 5	413	6000	1.03	450	Test A at IB
5	100	100	- 5	0	371	6000	1.01	450	Test A at IB
6	100	100	- 5	+ 5	678	6000	0.98	450	Test A at IB
7	100	100	+ 5	- 5	405	6000	0.99	450	Test A at IB
8	100	100	+ 5	0	402	6000	0.97	450	Test A at IB
9	100	100	+ 5	+ 5	714	6000	1.02	450	Test A at IB
10	100	100	- 5	- 10	445	6000	1.03	450	Test A at IB
11	100	100	- 5	+10	500	6000	0.97	450	Test A at IB
12	100	100	0	- 10	534	6000	1.00	450	Test A at IB
13	100	100	0	+ 10	415	6000	1.00	450	Test A at IB
14	100	100	+ 5	- 10	542	6000	0.99	450	Test A at IB
15	100	100	+ 5	+ 10	518	6000	0.97	450	Test A at IB
16	100	100	- 10	- 10	709	6000	0.98	450	Test A at IB
17	100	100	- 10	- 5	346	6000	1.03	450	Test A at IB
18	100	100	- 10	0	330	6000	1.01	450	Test A at IB
19	100	100	- 10	+ 5	361	6000	1.03	450	Test A at IB
20	100	100	- 10	+ 10	330	6000	1.00	450	Test A at IB
21	100	100	+ 10	- 10	530	6000	1.00	450	Test A at IB
22	100	100	+ 10	- 5	422	6000	1.01	450	Test A at IB
23	100	100	+ 10	0	714	6000	0.99	450	Test A at IB
24	100	100	+ 10	+ 5	540	6000	0.97	450	Test A at IB
25	100	100	+ 10	+ 10	418	6000	1.02	450	Test A at IB

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

4.9.4.2	**Active methods tested with a resonant circuit in accordance with EN 62116 - test condition B (EUT output = 50 %–66 %)**	**P**
Model	GT1-6KD1	

Test conditions B

Disconnection limit			2.0 s						
No	P_{EUT} [a] (% of EUT rating)	Reactive load (% of Q_L in 6.1.d)	P_{ac} [b] (% of nominal)	Q_{ac} [c] (% of nominal)	Run on Time (ms)	P_{EUT} (W)	Actual Q_f	V_{DC}	Remarks [d]
1	66	66	0	- 5	379	4000	0.98	300	Test B at IB
2	66	66	0	- 4	399	4000	0.99	300	Test B at IB
3	66	66	0	- 3	450	4000	0.98	300	Test B at IB
4	66	66	0	- 2	684	4000	0.97	300	Test B at IB
5	66	66	0	- 1	620	4000	1.02	300	Test B at IB
6	66	66	0	0	774	4000	1.02	300	Test B at BL
7	66	66	0	+ 1	750	4000	1.01	300	Test B at IB
8	66	66	0	+ 2	634	4000	0.98	300	Test B at IB
9	66	66	0	+ 3	716	4000	0.99	300	Test B at IB
10	66	66	0	+ 4	576	4000	0.97	300	Test B at IB
11	66	66	0	+ 5	520	4000	1.02	300	Test B at IB

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

4.9.4.2	**Active methods tested with a resonant circuit in accordance with EN 62116 - test condition C (EUT output = 25 %-33 %)**	**P**
Model	GT1-6KD1	

Test conditions C

Disconnection limit			2.0 s						
No	P_{EUT} [a] (% of EUT rating)	Reactive load (% of Q_L in 6.1.d)	P_{ac} [b] (% of nominal)	Q_{ac} [c] (% of nominal)	Run on Time (ms)	P_{EUT} (W)	Actual Q_f	V_{DC}	Remarks [d]
1	33	33	0	- 5	342	2000	1.02	225	Test C at IB
2	33	33	0	- 4	335	2000	0.99	225	Test C at IB
3	33	33	0	- 3	395	2000	0.98	225	Test C at IB
4	33	33	0	- 2	390	2000	0.97	225	Test C at IB
5	33	33	0	- 1	554	2000	1.01	225	Test C at IB
6	33	33	0	0	888	2000	1.00	225	Test C at BL
7	33	33	0	+ 1	868	2000	1.01	225	Test C at IB
8	33	33	0	+ 2	770	2000	0.97	225	Test C at IB
9	33	33	0	+ 3	548	2000	0.98	225	Test C at IB
10	33	33	0	+ 4	512	2000	0.99	225	Test C at IB
11	33	33	0	+ 5	289	2000	1.02	225	Test C at IB

Note:

[a] *P*EUT: EUT output power.

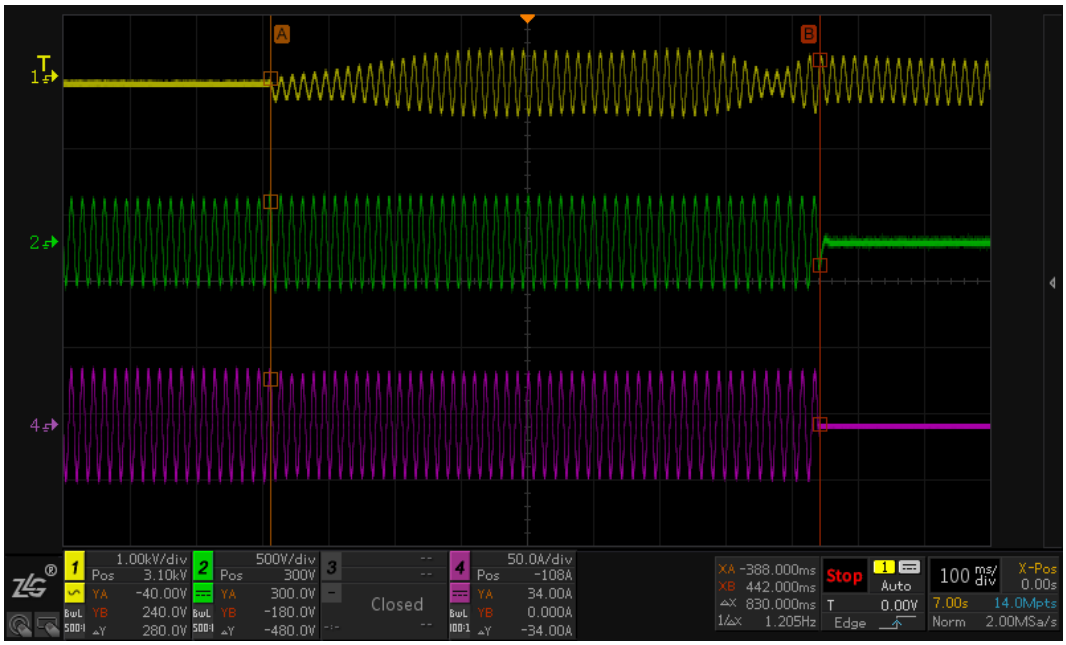
[b] *P*ac: Active power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.

[c] Q_{ac}: Reactive power flow at S1 in Figure 1. Positive means power from EUT to utility. Nominal is the 0 % test condition value.

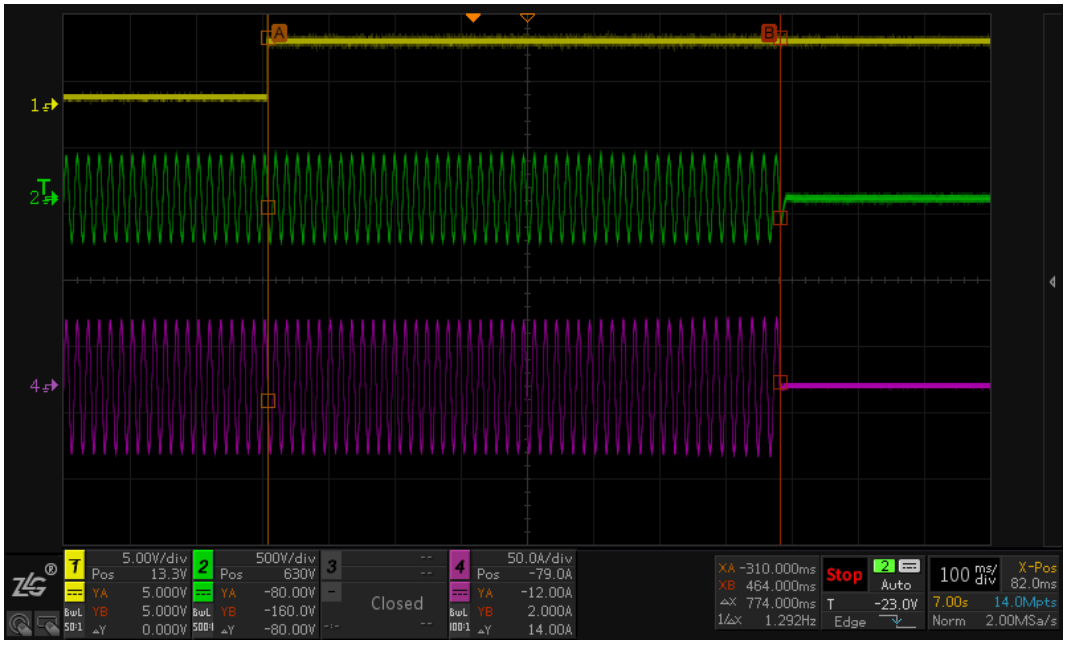
[d] BL: Balance condition, IB: Imbalance condition.

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

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

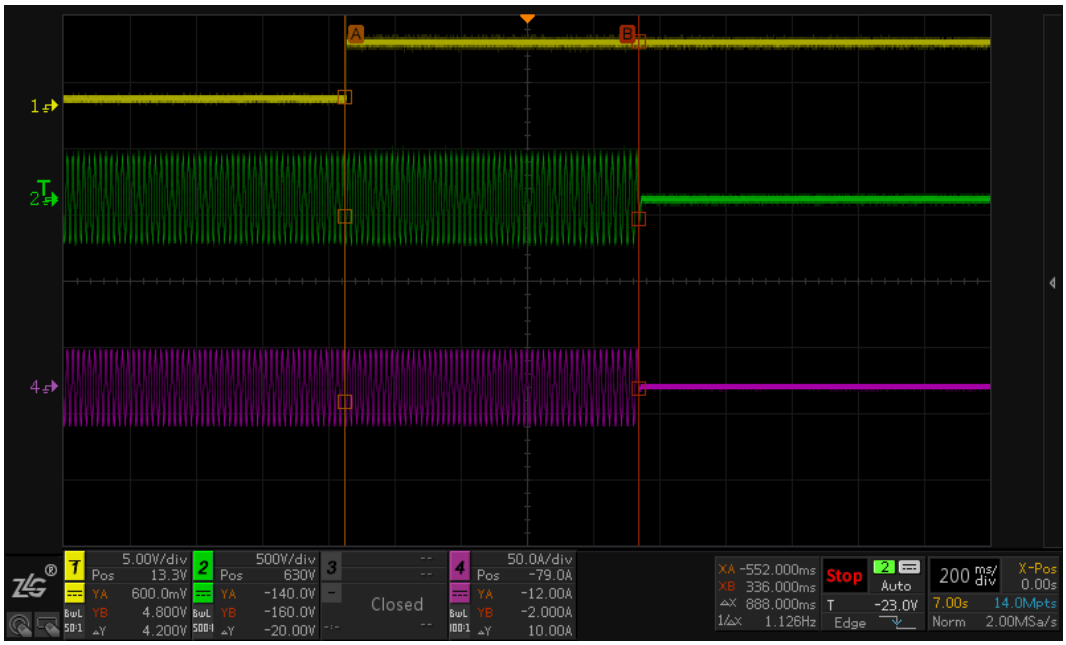


Graph of disconnection at P_{AC} 0% and Q_{AC} 0% reactive load and 66% nominal power



EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Graph of disconnection at P_{AC} 0% and Q_{AC} 0% reactive load and 33% nominal power



EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

4.10.2	**TABLE: Automatic reconnection after tripping**			**P**
Model	GT1-6KD1			
Setting values	Parameter	Range	Default setting	
	Lower frequency [Hz]:	47.0 - 50.0	49.5	
	Upper frequency [Hz]:	50.0 - 52.0	50.2	
	Lower voltage [V]:	115.0 - 230.0	195.5	
	Upper voltage [V]:	230.0 - 276.0	253.0	
	Observation time [s]:	10 - 600	60	
	Active power increase gradient:	6% - 3000%/min	10%/min	

