TEST REPORT
VDE-AR-N 4105:2011 in conjunction with E DIN V VDE V 0124-100:2012
Power generation systems connected to the low-voltage distribution network

Report Reference No. ..... :	180903074GZU-001
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Testing Laboratory ..... :	Intertek Testing Services Shenzhen Ltd. Guangzhou Branch
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Testing location/ address ..... :	Same as above
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Approved by (+ signature) ..... :	Tommy Zhong Assistant Technical Manager
Applicant's name ..... :	Shenzhen SOFAR SOLAR Co., Ltd.
Address ..... :	401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China
Test specification:	
Standard ..... :	VDE-AR-N 4105:2011 in conjunction with E DIN V VDE V 0124-100:2012-07
Test procedure ..... :	Type approval
Non-standard test method..... :	N/A
Test Report Form No. ..... :	VDE-AR-N 4105b
Test Report Form(s) Originator ..... :	Intertek Taiwan
Master TRF ..... :	Dated 2013-10

Test item description ..... :	Hybrid Inverter
Trade Mark ..... :	SOFAR SOLAR
Manufacturer ..... :	Same as Applicant
Model/Type reference ..... :	HYD 6000-ES, HYD 5000-ES, HYD 4000-ES, HYD 3600-ES, HYD 3000-ES

Rating……:

Model	HYD 3000-ES	HYD 3600-ES	HYD 4000-ES	HYD 5000-ES	HYD 6000-ES
Max. DC Input Voltage	600 d.c.V				
Max. PV Isc	2 X 15 d.c.A				
Battery Type	Lead-acid, Lithium-ion				
Battery Voltage Range	42-58 d.c.V				
Max. Charging Current	65 d.c.A				
Max. Discharging Current	70 d.c.A				
Max. Charging & Discharging Power	3000VA				
Nominal Grid voltage	230 a.c.V				
Nominal Output Voltage (backup)	230 a.c.V				
Max. output current	13.7 a.c.A	16 a.c.A	18.2 a.c.A	22.8 a.c.A	27.3 a.c.A
Nominal Grid Frequency	50Hz				
Power Factor	1 (adjustable +/-0.8)				
Nominal output power	3000VA	3680VA	4000VA	5000VA	6000VA
Backup Rated current	13.2 a.c.A				
Backup Rated Apparent Power	3000VA				
Ingress Protection	IP 65				
Protective Class	Class I				
Operating temperature range	-25 ~ +60℃				
FW Version	V1.00				

Summary of testing:

Tests performed (name of test and test clause):

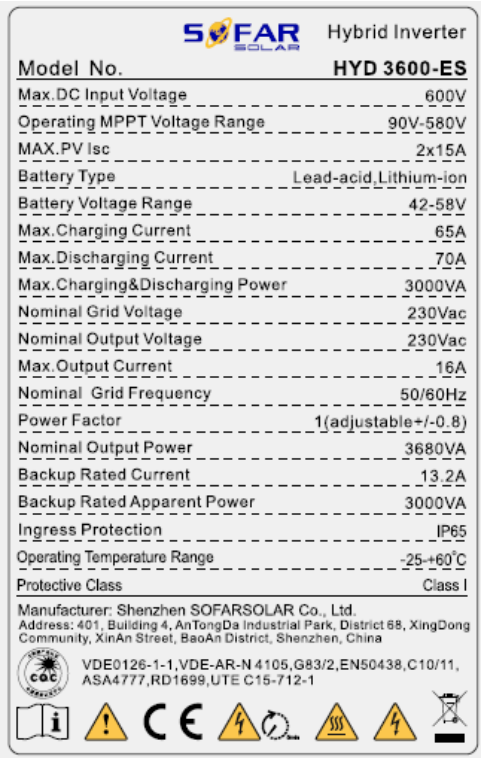
VDE4105 (VDE0124)	Test Description
5.4.2 (5.1.2)	Rapid voltage change
5.4.3 (5.1.3)	Flicker
5.4.4 (5.1.4)	Harmonics and inter-harmonics
5.5 & 5.6 (5.2)	Symmetry Behavior of Three-Phase Inverter Units
5.7.3.2 (5.3.3)	Generation management/network security management
5.7.3.3 (5.3.4)	Active power feed-in at overfrequency
5.7.3.4 (5.3.5)	Active power feed-in at underfrequency
5.7.5 (5.3.2 & 5.3.6)	Measurement of reactive and active power range
6.3 (5.4.3)	Integrated NS protection
6.4 (5.4.4.1 & 5.4.4.2)	Interface switch
6.5.1 (5.4.5.1 & 5.4.5.2)	Protective arrangements for the Interface switch
6.5.2 (5.4.5.3 & 5.4.5.5)	Protective functions
6.5.3 (5.4.6.1& 5.4.6.2)	Islanding detection
8.3.1 (5.4.7.1 & 5.4.7.2)	Connection conditions and synchronisation
8.3.4	Connection of power generation units with inverters

Testing location:

Intertek Testing Services Shenzhen Ltd. Guangzhou Branch

Block E, No.7-2 Guang Dong Software Science Park, Caipin Road, Guangzhou Science City, GETDD, Guangzhou, China

Copy of representative marking plate (representative):

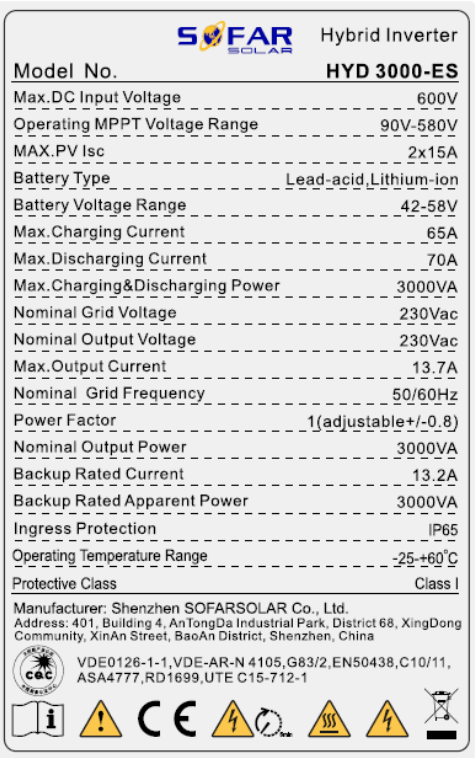


SOFAR SOLAR Hybrid Inverter

Model No.	HYD 3600-ES
Max.DC Input Voltage	600V
Operating MPPT Voltage Range	90V-580V
MAX.PV Isc	2x15A
Battery Type	Lead-acid,Lithium-ion
Battery Voltage Range	42-58V
Max.Charging Current	65A
Max.Discharging Current	70A
Max.Charging&Discharging Power	3000VA
Nominal Grid Voltage	230Vac
Nominal Output Voltage	230Vac
Max.Output Current	16A
Nominal Grid Frequency	50/60Hz
Power Factor	1(adjustable+/-0.8)
Nominal Output Power	3680VA
Backup Rated Current	13.2A
Backup Rated Apparent Power	3000VA
Ingress Protection	IP65
Operating Temperature Range	-25-+60°C
Protective Class	Class I

Manufacturer: Shenzhen SOFARSOLAR Co., Ltd.
Address: 401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China

VDE0126-1-1,VDE-AR-N 4105,G83/2,EN50438,C10/11, ASA4777,RD1699,UTE C15-712-1



SOFAR SOLAR Hybrid Inverter

Model No.	HYD 3000-ES
Max.DC Input Voltage	600V
Operating MPPT Voltage Range	90V-580V
MAX.PV Isc	2x15A
Battery Type	Lead-acid,Lithium-ion
Battery Voltage Range	42-58V
Max.Charging Current	65A
Max.Discharging Current	70A
Max.Charging&Discharging Power	3000VA
Nominal Grid Voltage	230Vac
Nominal Output Voltage	230Vac
Max.Output Current	13.7A
Nominal Grid Frequency	50/60Hz
Power Factor	1(adjustable+/-0.8)
Nominal Output Power	3000VA
Backup Rated Current	13.2A
Backup Rated Apparent Power	3000VA
Ingress Protection	IP65
Operating Temperature Range	-25-+60°C
Protective Class	Class I

Manufacturer: Shenzhen SOFARSOLAR Co., Ltd.
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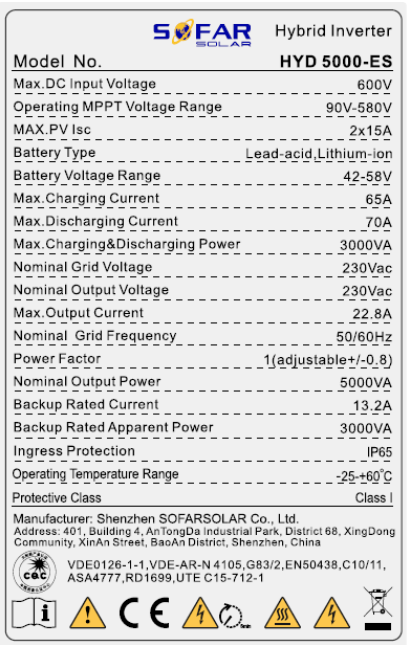
VDE0126-1-1,VDE-AR-N 4105,G83/2,EN50438,C10/11, ASA4777,RD1699,UTE C15-712-1

SOFAR SOLAR Hybrid Inverter

Model No.	HYD 4000-ES
Max.DC Input Voltage	600V
Operating MPPT Voltage Range	90V-580V
MAX.PV Isc	2x15A
Battery Type	Lead-acid,Lithium-ion
Battery Voltage Range	42-58V
Max.Charging Current	65A
Max.Discharging Current	70A
Max.Charging&Discharging Power	3000VA
Nominal Grid Voltage	230Vac
Nominal Output Voltage	230Vac
Max.Output Current	18.2A
Nominal Grid Frequency	50/60Hz
Power Factor	1(adjustable+/-0.8)
Nominal Output Power	4000VA
Backup Rated Current	13.2A
Backup Rated Apparent Power	3000VA
Ingress Protection	IP65
Operating Temperature Range	-25-+60°C
Protective Class	Class I

Manufacturer: Shenzhen SOFARSOLAR Co., Ltd.
Address: 401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China

VDE0126-1-1,VDE-AR-N 4105,G83/2,EN50438,C10/11, ASA4777,RD1699,UTE C15-712-1



SOFAR SOLAR Hybrid Inverter

Model No.	HYD 5000-ES
Max.DC Input Voltage	600V
Operating MPPT Voltage Range	90V-580V
MAX.PV Isc	2x15A
Battery Type	Lead-acid,Lithium-ion
Battery Voltage Range	42-58V
Max.Charging Current	65A
Max.Discharging Current	70A
Max.Charging&Discharging Power	3000VA
Nominal Grid Voltage	230Vac
Nominal Output Voltage	230Vac
Max.Output Current	22.8A
Nominal Grid Frequency	50/60Hz
Power Factor	1(adjustable+/-0.8)
Nominal Output Power	5000VA
Backup Rated Current	13.2A
Backup Rated Apparent Power	3000VA
Ingress Protection	IP65
Operating Temperature Range	-25-+60°C
Protective Class	Class I

Manufacturer: Shenzhen SOFARSOLAR Co., Ltd.
Address: 401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China

VDE0126-1-1,VDE-AR-N 4105,G83/2,EN50438,C10/11, ASA4777,RD1699,UTE C15-712-1

SOFAR SOLAR Hybrid Inverter

Model No.	HYD 6000-ES
Max.DC Input Voltage	600V
Operating MPPT Voltage Range	90V-580V
MAX.PV Isc	2x15A
Battery Type	Lead-acid,Lithium-ion
Battery Voltage Range	42-58V
Max.Charging Current	65A
Max.Discharging Current	70A
Max.Charging&Discharging Power	3000VA
Nominal Grid Voltage	230Vac
Nominal Output Voltage	230Vac
Max.Output Current	27.3A
Nominal Grid Frequency	50/60Hz
Power Factor	1(adjustable+/-0.8)
Nominal Output Power	6000VA
Backup Rated Current	13.2A
Backup Rated Apparent Power	3000VA
Ingress Protection	IP65
Operating Temperature Range	-25-+60°C
Protective Class	Class I

Manufacturer: Shenzhen SOFARSOLAR Co., Ltd.
Address: 401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China

VDE0126-1-1,VDE-AR-N 4105,G83/2,EN50438,C10/11, ASA4777,RD1699,UTE C15-712-1

Note:

1. The above markings are the minimum requirements required by the safety standard. For the final production samples, the additional markings which do not give rise to misunderstanding may be added.
2. Label is attached on the side surface of enclosure and visible after installation.

Test item particulars:	
Temperature range:	-25°C ~ +60 °C
AC Overvoltage category:	☐ OVC I ☐ OVC II ☒ OVC III ☐ OVC IV
DC Overvoltage category:	☐ OVC I ☒ OVC II ☐ OVC III ☐ OVC IV
IP protection class:	IP65
Possible test case verdicts:	
- test case does not apply to the test object:	N/A (Not applicable)
- test object does meet the requirement:	P (Pass)
- test object does not meet the requirement:	F (Fail)
Testing:	
Date of receipt of test item:	03 Sep., 2018
Date (s) of performance of tests:	03 Sep., 2018 – 28 Nov., 2018

General remarks:

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

When determining for test conclusion, measurement uncertainty of tests has been considered.
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The test report only allows to be revised only within the report defined retention period unless standard or regulation was withdrawn or invalid.

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

Factory information:

Dongguan SOFAR SOLAR Co., Ltd.

1F-6F, Building E, No.1 JinQi Road, Bihu Industrial Park, Wulian Village, Fenggang Town, Dongguan City

General product information:

The unit is a single-phase hybrid inverter, it can converts the high PV voltage and Grid voltage to low DC for charge battery, also converts PV voltage and battery voltage to AC output .

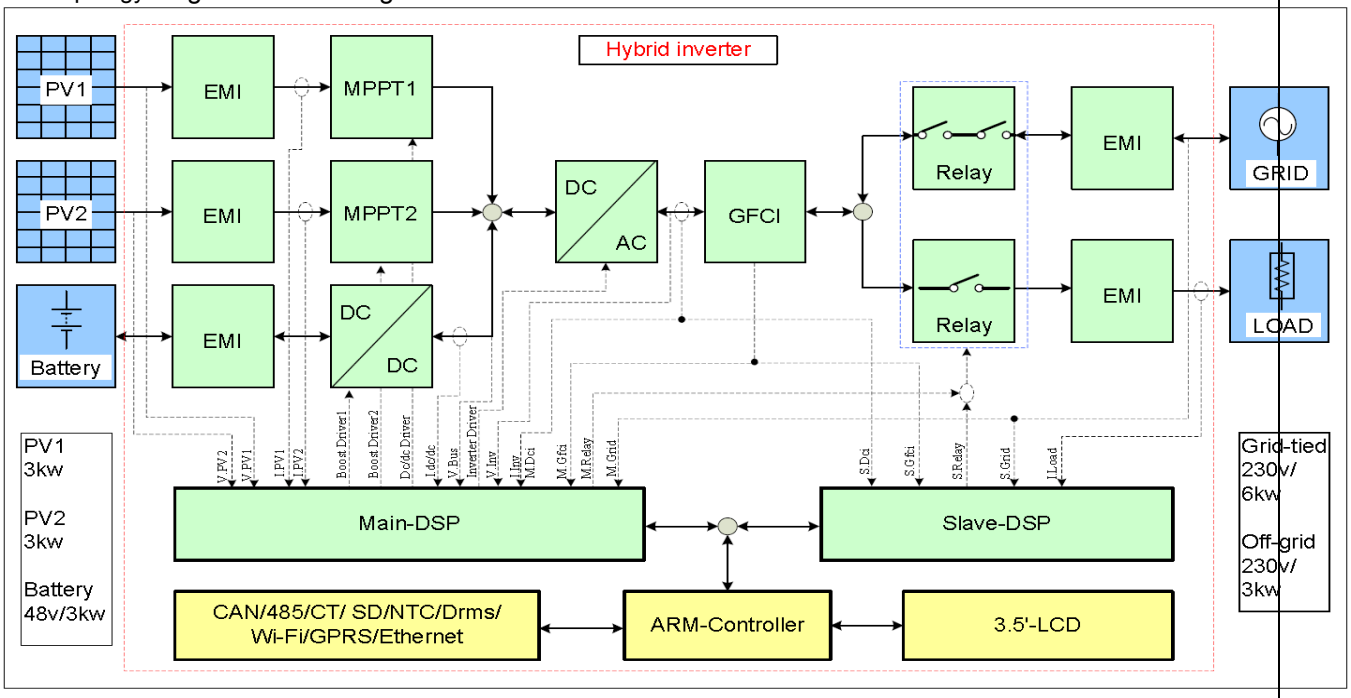
The unit is providing EMC filtering at the PV and battery side. It does provide galvanic separation from PV side to Grid. The battery circuit does provide high frequency isolation to PV side and AC mains.

The unit has two controllers. the master DSP controller monitor the charge or discharge statue; measure the PV voltage and current, battery voltage, bus voltage, buck voltage and current, AC voltage, current, GFCI and frequency.

The slave DSP controller monitor AC voltage , current ,frequency , GFCI and communicate with the master controller

The master DSP and slave DSP are used together to control relay open or close, if the single fault on one DSP, the other one DSP can be capable to open the relay, so that still providing safety means

The topology diagram as following:



Model differences:

The models HYD 3000-ES, HYD 3600-ES, HYD 4000-ES , HYD 5000-ES and HYD 6000-ES are completely identical and output power derated by software, except for the following table.

Model	HYD 6000-ES	HYD 5000-ES	HYD 4000-ES	HYD 3600-ES	HYD 3000-ES
R332, R334,R336	0Ω, NC, 0Ω		NC, 0Ω, NC		
Bus capacitance	8pcs		6pcs		
INV inductor	0.75mH		1.035mH		
R123,R132	1.5KΩ, 1.5KΩ		499Ω, 499Ω		

Other than special notes, typical model HYD 6000-ES used as representative for testing in this report.

VDE-AR-N 4105:2011 in conjunction with E DIN V VDE V 0124-100:2013			
Clause	Requirement - Test	Result - Remark	Verdict
4	**General framework conditions**		N/A
4.1	**Provisions and regulations**	This report is only evaluated and tested for PGU; The PGS incorporated with the PGU shall further consider this clause and sub-clause.	N/A
4.2	**Application procedure and connection relevant document**	Shall consider in final PGS	N/A
4.3	**Initial start-up of the power generation system**	Shall consider in final PGS	N/A
5	**Network connection**		**P**
5.1	**Principles for determination of the network connection point** Power generation systems shall be connected at a suitable point in the network, the network operator determines the suitable network connection point that ensures safe network operation, also when taking account of the power generation system, and at which the power applied for can be drawn and transmitted. The decisive aspect for evaluation of the network connection is always the behaviour of the power generation system at the network connection point or at the PCC. This is to ensure that the power generation system is operated without interfering reactions and without affecting the supply of other customers. Annex E shows examples for connection evaluations of power generation systems. Power generation systems which are installed on different plots with their own respective network connections shall, as a rule, not be connected to the network operator's network together in the same network connection point. Power generation systems installed on a building with several network connections may be connected to the network operator's network together at the same network connection point. All separate supply points shall be permanently marked by te supply point owner with the following label "Sectioning point" power generation system/ supply network".	Shall consider in final PGS	N/A

VDE-AR-N 4105:2011 in conjunction with E DIN V VDE V 0124-100:2013			
Clause	Requirement - Test	Result - Remark	Verdict
5.2	**Rating of the network equipment** Power generation systems may cause higher loading of lines, transformers and other network equipment. Therefore, the network operator examines the loading capacity of the network equipment with regard to the connected power generation systems in accordance with the relevant rating regulations. For calculation purposes the maximum apparent power of the sum of all power generation systems S_{Amax} and usually the load factor m=1 shall be used. The only exceptions are buried cables for the connection of photovoltaic systems for which a load factor m= 0.7 shall be used.	Shall consider in final PGS	N/A
5.3	Permissible voltage change For undisturbed operation of the network, the amount of the voltage change caused by all power generation systems with a network connection point in a low-voltage network shall at none of the PCCs in this network may a value of 3 % as compared with the voltage without power generation systems. If stipulated by the network operator and if necessary, taking into account the possibilities of the static voltage stability it may be permitted in individual justified cases to deviate from this value of 3%. When calculating the voltage change, the displacement factor shall be taken into account which is provided by the network operator for the maximum apparent connection power of the power generation system S_{Amax}. For determination of the voltage change for meshed low-voltage networks an high spatially distributed feed-in powers, it is recommended to use complex load-flow calculations.	Shall consider in final PGS	N/A
5.4	**System reactions**		**P**
5.4.1	**General** The electrical installations of the customer system shall be planned, constructed and operated so that reactions to the network operator's network and to the systems of other customers are permanently reduced to a permissible minimum. Should interfering reactions on the network operator's network occur nonetheless, the customer shall apply measured to his system that is to be coordinated with the network operator. The network operator is entitled to disconnect the power generation system concerned from the network until the deficiencies are corrected. The connection owner provides the network operator with values from the device documents of the manufacturer which are necessary in order to evaluate system reactions (see Annex F.3).		P

VDE-AR-N 4105:2011 in conjunction with E DIN V VDE V 0124-100:2013			
Clause	Requirement - Test	Result - Remark	Verdict
5.4.2	**Rapid voltage changes** Voltage chances at the PCC attributable to the simultaneous connection and disconnection of power generation units do not give rise to inadmissible network reactions if the maximum voltage change does not exceed a value of 3% (related to Un) at the PCC. For a value of 3% the frequency shall not exceed once every 10 min. Depending on the network short-circuit power S_{kV} at the PCC of maximum apparent connection power S_{Emax} of the activated power generation unit and on th ratio of starting current I_a to rated current I_{rE}, the voltage change can be estimated.	Kimax is measured to comply with Cl.8.3.4 The final installation of PGS shall be calculated	P
5.4.3	Flicker The measured variable and the evaluation criterion for flicker caused by power generation systems is the long-term flicker strength P_{lt}. For power generation systems with rated currents of up to 75 A, reactions are deemed to be limited sufficiently, if the power generation units comply with the limit values given in DIN EN 61000-3-3 (VDE 0838-3) or DIN EN 61000-3-11 (VDE 0838-11), respectively. Together, all power generation systems in the low-voltage network shall not exceed the following flicker strength at the most unfavourable PCC: Long-term flicker strength: $P_{lt} = 0.5$. This value also applies to power generation systems with rated currents above 75A.	The limited value for PGS shall be considered in final installation The P_{lt} is calculated for PGS final installation	P
5.4.4	**Harmonics and inter-harmonics** The currents of harmonics and inter-harmonics generated by power generation systems shall be included in the conformity check. For power generation systems reactions are deemed to be limited sufficiently, if the power generation units comply with the following limit values: - for rated currents of up to and including 16 A per conductor: the limit values of class A (Table 1) specified in DIN EN 61000-3-2 (VDE0838-2); - for rated currents above 16 A and up to and including 75 A per conductor: the limit values of Table 2 and Table 3 specified in DIN EN 61000-3-12 (VDE 0838-12). If in the standard mentioned, limit values are explicitly stated for power generation units then these limit values shall apply.	Harmonics is measured according to VDE V 0124-100 CL.5.1.4 The inverter comply with the limit of DIN EN 61000-3-3 Test performed as required by paragraph 5.1.4 of DIN VDE V 0124-100	P

VDE-AR-N 4105:2011 in conjunction with E DIN V VDE V 0124-100:2013			
Clause	Requirement - Test	Result - Remark	Verdict
5.4.5	**Voltage unbalance** If several single-phase power generation systems are connected to the same network connection point, then uniform distribution of the power supplied to the three line conductors shall be aimed for, where a maximum power difference of 4.6kVA shall not exceed.	Single-phase inverter that make up a systems are not supplied to the three line conductors	N/A
5.4.6	**Commutation notches** The relative depth of commutation notches d_{kom} through line-commutated inverters shall not exceed the value of d_{kom} = 5 %		P
5.4.7	**Audio-frequency centralised ripple-control** Audio-frequency centralised ripple-control are usually operated at frequencies between approx. 100 Hz and 1500 Hz. Information about the locally applied ripple-control frequency can be obtained from the network operator. Broadcasting levels of audio-frequency impulses are normally about 1 % U_n to 4 % U_n. Apart from the limitation of the level reduction, it is not allowed to generate inadmissible interference voltages. The following rules shall apply in particular: - The interference voltage caused by a power generation system whose frequency corresponds to the locally applied ripple-control frequency or is very close to it (+/- 5 Hz), shall not exceed the value of 0.1 % U_n. - The interference voltage caused by a power generation system whose frequency lies at the ambient frequencies of +/- 100 Hz to the locally applied ripple-control frequency or in its immediate proximity, shall not exceed a value of 0.3 % U_n.	Considered for final PGS	N/A
5.4.8	**Carrier frequency usage of the customer network** If the system operator runs a system with carrier frequency usage of this network, then shall be ensured by means of suitable devices that interfering influences on other customer systems as well as on the systems of the network operator are avoided. Shared usage of the network operator's network by the customer is permitted solely with the network operator's consent for the carrier frequent transmission of signals.	Considered for final PGS	N/A
5.4.9	**Precautionary measures against voltage drops and voltage interruptions** If power generation systems are sensitive to short-time voltage drops or interruptions of supply, then the customer shall take suitable measured to safeguard the system and to ensure operation operational safety.		N/A