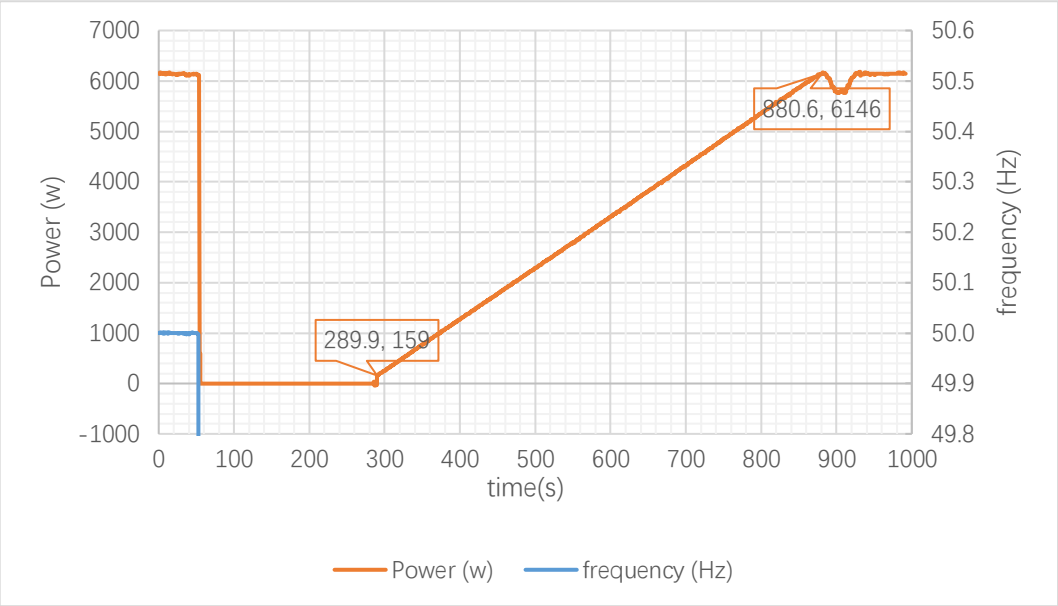
Connecting conditions for frequencies:			
	f_{act}	Reconnection time:	Limit:
a)	< 49.50 Hz	Not reconnect	No reconnection permitted
	Switch to:		
b)	≥ 49.50 Hz	67.6 s	≥ 60 s
c)	> 50.20 Hz	Not reconnect	No reconnection permitted
	Switch to:		
d)	≤ 50.20 Hz	63.3 s	≥ 60 s

Connecting conditions for voltages:			
	U_{act}	Reconnection time:	Limit:
e)	< 0.85 U_n	Not reconnect	No reconnection permitted
	Switch to:		
f)	≥ 0.85 U_n	64.3 s	≥ 60 s
g)	> 1.10 U_n	Not reconnect	No reconnection permitted
	Switch to:		
h)	≤ 1.10 U_n	65.3 s	≥ 60 s
After reconnection:	Active power gradient [%]	10 %	≤10 %

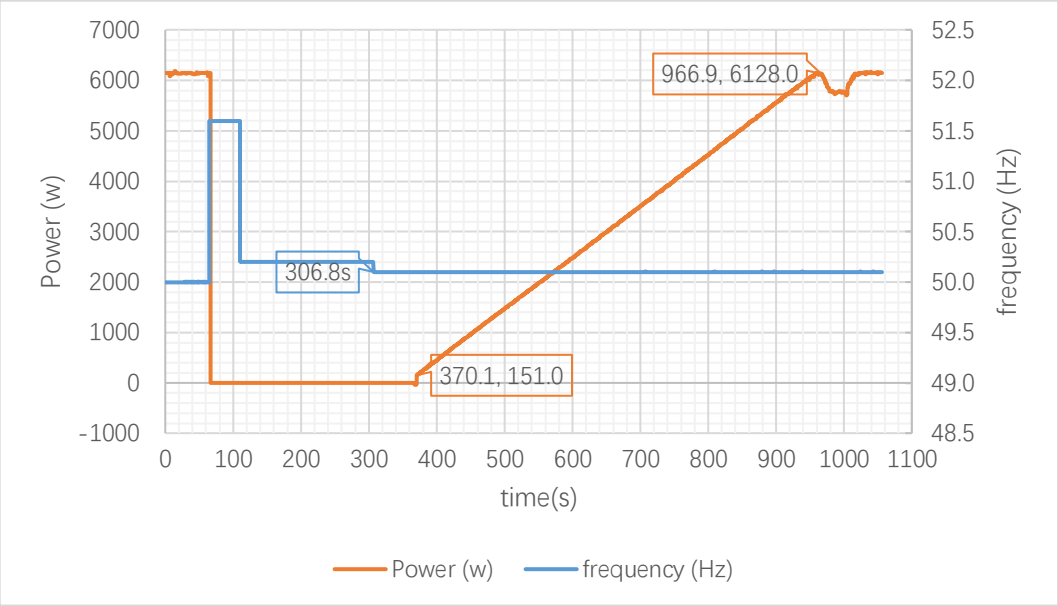
Note:
After reconnection the active power generated by the generating plant shall not exceed a specified gradient expressed as a percentage of the active nominal power of the unit per minute. If no gradient is specified by the DSO, the default setting is 10 % Pn/min. Non-adjustable or partly adjustable generating units may connect after 1 min to 10 min (randomised value) or later

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Reconnection: Lower frequency f ≥ 49.50 Hz

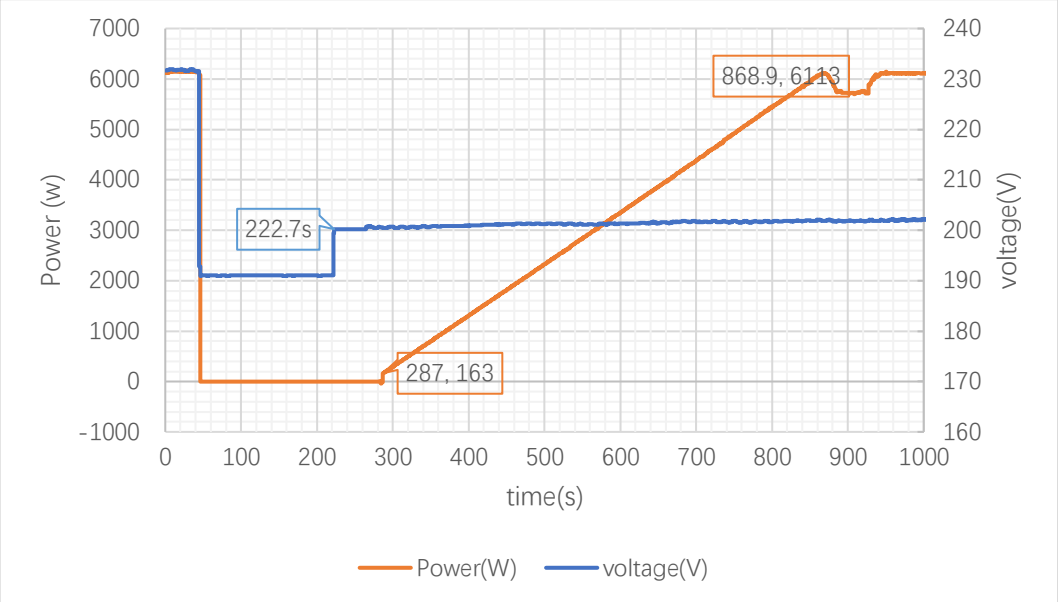


Reconnection: Upper frequency f ≤ 50.20 Hz

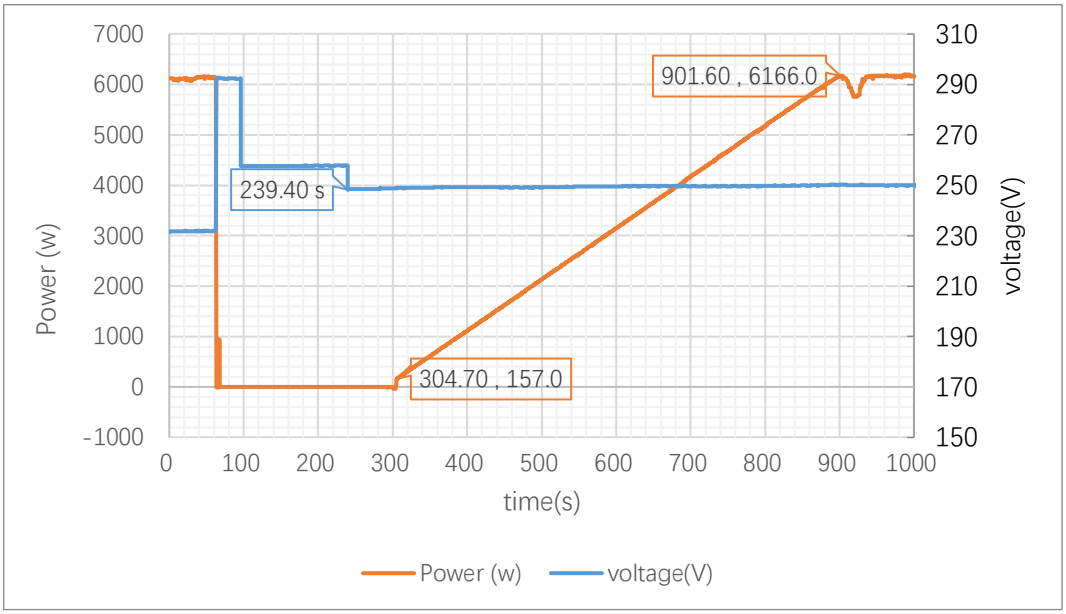


EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Reconnection: U ≥ 0.85 U_n



Reconnection: U ≤ 1.10 U_n



EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

4.10.3	**TABLE: Start of generating electrical power**			**P**
Model	GT1-6KD1			
Setting values	Parameter	Range	Default setting	
	Lower frequency [Hz]:	47.0 – 50.0	49.5	
	Upper frequency [Hz]:	50.0 – 52.0	50.1	
	Lower voltage [V]:	115.0 – 230.0	195.5	
	Upper voltage [V]:	230.0 – 276.0	253.0	
	Observation time [s]:	10 – 600	60	
	Active power increase gradient:	6% – 3000%/min	Disabled	

Start conditions for frequencies:

	f_{act}	Reconnection time:	Limit:
a)	< 49.50 Hz	No starting	No starting permitted
	Switch to:		
b)	≥ 49.50 Hz	62.6 s	≥ 60 s
c)	> 50.10 Hz	No starting	No starting permitted
	Switch to:		
d)	≤ 50.10 Hz	63.1 s	≥ 60 s

Start conditions for voltages:

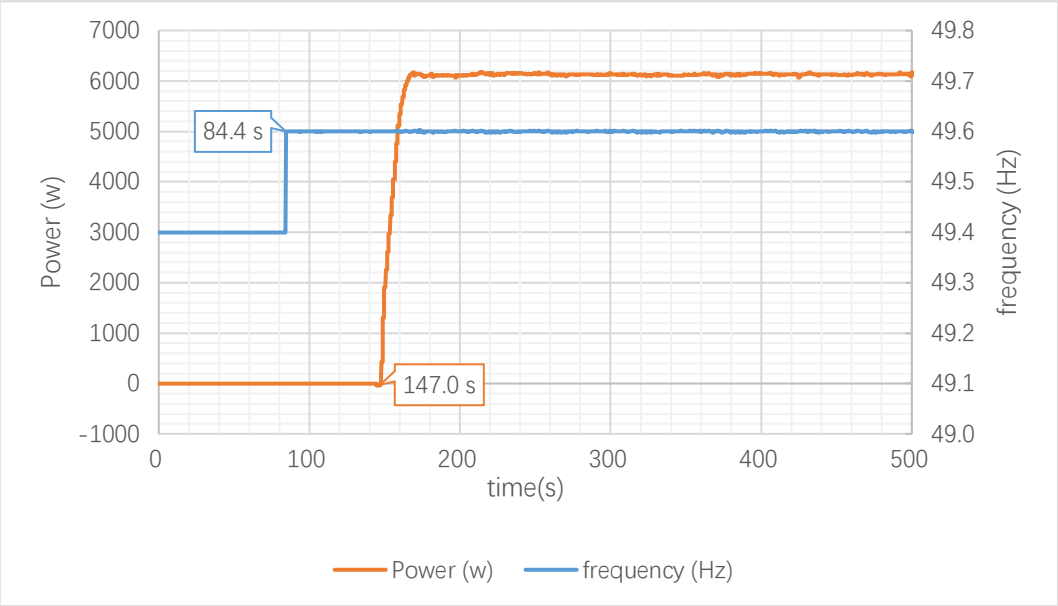
	U_{act}	Reconnection time:	Limit:
e)	< 0,85 U_n	No starting	No starting permitted
	Switch to:		
f)	≥ 0,85 U_n	63.9 s	≥ 60 s
g)	> 1,10 U_n	No starting	No starting permitted
	Switch to:		
h)	≤ 1,10 U_n	68.8 s	≥ 60 s
After reconnection:		Active power gradient [%] --	--

Note:
If applicable, the power gradient shall not exceed the maximum gradient specified by the DSO and the responsible party.

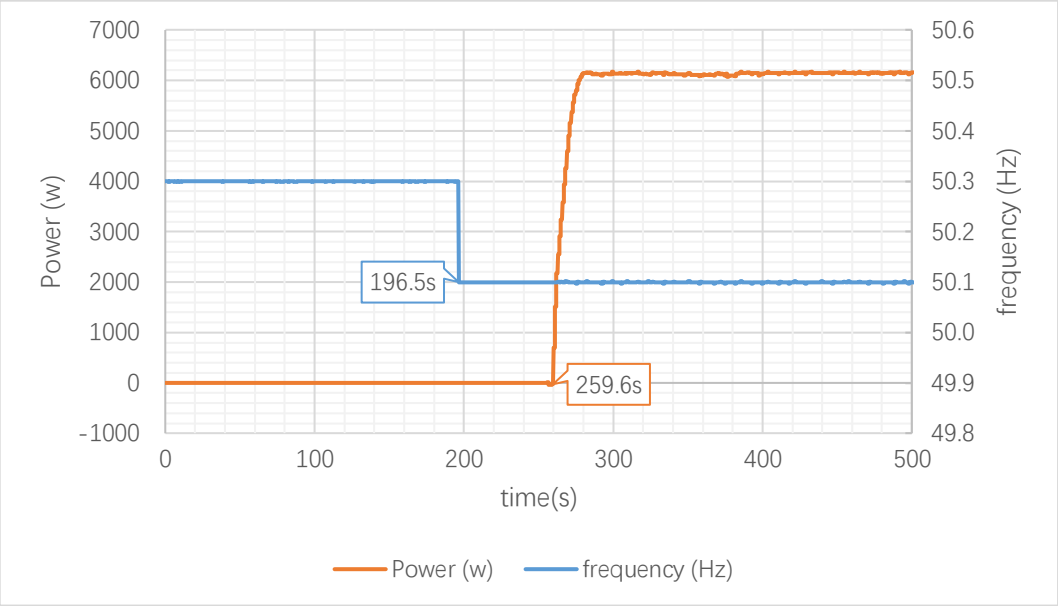
For manual operations performed on site (e.g. for the purpose of initial start-up or maintenance) it is permitted to deviate from the observation time and ramp rate.