VDE-AR-N 4105:2011 in conjunction with E DIN V VDE V 0124-100:2013			
Clause	Requirement - Test	Result - Remark	Verdict
5.5	**Connection criteria** For the technical execution of connections of the power generation system or the customer system with a power generation system, the technical connections of the network operator shall be considered. If the generated power is fully supplied to the network operator's network, then the connection line of the power generation system shall be firmly connected to the meter panel within the customer system and the meter panel shall then be executed in accordance with the applicable Technical connection condition. Power generation systems may also be single-phase connected to the network, if the sum of all single-phase connected power generation units per network connection does not exceed the flowing: S_{Emax}= ≦4.6kVA per line conductor. It is possible to connect in single phase, distributed to the three line conductors, at maximum 3 x 4.6kVA= S_{Emax} ≦13.8kVA. The limits given above are exceeded at the network connection point, any extension shall be three-phase connected to the three-phase system. This requirement may also be satisfied by communicatively coupling single-phase connected power generation units of the same primary energy carrier. The communicative coupling between power generation units ensures the power generation system's balanced supply to the individual line conductors of the three-phase network in accordance with three-phase inverter systems. For all that, the maximum permissible imbalance of 4.6kVA at a single network connection point for the sum of all power generation systems applies here as well.	For PGS only	N/A
5.6	**Three-phase network**		N/A
5.6.1	**General** For the purposes of maintaining the symmetric characteristics of the three-phase network, three-phase power generation systems shall have the characteristics described in the following.		N/A
5.6.2	**Three-phase synchronous generators** Synchronous generators generate an electromotive force (EMF) or synchronous generated voltage (open-circuit voltage), respectively, satisfying the conditions for ideal balance.		N/A

VDE-AR-N 4105:2011 in conjunction with E DIN V VDE V 0124-100:2013			
Clause	Requirement - Test	Result - Remark	Verdict
5.6.3	**Three-phase inverter systems** For three-phase power generation systems with network feed-in over inverters, the power shall be fed three-phase balanced into the three line conductors. The inverter circuit shall preferably be set up as a three-phase current unit. A circuit of single –phase inverters is deemed to be technically equivalent, if these inverters feed three-phase balanced into the three line conductors by means of a suitable communicative coupling. In the medium term, three-phase inverter systems shall provide all the three-phase related functions of the three-phase synchronous generators.	Considered for final PGS	N/A
5.7	**Behaviour of the power generation system at the network**		**P**
5.7.1	**General** Automatic disconnection from the network is not permitted for frequency deviations within the range of 47.5 Hz to 51.5 Hz. The mode of action is described in detail in 5.7.3.3 and 5.7.3.4. Implementation of the frequency dependent active load control is carried out in the open-loop control of the power generation units.	The PGU remain operation during the frequency range 47.5Hz to 51.5Hz	P
5.7.2	**Maximum permissible short-circuit current** Due to operation of power generation system, the short-circuit current of the low-voltage network is increased by the short-circuit current of the power generation system. Therefore, information about the short-circuit current of the power generation system to be expected at the network connection point has shall be provided in accordance with 4.2. For determination of the short-circuit current contributed by the power generation system the following roughly estimated values can be assumed : - For synchronous generators: 8 times the rated current: - For asynchronous generators: 6 times the rated current; - For generators with inverters: 1 time the rated current.	Considered in final PGS	N/A

VDE-AR-N 4105:2011 in conjunction with E DIN V VDE V 0124-100:2013			
Clause	Requirement - Test	Result - Remark	Verdict
5.7.3	**Active power output**		**P**
5.7.3.1	**Basics**		P
5.7.3.2	**Generation management/network security management** Power generation systems with a system power of more than 100 kW shall be able to reduce their active power in steps of not more than 10 % of the maximum active power P_{Amax}. For every operational state and from each and every operation point, it shall be possible for this power to be reduced to a set point provided by the network operator. This set point is generally provided at the network connection point gradually or continually and it corresponds to a percentage related to the maximum active power P_{Amax}. Variable power generation systems shall carry out the power output reduction to the respective set point immediately, however, at maximum within a minute. It shall be technically possible for these power generation systems to reduce the power to the set point 10% without automatic disconnection from the network, and only at a value o less than 10% of the maximum active power P_{Amax} is they permitted to disconnect the network. All other power generation systems shall carry out the power output reduction to the respective set point within a maximum period of five minutes. If the set point is not reached within five minutes, then the power generation system shall be disconnected.	The PGU is able to reduce active output power via RS485 interface. The final PGS installation shall be equipped with an interface device between the dry contacts of network operator. Although the power of PGU is less than 100KW. However, it can fulfil the requirement of EEG The communication port of PGU is RS 485. it should be adapted with external dry contact signals for final PGS installation	P

VDE-AR-N 4105:2011 in conjunction with E DIN V VDE V 0124-100:2013			
Clause	Requirement - Test	Result - Remark	Verdict
5.7.3.3	**Active power feed-in at overfrequency** At frequencies between 50.2 Hz and 51.5 Hz, all adjustable power generation systems shall reduce or increase the active power P_M generated instantaneously with a gradient of 40 % of P_M per Hz. It follows that the power generation unit will continuously move up and down the frequency characteristic curve in the frequency range of 50.2 Hz to 51.5 Hz with regard to its active power feed-in. the increment of the frequency measurement shall be ≤10 mHz. If the mains frequency drops again to a value below 50.2 Hz and if the possible generation power is greater at that instant than the active power P_M, then the increase of the active power supplied to the network operator's network shall not exceed a gradient of 10 % of the maximum active power P_{Amax} per minute. At mains frequencies > 51.5 Hz, the power generation system shall disconnect from the network immediately. There ar no restrictions for frequencies of 47.5 Hz ≤ f_{mains}≤ 50.2 Hz. Disconnection from the network is required for f_{mains} ≤ 47.5 Hz and f_{mains} ≥ 51.5 Hz.	(See appended table)	P
5.7.3.4	**Active power feed-in at underfrequency** For frequencies between 47.5 Hz and 50.0 Hz, automatic disconnection from the network as a result of a frequency deviation is not permitted.	PGU normally operate.	P
5.7.4	**Principles for network support** Power generation systems shall be able to contribute to the static voltage stability in the network operator's network. Static voltage stability is understood to be the voltage stability in the low-voltage network at which the slow voltage changes are maintained within compatible limits in the distribution network.	Considered in final PGS	N/A

VDE-AR-N 4105:2011 in conjunction with E DIN V VDE V 0124-100:2013			
Clause	Requirement - Test	Result - Remark	Verdict
5.7.5	**Reactive power** Irrespective of the number of feed-in phases, power generation systems shall allow for operation under normal stationary operating conditions in the voltage tolerance band U_n +/- 10% and in their permissible operation points starting with an active power of more than 20 % of the rated active power with the following displacement factors cosφ: - power generation system $S_{Emax} \leqq 3.68$ kVA: cosφ= 0.95 $_{under\text{-}excited}$ to 0.95 $_{over\text{-}excited}$. - power generation system 3.68 kVA < $S_{Emax} \leqq 13.8$ kVA: characteristic curve provided by the network operator within cosφ= 0.95 $_{under\text{-}excited}$ to 0.95 $_{over\text{-}excited}$ - power generation system S_{Emax} > 13.8 kVA: characteristic curve provided by the network operator within cosφ= 0.90 $_{under\text{-}excited}$ to 0.90 $_{over\text{-}excited}$.	PGU $S_{Emax} \leqq 3.68$ kVA characteristic curve provided by the network operator within cosφ= 0.95 $_{under\text{-}excited}$ to 0.95 $_{over\text{-}excited}$. （See appended table ）	P
6	**Construction of the power generation system/network and system protection (NS protection)**		P
6.1	**General requirements** The network and system protection (NS protection) is a type-tested protective device with a conformity certificate in which all protective functions specified in 6.5 are installed. The NS protection acts on the interfaces switch in accordance with 6.4. The NS protection shall be realized as central NS protection at the central meter panel. For power generation systems of ≤ 30kVA it is also permitted to have an NS protection installed in the power generation unit(s). depending on the sum of the maximum apparent powers of all power generation systems connected to the same network connection point, S_{Amax}. The following conditions apply for the NS protection: - S_{Amax} > 30kVA: Central NS protection at the central meter panel. - SAmax ≤ 30kVA: Central NS protection at the central meter panel or decentralized in a sub-distribution or integrated NS protection The loss of the auxiliary voltage of the central NS protection or the control of the integrated NS protection shall lead to an instantaneous tripping of the interface switch. Tripping of a relay of the integrated protection disconnection periods is kept. The protective functions shall be maintained even in the event of a malfunction in the system control. Single-fault tolerance shall be ensured for both central and integrated NS protection.	Integrated NS protection	P

VDE-AR-N 4105:2011 in conjunction with E DIN V VDE V 0124-100:2013			
Clause	Requirement - Test	Result - Remark	Verdict
6.2	**Central NS protection** The central NS protection shall be accommodated as independent apparatus in a suitable circuit distributor in accordance with TAB 2007, Clause 8, Paragraph 1, and not in the upper connection compartment specified in TAB 2007, 7.2, Paragraph 9 and connected to the central meter panel.		N/A
6.3	**Integrated NS protection** The NS protection can be integrated in the programmable system control of the power generation units. If so, then both the test button and the sealing may be omitted, however, password protection is required, if the protective function U > is adjustable.		P
6.4	**Interface switch**		P
6.4.1	**General** For the connection of the power generation system to the network operator's low-voltage network or to the remaining customer system, it is necessary to use an interface switch. It consists of two electric switching devices connected in series and shall thus be constructed redundantly. The interface switch is controlled by the NS protection and activates automatically if at least one protective function responds. The breaking devices of the interface switch shall be designed to be short-circuit proof and shall be releasable without delay and with due regard to the protective devices required by clause 6.5. The breaking capacity of the two breaking devices of the interface switch shall be dimensioned at least in accordance with the responding range of the upstream safety fuse or the maximum short-circuit current contribution of the power generation system. Switches with at least breaking capacity shall be use for both breaking devices of the interface switch. In addition to that, all-pole disconnection shall be ensured.	Integrated power relay in the PGU. Each live conductor is constructed with two relays comply with A.6 requirement	P
6.4.2	**Central interface switch** The two break devices of the central interface switch shall be executed as galvanic break devices. The two break devices of the interface switch shall be installed directly at the central meter panel in the circuit distributor of the power generation system.		N/A

VDE-AR-N 4105:2011 in conjunction with E DIN V VDE V 0124-100:2013			
Clause	Requirement - Test	Result - Remark	Verdict
6.4.3	**Integrated interface switch** Construction of the interface switch shall be carried out taking into consideration the single-fault tolerance. An interface switch ensures a single-fault tolerant all-phase galvanic breaking. For power generation systems with inverters, the interface switch shall be provided on the inverter's network side. A short circuit in the inverter shall not impair the switching function of the interface switch.	Two series relays	P
6.5	**Protective devices for the interface switch**		P
	Comments:		
6.5.1	**General** The purpose of the NS protection is to disconnect the power generation system from the net in the event of inadmissible voltage and frequency values. This is intended to prevent an unintentional feed-in of the power generation system into a power-supply unit separated from the remaining distribution network as well as the feed-in of faults within this network. The system operator shall himself take precautions to prevent damages to his systems and installations as might be caused by switching actions, voltage fluctuations and automatic reclosings in the network connected upstream or other process in the network of the network operator. The following functions of the decoupling protection shall be implemented: - Voltage drop protection *U* <; - Rise-in-voltage protection *U* >; - Rise-in-voltage protection *U* >>; - Frequency decrease protection *f* <; - Frequency increase protection *f* >; - Islanding detection. The setting values of the protective functions and the last five dated failure reports shall be readable at the NS protection. Interruptions of supply with durations of 3 s or longer shall not lead to loss of any of the failure reports. Read-out shall be possible at the central NS protection irrespective of the operational state of the power generation system and without any additional aids. For integrated NS protection read-out may be carried out using a data interface.		P

VDE-AR-N 4105:2011 in conjunction with E DIN V VDE V 0124-100:2013			
Clause	Requirement - Test	Result - Remark	Verdict
6.5.2	**Protective functions** The protective functions of the NS protection shall be designed so that the disconnection time (the sum of the proper times of NS protection and interface switch plus a delay for the protection relay, which may or may not be adjustable) does not exceed 200 ms.		P
6.5.3	**Islanding detection** The islanding detection is implemented in the central NS protection or in the integrated NS protection of the power generation unit. If an islanding detection system acting on the integrated interface switch is integrated in all power generation units of a power generation system, then it is permitted to omit the islanding detection in the central NS protection regardless of the system power. Detection of an isolated network and disconnection of the power generation system by means of the interface switch shall be completed within 5 seconds.		P
7	**Metering for billing purposes**		N/A
	Installation and operation of the measuring devices shall be agreed in due time between the system operator and the network or metering point operator, respectively. According to the German Calibration Act, only certified and calibrated meters and transformers shall be used in the course of business.		N/A
8	**Operation of the system**		**P**

VDE-AR-N 4105:2011 in conjunction with E DIN V VDE V 0124-100:2013			
Clause	Requirement - Test	Result - Remark	Verdict
8.1	**General** The operation of electrical installations included all technical and organisational activities required to ensure the functional efficiency and safety of the systems. These activities include all operating measures as well as electrical and non-electrical operations as described in the applicable rules and regulations. For connection of the power generator systems, the conditions given in 8.3 shall be satisfied. During operation, the conditions of clause 5, which the decisions regarding the connection of the power generation system were based on, shall only be changed with the consent of the network operator. The system operator shall ensure that the equipment - required for parallel operation with the low-voltage network is always in proper technical condition. It is required to have an electrically skilled person check the switches and protective devices for proper functioning at regular intervals. This requirement is deemed to be satisfied for normal operating and environmental conditions if the test intervals mentioned in BGV A3 or TRBS 1201 are adhered to. Te repeat tests shall include at least the following: - Check of the environmental conditions and elimination of deficiencies, if required; - Tripping control of the interface switch. Power reduction or disconnection required due to network conditions: upon request of the network operator, the system operator is obliged to switch off the power generation system or to disconnect it from the network if this is required for conduction work that are necessary for operational purposes in the network operator's network. Access: upon co-ordination with the system operator, the network operator shall be granted access to all components of the power generation system, interfaces switch, facilities of the power generation/ network security management, and the power generation units. Exchange of information: the network operator will inform the system operator about substantial modifications in his network which will have an impact on the current parallel operation. Coupling of network connection points: different network connection points on the network of the network operator shall not be operated in galvanic connection through systems of one or more system operators. Behaviour in the event of disturbances: the reconnection conditions given in 8.3 shall be satisfied.	The PGU is type tested in term of this standard and the installation into PGS shall also comply with this standard. The PGU can be informed to reduce the power output. The installation of PGS shall be considered with consent of network operator.	P

VDE-AR-N 4105:2011 in conjunction with E DIN V VDE V 0124-100:2013			
Clause	Requirement - Test	Result - Remark	Verdict
8.2	**Particular characteristics of the management of the network operator's network** - Earthing and short-circuiting for works on the network: After isolation, a prerequisite for the safety of works on the network is to prevent any voltage sources from reconnecting unintentionally. - Operation of the network stand-by systems: For certain works on the network, the network operator has to disconnect sub-networks from the remaining network. In order to ensure continuous supply to the customers during this time, the network operator may use network stand-by systems. Normally, the network operator will inform the customers concerned about the use and operation of network stand-by systems.	Considered in final PGS installation	N/A
8.3	**Connection conditions and synchronisation**		P
8.3.1	**General** A power generation system shall be connected to the network operator's network only if a suitable device determines that both the mains voltage and the mains frequency are within the tolerance range of 85 % Un to 110 % Un or 47.5 Hz to 50.05 Hz, respectively, for a period of at least 60 seconds. If decoupling protection devices are tripped because of a short interruption, then the power generation system is permitted to already reconnect as soon as the mains voltage and mains frequency have uninterruptedly remained within the tolerance ranges given above for a period of 5 seconds. Short time interruptions are characterised by the NS protection settings of the mains frequency and/ or network voltage being exceeded or undershot for a maximum period of 3 seconds. The power generation system being reconnected to the network operator's network at the tripping of the decoupling protection device, the active power of controllable power generation systems supplied to the network operator's network shall not exceed the gradient of 10 % of the active power per minute.	(See appended table)	P

VDE-AR-N 4105:2011 in conjunction with E DIN V VDE V 0124-100:2013			
Clause	Requirement - Test	Result - Remark	Verdict
8.3.2	**Connection of synchronous generators** A synchronisation device shall be provided in a suitable place for synchronous generators coupled directly to the network.		N/A
8.3.3	**Connection of asynchronous generator** For asynchronous generators started by a prime mover and connected at a rotational speed between 95 % and 105 % of the synchronous rotational speed, k_{imax} is expected to be = 4.		N/A
8.3.4	**Connection of power generation units with inverters** Power generation units with inverters shall only be connected with $k_{imax} \leq 1.2$.	The k_{im}ax is 0.311	P
8.4	**Reactive power compensation** Equipment for reactive power compensation shall either: be connected or disconnected together with the consumption devices or power generation systems; or operated via control equipment.	See clause 5.7.5	P

VDE-AR-N 4105:2011 in conjunction with E DIN V VDE V 0124-100:2013			
Clause	Requirement - Test	Result - Remark	Verdict

9	**Verification of the electrical properties**		**P**
9.1	**General** The certificates of conformity issued for the power generation units and the NS protection shall confirm their conformity with requirements of this VDE application guide at least with regard to the properties described in 9.2 to 9.4.		P
9.2	**Verification of the feed-in power**		**P**
9.2.1	**Verification of the feed-in power** For power generation units, it is sufficient to indicate the maximum active power feed-in.		P
9.2.2	**Verification of the reactive power values** Indication of the maximum reactive powers for inductive and maximum capacitive reactive power extraction as a function of the feed-in active power is required. For this at least the conditions give in 5.7.5 shall be satisfied. For power generations units with a generator directly coupled to the network which, due its very operational principle, cannot control the reactive power and, therefore, uses non-controllable, fixed capacities cosφ shall be reached within 60 seconds. The maximum deviation at cosφ nominal voltage shall be 0.02.		P
9.2.3	**Verification of the reactive power transition function** In order to check the standard characteristic curve cos φ (P) given in 5.7.5, the change of the active power mode of operation is to be checked in correspondence to the magnitude of the active power feed-in.		P
9.3	**Verification of the network reactions** In order to verity the permissible network reactions specified in 5.4, it is required to submit evidence provided by the manufacturer for the radiated interference produced by the power generation unit.		P
9.4	**Verification of the features of the network and system protection** Compliance with the conditions required by Clause 6 for NS protection for the protection against inadmissible voltage and frequency increase/decrease shall be verified based on measurements.		P

VDE-AR-N 4105:2011 in conjunction with E DIN V VDE V 0124-100:2013			
Clause	Requirement - Test	Result - Remark	Verdict
	Annex A: Explanations (informative)		--
	Annex B: Connection examples (informative)		--
	Annex C: Examples of meter panel configurations (informative)		--
	Annex D: Islanding detection (normative)		P
D.1	Islanding detection by means of the oscillation circuit test		P
D.2	Islanding detection by three-phase voltage monitoring		P
	Annex E: Examples for the connection evaluation of power generation systems (informative)		**--**
	Annex F: Forms (mandatory)		**P**
F.1	Initial start-up protocol – Power generation systems, low voltage		N/A
F.2	Data sheet for power generation systems		P
F.3	Requirements for the test report for power generation units		P
F.4	Requirements for the test report for the NS protection		P
	Annex G: Forms (optional) (informative)		N/A
G.1	**Application**		N/A
G.2	**Certificate of conformity for power generation units**		N/A
G.3	**Certificate of conformity of the network and system protection**		N/A

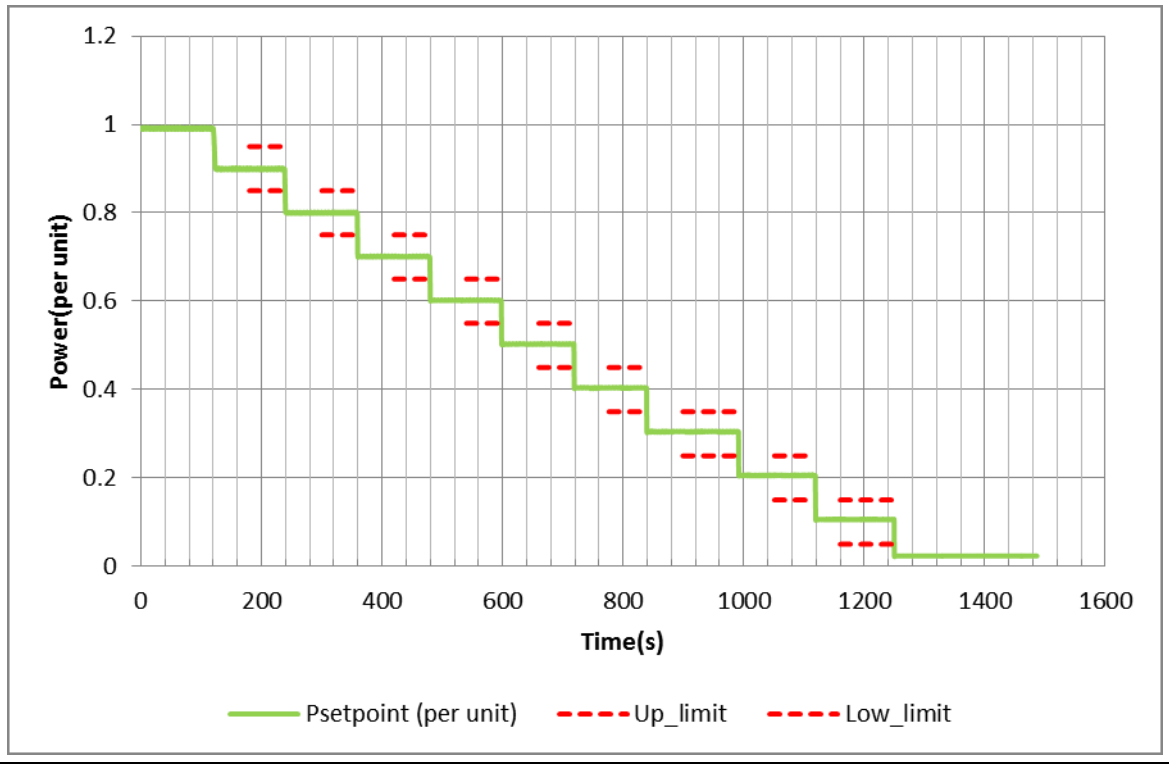
Appendix 1- Test Result

5.7.3.2	Table: Generation management/network security management (the signal of the reference value must be reduced from 100%, 90% …10% P_n)					P
String	1	U_{DC} = Un	407 Vdc	Uac = Un	230Vac	P_{Emax} (KW)	6.0
Model		HYD 6000-ES				

1 min mean value P/Pn	Psetpoint (per unit)	P_{Emax}(per unit)	ΔP_{Emax}/ Psetpoint(%)
100%	0.9909	1.0000	-0.91
90%	0.8992	0.9000	-0.08
80%	0.8001	0.8000	0.01
70%	0.7009	0.7000	0.09
60%	0.6020	0.6000	0.20
50%	0.5020	0.5000	0.20
40%	0.4040	0.4000	0.40
30%	0.3047	0.3000	0.47
20%	0.2057	0.2000	0.57
10%	0.1061	0.1000	0.61
Response time for a change in the required value of 100% to 30% of the nominal power P_{Emax}			8s

Supplementary information:

The limited ΔP_{Emax}/ Psetpoint is 5% P_{Emax}



Appendix 1- Test Result

5.7.3.3	Table: Active poewr output feed-in at overfrequency	P
	Model No.: HYD 6000-ES	--

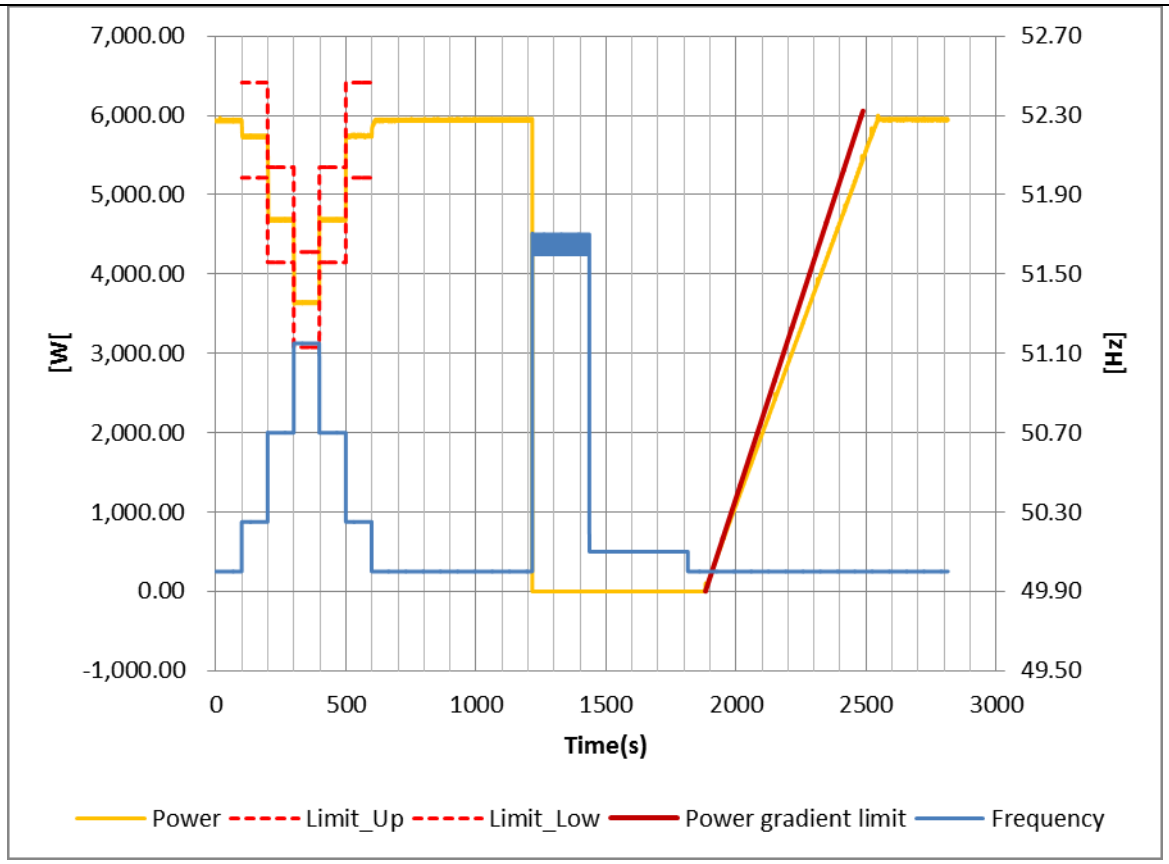
	> 80% P_{Emax}				
	40%P_M (W)		2373.06	10%P_{Emax} (W)	600
	f (Hz)	Measured output Power (W)	Measured $\triangle P=P_{measured}$ - P_M (W)	Calculated from standard characteristic curve P (W)	Tolerance between measured P and calculated P (W)
50Hz ± 0.01Hz	50.00	5932.65	--	--	--
50.25Hz ± 0.05Hz	50.25	5736.99	-195.66	5813.99	-77.00
50.70Hz ± 0.10Hz	50.70	4699.99	-1232.66	4746.12	-46.13
51.15Hz ± 0.05Hz	51.15	3646.40	-2286.25	3678.24	-31.84
50.70Hz ± 0.10Hz	50.70	4683.86	-1248.79	4746.12	-62.26
50.25Hz ± 0.05Hz	50.25	5736.63	-196.02	5813.99	-77.36
50Hz ± 0.01Hz	50.00	5930.33	--	--	--
	40% ~ 60% of PEmax				
	40%P_M (W)		1210.31	10%P_{Emax} (W)	600
	f (Hz)	Measured output Power (W)	Measured $\triangle P=P_{measured}$ - P_M (W)	Calculated from standard characteristic curve P (W)	Tolerance between measured P and calculated P (W)
50Hz ± 0.01Hz	50.00	3025.78	--	--	--
50.25Hz ± 0.05Hz	50.25	2930.86	-94.92	2965.26	-34.4
50.70Hz ± 0.10Hz	50.70	2411.74	-614.04	2420.64	-8.9
51.15Hz ± 0.05Hz	51.15	1876.49	-1149.29	1875.98	0.51
50.70Hz ± 0.10Hz	50.70	2402.13	-623.65	2420.64	-18.51
50.25Hz ± 0.05Hz	50.25	2926.71	-99.07	2965.26	-38.55
50Hz ± 0.01Hz	50.00	3025.13	--	--	--

Supplementary information:

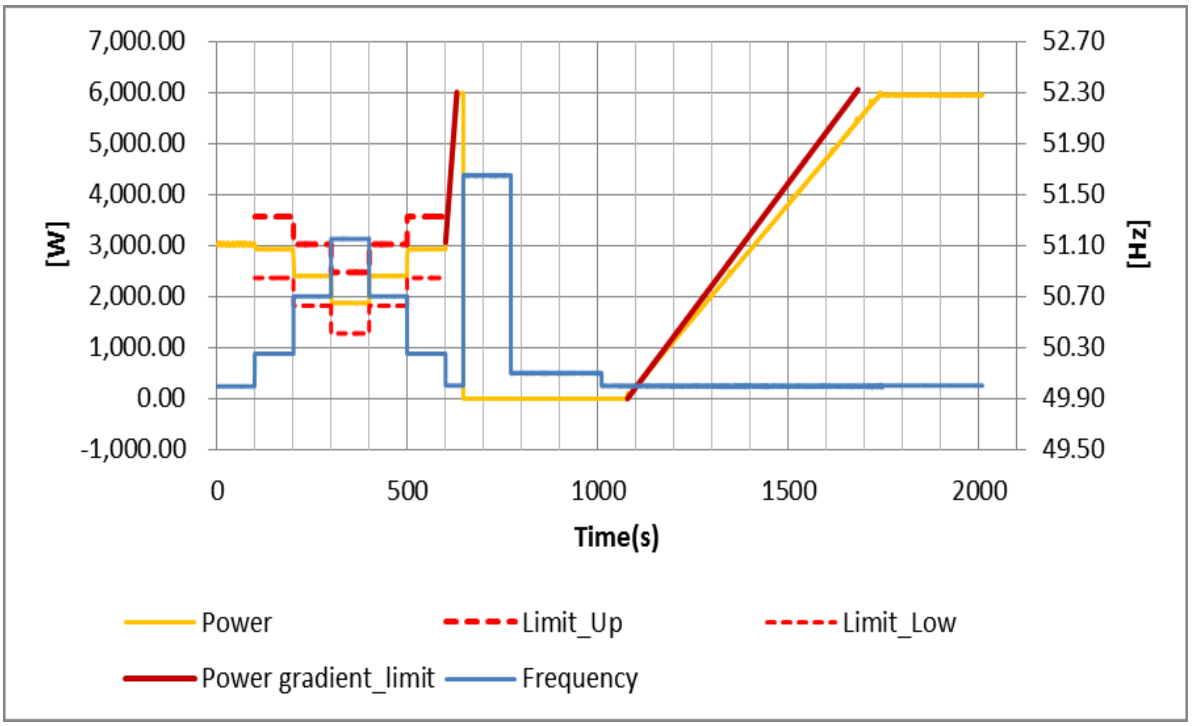
Amplitude increase or decrease of 40%Pm/Hz, the tolerance is less than or equal to 10%P

	> 80% P_{Emax} . Disconnection from the network?	Trip time (ms)	40% ~ 60% of PEmax Disconnection from the network?	Trip time (ms)	Remark
51.65Hz ± 0.05Hz	☑Yes ☐No	138.5	☑Yes ☐No	136.5	--
	Start up?		Start up?		Gradient (W/min)
50.1Hz ± 0.01Hz	☐Yes ☑No		☐Yes ☑No		--
50Hz ± 0.01Hz	☑Yes ☐No		☑Yes ☐No		562.50

Appendix 1- Test Result



> 80% P_{Emax}



40% ~ 60% of P_{Emax}

Appendix 1- Test Result

5.7.3.4	**Active power feed-in at underfrequency**	**Pass**
DC input:	AC output:	Rated Output Power
400Vdc	230Vac, 50Hz	6.0kW
Power Adjustable		
☒adjustable ☐conditionally adjustable PGU ☐linear generators with SEmax ≤ 30kVA		
	f (Hz)	Power (W)
50.00 ± 0.01Hz	50.00	5992.12
47.50 ~ 47.60Hz	47.55	5991.88

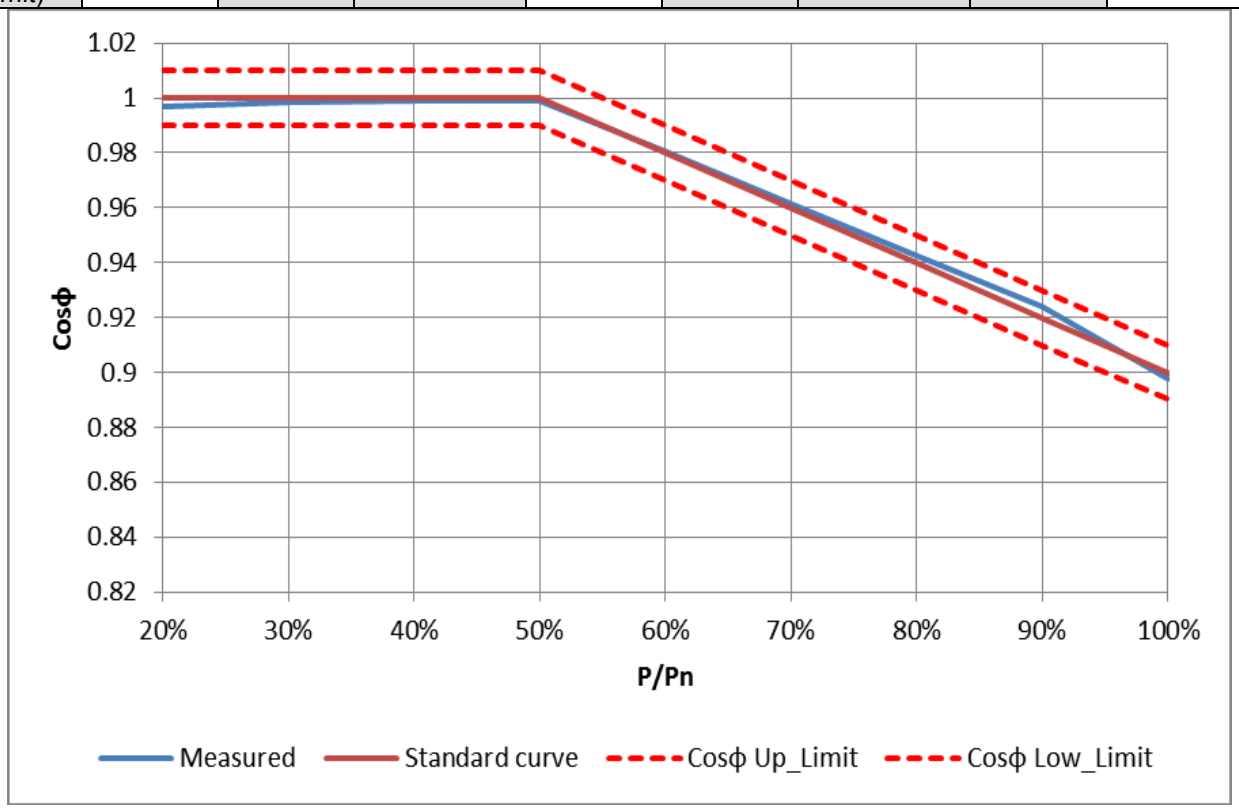
5.7.5	**Measurement of the Range of Power and of the Reactive Power**			
DC input:	AC output: 1.0Un			Rated Active Power
400 Vdc	230 Vac; 50 Hz			6.0 kW
Measurement Item	cosφ	Apparent Power (VA)	Active Power (W)	Reactive Power (Var)
a)	0.9995	5965.95	5962.70	197.04
b)	0.8045	5954.48	4790.14	-3536.89
c)	0.8040	6084.25	4891.80	3617.66
d)	0.8030	1493.81	1199.54	-890.26
	0.8037	2246.76	1805.61	-1336.99
e)	0.7991	1506.89	1204.12	905.97
	0.7967	2271.61	1809.77	1372.89
DC input:	AC output: 1.09Un			Rated Active Power
400 Vdc	250.7 Vac; 50 Hz			6.0 kW
Measurement Item	cosφ	Apparent Power (VA)	Active Power (W)	Reactive Power (Var)
a)	0.9947	5951.49	5948.35	191.61
b)	0.8060	5931.58	4780.94	-3510.75
c)	0.8020	6086.89	4881.75	3635.65
d)	0.8003	1503.75	1203.49	-901.56
	0.7984	2266.10	1809.23	-1364.46
e)	0.8000	1507.02	1205.63	904.17
	0.8008	2264.03	1812.90	1356.14
S_{Emax} (kVA)	6086.89			
P_{Emax} (kW)	5962.70			
Remark: negative denotes lagging, positive denotes leading.				

5.7.5	**Testing for the *cos φ* adjustment accuracy**								
91% Un					109% Un				
Step	S(VA)	P(W)	Q(VAR)	cosφ	Step	S(VA)	P(W)	Q(VAR)	cosφ
a)	--	--	--	--	a)	--	--	--	--
Smax	--	--	--	--	Smax	--	--	--	--
b)	--	--	--	--	b)	--	--	--	--
Smax	--	--	--	--	Smax	--	--	--	--
c)	--	--	--	--	c)	--	--	--	--
Smax	--	--	--	--	Smax	--	--	--	--
100% Un					109% Un				

Appendix 1- Test Result

d)	4013.62	3620.49	1732.28	0.9021	d)	2692.33	2429.02	1161.25	0.9022
Smax	6057.25	5460.81	2620.87	0.9015	Smax	6053.81	5448.20	2639.11	0.8999
e)	4012.92	3616.75	-1738.45	0.9013	e)	2685.81	2421.26	-1162.36	0.9015
Smax	5964.10	5378.01	-2578.11	0.9017	Smax	5949.66	5373.21	-2554.65	0.9031
Remark: negative denotes lagging, positive denotes leading.									

5.7.5		**Testing of a displacement factor/active power characteristic curve cosφ(*P*)**								
Model		HYD 6000-ES								
Step		20% P_{Emax}	30% P_{Emax}	40% P_{Emax}	50% P_{Emax}	60% P_{Emax}	70% P_{Emax}	80% P_{Emax}	90% P_{Emax}	100% P_{Emax}
a)	P(W)	1203.29	1812.91	2418.84	3021.13	3617.31	4209.08	4799.17	5392.83	5352.91
	Cosφ (actual)	0.9969	0.9984	0.9989	0.9992	0.9804	0.9614	0.9427	0.9238	0.8974
	Cosφ (limit)	1	1	1	1	0.98	0.96	0.94	0.92	0.90
	△Cosφ	-0.0031	-0.0016	-0.0011	-0.0008	0.0004	0.0014	0.0027	0.0031	-0.0016
b)	P(W)	1202.77	--	--	3021.42	--	--	--	5596.27	--
	Cosφ (actual)	0.9971	--	--	0.9992	--	--	--	0.9235	--
	Cosφ (limit)	1	--	--	1	--	--	--	0.92	--
	Settling time (actual)	7.0	--	--	7.0	--	--	--	8.0	--
	Settling time (limit)	10s	--	--	10s	--	--	--	10s	--



Appendix 1- Test Result

6.1 (6.5.1)	TABLE: General requirements	P

Design of functional safety:

The internal control is redundant built. It consists of Microcontroller main CPU and slave CPU.

The master DSP controller monitor the charge or discharge statue; measure the PV voltage and current, battery voltage, bus voltage, buck voltage and current, AC voltage, current, GFCI and frequency.

The slave DSP controller monitor AC voltage , current ,frequency , GFCI and communicate with the master controller

The master DSP and slave DSP are used together to control relay open or close, if the single fault on one DSP, the other one DSP can be capable to open the relay, so that still providing safety means

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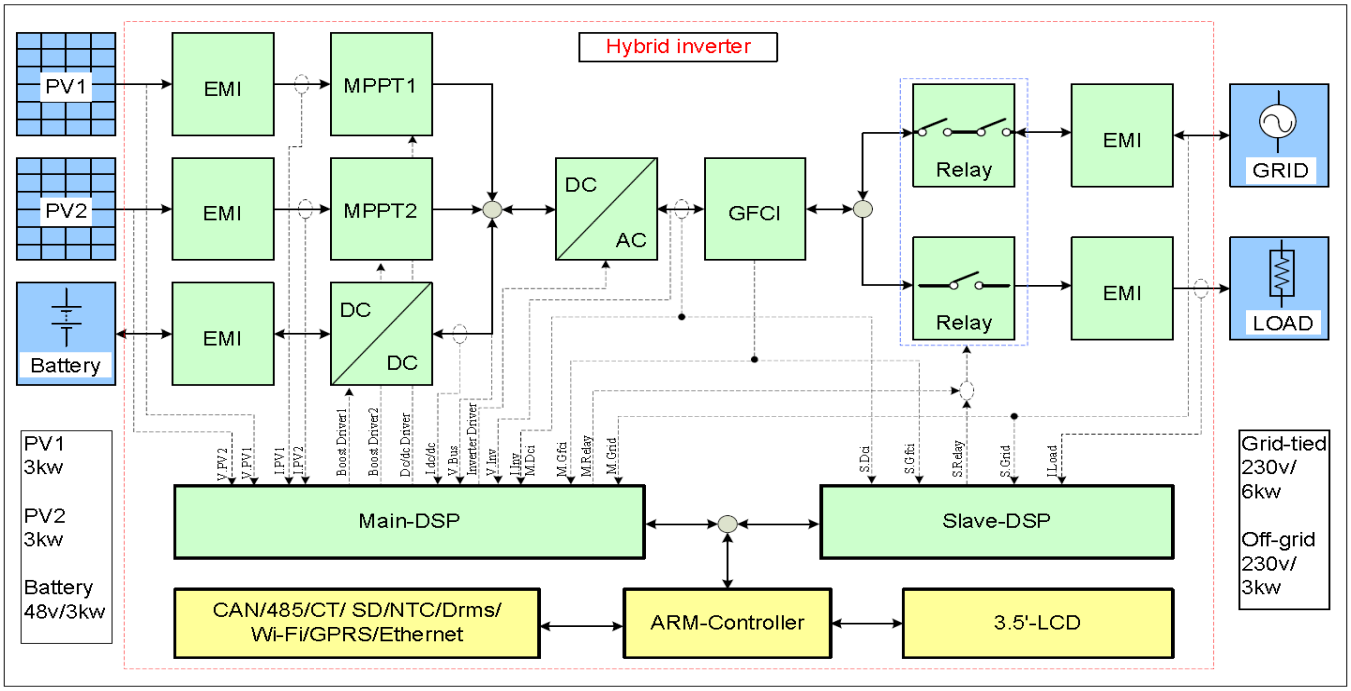


Supplementary information:

Two series relays would be automatically checked before the inverter starts operation

String	1	U_{DC} = Un	520Vdc	Uac = Un	230Vac	P = (W)	6K

Component No.	Fault	Observation
Relay RY1 defect	Short circuit before energizd	Indicate Relay fault, error code “ID55” (RecoverRelayFail). Do not connect to AC mainsn. No damage, no hazards.
Relay RY2 defect	Short circuit before energized	Indicate Relay fault, error code “ID55” (RecoverRelayFail). Do not connect to AC mainsn. No damage, no hazards.
Relay RY3 defect	Short circuit before energized	Indicate Relay fault, error code “ID55” (RecoverRelayFail). Do not connect to AC mainsn. No damage, no hazards.

Appendix 1- Test Result

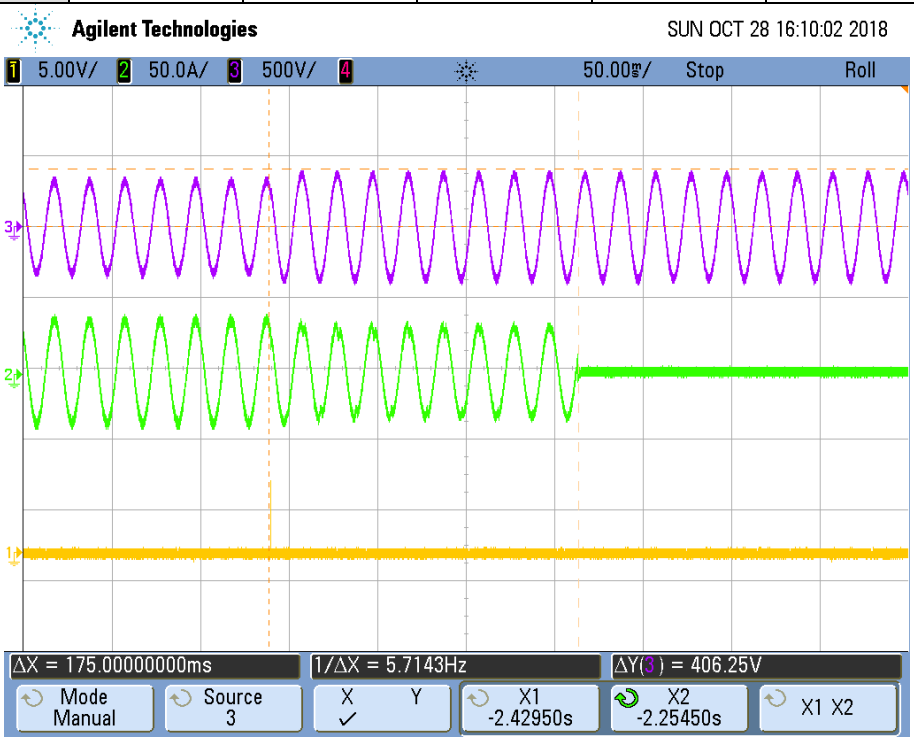
Relay RY4 defect	Short circuit before energized	Indicate Relay fault, error code “ID55” (RecoverRelayFail). Do not connect to AC mainsn. No damage, no hazards.
Relay RY5 defect	Short circuit before energized	Indicate Relay fault, error code “ID55” (RecoverRelayFail). Do not connect to AC mainsn. No damage, no hazards.
Relay RY6 defect	Short circuit before energized	Indicate Relay fault, error code “ID55” (RecoverRelayFail). Do not connect to AC mainsn. No damage, no hazards.
Monitoring voltage defect R508	short	Output a.c. relays operated, disconnected with grid. Q59 damage. No hazards.
Monitoring voltage defect Q59 pin 1-2	short	Output a.c. relays operated, disconnected with grid , error code “ID55” (RecoverRelayFail). No damage, no hazards.
Monitoring voltage defect U46 pin 1-2	short	Output a.c. relays operated, disconnected with grid , error code “ID55” (RecoverRelayFail). No damage, no hazards.
Monitoring voltage defect R511	short	Output a.c. relays operated, disconnected with grid , error code “ID55” (RecoverRelayFail). No damage, no hazards.
Monitoring voltage defect R509	open	The unit was in check state. No damage. No hazards.
Monitoring voltage defect U46 pin 3-4	short	Output a.c. relays operated, disconnected with grid , error code “ID55” (RecoverRelayFail). U46 damage, no hazards.
Voltage measurement disabled R204	Open	Output a.c. relays operated, disconnected with grid , error code “ID01” (The grid voltage is too high). No damage. No hazards.
Loss of control XL1	Short	Output a.c. relays operated, disconnected with grid , error code “ID53, ID54” (SPI communication is fault, SCI communication is fault). No damage. No hazards.
Loss of control C738(3.3VDD)	Short	Output a.c. relays operated, disconnected with grid , error code “ID53, ID54” (SPI communication is fault, SCI communication is fault). No damage. No hazards.

Appendix 1- Test Result

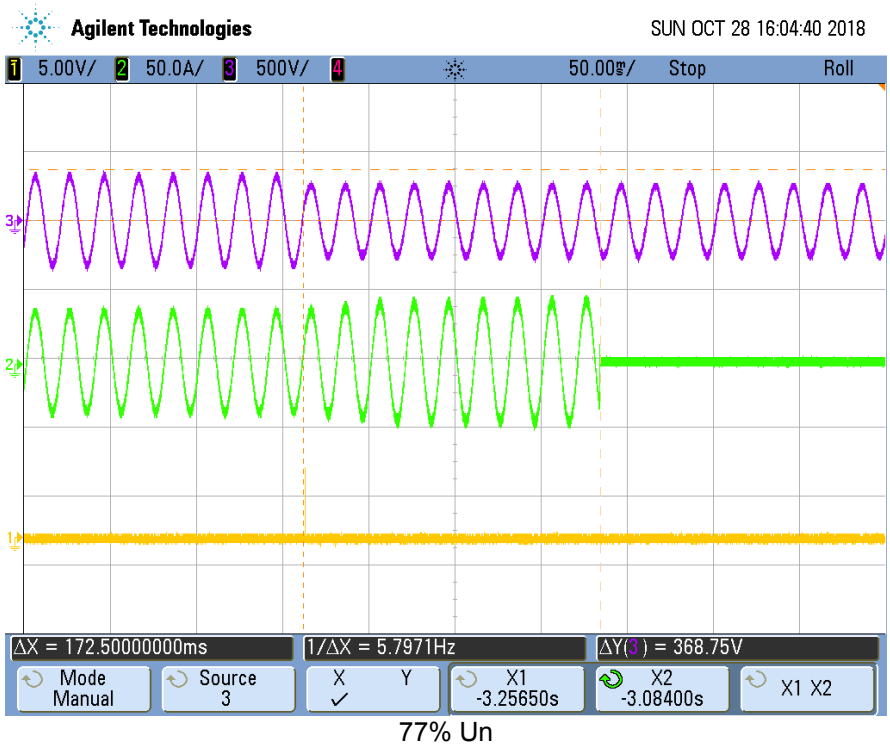
Communication microcontroller defect U4 pin1 to pin2	Short	Output a.c. relays operated, disconnected with grid , error code “ID53, ID54, ID75” (SPI communication is fault, SCI communication is fault, Unrecoverable EEPROM write). No damage. No hazards.
ISO defect R531	Short circuit before energized	Indicate ISO fault, error code “ID56” (The insulation resistance is too low). Do not connect to AC mainsn. No damage, no hazards.
ISO defect R598	Open circuit before energized	Indicate ISO fault, error code “ID56” (The insulation resistance is too low). Do not connect to AC mainsn. No damage, no hazards.
ISO defect R602	Open circuit before energized	Indicate ISO fault, error code “ID56” (The insulation resistance is too low). Do not connect to AC mainsn. No damage, no hazards.
ISO defect R605	Open circuit before energized	Indicate ISO fault, error code “ID56” (The insulation resistance is too low). Do not connect to AC mainsn. No damage, no hazards.
ISO defect R355	Short circuit before energized	Indicate ISO fault, error code “ID56” (The insulation resistance is too low). Do not connect to AC mainsn. No damage, no hazards.
ISO defect R303	Open circuit before energized	Indicate ISO fault, error code “ID56” (The insulation resistance is too low). Do not connect to AC mainsn. No damage, no hazards.
ISO defect R307	Short circuit before energized	Indicate ISO fault, error code “ID56” (The insulation resistance is too low). Do not connect to AC mainsn. No damage, no hazards.
ISO defect U23 pin 13-14	ISO defect U23 pin 13-14	Indicate ISO fault, error code “ID56” (The insulation resistance is too low). Do not connect to AC mainsn. No damage, no hazards.
GFCI defect R292	GFCI defect R292	Indicate GFCI fault, error code “ID48” (The GFCI sampling value between the master DSP and slave DSP is not consistent). Do not connect to AC mainsn. No damage, no hazards.
Supplementary information: SC: Short-circuited; OC: Open-circuited; O/L: Overloaded. During the test: Fire do not propagates beyond the EUT; Equipment do not emit molten metal; Enclosures do not deform to cause non-compliance with the standard. Pass the dielectric test.		

Appendix 1- Test Result

6.5.2	Protective functions (Results of Voltage monitoring)					
Rated Voltage (Un)	230V		Rated Frequency		50 Hz	
	1		2		3	
Phase	(V)	(ms)	(V)	(ms)	(V)	(ms)
118% Un	263.12	175.0	263.13	173.5	263.18	166.0
77% Un	185.75	149.5	185.61	148.5	185.73	172.5



118% Un

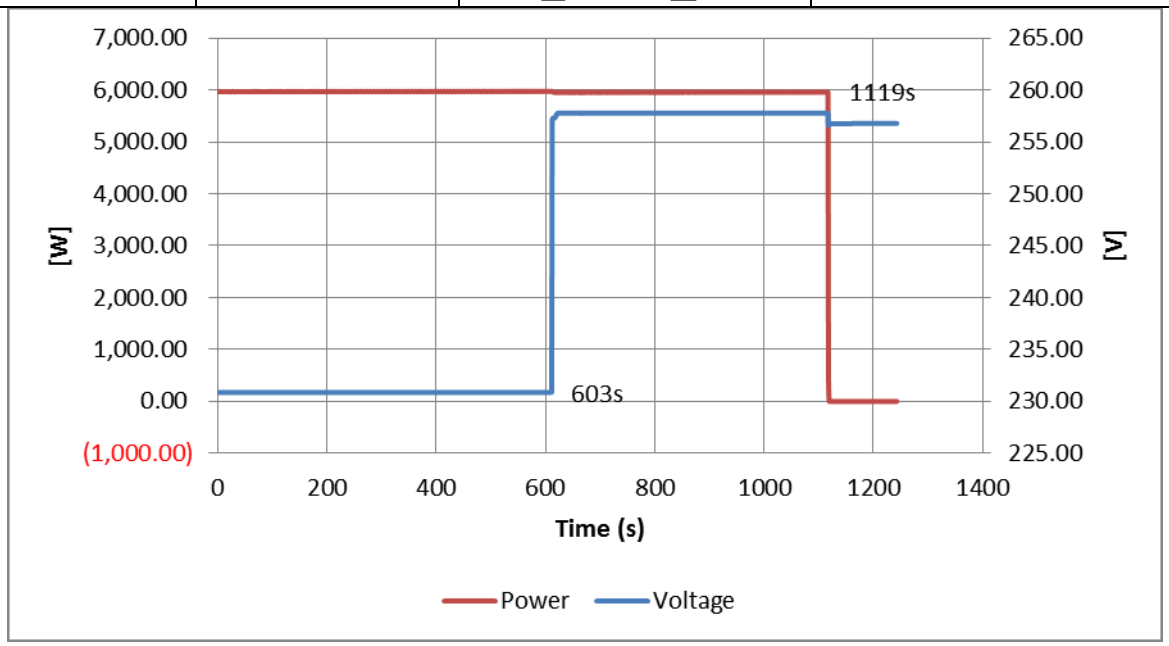


77% Un

Color Purple denotes Voltage of output, Green denotes current of output, Yellow denotes trip signal.

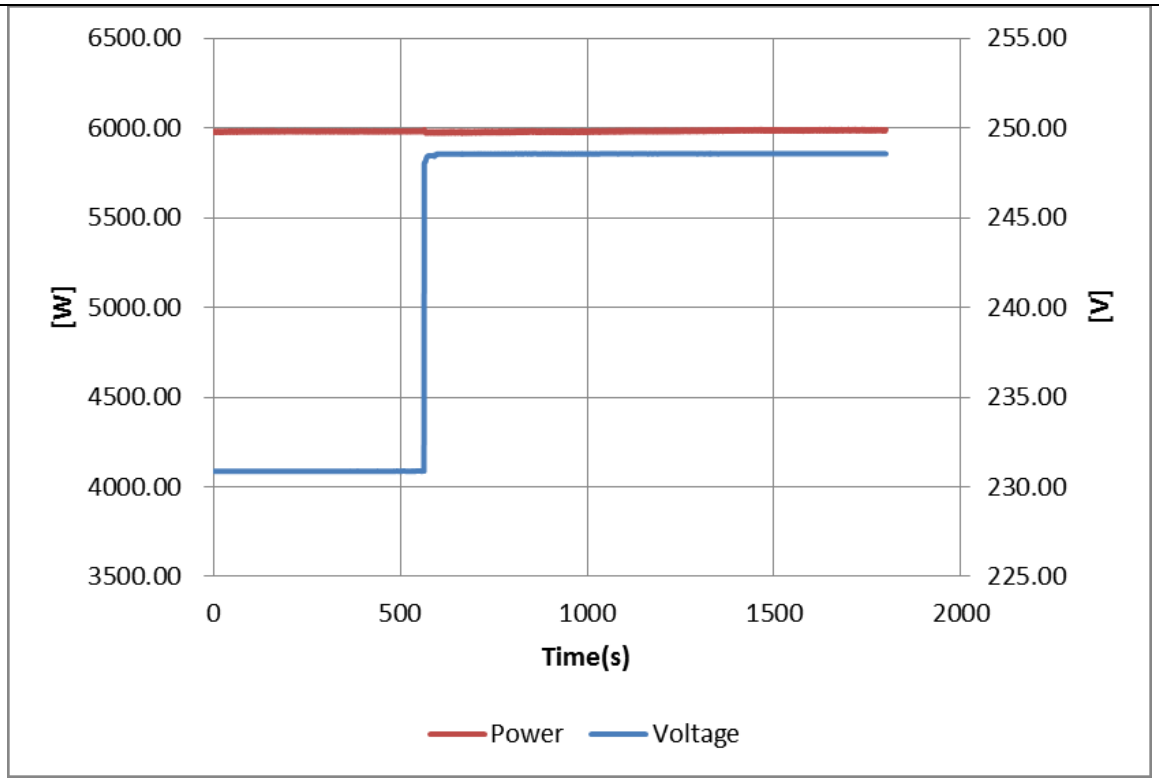
Appendix 1- Test Result

6.5.2	Protective functions (Results of the Protection of the Increase in Voltage as 10-min moving average)		
	Output Voltage (V)	Switch	
		On/Off state Finally	Time until Switch off (s)
100% Un	230.0	☒On ☐Off	Work normally
112% Un	257.6	☐On ☒Off	516
100% Un	230.0	☒On ☐Off	Work normally
108% Un	248.4	☒On ☐Off	Work normally
106% Un	243.8	☒On ☐Off	Work normally
114% Un	262.2	☐On ☒Off	302

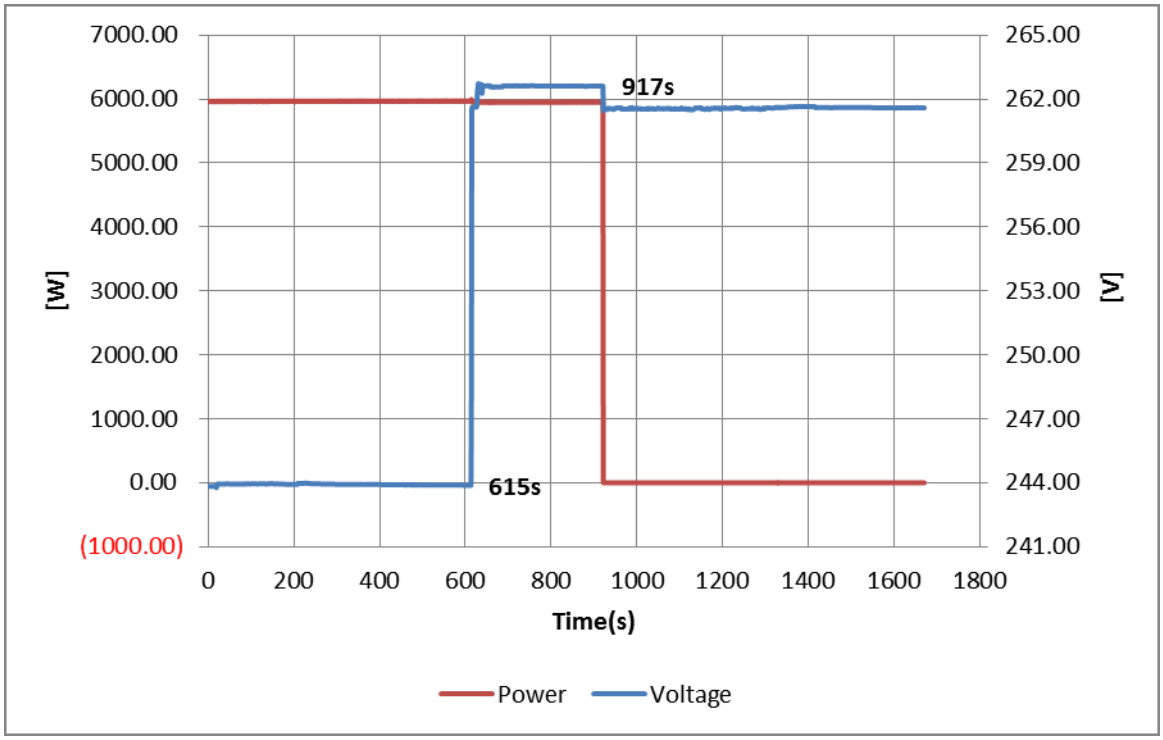


Un to 1.12Un

Appendix 1- Test Result



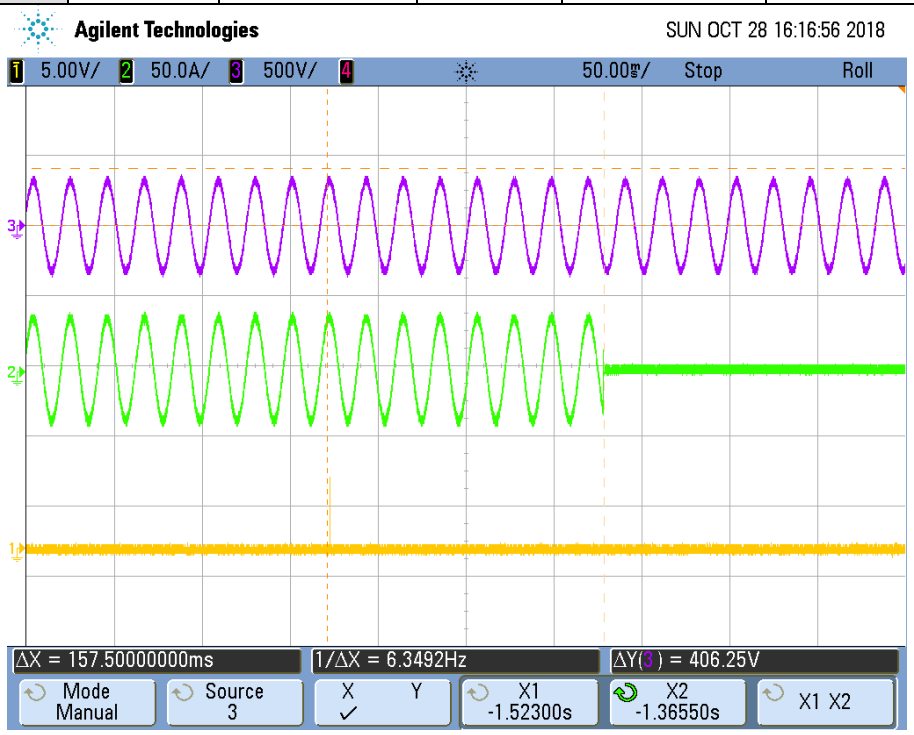
Un to 1.08Un



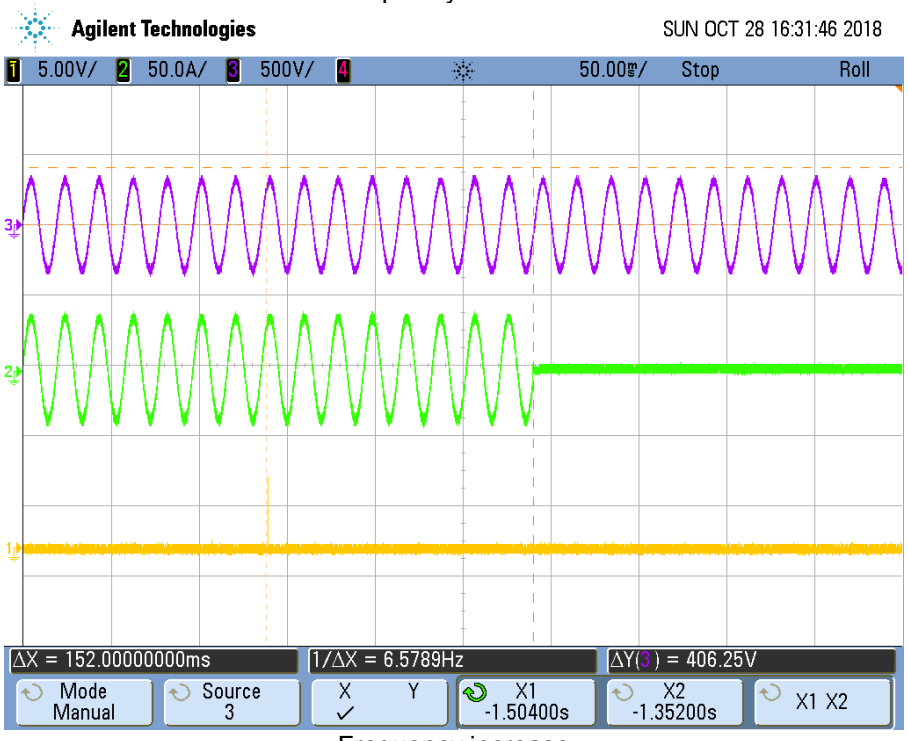
1.06 Un to 1.14Un

Appendix 1- Test Result

6.5.2	Protective functions (Results of Frequency)					
	1		2		3	
	f (Hz)	Trip time (ms)	f (Hz)	Trip time (ms)	f (Hz)	Trip time (ms)
Frequency decrease	47.50	157.5	47.50	156.0	47.50	154.5
Frequency increase	51.48	138.5	51.48	136.5	51.48	152.0



Frequency decrease

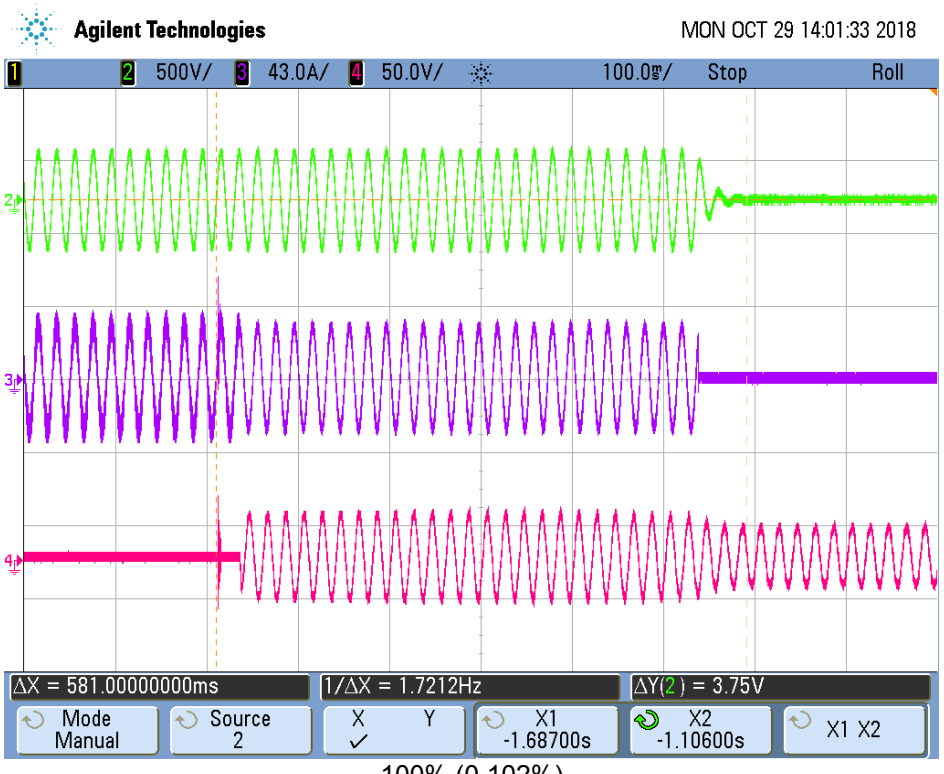


Frequency increase

Color Purple denotes Voltage of output, Green denotes current of output, Yellow denotes trip signal.

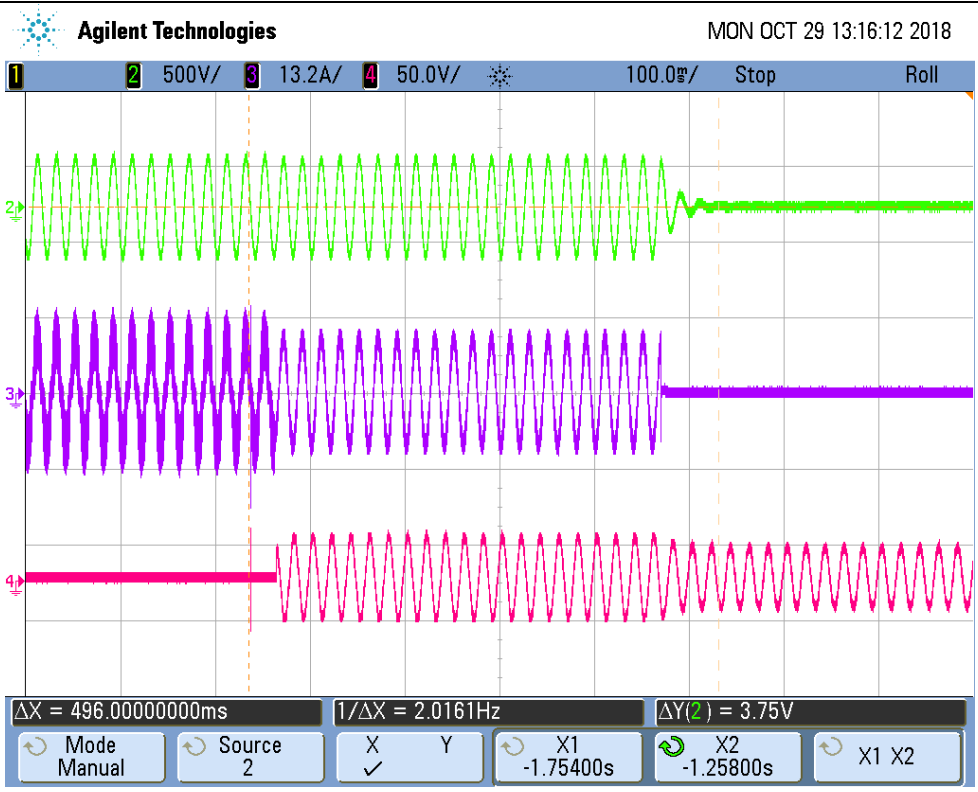
Appendix 1- Test Result

6.5.3	TABLE: Detection of islanding operation				P
Test conditions:	Frequency: 50+/-0,2Hz U_N=230+/-3Vac RLC consumes inverter real power within +/-3% Distortion factor of chokes <3% Quality Q>2				
P = 1.0 P_N = (W)	6020W	P = 0.5 P_N = (W)	3010W	P = 0.25 P_N = (W)	1453W
Q_L = 12.62KVar	Cut-off time (ms)	Q_L = 7.73KVar	Cut-off time (ms)	Q_L = 4.04KVar	Cut-off time (ms)
95%	365.0	95%	214.0	95%	410.0
96%	387.0	96%	307.0	96%	465.0
97%	473.0	97%	372.0	97%	532.0
98%	383.0	98%	361.0	98%	373.0
99%	537.0	99%	419.0	99%	582.0
100%	477.0	100%	410.0	100%	496.0
101%	422.0	101%	172.0	101%	418.0
102%	581.0	102%	439.0	102%	445.0
103%	427.0	103%	420.0	103%	417.0
104%	387.0	104%	434.0	104%	409.0
105%	381.0	105%	496.0	105%	370.0