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Starting connection: Lower frequency f≥ 49.50 Hz

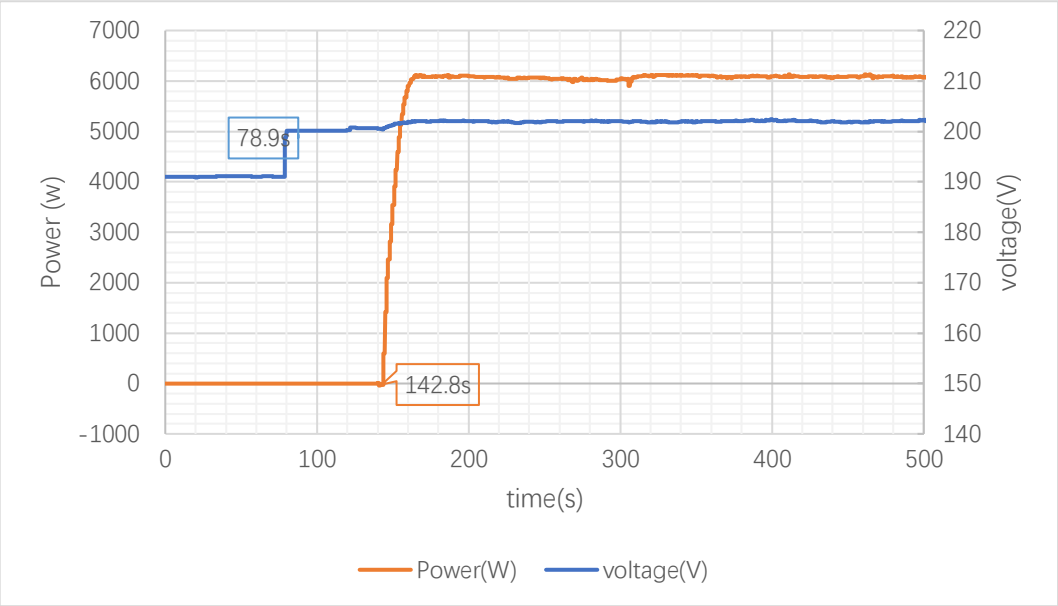


Starting connection: Upper frequency f ≤ 50.10 Hz

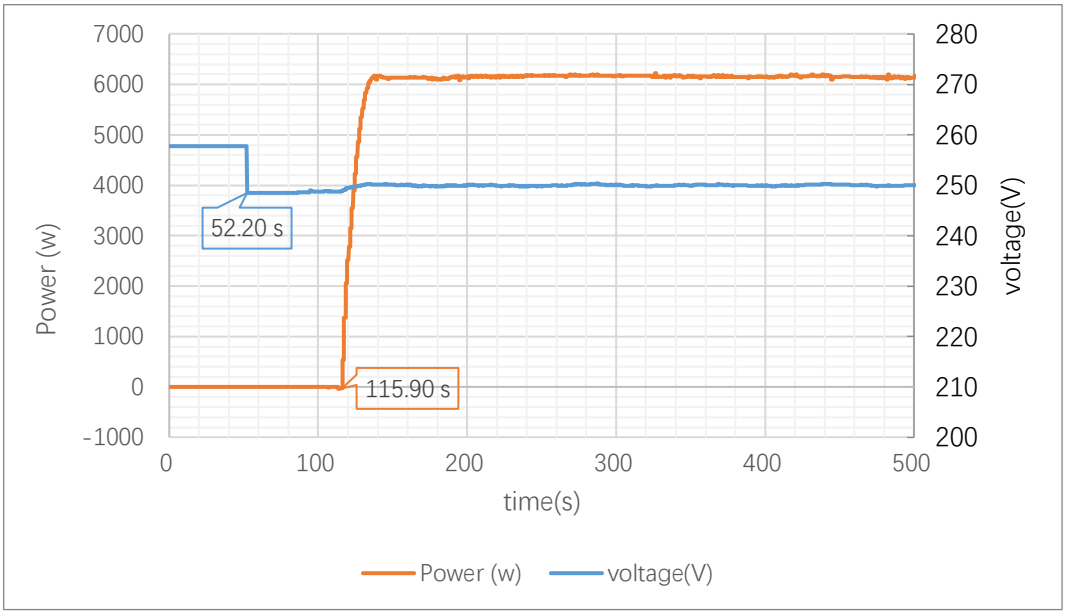


EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Starting connection: U ≥ 0,85 U_n



Starting connection: U ≤ 1,10 U_n



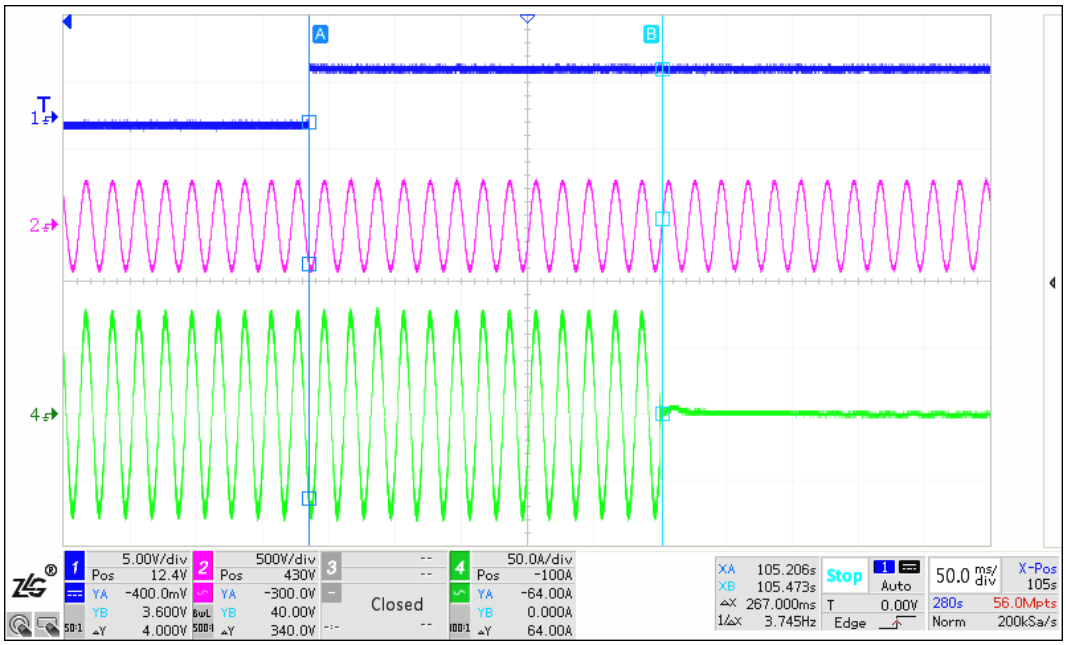
EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

4.11.1	**TABLE: Ceasing active power**	P

Reducing the active power form 100% *P*Amax to 0

Measured max power [kW]	Ceasing power [kW]	Ceasing time [s]	Limit [s]
6	0	0.267S	5

Graph for ceasing active power



EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

4.11.2	**TABLE: Reduction of active power on set point**		P
Test Conditions	Measurements		Limit
P/P_n	P/P_n	$\Delta P/P_n$	$\Delta P/P_n$
100%	102.3%	2.3%	≤ ± 5%
90%	92.7%	2.7%	
80%	82.1%	2.1%	
70%	71.6%	1.6%	
60%	62.1%	2.1%	
50%	51.4%	1.4%	
40%	41.1%	1.1%	
30%	30.6%	0.6%	
20%	21.0%	1.0%	
10%	10.6%	0.6%	
0-5%	5.6%	0.6%	--

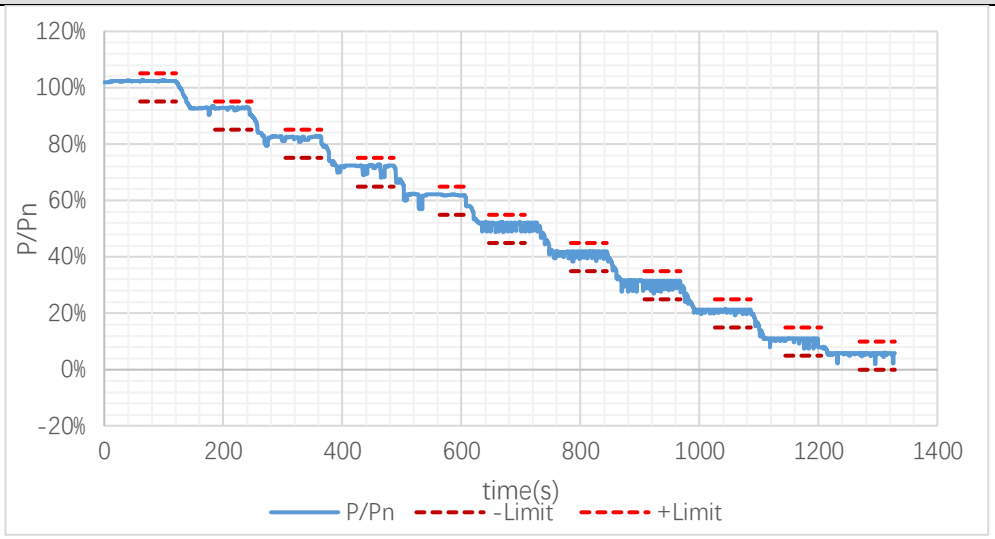
Test Conditions	Measurements	Limitation
P/P_n	Power gradient	Gradient
100%→5%	0.42%P_n / s	0.33-0.66%P_n / s
5%→100%	0.44%P_n / s	

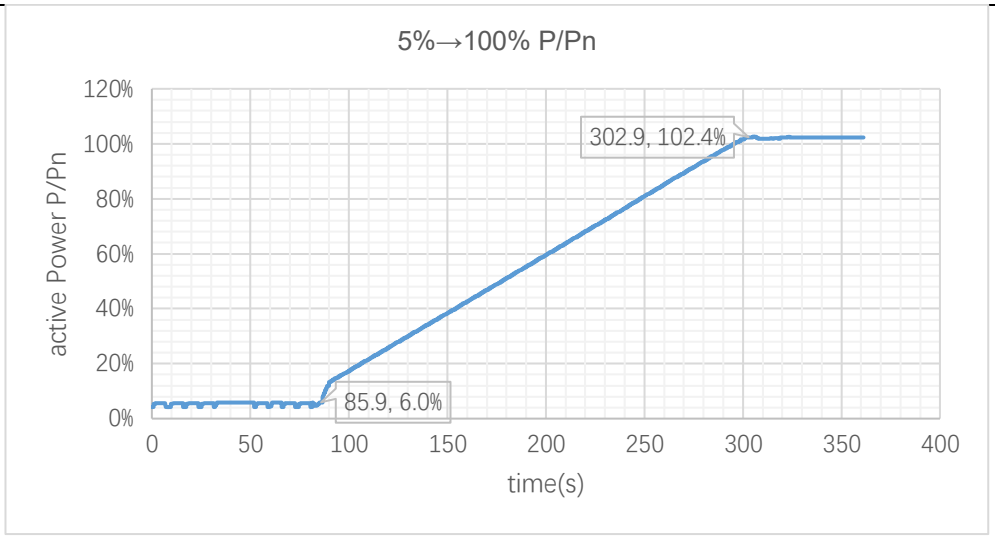
Note(s):
A generation unit/plant shall be capable of carrying out the power output reduction to the respective limit within an envelope of not faster than 0,66 % P_n/s and not slower than 0,33 % P_n/ s with an accuracy of 5 % of nominal power. Generating plants are permitted to disconnect from the network at a limit value below it minimum regulating level. If required by the DSO, this includes remote operation.

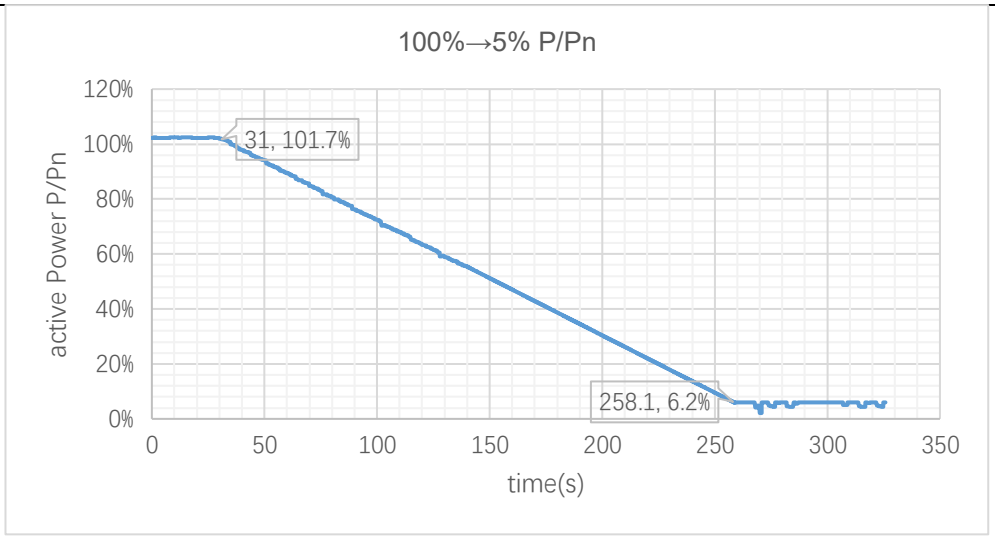
With a programmable AC source, the PGU is operated at 100% P_n and 50±0,01 Hz, set power factor equal to 1.

EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

Diagram of reduction of active power on set point







EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

4.13	**TABLE: Requirements regarding single fault tolerance of interface protection system and interface switch (Functional safety)**							**P**
	ambient temperature (°C) .....:				25			--
Component No.	Fault	test voltage (V)		Test time	fuse No.	fuse current (A)		Result
		AC	DC			AC	DC	
DSP failure (C38)	s-c	230 V	500 V	10 min	--	--	--	SID: communication fault SD: ☒ Yes / ☐ No DG: ☒ Yes / ☐ No RO: ☒ Yes / ☐ No NCD: ☒ Yes / ☐ No NH: ☒ Pass / ☐ Fail. DST: ☒ Pass / ☐ Fail.
DSP failure (U7)	s-c	241 V	500 V	10 min	--	--	--	SID: grid voltage fault SD: ☒ Yes / ☐ No DG: ☒ Yes / ☐ No RO: ☒ Yes / ☐ No NCD: ☒ Yes / ☐ No NH: ☒ Pass / ☐ Fail. DST: ☒ Pass / ☐ Fail.
DSP failure (R98)	o-c	40.8 V	500 V	10 min	--	--	--	SID: grid voltage fault SD: ☒ Yes / ☐ No DG: ☒ Yes / ☐ No RO: ☒ Yes / ☐ No NCD: ☒ Yes / ☐ No NH: ☒ Pass / ☐ Fail. DST: ☒ Pass / ☐ Fail.
PV/DC Voltage detector (R73)	o-c	240 V	500 V	10 min	--	--	--	SID: PV voltage fault, grid relay Disconnection SD: ☒ Yes / ☐ No DG: ☒ Yes / ☐ No RO: ☒ Yes / ☐ No NCD: ☒ Yes / ☐ No NH: ☒ Pass / ☐ Fail. DST: ☒ Pass / ☐ Fail.
PV/DC current detector (R32)	o-c	230 V	300 V	10 min	--	--	--	SID: DC-link overvoltage, PV over current, grid relay disconnection SD: ☒ Yes / ☐ No DG: ☒ Yes / ☐ No RO: ☒ Yes / ☐ No NCD: ☒ Yes / ☐ No NH: ☒ Pass / ☐ Fail. DST: ☒ Pass / ☐ Fail.

EN 50549-1								
Clause	Requirement - Test					Result - Remark		Verdict
BUS Voltag detector (R47)	o-c	230 V	500 V	10 min	--	--	--	SID: DC-link overvoltage, PV over current, grid relay disconnection SD: ☒ Yes / ☐ No DG: ☒ Yes / ☐ No RO: ☒ Yes / ☐ No NCD: ☒ Yes / ☐ No NH: ☒ Pass / ☐ Fail. DST: ☒ Pass / ☐ Fail.
Inverter current detector (R74)	o-c	230 V	300 V	10 min	--	--	--	SID: AC overcurrent, grid relay disconnection SD: ☒ Yes / ☐ No DG: ☒ Yes / ☐ No RO: ☒ Yes / ☐ No NCD: ☒ Yes / ☐ No NH: ☒ Pass / ☐ Fail. DST: ☒ Pass / ☐ Fail.
Inverter voltage detector (R77)	o-c	240 V	286 V	10 min	--	--	--	SID: de-rating to 50% powe operation SD: ☐ Yes / ☒ No DG: ☐ Yes / ☒ No o RO: ☒ Yes / ☐ No NCD: ☒ Yes / ☐ No NH: ☒ Pass / ☐ Fail. DST: ☒ Pass / ☐ Fail.
Grid/AC voltage detector (R98)	o-c	40.8 V	500 V	10 min	--	--	--	SID: grid voltage fault SD: ☒ Yes / ☐ No DG: ☒ Yes / ☐ No RO: ☒ Yes / ☐ No NCD: ☒ Yes / ☐ No NH: ☒ Pass / ☐ Fail. DST: ☒ Pass / ☐ Fail.
Relay / Contactor function check (K3)	s-c	240 V	500 V	10 min	--	--	--	SID: grid voltage fault SD: ☒ Yes / ☐ No DG: ☒ Yes / ☐ No RO: ☐ Yes / ☒ No NCD: ☒ Yes / ☐ No NH: ☒ Pass / ☐ Fail. DST: ☒ Pass / ☐ Fail.
Relay / Contactor function check (K1)	s-c	240 V	500 V	10 min	--	--	--	SID: grid voltage fault SD: ☒ Yes / ☐ No DG: ☒ Yes / ☐ No RO: ☐ Yes / ☒ No NCD: ☒ Yes / ☐ No

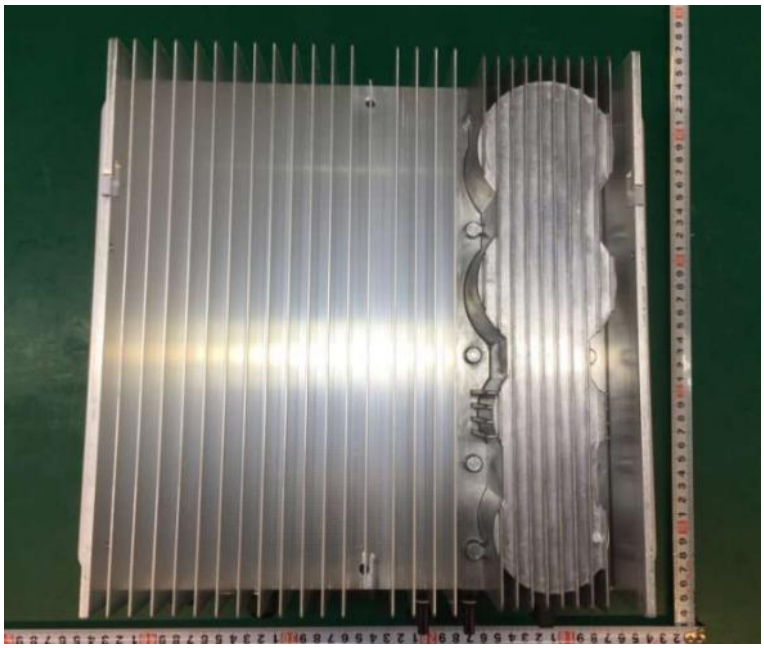
EN 50549-1			
Clause	Requirement - Test	Result - Remark	Verdict

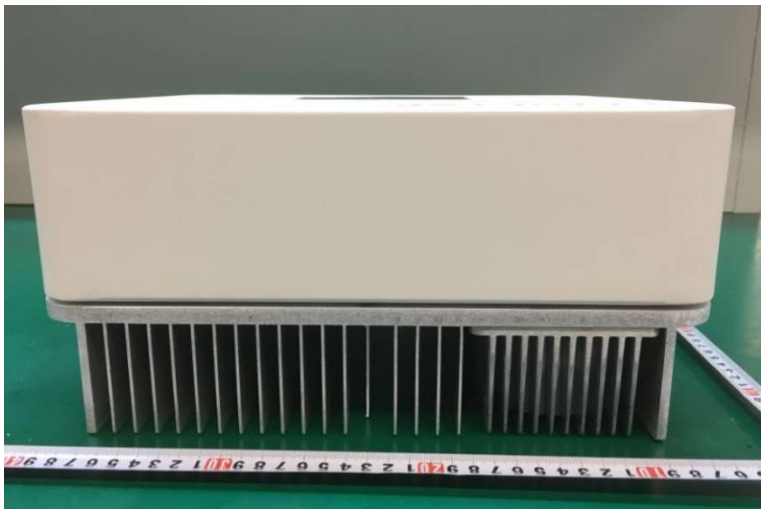
								NH: ☒ Pass / ☐ Fail. DST: ☒ Pass / ☐ Fail.
Ambient Temperatur detector (P2)	s-c	243 V	400 V	10 min	--	--	--	SID: R264 damage SD: ☒ Yes / ☐ No DG: ☒ Yes / ☐ No RO: ☐ Yes / ☒ No NCD: ☐ Yes / ☒ No NH: ☒ Pass / ☐ Fail. DST: ☒ Pass / ☐ Fail.
Ambient Temperatur detector (P2)	o-c	243 V	400 V	10 min	--	--	--	SID: PCE normal operation SD: ☐ Yes / ☒ No DG: ☐ Yes / ☒ No RO: ☐ Yes / ☒ No NCD: ☒ Yes / ☐ No NH: ☒ Pass / ☐ Fail. DST: ☒ Pass / ☐ Fail.
Heat-sink Temperatur detector (P24)	s-c	243 V	400 V	10 min	--	--	--	SID: PCE normal operation SD: ☐ Yes / ☒ No DG: ☐ Yes / ☒ No RO: ☐ Yes / ☒ No NCD: ☒ Yes / ☐ No NH: ☒ Pass / ☐ Fail. DST: ☒ Pass / ☐ Fail.

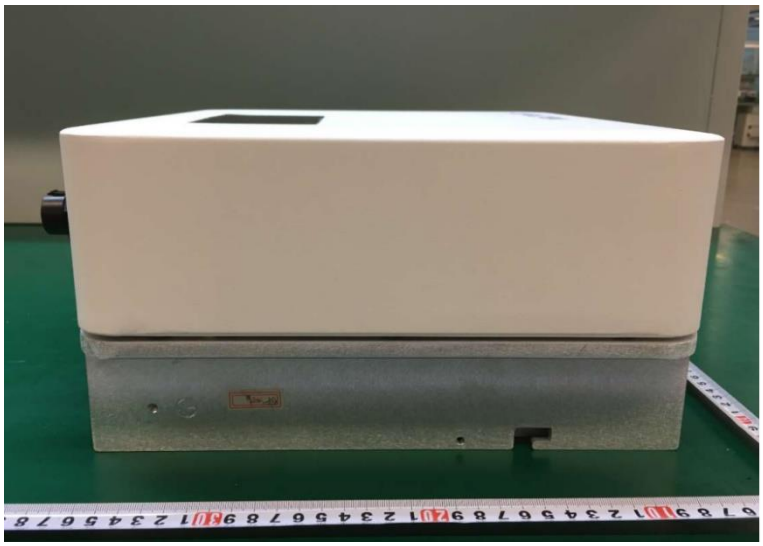
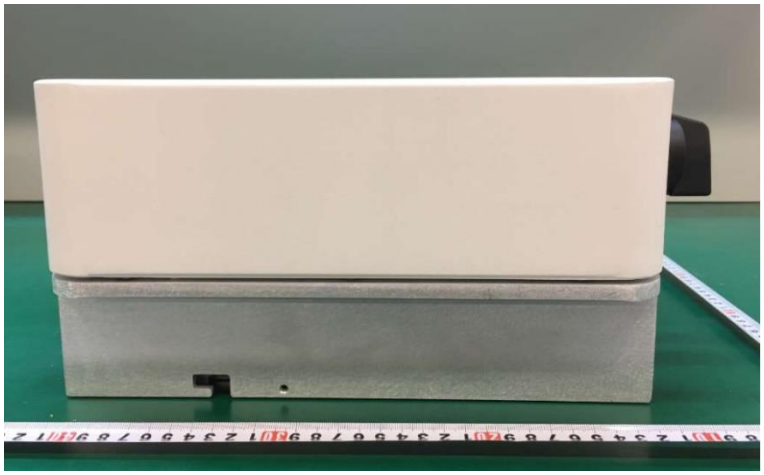
supplementary information:
The errors in the control circuit simulate that the safety is even under one error ensured.
s-c: short-circuited; o-c: open-circuited;
SID: Status Indication;
SD: EUT Shutdown;
DG: EUT Disconnect form the Grid;
RO: Recovered to Operate after removing the single fault setting;
NCD: No comp. or parts damaged;
NH: No Hazard; NR: No Reconnection
DST: Dielectric strength test

Appendix: Pictures

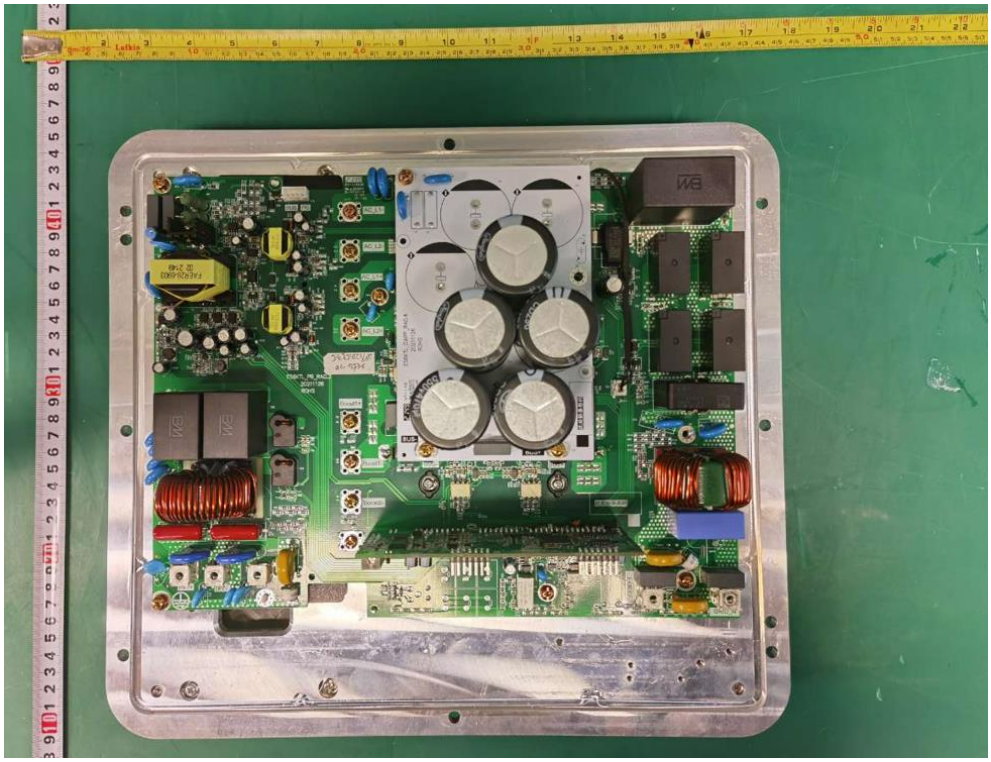
Enclosure –Front view of GT1-6KD1

Enclosure – Rear View of GT1-6KD1


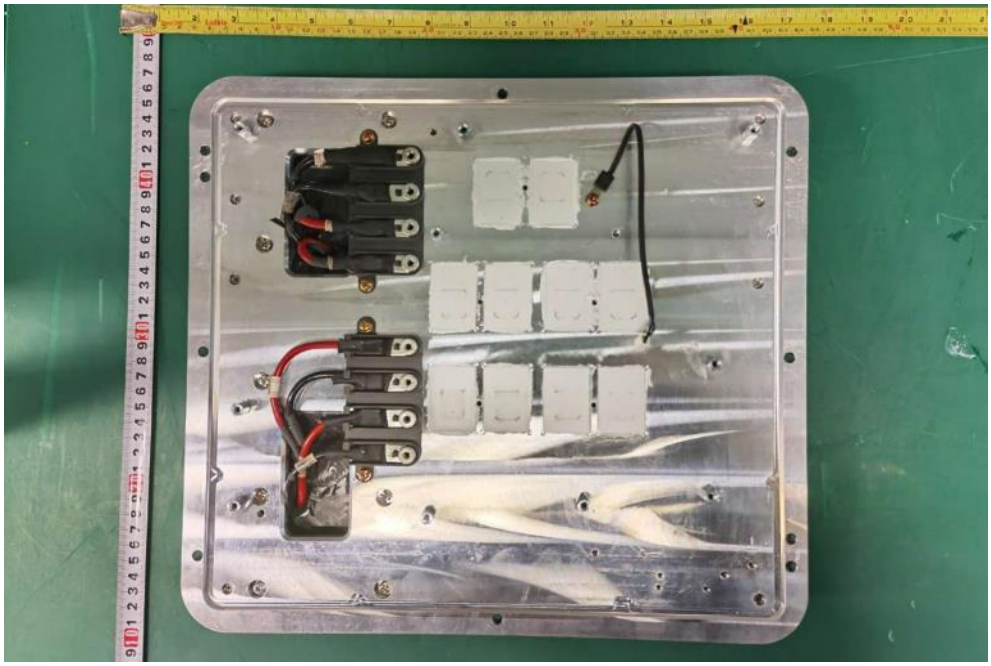
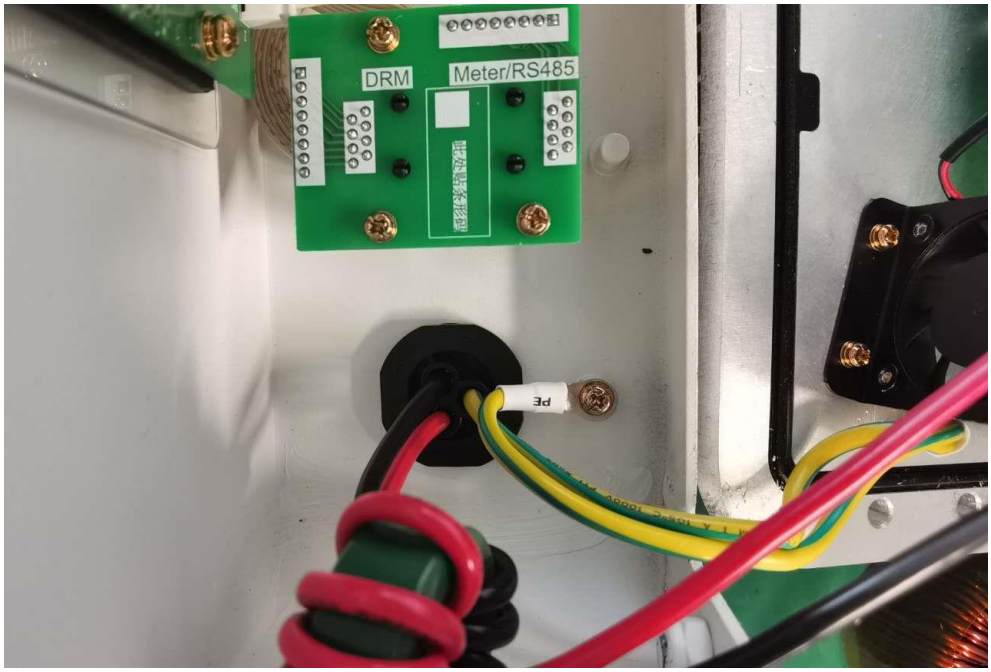
Enclosure –Top view of GT1-6KD1

Enclosure –Bottom view of GT1-6KD1

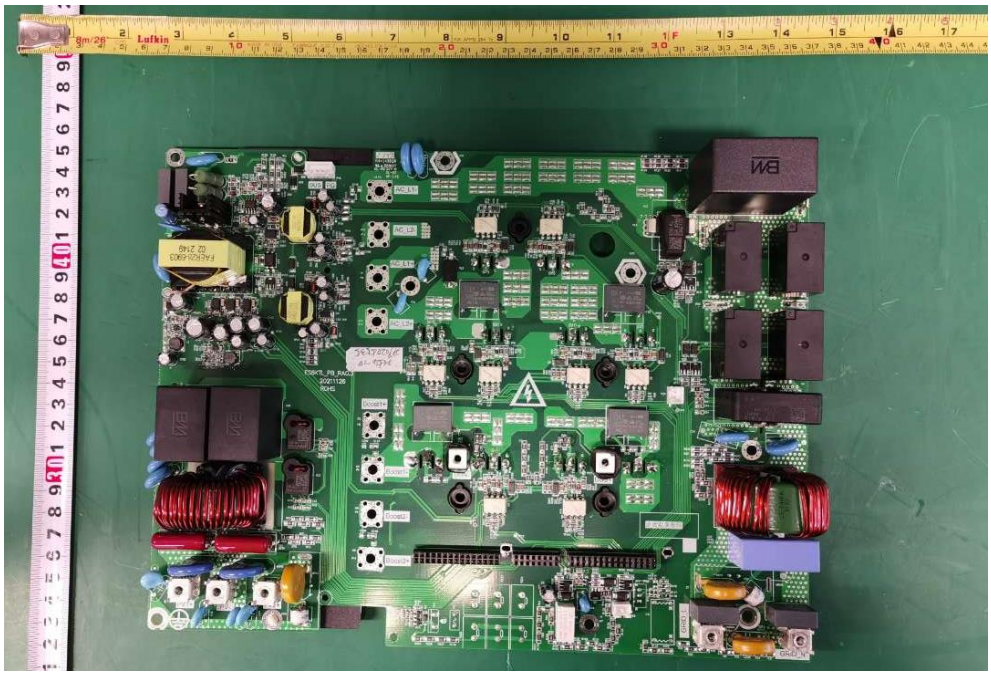
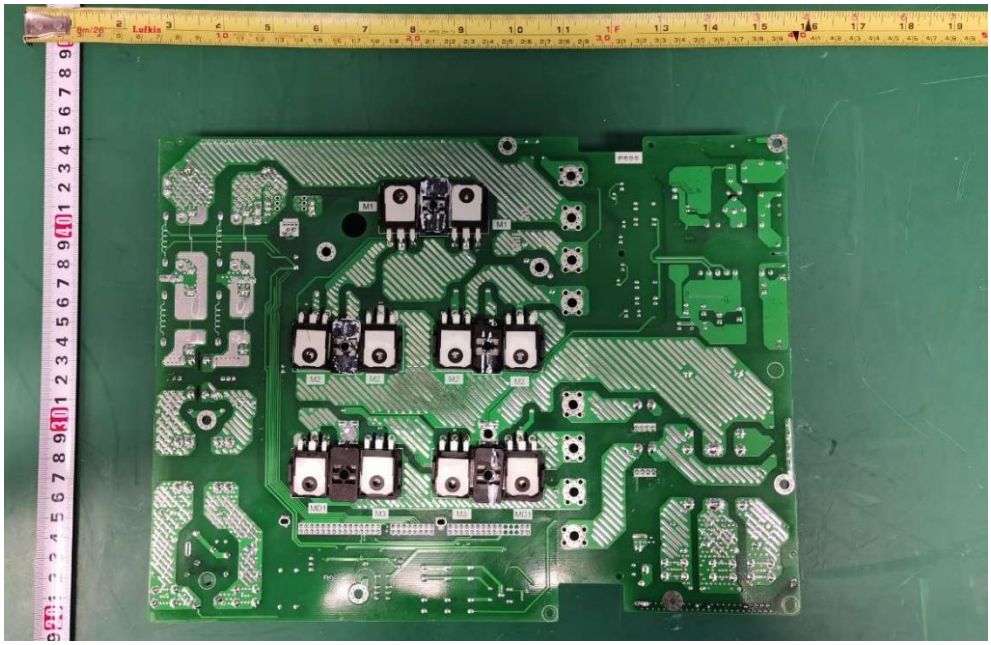