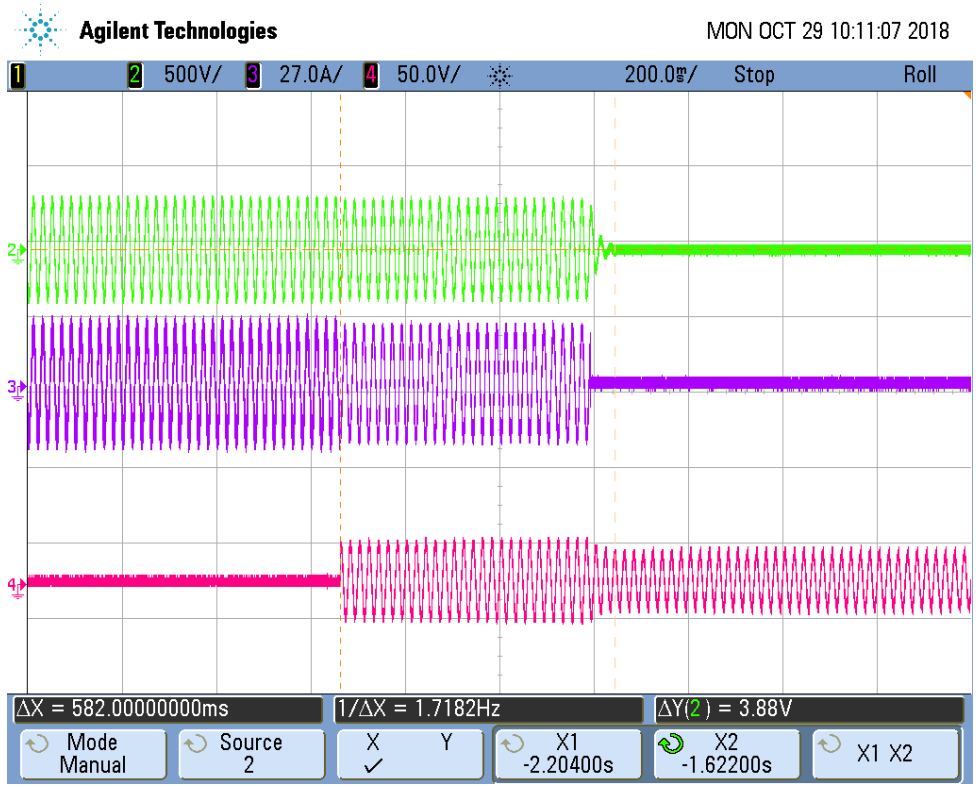


100% (0.102%)

Appendix 1- Test Result



50% (0,105%)



25 %(0,-1%)

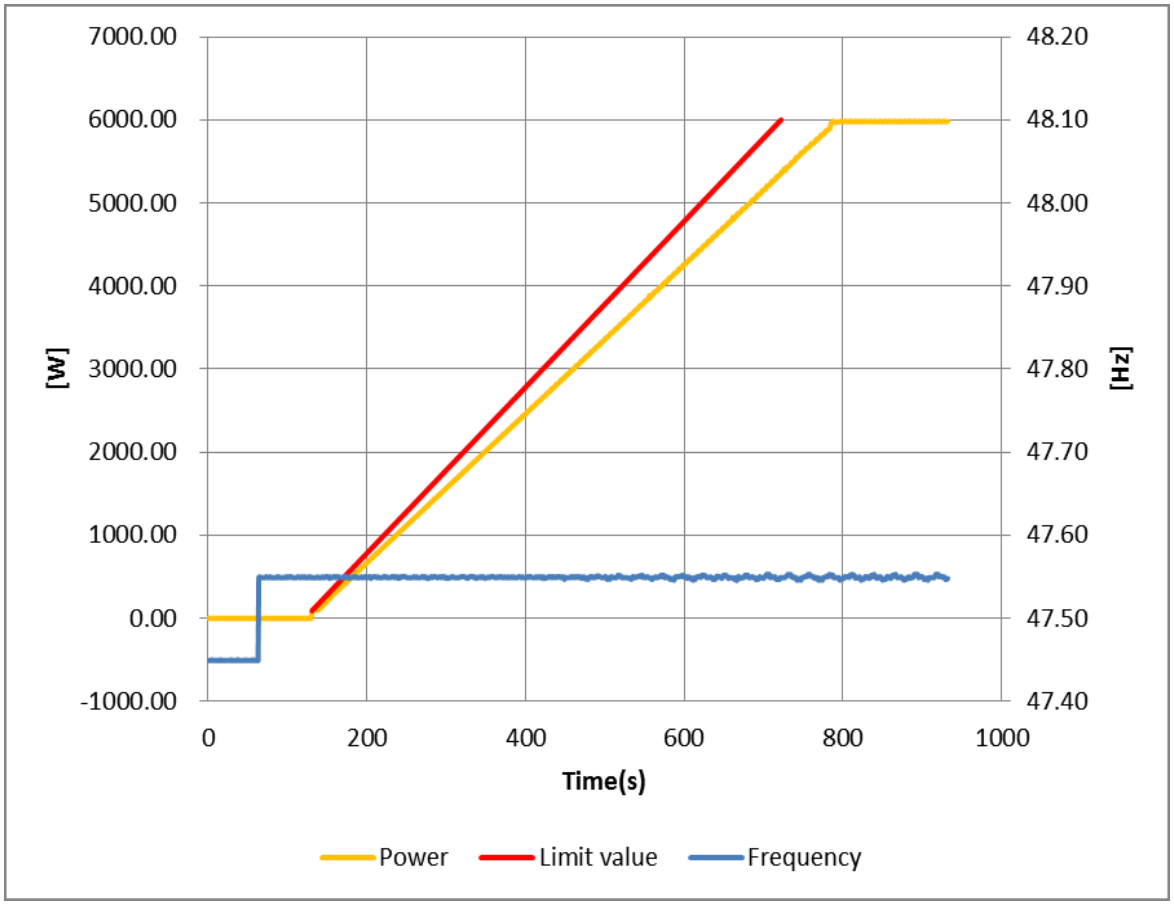
The measured trip time was captured by oscilloscope, which colour Pink denotes trip signal, Green denotes output voltage of EUT, and Purple denotes output current of EUT

Appendix 1- Test Result

8.3.1 (5.5.1 & 5.5.2)	**Connection conditions**		
DC input:	AC output:		Rated Output Power
400Vdc	230Vac;	50Hz	6.0kW

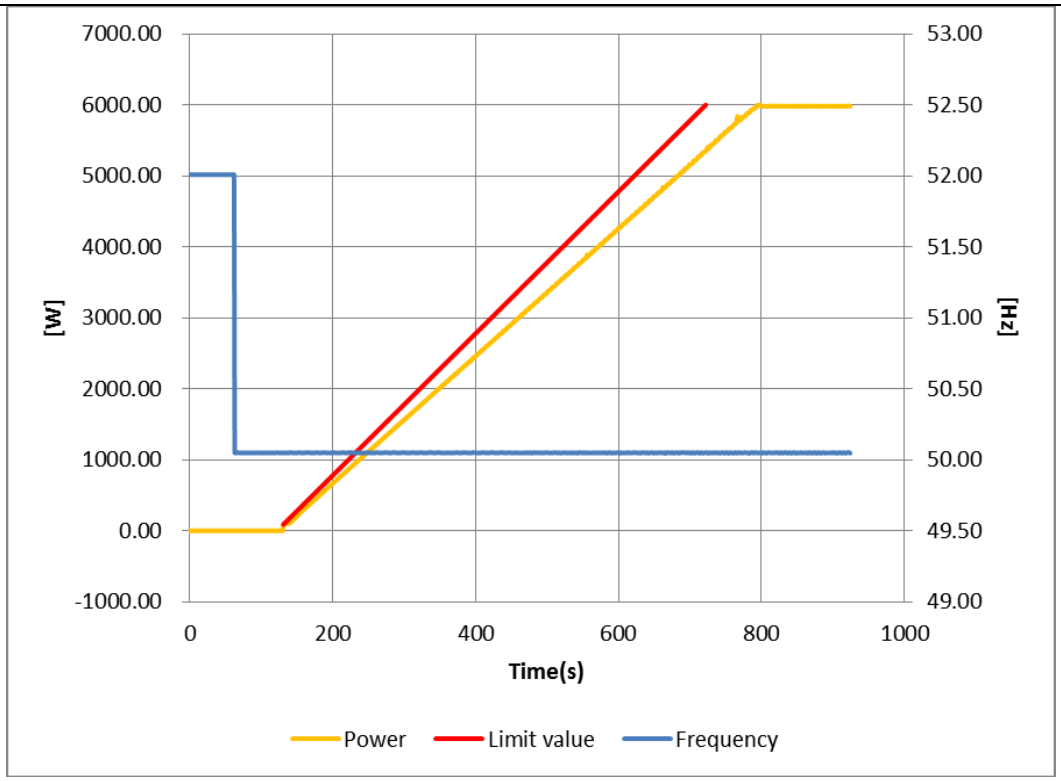
Measure Item	Reconnection?		Reconnection Time (>60s)
f_{ist} = 47,45Hz	☐ Yes	☒ No	Cannot reconnection
f_{ist} ≥ 47,55Hz	☒ Yes	☐ No	73.0s
f_{ist} = 50,1Hz	☐ Yes	☒ No	Cannot reconnection
f_{ist} ≤ 50,0Hz	☒ Yes	☐ No	72.0s
U_{ist} < 85% U_n	☐ Yes	☒ No	Cannot reconnection
U_{ist} ≥ 85% U_n	☒ Yes	☐ No	71.0s
U_{ist} > 110% U_n	☐ Yes	☒ No	Cannot reconnection
U_{ist} ≤ 110% U_n	☒ Yes	☐ No	72.0s

Graph of the gradual power supply and reconnection: for 47.55Hz

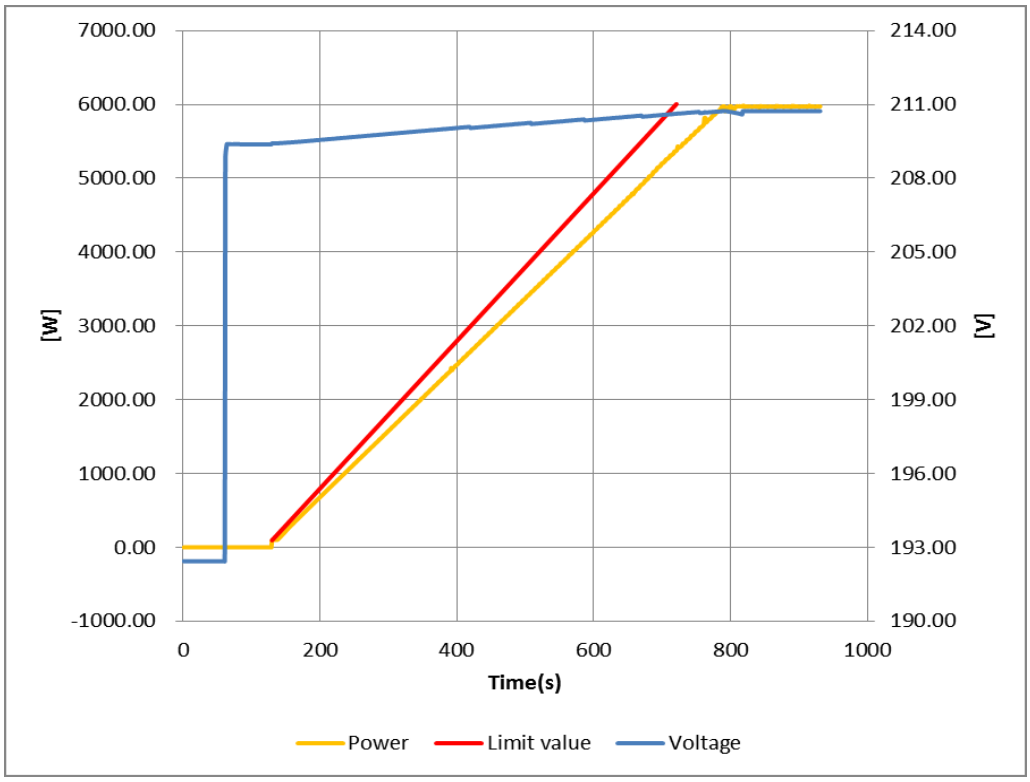


Graph of the gradual power supply and reconnection: for 50.0Hz

Appendix 1- Test Result

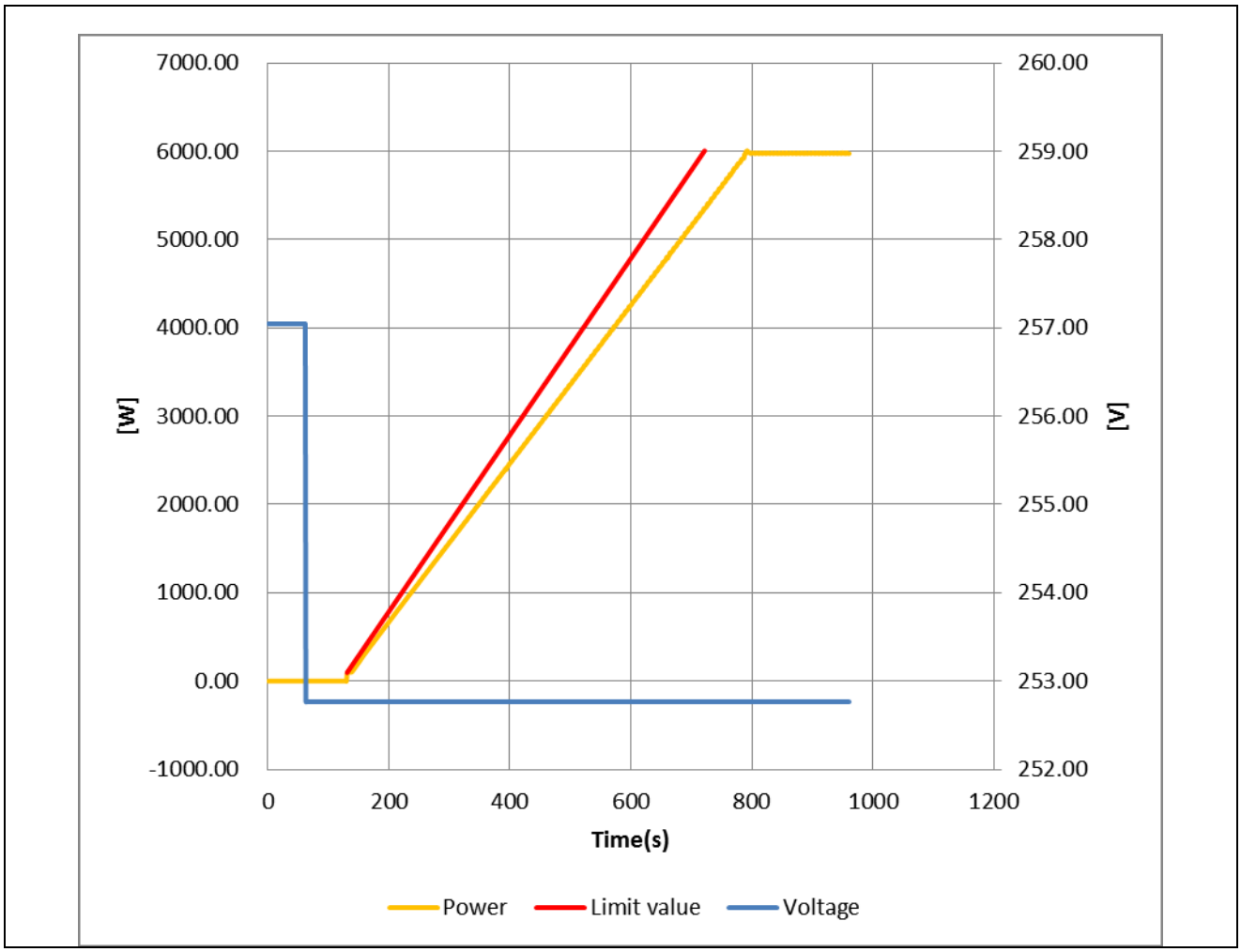


Graph of the gradual power supply and reconnection: for 85%Un



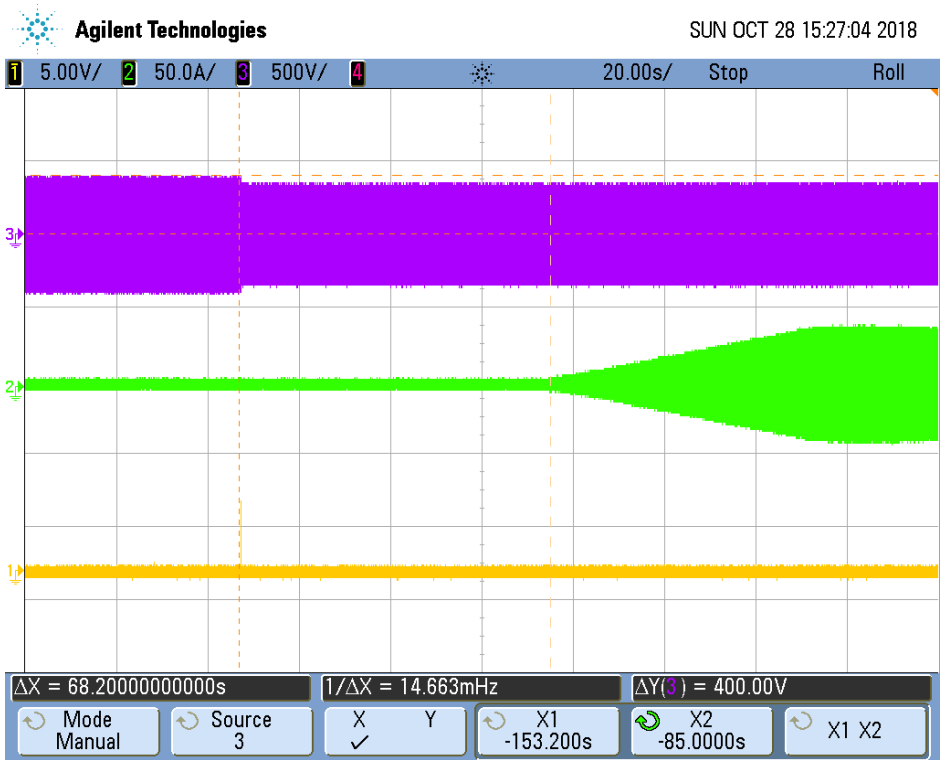
Graph of the gradual power supply and reconnection: for 110%Un

Appendix 1- Test Result



Appendix 1- Test Result

8.3.1 (5.5.1 & 5.5.2)	Short-time Interruption								
	1			2			3		
	U_n (V)	Repeated Time (s)	Gradient (W/min)	U_n (V)	Repeated Time (s)	Gradient (W/min)	U_n (V)	Repeated Time (s)	Gradient (W/min)
After 2s of 77% Un	230	69.8	544.02	230	68.7	543.70	230	68.5	543.05
After 4s of 77% Un	230	68.2	542.07	230	67.50	543.02	230	67.30	542.52



After 2s of 77% Un

Appendix 1- Test Result

F.3 Requirements for the test report for power generation units

Extract from test report for unit certificate: 180903074GZU-001										
Determination of electrical properties										
Installation Type:	Hybrid Inverter									
Manufacturer:	Shenzhen SOFAR SOLAR Co., Ltd.									
Rated Voltage:	230V									
Reactive power reference										
Active power P/P_n(%)	10	20	30	40	50	60	70	80	90	100
Max. possible cos φ underexcited	0.8905	0.833	0.8099	0.8017	0.7967	0.7935	0.7915	0.8001	0.7991	0.7985
Max. possible cos φ overexcited	0.6894	0.7312	0.7933	0.7946	0.8028	0.8075	0.8014	0.8036	0.805	0.8064
Compliance of required displacement factor cos φ										
Default in system control	0.90 over	0.92 over	0.94 over	0.96 over	0.98 over	1.00	0.98 under	0.96 under	0.94 under	0.92 under	0.90 under
Measured value at PGU terminals	0.9020	0.9215	0.9409	0.9605	0.9799	0.9995	0.9797	0.9600	0.9404	0.9208	0.9013
Reactive power transfer function – Standard-cos φ -(P)-characteristic										
Active power P/P_n (%)	10	20	30	40	50	60	70	80	90	100
cos φ	0.9969	0.9984	0.9989	0.9992	0.9804	0.9614	0.9427	0.9238	0.8974	0.9969
Conform to Standard-cos φ-(P)-characteristic										

Switching actions		
Making operation without default (of primary energy carrier)	k_i	<1
Worst case at switch over of generator sections	k_i	<1
Making operation at reference conditions (of primary energy carrier)	k_i	<1
Breaking operation at nominal power	k_i	<1
Worst-case value of all switching operations	k_{imax}	0.311

Flicker	
Angle of network impedance ψ_k:	32°
Coefficient of system flicker $C\psi$:	8.04
Long-term flicker strength Plt:	0.41
Short-term flicker strength Pst:	0.43

Appendix 1- Test Result

HYD 3000-ES											
Active power P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
Harmonic number	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]
2	0.0147	0.0139	0.0193	0.0572	0.0688	0.1059	0.1168	0.1531	0.0866	0.1941	0.1863
3	0.4005	0.5606	0.6943	0.6998	0.7160	0.7663	0.7980	0.8157	0.8567	0.8784	0.7949
4	0.0108	0.0085	0.0201	0.0302	0.0309	0.0503	0.0572	0.0650	0.0495	0.0889	0.0905
5	0.2451	0.2900	0.2992	0.3016	0.2977	0.3271	0.2884	0.3116	0.2992	0.2930	0.2992
6	0.0093	0.0217	0.0139	0.0217	0.0271	0.0348	0.0371	0.0456	0.0441	0.0495	0.0657
7	0.1562	0.2374	0.1802	0.1662	0.1662	0.1616	0.1639	0.1554	0.1577	0.2126	0.1539
8	0.0131	0.0224	0.0131	0.0147	0.0217	0.0224	0.0193	0.0332	0.0247	0.0425	0.0495
9	0.1407	0.2157	0.1245	0.1021	0.1052	0.1083	0.0982	0.1098	0.1028	0.1291	0.1090
10	0.0116	0.0193	0.0077	0.0085	0.0070	0.0224	0.0186	0.0294	0.0186	0.0263	0.0348
11	0.1222	0.2126	0.0943	0.0665	0.0773	0.0711	0.0479	0.0773	0.0688	0.0920	0.0835
12	0.0124	0.0116	0.0131	0.0108	0.0162	0.0224	0.0278	0.0356	0.0170	0.0294	0.0286
13	0.0704	0.1902	0.0634	0.0448	0.0626	0.0448	0.0271	0.0642	0.0704	0.0874	0.0750
14	0.0101	0.0031	0.0077	0.0116	0.0193	0.0217	0.0247	0.0309	0.0240	0.0232	0.0363
15	0.0642	0.1701	0.0402	0.0363	0.0456	0.0503	0.0340	0.0650	0.0812	0.0804	0.0750
16	0.0116	0.0093	0.0116	0.0077	0.0170	0.0139	0.0186	0.0170	0.0162	0.0217	0.0325
17	0.0719	0.1562	0.0541	0.0387	0.0356	0.0626	0.0410	0.0673	0.0773	0.0851	0.0619
18	0.0077	0.0147	0.0046	0.0062	0.0085	0.0101	0.0077	0.0155	0.0170	0.0178	0.0108
19	0.0951	0.1415	0.0588	0.0325	0.0232	0.0650	0.0387	0.0657	0.0688	0.0835	0.0688
20	0.0101	0.0201	0.0124	0.0070	0.0077	0.0062	0.0101	0.0209	0.0155	0.0247	0.0077
21	0.0936	0.1423	0.0588	0.0402	0.0255	0.0472	0.0650	0.0696	0.0626	0.0735	0.0765
22	0.0131	0.0209	0.0162	0.0054	0.0124	0.0093	0.0139	0.0147	0.0147	0.0162	0.0186
23	0.0851	0.0711	0.0650	0.0487	0.0139	0.0456	0.0387	0.0727	0.0650	0.0781	0.0789
24	0.0108	0.0147	0.0116	0.0077	0.0046	0.0062	0.0139	0.0139	0.0108	0.0101	0.0209
25	0.0657	0.0650	0.0765	0.0410	0.0124	0.0433	0.0402	0.0657	0.0758	0.0820	0.0750
26	0.0093	0.0124	0.0124	0.0046	0.0054	0.0054	0.0139	0.0108	0.0077	0.0147	0.0131
27	0.0557	0.0889	0.0820	0.0425	0.0178	0.0394	0.0332	0.0619	0.0711	0.0758	0.0727
28	0.0062	0.0031	0.0093	0.0070	0.0093	0.0070	0.0116	0.0139	0.0155	0.0131	0.0077
29	0.0665	0.1028	0.0858	0.0503	0.0278	0.0325	0.0325	0.0580	0.0557	0.0735	0.0789
30	0.0093	0.0046	0.0085	0.0062	0.0070	0.0093	0.0108	0.0093	0.0093	0.0131	0.0077
31	0.0704	0.1090	0.0897	0.0495	0.0348	0.0325	0.0317	0.0541	0.0557	0.0727	0.0719
32	0.0085	0.0077	0.0108	0.0062	0.0054	0.0070	0.0054	0.0054	0.0046	0.0116	0.0147
33	0.0711	0.1036	0.0858	0.0379	0.0348	0.0332	0.0302	0.0510	0.0503	0.0642	0.0735
34	0.0085	0.0101	0.0070	0.0062	0.0077	0.0062	0.0093	0.0054	0.0085	0.0155	0.0108
35	0.0611	0.0881	0.0881	0.0363	0.0387	0.0325	0.0317	0.0456	0.0495	0.0588	0.0626
36	0.0046	0.0116	0.0054	0.0062	0.0085	0.0070	0.0116	0.0046	0.0077	0.0070	0.0108
37	0.0588	0.0611	0.0905	0.0394	0.0456	0.0294	0.0309	0.0387	0.0456	0.0541	0.0588
38	0.0070	0.0093	0.0054	0.0093	0.0093	0.0077	0.0124	0.0046	0.0039	0.0093	0.0085
39	0.0510	0.0394	0.0851	0.0371	0.0410	0.0286	0.0271	0.0363	0.0402	0.0549	0.0611
40	0.0070	0.0070	0.0046	0.0070	0.0046	0.0070	0.0093	0.0039	0.0039	0.0062	0.0046