Enclosure –Right side view of GT1-6KD1

Enclosure –Left side view of GT1-6KD1


Internal view of GT1-6KD1

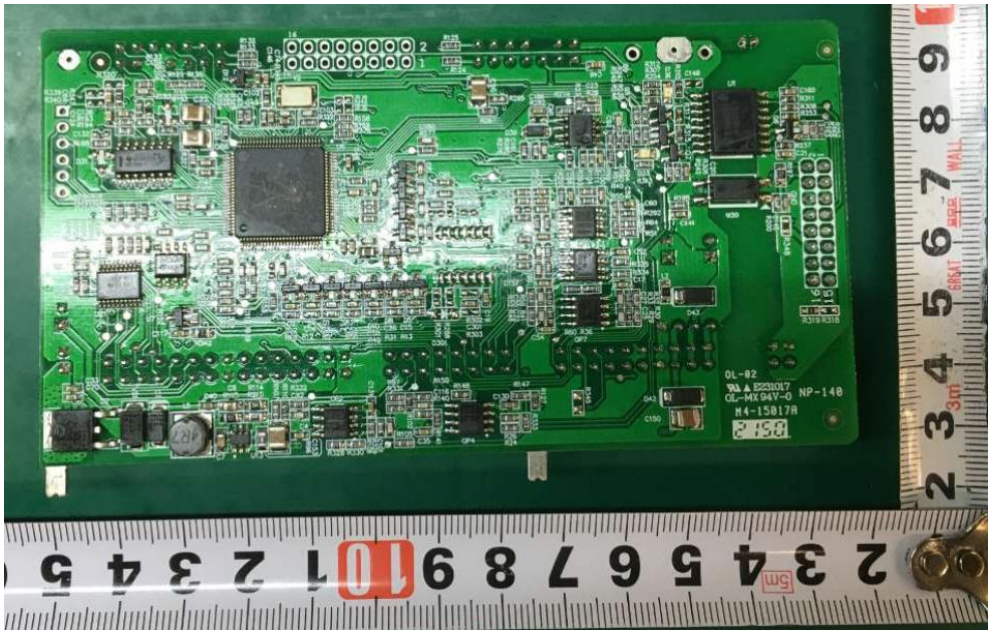


Internal view of GT1-6KD1

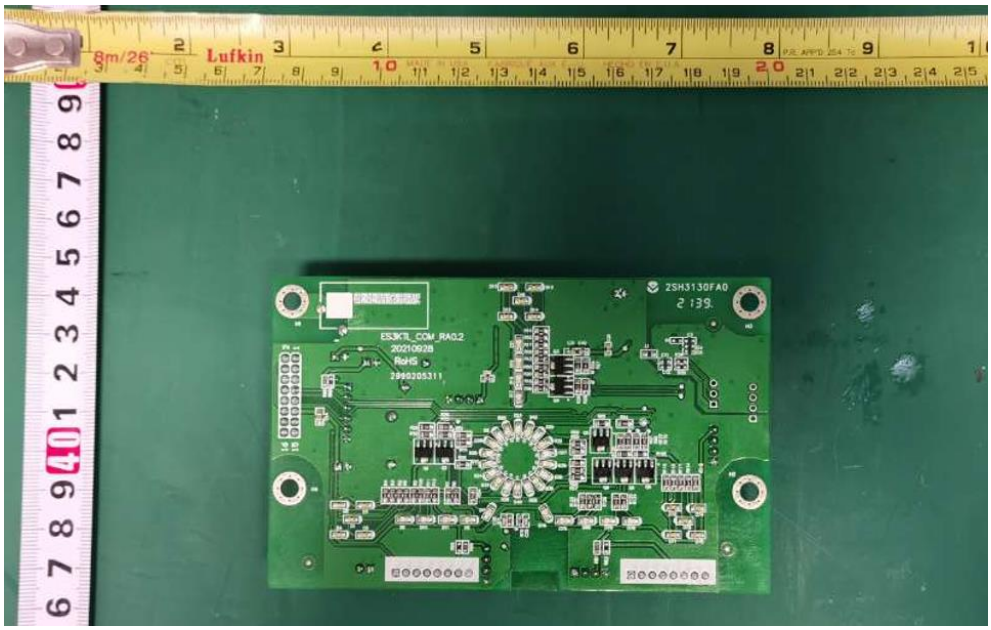
Internal view of GT1-6KD1

protective earth terminal of GT1-6KD1


Top side of PCBA ES6KTL_PB_RA0.3

Bottom side of PCBA ES6KTL_PB_RA0.3


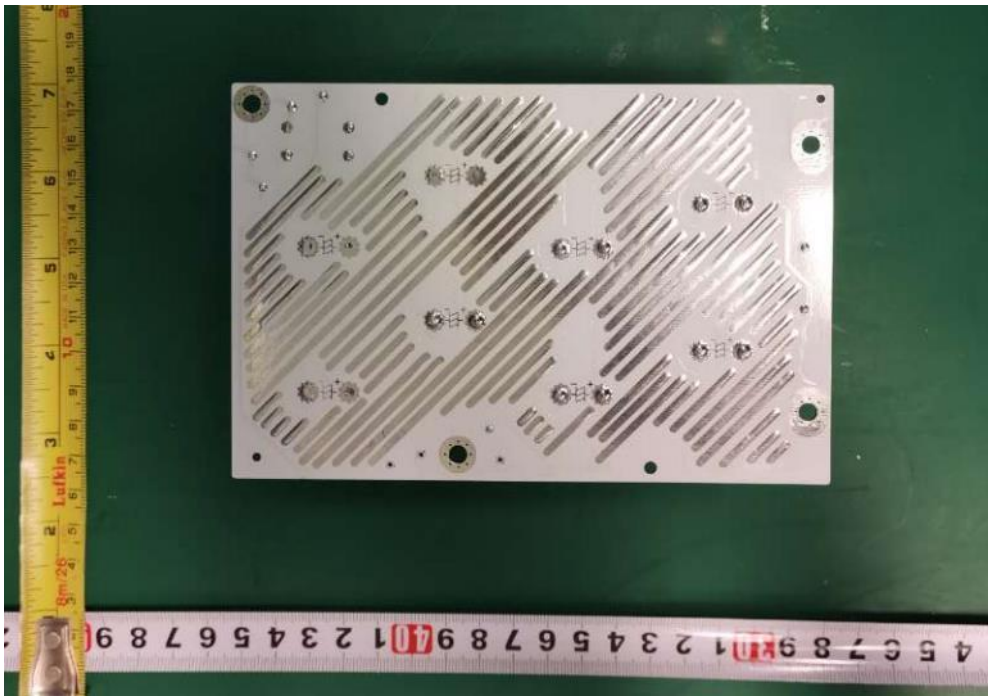
Top side of PCBA ES6KTL_CB_RA0.3

Bottom side of PCBA ES6KTL_CB_RA0.3


Top side of ESKTL_COM_RA0.4

Bottom side of ESKTL_COM_RA0.4


Top side of PCBA ES6KTL_CAPP_RA0.4

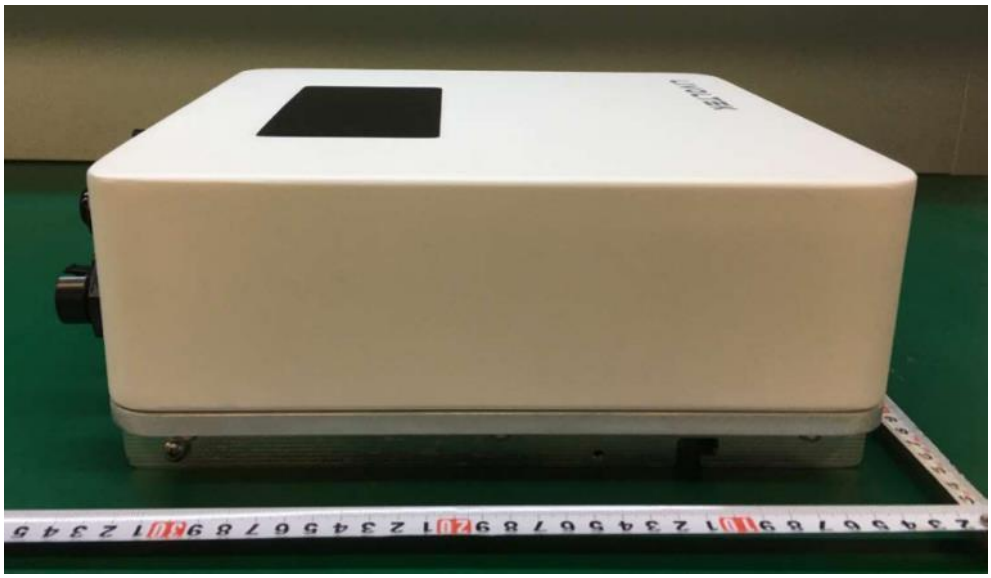
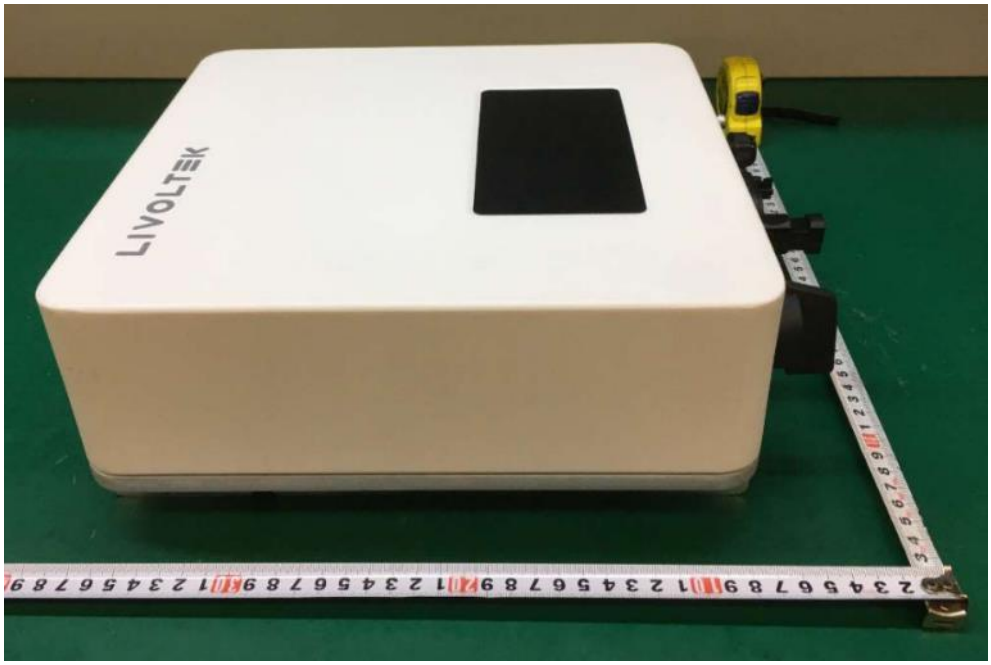
Bottom side of PCBA ES6KTL_CAPP_RA0.4