Appendix 1- Test Result

HYD 3000-ES											
Active power P/Pn [%]	0	10	20	30	40	50	60	70	80	90	100
Frequency [Hz]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]
75	0.0116	0.0441	0.0967	0.1678	0.2111	0.2992	0.3379	0.4276	0.4152	0.5467	0.5443
125	0.0186	0.0332	0.0271	0.0309	0.0526	0.0967	0.1028	0.1423	0.1268	0.1833	0.1531
175	0.0170	0.0325	0.0371	0.0503	0.0588	0.0812	0.0912	0.1090	0.1098	0.1430	0.1407
225	0.0162	0.0456	0.0394	0.0394	0.0472	0.0564	0.0603	0.0742	0.0773	0.0997	0.1028
275	0.0186	0.0603	0.0325	0.0340	0.0456	0.0572	0.0657	0.0750	0.0858	0.0912	0.0967
325	0.0170	0.0572	0.0410	0.0371	0.0503	0.0410	0.0518	0.0495	0.0735	0.0680	0.0936
375	0.0209	0.0534	0.0247	0.0178	0.0317	0.0433	0.0425	0.0634	0.0572	0.0719	0.0464
425	0.0201	0.0634	0.0332	0.0224	0.0371	0.0309	0.0425	0.0394	0.0626	0.0472	0.0758
475	0.0217	0.0526	0.0433	0.0217	0.0240	0.0433	0.0340	0.0518	0.0340	0.0634	0.0302
525	0.0209	0.0603	0.0302	0.0155	0.0232	0.0255	0.0332	0.0294	0.0433	0.0255	0.0410
575	0.0201	0.0541	0.0371	0.0224	0.0348	0.0271	0.0332	0.0510	0.0247	0.0588	0.0526
625	0.0217	0.0603	0.0286	0.0193	0.0240	0.0217	0.0224	0.0317	0.0278	0.0263	0.0271
675	0.0217	0.0603	0.0263	0.0193	0.0240	0.0224	0.0340	0.0356	0.0294	0.0518	0.0541
725	0.0224	0.0549	0.0340	0.0217	0.0317	0.0209	0.0232	0.0278	0.0263	0.0278	0.0441
775	0.0217	0.0541	0.0325	0.0131	0.0201	0.0186	0.0240	0.0302	0.0410	0.0387	0.0650
825	0.0193	0.0433	0.0317	0.0162	0.0170	0.0186	0.0232	0.0247	0.0356	0.0209	0.0479
875	0.0201	0.0510	0.0240	0.0108	0.0155	0.0131	0.0162	0.0255	0.0263	0.0464	0.0162
925	0.0209	0.0433	0.0255	0.0108	0.0178	0.0147	0.0131	0.0201	0.0302	0.0232	0.0247
975	0.0178	0.0363	0.0263	0.0070	0.0193	0.0131	0.0124	0.0247	0.0232	0.0379	0.0232
1025	0.0178	0.0317	0.0240	0.0093	0.0186	0.0124	0.0139	0.0255	0.0217	0.0255	0.0124
1075	0.0162	0.0286	0.0240	0.0116	0.0108	0.0093	0.0178	0.0162	0.0178	0.0286	0.0325
1125	0.0178	0.0317	0.0247	0.0085	0.0139	0.0093	0.0147	0.0186	0.0155	0.0201	0.0247
1175	0.0147	0.0317	0.0224	0.0124	0.0131	0.0147	0.0162	0.0178	0.0193	0.0278	0.0371
1225	0.0162	0.0356	0.0209	0.0131	0.0131	0.0116	0.0186	0.0193	0.0162	0.0217	0.0325
1275	0.0201	0.0325	0.0224	0.0108	0.0131	0.0077	0.0162	0.0116	0.0193	0.0263	0.0170
1325	0.0170	0.0371	0.0232	0.0139	0.0139	0.0101	0.0139	0.0131	0.0201	0.0263	0.0317
1375	0.0170	0.0348	0.0201	0.0101	0.0155	0.0101	0.0147	0.0116	0.0162	0.0193	0.0209
1425	0.0170	0.0332	0.0193	0.0077	0.0124	0.0077	0.0155	0.0147	0.0209	0.0232	0.0193
1475	0.0155	0.0363	0.0186	0.0116	0.0147	0.0147	0.0116	0.0093	0.0101	0.0247	0.0217
1525	0.0162	0.0286	0.0178	0.0093	0.0108	0.0077	0.0131	0.0186	0.0131	0.0217	0.0162
1575	0.0139	0.0332	0.0186	0.0124	0.0108	0.0101	0.0085	0.0077	0.0139	0.0147	0.0224
1625	0.0155	0.0255	0.0193	0.0101	0.0101	0.0116	0.0101	0.0124	0.0162	0.0162	0.0209
1675	0.0131	0.0286	0.0170	0.0116	0.0116	0.0101	0.0101	0.0093	0.0093	0.0108	0.0116
1725	0.0131	0.0217	0.0186	0.0101	0.0101	0.0108	0.0124	0.0085	0.0139	0.0201	0.0155
1775	0.0131	0.0232	0.0178	0.0085	0.0124	0.0116	0.0124	0.0077	0.0070	0.0108	0.0108
1825	0.0131	0.0232	0.0162	0.0070	0.0116	0.0108	0.0116	0.0085	0.0093	0.0155	0.0131
1875	0.0162	0.0186	0.0147	0.0108	0.0070	0.0077	0.0093	0.0093	0.0070	0.0101	0.0108
1925	0.0147	0.0217	0.0178	0.0085	0.0085	0.0124	0.0116	0.0108	0.0077	0.0139	0.0085
1975	0.0131	0.0186	0.0139	0.0070	0.0101	0.0085	0.0093	0.0101	0.0124	0.0093	0.0170

Appendix 1- Test Result

HYD 3000-ES											
Active power P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
Frequency [kHz]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]
2.1	0.0046	0.0077	0.0093	0.0085	0.0046	0.0101	0.0062	0.0054	0.0039	0.0108	0.0062
2.3	0.0062	0.0085	0.0070	0.0062	0.0062	0.0108	0.0077	0.0101	0.0062	0.0031	0.0046
2.5	0.0054	0.0077	0.0070	0.0070	0.0062	0.0101	0.0085	0.0093	0.0093	0.0062	0.0070
2.7	0.0062	0.0077	0.0054	0.0085	0.0101	0.0116	0.0093	0.0093	0.0046	0.0031	0.0054
2.9	0.0085	0.0085	0.0077	0.0077	0.0077	0.0077	0.0085	0.0085	0.0046	0.0070	0.0070
3.1	0.0039	0.0085	0.0093	0.0093	0.0077	0.0070	0.0077	0.0085	0.0093	0.0062	0.0062
3.3	0.0046	0.0093	0.0101	0.0131	0.0077	0.0108	0.0046	0.0085	0.0101	0.0046	0.0062
3.5	0.0070	0.0077	0.0093	0.0124	0.0054	0.0062	0.0077	0.0070	0.0077	0.0062	0.0070
3.7	0.0077	0.0101	0.0062	0.0108	0.0085	0.0070	0.0085	0.0085	0.0093	0.0046	0.0108
3.9	0.0085	0.0139	0.0101	0.0131	0.0093	0.0093	0.0085	0.0077	0.0131	0.0124	0.0116
4.1	0.0054	0.0108	0.0054	0.0085	0.0155	0.0070	0.0039	0.0077	0.0062	0.0085	0.0093
4.3	0.0108	0.0108	0.0085	0.0046	0.0116	0.0046	0.0070	0.0077	0.0077	0.0054	0.0139
4.5	0.0155	0.0116	0.0070	0.0077	0.0116	0.0093	0.0054	0.0131	0.0062	0.0054	0.0108
4.7	0.0139	0.0085	0.0085	0.0031	0.0070	0.0054	0.0108	0.0046	0.0085	0.0046	0.0085
4.9	0.0093	0.0085	0.0054	0.0046	0.0046	0.0046	0.0108	0.0054	0.0070	0.0077	0.0077
5.1	0.0108	0.0147	0.0085	0.0054	0.0046	0.0070	0.0085	0.0077	0.0070	0.0054	0.0116
5.3	0.0116	0.0101	0.0077	0.0070	0.0062	0.0031	0.0077	0.0108	0.0093	0.0085	0.0116
5.5	0.0077	0.0046	0.0062	0.0070	0.0070	0.0062	0.0070	0.0093	0.0062	0.0093	0.0139
5.7	0.0131	0.0070	0.0046	0.0062	0.0093	0.0046	0.0085	0.0077	0.0101	0.0077	0.0116
5.9	0.0093	0.0039	0.0054	0.0046	0.0039	0.0054	0.0046	0.0124	0.0085	0.0093	0.0116
6.1	0.0131	0.0039	0.0039	0.0070	0.0085	0.0046	0.0108	0.0054	0.0085	0.0077	0.0139
6.3	0.0077	0.0054	0.0023	0.0062	0.0085	0.0101	0.0062	0.0085	0.0077	0.0077	0.0108
6.5	0.0101	0.0039	0.0031	0.0062	0.0070	0.0085	0.0054	0.0101	0.0077	0.0085	0.0124
6.7	0.0085	0.0062	0.0054	0.0031	0.0054	0.0062	0.0085	0.0070	0.0070	0.0062	0.0116
6.9	0.0108	0.0046	0.0108	0.0062	0.0070	0.0054	0.0023	0.0039	0.0054	0.0070	0.0085
7.1	0.0085	0.0031	0.0093	0.0046	0.0093	0.0062	0.0054	0.0031	0.0077	0.0054	0.0124
7.3	0.0077	0.0062	0.0062	0.0085	0.0054	0.0085	0.0046	0.0054	0.0093	0.0062	0.0116
7.5	0.0108	0.0093	0.0101	0.0070	0.0046	0.0070	0.0070	0.0085	0.0101	0.0070	0.0077
7.7	0.0062	0.0070	0.0070	0.0085	0.0070	0.0108	0.0139	0.0116	0.0085	0.0085	0.0077
7.9	0.0077	0.0124	0.0077	0.0162	0.0147	0.0170	0.0255	0.0255	0.0387	0.0356	0.0356
8.1	0.0046	0.0062	0.0085	0.0155	0.0162	0.0155	0.0186	0.0278	0.0348	0.0302	0.0309
8.3	0.0070	0.0070	0.0085	0.0124	0.0124	0.0108	0.0062	0.0147	0.0131	0.0124	0.0085
8.5	0.0046	0.0077	0.0085	0.0077	0.0070	0.0085	0.0085	0.0070	0.0093	0.0085	0.0085
8.7	0.0062	0.0046	0.0085	0.0085	0.0070	0.0062	0.0046	0.0062	0.0093	0.0031	0.0070
8.9	0.0046	0.0062	0.0085	0.0093	0.0077	0.0093	0.0062	0.0108	0.0124	0.0093	0.0101

Appendix 1- Test Result

HYD 3600-ES											
Active power P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
Harmonic number	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]
2	0.0153	0.0191	0.0402	0.0593	0.0816	0.1205	0.1027	0.1326	0.1479	0.2289	0.1913
3	0.3316	0.4546	0.5713	0.6128	0.6313	0.6446	0.6950	0.6893	0.6746	0.5847	0.7543
4	0.0102	0.0102	0.0166	0.0261	0.0376	0.0453	0.0472	0.0631	0.0644	0.1154	0.1167
5	0.2187	0.2028	0.2468	0.2461	0.2582	0.2500	0.2595	0.2519	0.2251	0.2582	0.1224
6	0.0083	0.0045	0.0140	0.0249	0.0236	0.0281	0.0312	0.0510	0.0370	0.0459	0.1530
7	0.1371	0.1460	0.1377	0.1352	0.1282	0.1301	0.1307	0.1173	0.1607	0.1958	0.2162
8	0.0096	0.0134	0.0128	0.0159	0.0204	0.0268	0.0338	0.0536	0.0453	0.0714	0.0803
9	0.1135	0.1307	0.0886	0.0797	0.0950	0.0803	0.0842	0.0861	0.1192	0.0823	0.0778
10	0.0102	0.0102	0.0108	0.0077	0.0166	0.0134	0.0261	0.0223	0.0363	0.0886	0.0682
11	0.1116	0.1288	0.0682	0.0529	0.0587	0.0357	0.0561	0.0599	0.0676	0.1001	0.1212
12	0.0102	0.0070	0.0057	0.0083	0.0153	0.0198	0.0153	0.0147	0.0217	0.0829	0.1154
13	0.0937	0.1243	0.0414	0.0414	0.0421	0.0281	0.0459	0.0606	0.0555	0.1129	0.0861
14	0.0121	0.0089	0.0089	0.0121	0.0089	0.0153	0.0121	0.0217	0.0204	0.0606	0.0670
15	0.0778	0.1269	0.0325	0.0376	0.0440	0.0332	0.0548	0.0638	0.0606	0.0612	0.0765
16	0.0108	0.0096	0.0134	0.0121	0.0083	0.0166	0.0134	0.0128	0.0102	0.0351	0.0446
17	0.0650	0.1294	0.0332	0.0332	0.0580	0.0440	0.0663	0.0580	0.0721	0.1014	0.1282
18	0.0096	0.0038	0.0077	0.0077	0.0089	0.0115	0.0121	0.0249	0.0217	0.0363	0.0925
19	0.0606	0.1428	0.0191	0.0319	0.0491	0.0414	0.0631	0.0529	0.0631	0.0631	0.0414
20	0.0108	0.0108	0.0077	0.0051	0.0077	0.0064	0.0147	0.0089	0.0108	0.0191	0.0421
21	0.0670	0.1511	0.0249	0.0236	0.0414	0.0351	0.0587	0.0555	0.0701	0.0944	0.0797
22	0.0115	0.0108	0.0077	0.0077	0.0102	0.0070	0.0134	0.0057	0.0147	0.0204	0.0147
23	0.0727	0.1384	0.0204	0.0210	0.0536	0.0402	0.0663	0.0644	0.0708	0.0791	0.1033
24	0.0102	0.0077	0.0057	0.0057	0.0064	0.0045	0.0102	0.0096	0.0128	0.0140	0.0421
25	0.0759	0.1071	0.0230	0.0191	0.0357	0.0370	0.0497	0.0606	0.0676	0.0893	0.0485
26	0.0077	0.0051	0.0070	0.0083	0.0051	0.0032	0.0077	0.0089	0.0102	0.0153	0.0236
27	0.0695	0.0663	0.0338	0.0230	0.0293	0.0236	0.0478	0.0593	0.0644	0.0956	0.0912
28	0.0077	0.0102	0.0064	0.0077	0.0064	0.0057	0.0064	0.0077	0.0147	0.0281	0.0185
29	0.0593	0.0491	0.0453	0.0306	0.0236	0.0185	0.0459	0.0548	0.0625	0.0689	0.0835
30	0.0077	0.0070	0.0096	0.0102	0.0057	0.0089	0.0077	0.0064	0.0070	0.0140	0.0338
31	0.0561	0.0414	0.0536	0.0357	0.0153	0.0204	0.0485	0.0574	0.0606	0.0848	0.0574
32	0.0070	0.0057	0.0051	0.0045	0.0051	0.0057	0.0057	0.0045	0.0057	0.0268	0.0185
33	0.0529	0.0427	0.0542	0.0338	0.0166	0.0179	0.0414	0.0536	0.0599	0.0708	0.0797
34	0.0051	0.0064	0.0064	0.0038	0.0032	0.0045	0.0077	0.0070	0.0077	0.0140	0.0159
35	0.0529	0.0593	0.0587	0.0357	0.0191	0.0102	0.0357	0.0478	0.0574	0.0759	0.0657
36	0.0064	0.0057	0.0051	0.0064	0.0070	0.0064	0.0064	0.0077	0.0102	0.0172	0.0077
37	0.0440	0.0752	0.0644	0.0395	0.0159	0.0115	0.0325	0.0446	0.0497	0.0689	0.0619
38	0.0057	0.0083	0.0057	0.0083	0.0083	0.0064	0.0064	0.0064	0.0089	0.0089	0.0089
39	0.0472	0.0740	0.0619	0.0332	0.0179	0.0134	0.0312	0.0421	0.0523	0.0657	0.0721
40	0.0064	0.0057	0.0064	0.0038	0.0057	0.0045	0.0070	0.0051	0.0032	0.0077	0.0191

Appendix 1- Test Result

HYD 3600-ES											
Active power P/Pn [%]	0	10	20	30	40	50	60	70	80	90	100
Frequency [Hz]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]
75	0.0166	0.0491	0.1084	0.1645	0.2283	0.2455	0.3246	0.3934	0.4240	0.4687	0.5726
125	0.0210	0.0128	0.0446	0.0459	0.0695	0.0848	0.1173	0.1078	0.1575	0.1728	0.1658
175	0.0242	0.0108	0.0319	0.0402	0.0631	0.0619	0.0810	0.1020	0.1065	0.1180	0.1460
225	0.0185	0.0102	0.0261	0.0293	0.0446	0.0402	0.0523	0.0650	0.0650	0.0721	0.1173
275	0.0204	0.0134	0.0319	0.0370	0.0421	0.0402	0.0599	0.0733	0.0778	0.0682	0.1122
325	0.0185	0.0153	0.0274	0.0370	0.0281	0.0536	0.0434	0.0663	0.0555	0.0619	0.1020
375	0.0217	0.0293	0.0281	0.0159	0.0383	0.0300	0.0510	0.0510	0.0759	0.0676	0.0733
425	0.0198	0.0255	0.0223	0.0274	0.0306	0.0312	0.0478	0.0619	0.0580	0.0638	0.0835
475	0.0223	0.0198	0.0332	0.0147	0.0210	0.0217	0.0389	0.0274	0.0504	0.0357	0.0465
525	0.0210	0.0223	0.0268	0.0102	0.0300	0.0268	0.0357	0.0395	0.0561	0.0325	0.0631
575	0.0230	0.0198	0.0274	0.0185	0.0159	0.0185	0.0185	0.0236	0.0312	0.0268	0.0274
625	0.0217	0.0159	0.0223	0.0159	0.0159	0.0166	0.0249	0.0204	0.0376	0.0312	0.0274
675	0.0242	0.0204	0.0217	0.0223	0.0166	0.0204	0.0185	0.0332	0.0287	0.0497	0.0351
725	0.0223	0.0172	0.0242	0.0185	0.0166	0.0115	0.0140	0.0210	0.0230	0.0370	0.0210
775	0.0261	0.0153	0.0185	0.0185	0.0172	0.0153	0.0236	0.0370	0.0306	0.0357	0.0440
825	0.0230	0.0147	0.0204	0.0134	0.0134	0.0198	0.0191	0.0319	0.0236	0.0306	0.0325
875	0.0261	0.0108	0.0236	0.0089	0.0185	0.0172	0.0261	0.0204	0.0306	0.0185	0.0542
925	0.0210	0.0172	0.0179	0.0108	0.0102	0.0134	0.0204	0.0242	0.0268	0.0357	0.0472
975	0.0217	0.0140	0.0191	0.0108	0.0140	0.0089	0.0166	0.0089	0.0223	0.0198	0.0293
1025	0.0191	0.0159	0.0108	0.0070	0.0140	0.0108	0.0198	0.0153	0.0198	0.0210	0.0363
1075	0.0204	0.0147	0.0153	0.0096	0.0089	0.0128	0.0159	0.0102	0.0217	0.0236	0.0134
1125	0.0179	0.0134	0.0159	0.0089	0.0096	0.0102	0.0115	0.0108	0.0191	0.0147	0.0204
1175	0.0210	0.0153	0.0134	0.0115	0.0077	0.0115	0.0128	0.0242	0.0172	0.0249	0.0268
1225	0.0179	0.0153	0.0134	0.0077	0.0077	0.0083	0.0140	0.0153	0.0185	0.0261	0.0159
1275	0.0191	0.0159	0.0147	0.0089	0.0089	0.0115	0.0147	0.0210	0.0172	0.0268	0.0179
1325	0.0172	0.0134	0.0134	0.0108	0.0045	0.0077	0.0121	0.0159	0.0230	0.0223	0.0147
1375	0.0166	0.0140	0.0166	0.0064	0.0089	0.0083	0.0089	0.0147	0.0217	0.0230	0.0300
1425	0.0159	0.0121	0.0134	0.0064	0.0083	0.0089	0.0115	0.0166	0.0172	0.0236	0.0274
1475	0.0159	0.0128	0.0185	0.0057	0.0096	0.0140	0.0147	0.0102	0.0108	0.0128	0.0242
1525	0.0140	0.0147	0.0172	0.0089	0.0089	0.0089	0.0115	0.0121	0.0102	0.0185	#VALUE!
1575	0.0172	0.0128	0.0159	0.0102	0.0089	0.0077	0.0077	0.0108	0.0179	0.0210	0.0159
1625	0.0147	0.0096	0.0159	0.0077	0.0096	0.0070	0.0108	0.0089	0.0102	0.0140	0.0172
1675	0.0153	0.0121	0.0172	0.0077	0.0077	0.0096	0.0096	0.0159	0.0159	0.0191	0.0128
1725	0.0134	0.0102	0.0128	0.0083	0.0089	0.0064	0.0096	0.0102	0.0128	0.0191	0.0121
1775	0.0147	0.0121	0.0153	0.0070	0.0070	0.0077	0.0108	0.0134	0.0166	0.0198	0.0172
1825	0.0140	0.0115	0.0128	0.0064	0.0064	0.0083	0.0083	0.0108	0.0153	0.0185	0.0128
1875	0.0134	0.0096	0.0128	0.0064	0.0057	0.0064	0.0115	0.0070	0.0083	0.0121	0.0140
1925	0.0128	0.0121	0.0147	0.0051	0.0070	0.0083	0.0128	0.0108	0.0147	0.0179	0.0096
1975	0.0140	0.0083	0.0147	0.0045	0.0070	0.0083	0.0083	0.0064	0.0064	0.0108	0.0204

Appendix 1- Test Result

HYD 3600-ES											
Active power P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
Frequency [kHz]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]
2.1	0.0077	0.0089	0.0064	0.0064	0.0077	0.0051	0.0057	0.0038	0.0045	0.0134	0.0089
2.3	0.0083	0.0096	0.0045	0.0026	0.0051	0.0064	0.0064	0.0057	0.0064	0.0166	0.0172
2.5	0.0064	0.0083	0.0064	0.0064	0.0089	0.0051	0.0051	0.0057	0.0070	0.0134	0.0064
2.7	0.0077	0.0057	0.0051	0.0051	0.0045	0.0070	0.0064	0.0038	0.0051	0.0121	0.0108
2.9	0.0051	0.0064	0.0038	0.0057	0.0051	0.0077	0.0064	0.0064	0.0064	0.0064	0.0147
3.1	0.0070	0.0064	0.0083	0.0070	0.0064	0.0070	0.0038	0.0057	0.0045	0.0096	0.0064
3.3	0.0070	0.0077	0.0057	0.0070	0.0077	0.0064	0.0057	0.0070	0.0038	0.0115	0.0172
3.5	0.0045	0.0045	0.0089	0.0077	0.0051	0.0077	0.0038	0.0051	0.0064	0.0102	0.0108
3.7	0.0077	0.0064	0.0045	0.0115	0.0077	0.0077	0.0064	0.0083	0.0070	0.0121	0.0077
3.9	0.0077	0.0077	0.0064	0.0108	0.0064	0.0057	0.0070	0.0121	0.0102	0.0159	0.0128
4.1	0.0121	0.0121	0.0064	0.0121	0.0089	0.0121	0.0070	0.0057	0.0070	0.0108	0.0108
4.3	0.0089	0.0089	0.0083	0.0045	0.0070	0.0038	0.0051	0.0083	0.0064	0.0089	0.0070
4.5	0.0102	0.0083	0.0064	0.0064	0.0038	0.0051	0.0026	0.0083	0.0096	0.0115	0.0147
4.7	0.0083	0.0070	0.0134	0.0045	0.0070	0.0045	0.0083	0.0064	0.0083	0.0115	0.0147
4.9	0.0083	0.0064	0.0064	0.0045	0.0083	0.0083	0.0083	0.0083	0.0083	0.0140	0.0089
5.1	0.0077	0.0077	0.0051	0.0064	0.0051	0.0070	0.0268	0.0070	0.0083	0.0153	0.0108
5.3	0.0115	0.0051	0.0051	0.0070	0.0057	0.0070	0.0045	0.0083	0.0089	0.0147	0.0096
5.5	0.0070	0.0045	0.0045	0.0083	0.0038	0.0070	0.0070	0.0096	0.0077	0.0128	0.0121
5.7	0.0121	0.0026	0.0057	0.0083	0.0077	0.0077	0.0051	0.0064	0.0096	0.0128	0.0089
5.9	0.0096	0.0077	0.0026	0.0070	0.0051	0.0064	0.0051	0.0083	0.0083	0.0096	0.0102
6.1	0.0096	0.0038	0.0038	0.0057	0.0070	0.0057	0.0070	0.0083	0.0083	0.0121	0.0077
6.3	0.0064	0.0038	0.0032	0.0064	0.0089	0.0051	0.0051	0.0102	0.0089	0.0089	0.0083
6.5	0.0057	0.0083	0.0096	0.0089	0.0057	0.0045	0.0083	0.0070	0.0108	0.0102	0.0045
6.7	0.0077	0.0045	0.0038	0.0045	0.0077	0.0032	0.0089	0.0108	0.0064	0.0083	0.0057
6.9	0.0083	0.0038	0.0045	0.0045	0.0019	0.0045	0.0096	0.0077	0.0064	0.0077	0.0070
7.1	0.0057	0.0057	0.0045	0.0057	0.0070	0.0051	0.0064	0.0083	0.0102	0.0083	0.0064
7.3	0.0070	0.0038	0.0045	0.0051	0.0057	0.0032	0.0051	0.0051	0.0045	0.0102	0.0083
7.5	0.0045	0.0032	0.0032	0.0077	0.0057	0.0077	0.0057	0.0089	0.0083	0.0083	0.0077
7.7	0.0051	0.0102	0.0051	0.0070	0.0077	0.0070	0.0064	0.0089	0.0166	0.0147	0.0153
7.9	0.0057	0.0115	0.0102	0.0128	0.0147	0.0166	0.0057	0.0134	0.0536	0.0306	0.0338
8.1	0.0051	0.0083	0.0089	0.0140	0.0166	0.0147	0.0051	0.0210	0.0357	0.0255	0.0402
8.3	0.0057	0.0089	0.0057	0.0089	0.0070	0.0083	0.0064	0.0089	0.0108	0.0102	0.0128
8.5	0.0038	0.0077	0.0115	0.0070	0.0077	0.0051	0.0045	0.0051	0.0045	0.0077	0.0057
8.7	0.0026	0.0051	0.0064	0.0038	0.0045	0.0057	0.0032	0.0089	0.0045	0.0159	0.0115
8.9	0.0026	0.0070	0.0032	0.0057	0.0070	0.0077	0.0230	0.0051	0.0115	0.0070	0.0070

Appendix 1- Test Result

HYD 4000-ES											
Active power P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
Harmonic number	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]
2	0.0041	0.0244	0.0406	0.0655	0.0812	0.0945	0.1293	0.1357	0.2993	0.1682	0.2013
3	0.3068	0.4402	0.5324	0.5724	0.5840	0.5991	0.6235	0.6380	0.5295	0.7082	0.7917
4	0.0081	0.0157	0.0209	0.0255	0.0394	0.0325	0.0563	0.0661	0.1189	0.1114	0.1531
5	0.2007	0.1978	0.2303	0.2662	0.2216	0.2303	0.2285	0.1955	0.3642	0.1247	0.1102
6	0.0110	0.0110	0.0110	0.0278	0.0290	0.0267	0.0412	0.0487	0.0986	0.1647	0.1195
7	0.1102	0.1340	0.1340	0.1566	0.1148	0.1305	0.1096	0.1288	0.1096	0.2349	0.1224
8	0.0081	0.0099	0.0174	0.0197	0.0278	0.0168	0.0360	0.0429	0.0557	0.0934	0.0916
9	0.0887	0.1235	0.0870	0.1090	0.0592	0.0795	0.0725	0.0858	0.0934	0.0887	0.1728
10	0.0075	0.0145	0.0197	0.0197	0.0197	0.0151	0.0319	0.0331	0.0487	0.0626	0.1143
11	0.0992	0.1212	0.0580	0.0702	0.0394	0.0331	0.0510	0.0551	0.0829	0.1079	0.0957
12	0.0046	0.0075	0.0116	0.0110	0.0139	0.0087	0.0215	0.0186	0.0249	0.1102	0.0261
13	0.0870	0.1201	0.0429	0.0505	0.0319	0.0412	0.0383	0.0557	0.0876	0.0928	0.1038
14	0.0052	0.0035	0.0104	0.0122	0.0139	0.0122	0.0180	0.0133	0.0487	0.0638	0.1119
15	0.0742	0.1230	0.0348	0.0499	0.0389	0.0452	0.0545	0.0609	0.0487	0.0795	0.0789
16	0.0052	0.0116	0.0110	0.0110	0.0104	0.0093	0.0168	0.0162	0.0249	0.0383	0.0557
17	0.0679	0.1282	0.0371	0.0458	0.0447	0.0441	0.0528	0.0638	0.0737	0.1346	0.0661
18	0.0099	0.0104	0.0070	0.0093	0.0099	0.0093	0.0099	0.0186	0.0157	0.0795	0.0719
19	0.0563	0.1241	0.0319	0.0307	0.0423	0.0452	0.0626	0.0609	0.0476	0.0557	0.1537
20	0.0104	0.0081	0.0046	0.0104	0.0075	0.0052	0.0064	0.0151	0.0087	0.0592	0.0748
21	0.0563	0.1241	0.0290	0.0191	0.0418	0.0487	0.0638	0.0644	0.0800	0.0974	0.0458
22	0.0099	0.0133	0.0099	0.0145	0.0064	0.0110	0.0081	0.0122	0.0331	0.0168	0.0319
23	0.0621	0.1259	0.0215	0.0180	0.0371	0.0458	0.0597	0.0626	0.0522	0.1085	0.0400
24	0.0081	0.0081	0.0058	0.0064	0.0064	0.0058	0.0075	0.0070	0.0244	0.0458	0.0586
25	0.0713	0.1160	0.0180	0.0168	0.0319	0.0400	0.0597	0.0644	0.0858	0.0557	0.1154
26	0.0041	0.0093	0.0035	0.0081	0.0029	0.0064	0.0093	0.0041	0.0360	0.0267	0.0290
27	0.0713	0.0922	0.0162	0.0116	0.0232	0.0389	0.0615	0.0661	0.0412	0.0957	0.0766
28	0.0035	0.0081	0.0046	0.0081	0.0058	0.0070	0.0099	0.0087	0.0116	0.0122	0.0418
29	0.0644	0.0696	0.0145	0.0145	0.0197	0.0342	0.0539	0.0615	0.0684	0.0853	0.0464
30	0.0029	0.0070	0.0035	0.0099	0.0029	0.0041	0.0070	0.0099	0.0220	0.0226	0.0365
31	0.0597	0.0516	0.0162	0.0197	0.0203	0.0290	0.0499	0.0609	0.0505	0.0684	0.0760
32	0.0041	0.0070	0.0058	0.0099	0.0035	0.0052	0.0046	0.0075	0.0099	0.0180	0.0104
33	0.0522	0.0331	0.0162	0.0203	0.0174	0.0261	0.0464	0.0557	0.0586	0.0882	0.0800
34	0.0064	0.0052	0.0041	0.0099	0.0046	0.0058	0.0046	0.0081	0.0081	0.0168	0.0354
35	0.0464	0.0278	0.0226	0.0255	0.0191	0.0197	0.0429	0.0522	0.0534	0.0777	0.0539
36	0.0052	0.0075	0.0058	0.0081	0.0064	0.0041	0.0046	0.0052	0.0157	0.0116	0.0133
37	0.0418	0.0336	0.0273	0.0278	0.0203	0.0203	0.0394	0.0493	0.0441	0.0690	0.0626
38	0.0046	0.0064	0.0052	0.0093	0.0064	0.0035	0.0041	0.0035	0.0093	0.0075	0.0087
39	0.0325	0.0412	0.0487	0.0278	0.0209	0.0197	0.0354	0.0493	0.0510	0.0731	0.0673
40	0.0046	0.0070	0.0046	0.0075	0.0035	0.0046	0.0035	0.0075	0.0151	0.0157	0.0180

Appendix 1- Test Result

HYD 4000-ES											
Active power P/Pn [%]	0	10	20	30	40	50	60	70	80	90	100
Frequency [Hz]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]
75	0.0162	0.0551	0.1143	0.2279	0.2390	0.2656	0.3584	0.4083	0.4298	0.5434	0.5794
125	0.0186	0.0203	0.0325	0.0615	0.0777	0.1003	0.1125	0.1131	0.1589	0.1688	0.1711
175	0.0174	0.0331	0.0371	0.0597	0.0661	0.0690	0.0969	0.1148	0.1096	0.1520	0.1520
225	0.0180	0.0319	0.0110	0.0290	0.0481	0.0418	0.0621	0.0684	0.0603	0.1003	0.1102
275	0.0191	0.0290	0.0354	0.0528	0.0429	0.0516	0.0708	0.0922	0.0719	0.1056	0.1114
325	0.0197	0.0389	0.0168	0.0406	0.0389	0.0452	0.0458	0.0673	0.0615	0.1067	0.0887
375	0.0197	0.0331	0.0348	0.0481	0.0383	0.0458	0.0679	0.0708	0.0876	0.0754	0.0829
425	0.0180	0.0394	0.0162	0.0441	0.0284	0.0348	0.0464	0.0690	0.0644	0.0754	0.0841
475	0.0174	0.0441	0.0284	0.0412	0.0244	0.0180	0.0493	0.0348	0.0557	0.0528	0.0621
525	0.0168	0.0365	0.0168	0.0400	0.0226	0.0267	0.0429	0.0580	0.0400	0.0528	0.0621
575	0.0180	0.0447	0.0191	0.0244	0.0174	0.0191	0.0423	0.0238	0.0603	0.0203	0.0418
625	0.0162	0.0267	0.0110	0.0348	0.0232	0.0168	0.0394	0.0348	0.0493	0.0383	0.0528
675	0.0133	0.0400	0.0099	0.0203	0.0157	0.0174	0.0162	0.0296	0.0481	0.0325	0.0290
725	0.0180	0.0215	0.0093	0.0267	0.0081	0.0110	0.0307	0.0191	0.0371	0.0342	0.0267
775	0.0162	0.0487	0.0128	0.0151	0.0174	0.0238	0.0099	0.0331	0.0487	0.0499	0.0331
825	0.0191	0.0203	0.0081	0.0180	0.0122	0.0145	0.0209	0.0191	0.0365	0.0319	0.0203
875	0.0180	0.0296	0.0116	0.0099	0.0209	0.0128	0.0116	0.0307	0.0122	0.0539	0.0348
925	0.0197	0.0220	0.0116	0.0122	0.0145	0.0133	0.0168	0.0261	0.0191	0.0406	0.0336
975	0.0180	0.0261	0.0099	0.0110	0.0162	0.0104	0.0157	0.0244	0.0162	0.0197	0.0505
1025	0.0180	0.0249	0.0087	0.0116	0.0168	0.0093	0.0093	0.0255	0.0151	0.0487	0.0423
1075	0.0174	0.0186	0.0087	0.0128	0.0110	0.0110	0.0110	0.0162	0.0232	0.0267	0.0249
1125	0.0145	0.0278	0.0122	0.0104	0.0151	0.0064	0.0087	0.0209	0.0157	0.0261	0.0383
1175	0.0151	0.0133	0.0058	0.0099	0.0099	0.0133	0.0180	0.0099	0.0174	0.0220	0.0238
1225	0.0122	0.0261	0.0104	0.0122	0.0133	0.0110	0.0110	0.0133	0.0186	0.0331	0.0220
1275	0.0139	0.0145	0.0052	0.0099	0.0075	0.0128	0.0186	0.0139	0.0168	0.0186	0.0174
1325	0.0116	0.0244	0.0075	0.0099	0.0081	0.0099	0.0099	0.0116	0.0162	0.0203	0.0220
1375	0.0104	0.0157	0.0075	0.0099	0.0058	0.0104	0.0133	0.0145	0.0162	0.0278	0.0139
1425	0.0099	0.0215	0.0058	0.0104	0.0087	0.0070	0.0162	0.0128	0.0128	0.0180	0.0226
1475	0.0116	0.0180	0.0046	0.0075	0.0093	0.0087	0.0133	0.0191	0.0203	0.0278	0.0191
1525	0.0128	0.0180	0.0052	0.0075	0.0087	0.0064	0.0133	0.0151	0.0168	0.0232	0.0162
1575	0.0110	0.0186	0.0064	0.0081	0.0087	0.0110	0.0064	0.0145	0.0151	0.0162	0.0215
1625	0.0128	0.0139	0.0052	0.0087	0.0070	0.0099	0.0110	0.0145	0.0139	0.0168	0.0139
1675	0.0110	0.0203	0.0064	0.0070	0.0116	0.0075	0.0052	0.0104	0.0110	0.0255	0.0284
1725	0.0104	0.0128	0.0052	0.0058	0.0093	0.0087	0.0075	0.0133	0.0162	0.0220	0.0273
1775	0.0110	0.0203	0.0070	0.0064	0.0099	0.0052	0.0064	0.0075	0.0093	0.0168	0.0104
1825	0.0087	0.0110	0.0058	0.0087	0.0093	0.0087	0.0110	0.0151	0.0104	0.0267	0.0180
1875	0.0099	0.0186	0.0058	0.0081	0.0099	0.0058	0.0075	0.0099	0.0122	0.0128	0.0116
1925	0.0081	0.0133	0.0064	0.0058	0.0087	0.0052	0.0070	0.0081	0.0116	0.0110	0.0133
1975	0.0081	0.0186	0.0081	0.0075	0.0075	0.0075	0.0087	0.0110	0.0128	0.0186	0.0180

Appendix 1- Test Result

HYD 4000-ES											
Active power P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
Frequency [kHz]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]
2.1	0.0046	0.0070	0.0075	0.0046	0.0075	0.0035	0.0064	0.0052	0.0052	0.0070	0.0075
2.3	0.0058	0.0017	0.0029	0.0041	0.0058	0.0046	0.0029	0.0041	0.0075	0.0157	0.0104
2.5	0.0041	0.0046	0.0023	0.0058	0.0052	0.0017	0.0046	0.0058	0.0081	0.0058	0.0104
2.7	0.0064	0.0046	0.0046	0.0070	0.0070	0.0041	0.0070	0.0052	0.0081	0.0099	0.0116
2.9	0.0058	0.0029	0.0070	0.0058	0.0075	0.0023	0.0058	0.0035	0.0087	0.0145	0.0058
3.1	0.0046	0.0029	0.0058	0.0064	0.0052	0.0052	0.0070	0.0041	0.0099	0.0041	0.0075
3.3	0.0035	0.0041	0.0093	0.0081	0.0075	0.0058	0.0075	0.0046	0.0081	0.0099	0.0139
3.5	0.0041	0.0058	0.0070	0.0046	0.0064	0.0058	0.0064	0.0058	0.0070	0.0087	0.0104
3.7	0.0058	0.0052	0.0058	0.0058	0.0093	0.0052	0.0093	0.0058	0.0070	0.0064	0.0116
3.9	0.0099	0.0081	0.0064	0.0087	0.0058	0.0070	0.0075	0.0081	0.0064	0.0122	0.0128
4.1	0.0081	0.0099	0.0064	0.0058	0.0070	0.0046	0.0093	0.0093	0.0087	0.0122	0.0104
4.3	0.0058	0.0099	0.0052	0.0041	0.0064	0.0099	0.0041	0.0081	0.0075	0.0070	0.0104
4.5	0.0081	0.0064	0.0052	0.0075	0.0070	0.0058	0.0058	0.0087	0.0104	0.0116	0.0070
4.7	0.0070	0.0070	0.0058	0.0046	0.0052	0.0070	0.0052	0.0087	0.0110	0.0104	0.0052
4.9	0.0070	0.0046	0.0046	0.0035	0.0052	0.0075	0.0058	0.0087	0.0116	0.0087	0.0046
5.1	0.0122	0.0087	0.0046	0.0023	0.0046	0.0052	0.0052	0.0075	0.0139	0.0070	0.0122
5.3	0.0081	0.0070	0.0046	0.0041	0.0041	0.0052	0.0064	0.0081	0.0139	0.0081	0.0093
5.5	0.0081	0.0035	0.0041	0.0046	0.0052	0.0058	0.0081	0.0093	0.0133	0.0110	0.0116
5.7	0.0087	0.0023	0.0035	0.0075	0.0052	0.0058	0.0064	0.0070	0.0087	0.0081	0.0104
5.9	0.0081	0.0035	0.0035	0.0058	0.0052	0.0058	0.0064	0.0087	0.0110	0.0081	0.0116
6.1	0.0093	0.0029	0.0052	0.0064	0.0041	0.0046	0.0075	0.0075	0.0116	0.0093	0.0116
6.3	0.0081	0.0046	0.0023	0.0046	0.0052	0.0046	0.0046	0.0070	0.0104	0.0070	0.0110
6.5	0.0087	0.0023	0.0017	0.0064	0.0052	0.0035	0.0087	0.0093	0.0075	0.0052	0.0093
6.7	0.0064	0.0017	0.0023	0.0035	0.0081	0.0041	0.0041	0.0070	0.0099	0.0058	0.0104
6.9	0.0099	0.0017	0.0035	0.0046	0.0046	0.0064	0.0046	0.0070	0.0087	0.0052	0.0081
7.1	0.0058	0.0035	0.0064	0.0058	0.0064	0.0029	0.0052	0.0064	0.0070	0.0035	0.0070
7.3	0.0058	0.0058	0.0046	0.0052	0.0052	0.0046	0.0041	0.0064	0.0075	0.0104	0.0087
7.5	0.0052	0.0052	0.0064	0.0046	0.0052	0.0041	0.0035	0.0070	0.0075	0.0041	0.0087
7.7	0.0035	0.0052	0.0081	0.0052	0.0070	0.0075	0.0128	0.0070	0.0139	0.0116	0.0145
7.9	0.0035	0.0064	0.0110	0.0099	0.0174	0.0186	0.0215	0.0220	0.0249	0.0348	0.0383
8.1	0.0029	0.0070	0.0081	0.0110	0.0180	0.0157	0.0261	0.0249	0.0319	0.0354	0.0429
8.3	0.0058	0.0064	0.0058	0.0087	0.0046	0.0070	0.0075	0.0122	0.0110	0.0087	0.0099
8.5	0.0041	0.0075	0.0046	0.0041	0.0064	0.0081	0.0081	0.0052	0.0093	0.0058	0.0075
8.7	0.0035	0.0070	0.0075	0.0052	0.0064	0.0029	0.0046	0.0081	0.0093	0.0128	0.0110
8.9	0.0041	0.0041	0.0041	0.0087	0.0070	0.0058	0.0104	0.0046	0.0087	0.0070	0.0087

Appendix 1- Test Result

HYD 5000-ES											
Active power P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
Harmonic number	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]
2	0.0328	0.0300	0.0426	0.0576	0.0819	0.0917	0.1217	0.1278	0.1638	0.1713	0.1853
3	0.2729	0.3927	0.5125	0.5336	0.5584	0.5958	0.6230	0.6459	0.6627	0.6885	0.6997
4	0.0094	0.0098	0.0271	0.0290	0.0384	0.0435	0.0534	0.0557	0.0702	0.0768	0.0842
5	0.1788	0.1676	0.1999	0.2027	0.1980	0.1844	0.2181	0.2148	0.1727	0.1535	0.1975
6	0.0187	0.0159	0.0178	0.0201	0.0201	0.0304	0.0398	0.0440	0.0501	0.0459	0.0557
7	0.1039	0.1367	0.1301	0.1357	0.1287	0.1292	0.1137	0.1076	0.1357	0.1512	0.1137
8	0.0089	0.0206	0.0080	0.0150	0.0178	0.0290	0.0323	0.0267	0.0412	0.0370	0.0356
9	0.0955	0.1203	0.0950	0.0908	0.0763	0.0833	0.0917	0.0875	0.0861	0.0772	0.0852
10	0.0056	0.0206	0.0075	0.0112	0.0126	0.0206	0.0295	0.0197	0.0365	0.0262	0.0300
11	0.0796	0.0917	0.0571	0.0557	0.0407	0.0426	0.0445	0.0534	0.0524	0.0491	0.0417
12	0.0098	0.0168	0.0075	0.0103	0.0122	0.0112	0.0164	0.0159	0.0215	0.0314	0.0276
13	0.0838	0.0707	0.0440	0.0332	0.0239	0.0323	0.0403	0.0393	0.0520	0.0491	0.0314
14	0.0117	0.0201	0.0094	0.0098	0.0140	0.0178	0.0173	0.0201	0.0192	0.0332	0.0328
15	0.0824	0.0604	0.0351	0.0248	0.0271	0.0281	0.0388	0.0473	0.0552	0.0534	0.0421
16	0.0098	0.0192	0.0131	0.0075	0.0084	0.0178	0.0140	0.0243	0.0122	0.0211	0.0393
17	0.0777	0.0861	0.0398	0.0211	0.0267	0.0276	0.0440	0.0501	0.0571	0.0505	0.0571
18	0.0103	0.0164	0.0089	0.0070	0.0117	0.0131	0.0140	0.0140	0.0164	0.0192	0.0136
19	0.0697	0.0763	0.0393	0.0211	0.0290	0.0276	0.0407	0.0454	0.0679	0.0608	0.0548
20	0.0051	0.0136	0.0070	0.0066	0.0126	0.0094	0.0136	0.0084	0.0187	0.0122	0.0070
21	0.0665	0.0941	0.0276	0.0154	0.0248	0.0323	0.0370	0.0576	0.0618	0.0683	0.0599
22	0.0103	0.0122	0.0051	0.0080	0.0061	0.0066	0.0098	0.0084	0.0173	0.0117	0.0150
23	0.0655	0.1011	0.0257	0.0126	0.0257	0.0318	0.0374	0.0618	0.0599	0.0861	0.0660
24	0.0061	0.0126	0.0056	0.0056	0.0033	0.0080	0.0066	0.0122	0.0136	0.0183	0.0197
25	0.0599	0.1039	0.0206	0.0159	0.0271	0.0290	0.0365	0.0566	0.0585	0.0758	0.0651
26	0.0080	0.0084	0.0066	0.0033	0.0042	0.0080	0.0084	0.0075	0.0070	0.0173	0.0178
27	0.0576	0.0974	0.0192	0.0136	0.0276	0.0290	0.0342	0.0566	0.0576	0.0688	0.0632
28	0.0075	0.0098	0.0066	0.0051	0.0056	0.0084	0.0051	0.0061	0.0056	0.0094	0.0080
29	0.0580	0.0969	0.0211	0.0150	0.0276	0.0304	0.0314	0.0590	0.0599	0.0641	0.0669
30	0.0061	0.0112	0.0042	0.0042	0.0066	0.0051	0.0070	0.0066	0.0080	0.0084	0.0037
31	0.0608	0.0978	0.0173	0.0126	0.0290	0.0342	0.0271	0.0548	0.0580	0.0646	0.0641
32	0.0061	0.0080	0.0047	0.0056	0.0075	0.0047	0.0080	0.0066	0.0084	0.0047	0.0108
33	0.0627	0.0969	0.0150	0.0126	0.0248	0.0276	0.0281	0.0552	0.0599	0.0637	0.0641
34	0.0042	0.0108	0.0042	0.0042	0.0066	0.0042	0.0042	0.0070	0.0070	0.0117	0.0145
35	0.0557	0.0861	0.0126	0.0150	0.0225	0.0271	0.0295	0.0520	0.0590	0.0660	0.0641
36	0.0028	0.0094	0.0042	0.0023	0.0061	0.0080	0.0051	0.0047	0.0098	0.0112	0.0098
37	0.0505	0.0880	0.0150	0.0126	0.0206	0.0248	0.0257	0.0510	0.0538	0.0599	0.0651
38	0.0056	0.0112	0.0056	0.0056	0.0033	0.0042	0.0023	0.0047	0.0056	0.0056	0.0094
39	0.0477	0.0552	0.0159	0.0150	0.0201	0.0393	0.0267	0.0482	0.0524	0.0590	0.0599
40	0.0066	0.0098	0.0042	0.0037	0.0056	0.0037	0.0028	0.0070	0.0028	0.0023	0.0070