Enclosure –Front view of GT1-3K3S1

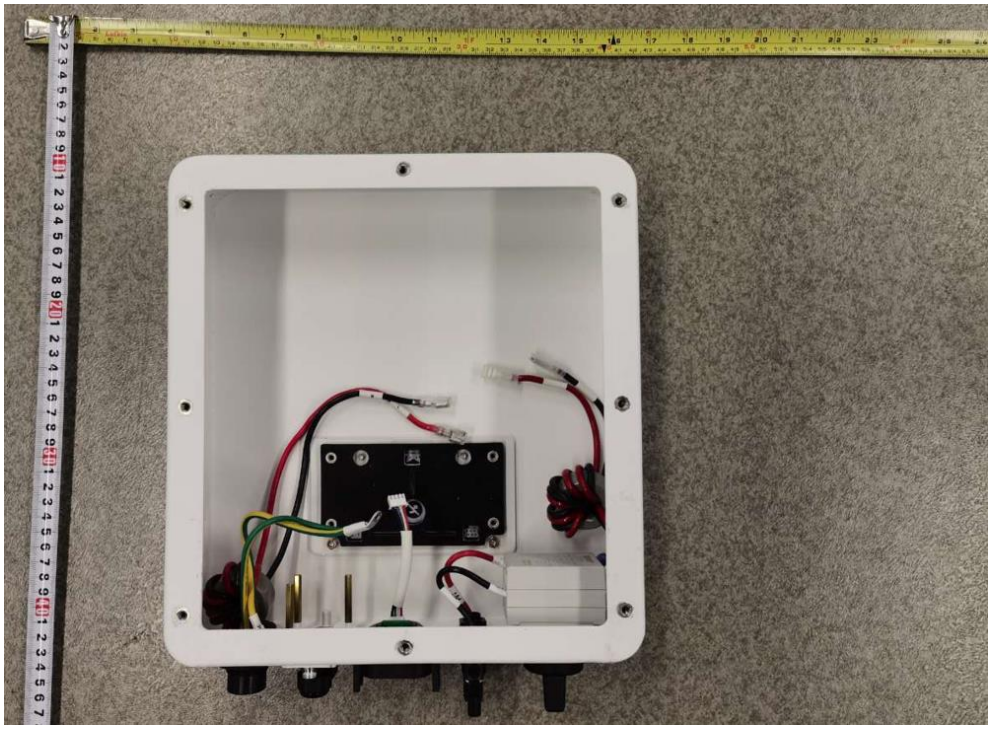
Enclosure – Rear View of GT1-3K3S1

Enclosure –Top view of GT1-3K3S1

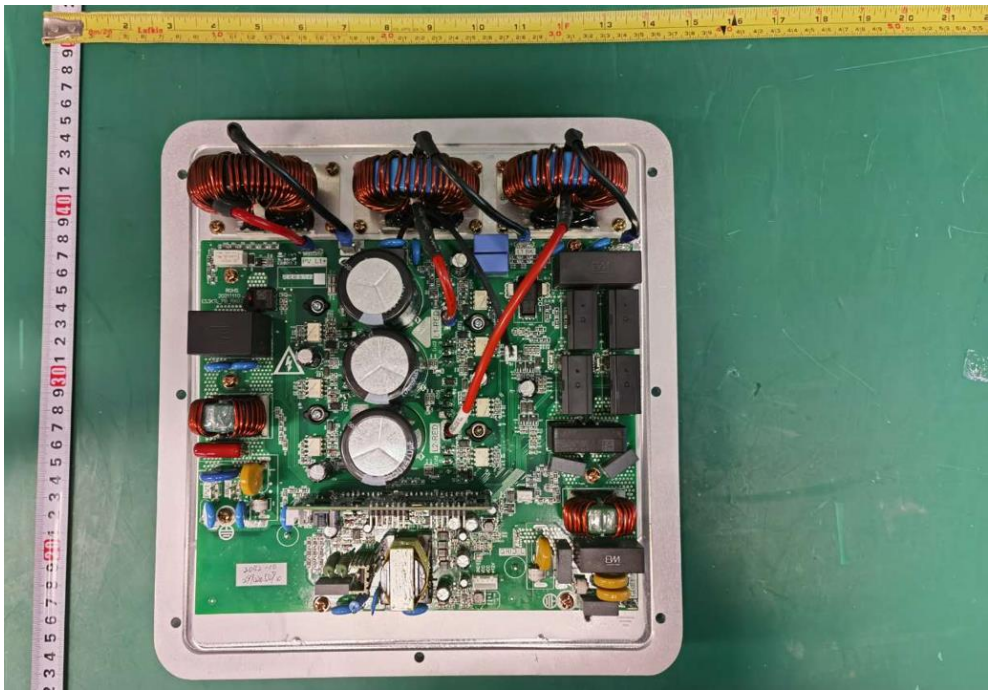
Enclosure –Bottom view of GT1-3K3S1


Enclosure –Right side view of GT1-3K3S1

Enclosure –Left side view of GT1-3K3S1


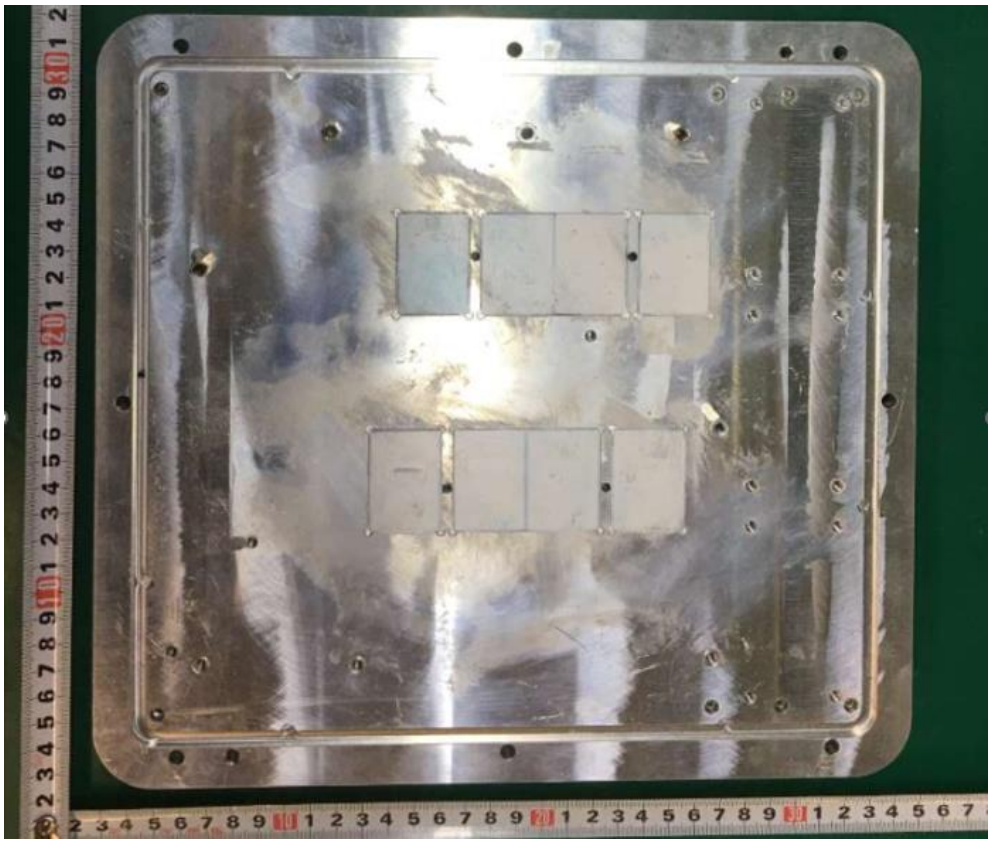
Internal view of GT1-3K3S1



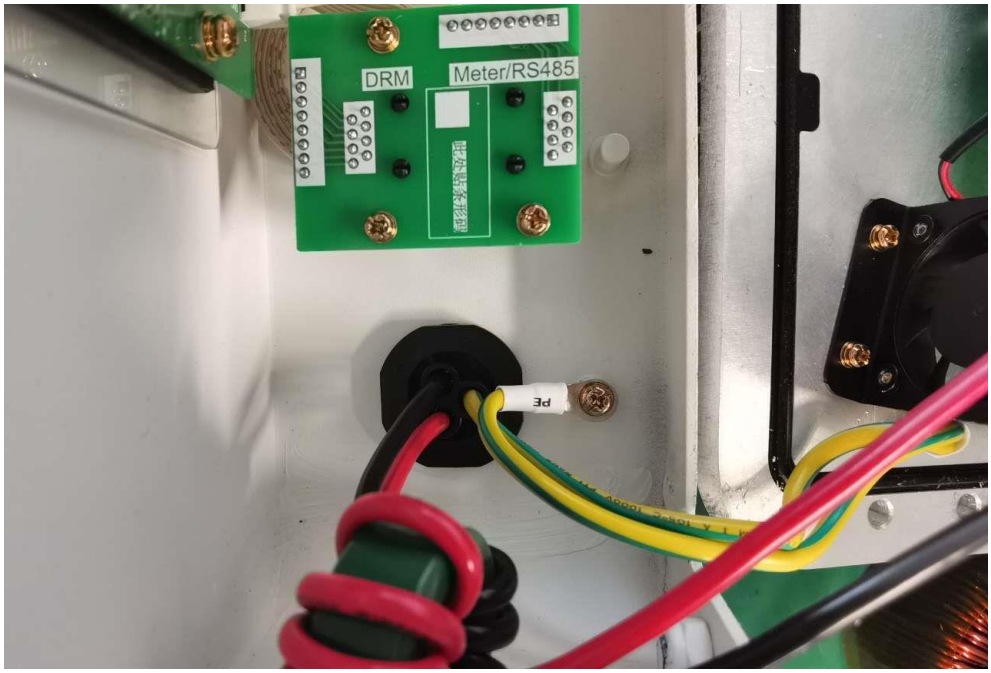
Internal view of GT1-3K3S1



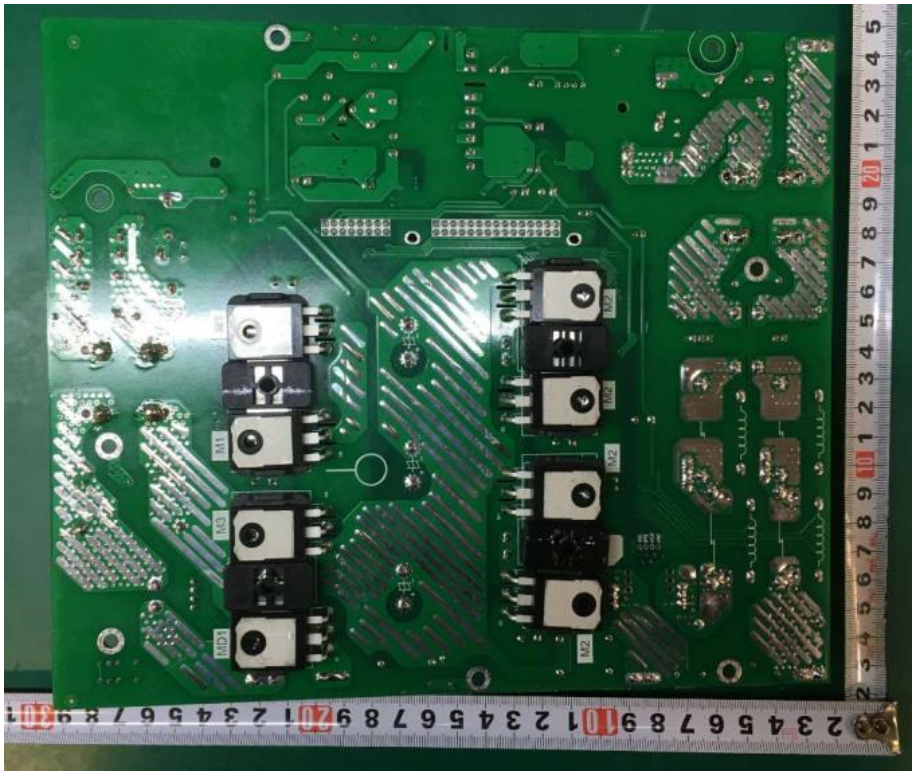
Internal view of GT1-3K3S1



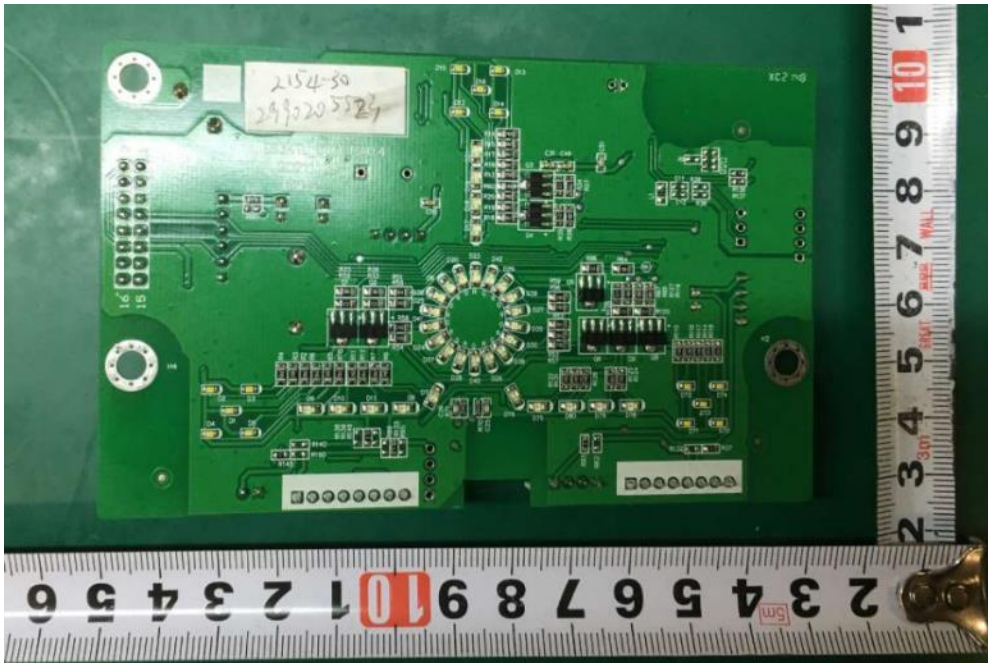
protective earth terminal GT1-3K3S1

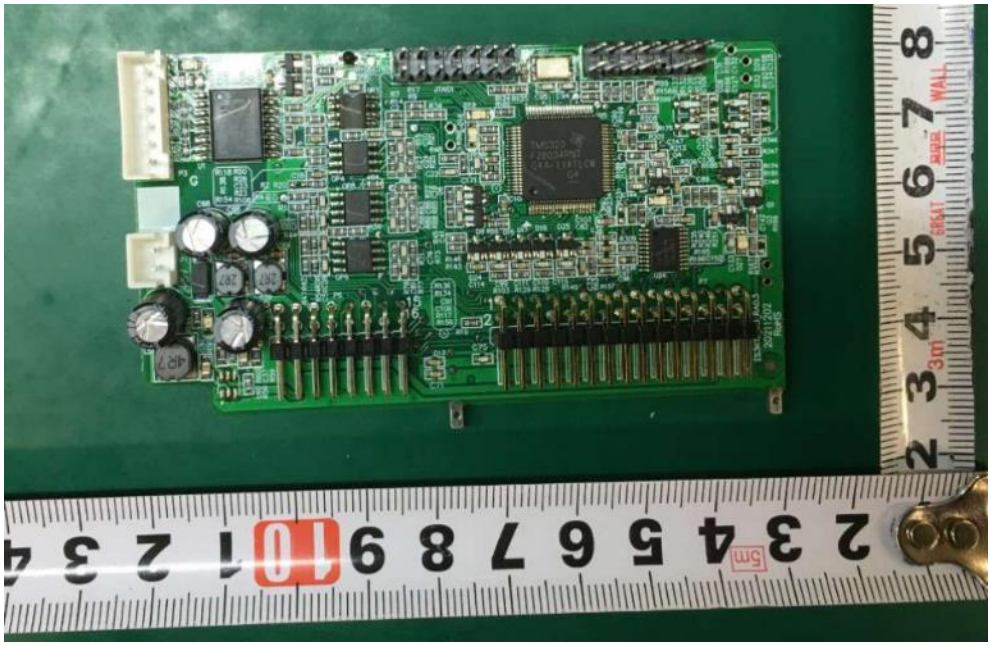


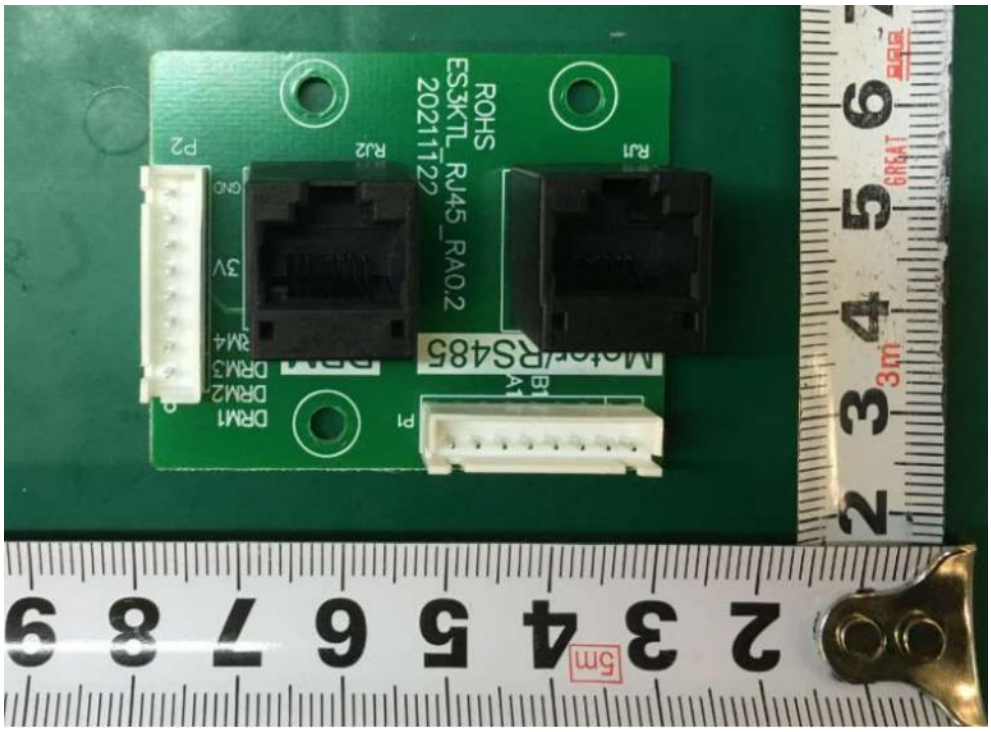
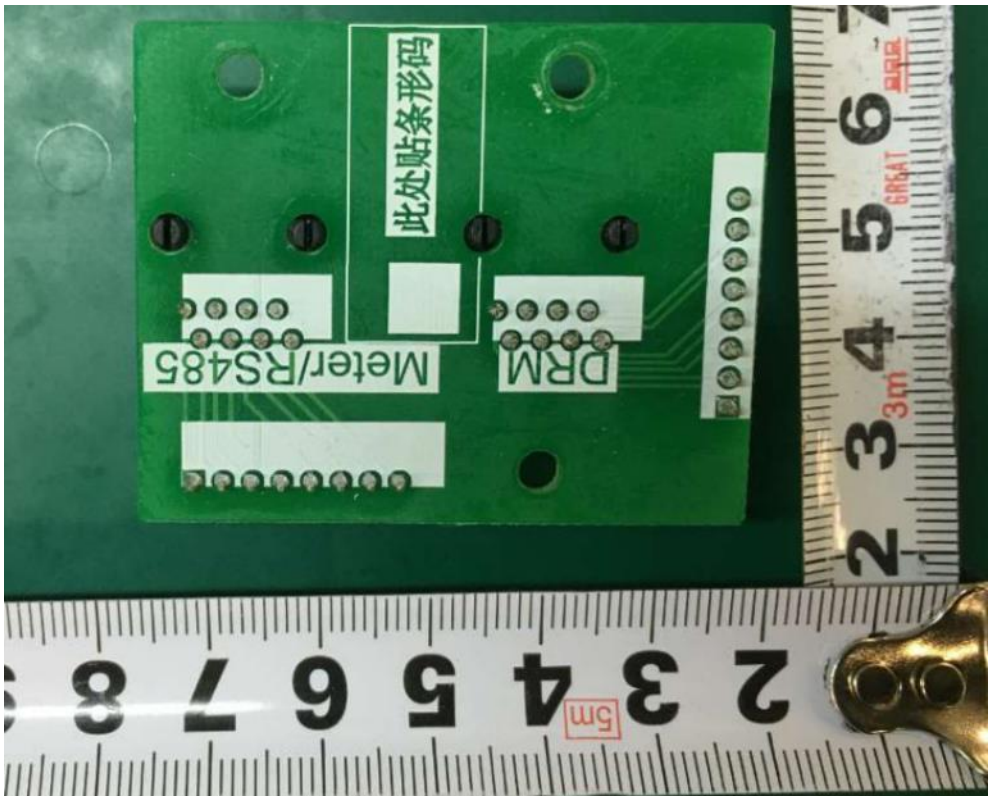
Top side of PCBA ES3KTL_PB_RA0.3

Bottom side of PCBA ES3KTL_PB_RA0.3


Top side of PCBA ES3KTL_COM_RA0.4

Bottom side of PCBA ES3KTL_COM_RA0.4


Top side of PCBA ES3KTL_CB_RA0.3

Bottom side of PCBA ES3KTL_CB_RA0.3


Top side of PCBA ES3KTL_RJ45_RA0.3

Bottom side of PCBA ES3KTL_RJ45_RA0.3


--- End of test report---

ATTESTATION OF CONFORMITY

Issued to:	Hangzhou Livoltek Power Co., Ltd. 1418-35 Moganshan Road, Shangcheng Industrial Zone, 310011 Hangzhou, Zhejiang Province, P.R. China.
For the product:	Grid-connected PV inverter
Trade name:	LIVOLTEK
Type/Model:	GT1-1K6S1, GT1-2K2S1, GT1-3KS1, GT1-3K3S1, GT1-3K6D1, GT1-4KD1, GT1-4K6D1, GT1-5KD1, GT1-6KD1
Ratings:	See Annex
Manufactured by:	Hangzhou Livoltek Power Co., Ltd. 1418-35 Moganshan Road, Shangcheng Industrial Zone, 310011 Hangzhou, Zhejiang Province, P.R. China
Requirements:	EN 50549-1:2019 (Requirements for type A Generating Units) COMMISSION REGULATION (EU) 2016/631 (NC RfG)

This Test Certificate is granted on account of an examination by DEKRA, the results of which are laid down in a confidential file no. 6138994.50

The examination has been carried out on one single specimen or several specimens of the product, submitted by the manufacturer. The certificate does not include an assessment of the manufacturer's production. Conformity of his production with the specimen tested by DEKRA is not the responsibility of DEKRA.

Arnhem, 28 November 2022 Number: 6138994.01AOC

DEKRA Testing and Certification (Shanghai) Ltd.

Kreny Lin
Certification Manager

DEKRA Testing and Certification (Shanghai) Ltd.
3F #250 Jiangchangsan Road Shibei Hi-Tech Park, 200436 Jing'an District, Shanghai, China
T +86 21 6056 7666 F +86 21 6056 7555 www.dekra-product-safety.com

Annex

Document no. : 6138994.01AOC

Ratings of the test product:

Technical Data	GT1-1K6S1	GT1-2K2S1	GT1-3KS1	GT1-3K3S1	GT1-3K6D1	GT1-4KD1	GT1-4K6D1	GT1-5KD1	GT1-6KD1
PV Input Data									
Max DC Input Power [W]	2400	3300	4500	4950	5400	6000	6900	7500	9000
Max DC Input Voltage[V]	550				550				
Min PV input voltage[V]	50				70				
Start-up DC Input Voltage[V]	70				90				
Nominal DC Input Voltage[V]	400				400				
MPPT Operating Range[V]	50-545				70-545				
MPPT Operating Range (Full-Load) [V]	120-500	165-500	225-500	250-500	135-500	150-500	170-500	185-500	225-500
Max DC Input Current[A]	14				14+14				
Max Short Circuit current[A]	20				20+20				
AC Output Data									
Nominal Output Power [W]	1600	2200	3000	3300	3600	4000	4600	5000	6000
Max Apparent Power [VA]	1760	2420	3300	3300	3960	4400	4600	5500	6600
Rated AC Grid Output Current[A]	7.0	9.6	13.0	14.3	15.7	17.4	20.0	21.7	26.1
Max AC Output Current[A]	7.7	10.5	14.3	14.3	17.2	19.1	20.0	23.9	28.7
Rated AC Grid Voltage[V]	220V/230V, L+N+PE								
AC Grid Voltage Range[V]	160-300								
Rated Grid Frequency [Hz]	50/60								
Grid Frequency Range [Hz]	45-55/55-65								
Power Factor	> 0.99 Rated power (Adjustable 0.8 Leading - 0.8Lagging)								

--- End ---

AUTHORIZATION TO MARK

This authorizes the application of the Certification Mark(s) shown below to the models described in the Product(s) Covered section when made in accordance with the conditions set forth in the Certification Agreement and Listing Report. This authorization also applies to multiple listee model(s) identified on the correlation page of the Listing Report.

This document is the property of Intertek Testing Services and is not transferable. The certification mark(s) may be applied only at the location of the Party Authorized To Apply Mark.

Applicant:	Hangzhou Livoltek Power Co., Ltd.	**Manufacturer:**	Hangzhou Livoltek Power Co., Ltd.
Address:	1418-35 Moganshan Road, Shangcheng Industrial Zone,310011 Hangzhou, Zhejiang Province	**Address:**	1418-35 Moganshan Road, Shangcheng Industrial Zone,310011 Hangzhou, Zhejiang Province
Country:	China	**Country:**	China

Party Authorized To Apply Mark: Same as Manufacturer
Report Issuing Office: Intertek Testing Services Shanghai Limited

Control Number: ***5023638*** **Authorized by:** for L. Matthew Snyder, Certification Manager

This document supersedes all previous Authorizations to Mark for the noted Report Number.

Intertek Testing Services NA Inc.
545 East Algonquin Road, Arlington Heights, IL 60005
Telephone 800-345-3851 or 847-439-5667 Fax 312-283-1672

Standard(s):	Inverters, Converters, Controllers and Interconnection System Equipment for use with Distributed Energy Resources [UL 1741:2021 Ed.3] Interconnecting Distributed Resources With Electric Power Systems (R2008) [IEEE 1547:2003] Amendment 1 to IEEE 1547 - Interconnecting Distributed Resources With Electric Power Systems [IEEE 1547a:2014] Standard Conformance Test Procedures For Equipment Interconnecting Distributed Resources With Electric Power Systems [IEEE 1547.1:2005]
Product:	Grid-connected PV inverter (Non-Isolated Utility Interactive Inverter)
Brand Name:	LIVOLTEK
Models:	GT1- followed by 1K6S1, 2K2S1, 3KS1, 3K3S1, 3K6D1, 4KD1, 4K6D1, 5KD1 or 6KD1.

CERTIFICATE

of Conformity
Low Voltage Directive 2014/35/EU

Registration No.: AN 50541814 0001

Report No.: CN22IJ7D 001

Holder:

Hangzhou Livoltek Power Co.,Ltd
1418-35 Moganshan Road,
Hangzhou,
310011 Zhejiang
P.R. China

Product:

PV-Inverter
ON-GRID SOLAR INVERTER

Identification:

Type Designation: GT1-1K6S1 GT1-2K2S1 GT1-3KS1 GT1-3K3S1
GT1-3K6D1 GT1-4KD1 GT1-4K6D1 GT1-5KD1
GT1-6KD1
Serial Number : Engineering samples
Remark : Refer to test report CN22IJ7D 001
for details.

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 Annex I of Council Directive 2014/35/EU, referred to as the Low Voltage Directive. This certificate does not imply assessment of the series-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 Annex IV of the Directive.

Certification Body

Date 28.04.2022

Weichun Li

TÜV Rheinland LGA Products GmbH - Tillystraße 2 - 90431 Nürnberg

CE The CE marking may 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.

Hangzhou Livoltek Power Co.,Ltd
Jesse Xia

1418-35 Moganshan Road,
Hangzhou,
310011 Zhejiang
P.R. China

Date : 28.04.2022
Our ref. : zhoudav 02
Your ref.: Jesse Xia

Ref : AN Certificate of Conf. Low Voltage D.

Type of Equipment : ON-GRID SOLAR INVERTER
Model Designation : See Certificate
Certificate No. : AN 50541814 0001
Report No. : CN22IJ7D 001

Dear Jesse Xia,

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

Weichun Li

Enclosure

TÜV Rheinland (China) Ltd.
莱茵检测认证服务（中国）有限公司
Room 301, 3F and Room 1203, 12F, Building C, CATIC Plaza , No. 15, Ronghua South Road, Beijing Economic-Technological Development Area, 100176, Beijing
北京市北京经济技术开发区荣华南路15号院中航技广场C座3层301室、12层1203室
邮编：100176
Tel: 86 10 8524 2222
Fax: 86 10 8524 2200
e-mail: info@bj.chn.tuv.com
Internet: http://www.chn.tuv.com

CERTIFICATE
of Conformity

TÜVRheinland®

Registration No.: AK 50538658 0001

Report No.: CN22RQA2 001

Holder:
Hangzhou Livoltek Power Co.,Ltd
1418-35 Moganshan Road,
Hangzhou,
310011 Zhejiang
P.R. China

Product:
PV-Inverter
(Grid Connected PV Inverter)

Identification:

Type Designation	: GT1-1K6S1	GT1-2K2S1	GT1-3KS1
	GT1-3K3S1	GT1-3K6D1	GT1-4KD1
	GT1-4K6D1	GT1-5KD1	GT1-6KD1
Serial Number	: Engineering Sample		
Firmware Version	: GT12LTK1ACA_Ver1.01		
Remark	: Refer to test report CN22RQA2 001 for detail.		

Tested acc. to:
IEC 61727:2004
IEC 62116:2014

The certificate of conformity refers to the above mentioned product. This is to certify that the specimen is in conformity with the assessment requirement mentioned above. 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.

Certification Body

TÜV Rheinland LGA Products GmbH TÜVRheinland®

Date 12.04.2022

Weichun Li

TÜV Rheinland LGA Products GmbH - Tillystraße 2 - 90431 Nürnberg

C E R T I F I C A T E

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

TÜVRheinland®

Registration No.: AE 50533067 0001

Report No.: CN21Y10O 001

Holder:
Hangzhou Livoltek Power Co.,Ltd
1418-35 Moganshan Road,
Hangzhou,
310011 Zhejiang
P.R. China

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

Identification:
See type designations in attachment 1.1
Serial No.: n.a.
Remark: Refer to test report CN21Y10O 001 for details.

Tested acc. to:
EN IEC 61000-6-4:2019
EN IEC 61000-6-3:2021
EN IEC 61000-6-2:2019
EN IEC 61000-6-1:2019
IEC 61000-6-4:2018
IEC 61000-6-3:2020
IEC 61000-6-2:2016
IEC 61000-6-1:2016

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

TÜV Rheinland LGA Products GmbH Zertifizierungsstelle TÜVRheinland

Date 17.02.2022

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

TÜVRheinland®

1.1

TÜV Rheinland
LGA Products GmbH
Tillystraße 2, 90431 Nürnberg

Attachment to
Registration No.: AE 50533067 0001
Report No.: CN21Y10O 001

Manufacturer: Hangzhou Livoltek Power Co.,Ltd
1418-35 Moganshan Road,
Hangzhou,
310011 Zhejiang
P.R. China

Scope: type designation:

GT1-1K6S1	GT1-2K2S1	GT1-3KS1	GT1-3K3S1	
GT1-3K6D1	GT1-4KD1	GT1-4K6D1	GT1-5KD1	GT1-6KD1

TÜV Rheinland LGA Products GmbH Zertifizierungsstelle

Certification Body

Date: 2022-02-17

Xinhua Lu

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

TÜVRheinland®
Precisely Right.

Hangzhou Livoltek Power Co.,Ltd

Date : 17.02.2022
Our ref. : Zhangleoh 01
Your ref.: X. J. G.

1418-35 Moganshan Road,
Hangzhou,
310011 Zhejiang
P.R. China

Ref : AE Certificate of Conformity EMC

Type of Equipment : Grid-connected PV Inverter
Model Designation : See Certificate
Certificate No. : AE 50533067 0001
Report No. : CN21Y10O 001

Dear Ladies and Gentlemen,

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: Hangzhou Livoltek Power Co.,Ltd

Enclosure