Appendix 1- Test Result

HYD 5000-ES											
Active power P/Pn [%]	0	10	20	30	40	50	60	70	80	90	100
Frequency [Hz]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]
75	0.0178	0.0501	0.1147	0.1666	0.2298	0.2860	0.3585	0.4142	0.4774	0.5176	0.5593
125	0.0215	0.0229	0.0379	0.0473	0.0754	0.0828	0.1062	0.1109	0.1413	0.1479	0.1643
175	0.0248	0.0140	0.0281	0.0421	0.0557	0.0707	0.0913	0.0917	0.1193	0.1161	0.1273
225	0.0168	0.0206	0.0239	0.0328	0.0440	0.0473	0.0576	0.0646	0.0805	0.0875	0.0978
275	0.0220	0.0309	0.0183	0.0337	0.0426	0.0534	0.0669	0.0622	0.0814	0.0763	0.0754
325	0.0178	0.0309	0.0234	0.0304	0.0271	0.0407	0.0491	0.0571	0.0637	0.0716	0.0716
375	0.0159	0.0417	0.0201	0.0201	0.0257	0.0318	0.0566	0.0384	0.0641	0.0440	0.0468
425	0.0168	0.0360	0.0192	0.0225	0.0393	0.0356	0.0449	0.0473	0.0641	0.0580	0.0538
475	0.0187	0.0332	0.0126	0.0159	0.0211	0.0159	0.0360	0.0248	0.0501	0.0328	0.0440
525	0.0168	0.0351	0.0126	0.0112	0.0173	0.0220	0.0482	0.0281	0.0543	0.0393	0.0337
575	0.0187	0.0379	0.0159	0.0164	0.0173	0.0206	0.0211	0.0295	0.0300	0.0384	0.0454
625	0.0201	0.0300	0.0145	0.0094	0.0126	0.0154	0.0286	0.0192	0.0454	0.0356	0.0286
675	0.0229	0.0346	0.0122	0.0150	0.0201	0.0262	0.0131	0.0384	0.0201	0.0426	0.0473
725	0.0187	0.0379	0.0154	0.0126	0.0154	0.0183	0.0192	0.0239	0.0229	0.0379	0.0417
775	0.0192	0.0346	0.0145	0.0131	0.0215	0.0215	0.0197	0.0304	0.0262	0.0379	0.0356
825	0.0197	0.0304	0.0168	0.0108	0.0192	0.0136	0.0140	0.0309	0.0178	0.0398	0.0440
875	0.0206	0.0281	0.0136	0.0112	0.0192	0.0117	0.0243	0.0201	0.0332	0.0215	0.0197
925	0.0192	0.0309	0.0122	0.0075	0.0178	0.0150	0.0168	0.0215	0.0215	0.0332	0.0295
975	0.0220	0.0281	0.0098	0.0103	0.0126	0.0094	0.0248	0.0187	0.0318	0.0131	0.0197
1025	0.0206	0.0290	0.0108	0.0066	0.0164	0.0140	0.0201	0.0136	0.0393	0.0206	0.0164
1075	0.0197	0.0271	0.0126	0.0112	0.0080	0.0094	0.0126	0.0234	0.0276	0.0248	0.0290
1125	0.0206	0.0271	0.0084	0.0080	0.0164	0.0103	0.0159	0.0112	0.0286	0.0145	0.0206
1175	0.0187	0.0239	0.0080	0.0084	0.0084	0.0131	0.0094	0.0262	0.0159	0.0337	0.0356
1225	0.0201	0.0243	0.0103	0.0094	0.0089	0.0136	0.0168	0.0211	0.0234	0.0229	0.0271
1275	0.0187	0.0257	0.0084	0.0066	0.0140	0.0126	0.0056	0.0164	0.0108	0.0243	0.0271
1325	0.0159	0.0225	0.0098	0.0080	0.0084	0.0136	0.0094	0.0239	0.0183	0.0248	0.0318
1375	0.0140	0.0225	0.0075	0.0084	0.0164	0.0089	0.0075	0.0122	0.0122	0.0150	0.0112
1425	0.0140	0.0215	0.0084	0.0047	0.0131	0.0136	0.0061	0.0131	0.0131	0.0211	0.0239
1475	0.0150	0.0225	0.0061	0.0070	0.0140	0.0070	0.0136	0.0145	0.0173	0.0098	0.0201
1525	0.0136	0.0215	0.0089	0.0075	0.0126	0.0089	0.0126	0.0089	0.0103	0.0112	0.0122
1575	0.0150	0.0201	0.0098	0.0075	0.0140	0.0070	0.0131	0.0173	0.0234	0.0201	0.0201
1625	0.0136	0.0206	0.0061	0.0080	0.0145	0.0080	0.0084	0.0136	0.0145	0.0126	0.0136
1675	0.0159	0.0225	0.0051	0.0056	0.0075	0.0117	0.0112	0.0187	0.0192	0.0211	0.0248
1725	0.0145	0.0192	0.0056	0.0066	0.0126	0.0136	0.0122	0.0173	0.0192	0.0183	0.0211
1775	0.0140	0.0211	0.0066	0.0070	0.0089	0.0089	0.0075	0.0126	0.0168	0.0145	0.0168
1825	0.0140	0.0197	0.0051	0.0051	0.0103	0.0094	0.0117	0.0136	0.0168	0.0197	0.0197
1875	0.0131	0.0192	0.0075	0.0056	0.0061	0.0075	0.0047	0.0094	0.0112	0.0136	0.0112
1925	0.0150	0.0192	0.0051	0.0047	0.0108	0.0122	0.0080	0.0103	0.0154	0.0178	0.0159
1975	0.0117	0.0192	0.0066	0.0070	0.0112	0.0056	0.0075	0.0126	0.0094	0.0094	0.0140

Appendix 1- Test Result

HYD 5000-ES											
Active power P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
Frequency [kHz]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]
2.1	0.0047	0.0047	0.0014	0.0084	0.0061	0.0033	0.0023	0.0042	0.0028	0.0070	0.0066
2.3	0.0047	0.0070	0.0028	0.0075	0.0047	0.0066	0.0023	0.0047	0.0051	0.0047	0.0056
2.5	0.0033	0.0051	0.0019	0.0037	0.0028	0.0047	0.0028	0.0080	0.0028	0.0042	0.0066
2.7	0.0019	0.0061	0.0033	0.0056	0.0019	0.0037	0.0033	0.0061	0.0051	0.0056	0.0070
2.9	0.0037	0.0047	0.0019	0.0070	0.0047	0.0037	0.0033	0.0028	0.0028	0.0066	0.0047
3.1	0.0042	0.0033	0.0047	0.0047	0.0042	0.0037	0.0033	0.0061	0.0051	0.0051	0.0056
3.3	0.0033	0.0023	0.0037	0.0042	0.0051	0.0023	0.0037	0.0089	0.0028	0.0075	0.0061
3.5	0.0042	0.0061	0.0056	0.0051	0.0061	0.0023	0.0037	0.0056	0.0056	0.0047	0.0051
3.7	0.0070	0.0056	0.0042	0.0051	0.0033	0.0047	0.0037	0.0070	0.0042	0.0047	0.0070
3.9	0.0094	0.0047	0.0075	0.0089	0.0098	0.0070	0.0037	0.0080	0.0056	0.0131	0.0136
4.1	0.0098	0.0042	0.0051	0.0084	0.0080	0.0042	0.0042	0.0075	0.0042	0.0075	0.0089
4.3	0.0047	0.0061	0.0061	0.0047	0.0023	0.0056	0.0042	0.0056	0.0061	0.0061	0.0028
4.5	0.0042	0.0037	0.0023	0.0056	0.0051	0.0019	0.0047	0.0028	0.0042	0.0033	0.0051
4.7	0.0061	0.0061	0.0051	0.0028	0.0033	0.0056	0.0047	0.0037	0.0061	0.0051	0.0066
4.9	0.0056	0.0028	0.0042	0.0028	0.0019	0.0023	0.0047	0.0047	0.0042	0.0051	0.0070
5.1	0.0056	0.0037	0.0023	0.0028	0.0042	0.0028	0.0047	0.0037	0.0066	0.0033	0.0042
5.3	0.0066	0.0042	0.0037	0.0037	0.0033	0.0051	0.0047	0.0033	0.0042	0.0047	0.0028
5.5	0.0061	0.0042	0.0023	0.0019	0.0037	0.0028	0.0051	0.0037	0.0070	0.0056	0.0047
5.7	0.0061	0.0066	0.0047	0.0042	0.0033	0.0056	0.0051	0.0042	0.0047	0.0037	0.0066
5.9	0.0056	0.0033	0.0037	0.0037	0.0037	0.0037	0.0051	0.0042	0.0070	0.0023	0.0033
6.1	0.0042	0.0051	0.0033	0.0033	0.0028	0.0033	0.0051	0.0061	0.0047	0.0019	0.0037
6.3	0.0061	0.0023	0.0047	0.0037	0.0028	0.0066	0.0051	0.0051	0.0075	0.0033	0.0033
6.5	0.0042	0.0037	0.0042	0.0042	0.0061	0.0061	0.0056	0.0047	0.0047	0.0037	0.0042
6.7	0.0042	0.0033	0.0056	0.0070	0.0042	0.0061	0.0056	0.0051	0.0075	0.0028	0.0037
6.9	0.0061	0.0042	0.0056	0.0047	0.0047	0.0056	0.0056	0.0028	0.0047	0.0042	0.0056
7.1	0.0037	0.0037	0.0042	0.0042	0.0037	0.0070	0.0061	0.0051	0.0080	0.0047	0.0051
7.3	0.0070	0.0061	0.0070	0.0080	0.0047	0.0042	0.0061	0.0075	0.0047	0.0047	0.0047
7.5	0.0042	0.0047	0.0080	0.0098	0.0080	0.0103	0.0061	0.0037	0.0094	0.0084	0.0098
7.7	0.0140	0.0206	0.0178	0.0150	0.0168	0.0248	0.0066	0.0178	0.0047	0.0150	0.0173
7.9	0.0178	0.0225	0.0271	0.0262	0.0211	0.0276	0.0066	0.0379	0.0098	0.0412	0.0627
8.1	0.0239	0.0323	0.0304	0.0286	0.0304	0.0440	0.0066	0.0351	0.0051	0.0505	0.0562
8.3	0.0159	0.0211	0.0183	0.0173	0.0183	0.0211	0.0066	0.0211	0.0136	0.0140	0.0164
8.5	0.0084	0.0075	0.0117	0.0126	0.0080	0.0089	0.0066	0.0094	0.0051	0.0089	0.0084
8.7	0.0033	0.0075	0.0061	0.0051	0.0042	0.0061	0.0070	0.0080	0.0150	0.0047	0.0080
8.9	0.0070	0.0066	0.0066	0.0066	0.0056	0.0051	0.0084	0.0075	0.0051	0.0080	0.0028

Appendix 1- Test Result

HYD 6000-ES											
Active power P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
Harmonic number	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]
2	0.0260	0.0245	0.0385	0.0420	0.0816	0.0940	0.0738	0.1279	0.1558	0.2075	0.2312
3	0.2110	0.3459	0.4383	0.4349	0.4803	0.5273	0.5744	0.5650	0.5868	0.5343	0.5868
4	0.0113	0.0148	0.0175	0.0152	0.0412	0.0443	0.0420	0.0575	0.0754	0.1197	0.1003
5	0.1407	0.1329	0.1729	0.1795	0.1446	0.1628	0.1395	0.1640	0.1127	0.3288	0.1181
6	0.0101	0.0074	0.0159	0.0128	0.0280	0.0385	0.0264	0.0439	0.0497	0.0816	0.1240
7	0.0898	0.0944	0.1119	0.0902	0.0975	0.1104	0.1174	0.1096	0.1139	0.0948	0.2658
8	0.0105	0.0058	0.0144	0.0113	0.0256	0.0299	0.0229	0.0330	0.0346	0.0715	0.1430
9	0.0672	0.0808	0.0766	0.0668	0.0552	0.0789	0.0711	0.0762	0.0676	0.0874	0.1197
10	0.0078	0.0074	0.0124	0.0105	0.0179	0.0198	0.0218	0.0167	0.0245	0.0431	0.1045
11	0.0668	0.0618	0.0497	0.0253	0.0202	0.0431	0.0439	0.0563	0.0373	0.0560	0.0773
12	0.0097	0.0074	0.0140	0.0085	0.0144	0.0113	0.0152	0.0179	0.0198	0.0346	0.0396
13	0.0727	0.0490	0.0210	0.0163	0.0152	0.0412	0.0346	0.0618	0.0439	0.0633	0.0610
14	0.0074	0.0051	0.0066	0.0074	0.0109	0.0152	0.0171	0.0218	0.0187	0.0361	0.0715
15	0.0699	0.0462	0.0194	0.0144	0.0187	0.0427	0.0369	0.0560	0.0529	0.0486	0.1457
16	0.0074	0.0085	0.0097	0.0085	0.0027	0.0124	0.0078	0.0202	0.0229	0.0295	0.0921
17	0.0668	0.0443	0.0229	0.0190	0.0284	0.0408	0.0474	0.0494	0.0509	0.0672	0.0490
18	0.0101	0.0039	0.0035	0.0066	0.0062	0.0117	0.0066	0.0136	0.0218	0.0260	0.0665
19	0.0661	0.0392	0.0179	0.0187	0.0361	0.0381	0.0517	0.0486	0.0548	0.0482	0.1084
20	0.0070	0.0039	0.0047	0.0039	0.0058	0.0047	0.0074	0.0054	0.0132	0.0206	0.0253
21	0.0606	0.0369	0.0136	0.0214	0.0346	0.0346	0.0482	0.0513	0.0571	0.0595	0.0692
22	0.0078	0.0066	0.0043	0.0039	0.0062	0.0066	0.0105	0.0074	0.0078	0.0144	0.0338
23	0.0595	0.0408	0.0089	0.0198	0.0280	0.0400	0.0505	0.0505	0.0618	0.0575	0.0400
24	0.0078	0.0054	0.0043	0.0023	0.0078	0.0058	0.0089	0.0109	0.0058	0.0140	0.0427
25	0.0567	0.0517	0.0109	0.0190	0.0272	0.0400	0.0470	0.0509	0.0633	0.0583	0.1057
26	0.0062	0.0047	0.0035	0.0043	0.0062	0.0051	0.0051	0.0078	0.0093	0.0062	0.0474
27	0.0525	0.0622	0.0155	0.0140	0.0241	0.0369	0.0424	0.0486	0.0653	0.0571	0.0361
28	0.0082	0.0047	0.0035	0.0035	0.0051	0.0043	0.0039	0.0085	0.0082	0.0140	0.0194
29	0.0490	0.0692	0.0222	0.0132	0.0241	0.0358	0.0466	0.0466	0.0591	0.0521	0.0727
30	0.0074	0.0051	0.0035	0.0043	0.0027	0.0058	0.0047	0.0051	0.0070	0.0054	0.0109
31	0.0486	0.0688	0.0229	0.0124	0.0272	0.0342	0.0443	0.0451	0.0563	0.0521	0.0649
32	0.0054	0.0047	0.0039	0.0031	0.0035	0.0043	0.0043	0.0070	0.0070	0.0082	0.0194
33	0.0462	0.0672	0.0218	0.0124	0.0245	0.0323	0.0416	0.0451	0.0587	0.0532	0.0490
34	0.0058	0.0039	0.0039	0.0043	0.0054	0.0031	0.0047	0.0082	0.0066	0.0047	0.0171
35	0.0447	0.0657	0.0222	0.0124	0.0229	0.0288	0.0427	0.0439	0.0552	0.0474	0.0684
36	0.0051	0.0047	0.0039	0.0039	0.0019	0.0043	0.0039	0.0051	0.0039	0.0062	0.0249
37	0.0400	0.0684	0.0229	0.0140	0.0241	0.0299	0.0396	0.0431	0.0517	0.0462	0.0478
38	0.0035	0.0043	0.0043	0.0035	0.0027	0.0035	0.0054	0.0031	0.0039	0.0039	0.0093
39	0.0377	0.0692	0.0210	0.0128	0.0218	0.0319	0.0377	0.0373	0.0517	0.0443	0.0529
40	0.0043	0.0035	0.0039	0.0047	0.0035	0.0027	0.0047	0.0019	0.0054	0.0039	0.0054

Appendix 1- Test Result

HYD 6000-ES											
Active power P/Pn [%]	0	10	20	30	40	50	60	70	80	90	100
Frequency [Hz]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]
75	0.0194	0.0505	0.1181	0.1488	0.2417	0.2934	0.3132	0.4018	0.4733	0.5639	0.6136
125	0.0253	0.0136	0.0350	0.0431	0.0754	0.0824	0.0925	0.1108	0.1368	0.1795	0.1947
175	0.0222	0.0214	0.0323	0.0361	0.0657	0.0793	0.0750	0.1003	0.1224	0.1601	0.1718
225	0.0218	0.0167	0.0140	0.0299	0.0416	0.0529	0.0459	0.0657	0.0824	0.1049	0.1092
275	0.0218	0.0136	0.0361	0.0264	0.0431	0.0653	0.0575	0.0766	0.0742	0.1111	0.1143
325	0.0175	0.0144	0.0171	0.0295	0.0381	0.0501	0.0377	0.0665	0.0692	0.0816	0.0750
375	0.0206	0.0155	0.0303	0.0307	0.0369	0.0431	0.0490	0.0427	0.0595	0.0898	0.0878
425	0.0183	0.0109	0.0183	0.0311	0.0326	0.0486	0.0400	0.0556	0.0583	0.0610	0.0649
475	0.0206	0.0206	0.0264	0.0276	0.0319	0.0225	0.0377	0.0214	0.0365	0.0727	0.0734
525	0.0183	0.0183	0.0218	0.0249	0.0241	0.0295	0.0334	0.0288	0.0427	0.0494	0.0424
575	0.0190	0.0155	0.0214	0.0225	0.0206	0.0132	0.0222	0.0346	0.0342	0.0602	0.0544
625	0.0198	0.0179	0.0163	0.0187	0.0241	0.0194	0.0288	0.0152	0.0276	0.0412	0.0420
675	0.0202	0.0124	0.0101	0.0152	0.0136	0.0214	0.0140	0.0400	0.0377	0.0490	0.0451
725	0.0187	0.0120	0.0128	0.0124	0.0159	0.0136	0.0167	0.0237	0.0229	0.0342	0.0280
775	0.0171	0.0163	0.0078	0.0124	0.0109	0.0222	0.0089	0.0323	0.0334	0.0319	0.0427
825	0.0171	0.0101	0.0105	0.0136	0.0124	0.0167	0.0148	0.0288	0.0303	0.0260	0.0311
875	0.0163	0.0128	0.0066	0.0117	0.0101	0.0159	0.0152	0.0183	0.0295	0.0323	0.0229
925	0.0183	0.0109	0.0054	0.0128	0.0066	0.0163	0.0105	0.0249	0.0299	0.0249	0.0225
975	0.0179	0.0132	0.0066	0.0109	0.0089	0.0093	0.0128	0.0117	0.0120	0.0198	0.0295
1025	0.0171	0.0117	0.0070	0.0136	0.0101	0.0140	0.0097	0.0109	0.0326	0.0222	0.0241
1075	0.0194	0.0109	0.0062	0.0128	0.0097	0.0074	0.0163	0.0202	0.0113	0.0187	0.0256
1125	0.0175	0.0120	0.0070	0.0120	0.0109	0.0062	0.0120	0.0117	0.0132	0.0194	0.0272
1175	0.0171	0.0117	0.0051	0.0124	0.0089	0.0085	0.0117	0.0326	0.0152	0.0132	0.0152
1225	0.0171	0.0136	0.0043	0.0097	0.0105	0.0066	0.0128	0.0218	0.0078	0.0179	0.0148
1275	0.0175	0.0136	0.0035	0.0105	0.0066	0.0128	0.0085	0.0128	0.0187	0.0128	0.0229
1325	0.0159	0.0093	0.0058	0.0097	0.0097	0.0113	0.0124	0.0159	0.0128	0.0124	0.0268
1375	0.0163	0.0120	0.0047	0.0105	0.0051	0.0082	0.0093	0.0062	0.0167	0.0085	0.0113
1425	0.0155	0.0109	0.0043	0.0082	0.0097	0.0101	0.0113	0.0144	0.0163	0.0175	0.0136
1475	0.0155	0.0124	0.0039	0.0109	0.0054	0.0070	0.0082	0.0085	0.0140	0.0066	0.0113
1525	0.0140	0.0105	0.0043	0.0082	0.0066	0.0105	0.0105	0.0082	0.0148	0.0132	0.0167
1575	0.0132	0.0089	0.0039	0.0070	0.0051	0.0062	0.0093	0.0136	0.0082	0.0074	0.0140
1625	0.0144	0.0089	0.0043	0.0085	0.0078	0.0062	0.0082	0.0089	0.0120	0.0136	0.0171
1675	0.0132	0.0101	0.0062	0.0074	0.0054	0.0074	0.0070	0.0148	0.0062	0.0078	0.0120
1725	0.0113	0.0082	0.0047	0.0078	0.0070	0.0054	0.0101	0.0128	0.0066	0.0117	0.0089
1775	0.0113	0.0101	0.0051	0.0074	0.0082	0.0070	0.0101	0.0078	0.0101	0.0054	0.0140
1825	0.0120	0.0078	0.0054	0.0074	0.0051	0.0078	0.0074	0.0117	0.0085	0.0082	0.0202
1875	0.0097	0.0097	0.0058	0.0054	0.0074	0.0078	0.0097	0.0074	0.0117	0.0074	0.0082
1925	0.0120	0.0085	0.0066	0.0078	0.0066	0.0093	0.0105	0.0070	0.0082	0.0054	0.0101
1975	0.0105	0.0105	0.0047	0.0070	0.0054	0.0062	0.0085	0.0109	0.0117	0.0089	0.0085

Appendix 1- Test Result

HYD 6000-ES											
Active power P/P_n [%]	0	10	20	30	40	50	60	70	80	90	100
Frequency [kHz]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]	I[%]
2.1	0.0039	0.0039	0.0031	0.0027	0.0031	0.0054	0.0043	0.0043	0.0062	0.0047	0.0155
2.3	0.0027	0.0043	0.0016	0.0054	0.0039	0.0027	0.0035	0.0035	0.0043	0.0054	0.0163
2.5	0.0031	0.0039	0.0019	0.0027	0.0031	0.0039	0.0027	0.0035	0.0043	0.0058	0.0066
2.7	0.0047	0.0054	0.0023	0.0023	0.0035	0.0027	0.0051	0.0019	0.0039	0.0047	0.0109
2.9	0.0031	0.0031	0.0035	0.0023	0.0016	0.0031	0.0043	0.0047	0.0062	0.0027	0.0074
3.1	0.0031	0.0039	0.0035	0.0035	0.0043	0.0047	0.0054	0.0054	0.0047	0.0039	0.0140
3.3	0.0019	0.0031	0.0027	0.0019	0.0035	0.0027	0.0039	0.0039	0.0031	0.0047	0.0078
3.5	0.0039	0.0035	0.0043	0.0035	0.0008	0.0031	0.0054	0.0031	0.0039	0.0051	0.0070
3.7	0.0054	0.0035	0.0043	0.0019	0.0035	0.0043	0.0051	0.0043	0.0062	0.0027	0.0039
3.9	0.0070	0.0051	0.0062	0.0016	0.0074	0.0035	0.0051	0.0023	0.0101	0.0097	0.0163
4.1	0.0051	0.0093	0.0027	0.0031	0.0051	0.0023	0.0101	0.0027	0.0070	0.0058	0.0085
4.3	0.0035	0.0031	0.0054	0.0047	0.0031	0.0035	0.0035	0.0047	0.0039	0.0051	0.0085
4.5	0.0054	0.0027	0.0031	0.0039	0.0023	0.0027	0.0054	0.0027	0.0031	0.0062	0.0031
4.7	0.0047	0.0062	0.0039	0.0062	0.0027	0.0039	0.0043	0.0070	0.0070	0.0085	0.0031
4.9	0.0031	0.0039	0.0047	0.0047	0.0027	0.0023	0.0039	0.0093	0.0031	0.0039	0.0043
5.1	0.0039	0.0039	0.0039	0.0124	0.0027	0.0035	0.0031	0.0225	0.0027	0.0027	0.0051
5.3	0.0051	0.0035	0.0031	0.0066	0.0035	0.0035	0.0039	0.0144	0.0035	0.0047	0.0047
5.5	0.0039	0.0035	0.0027	0.0047	0.0043	0.0043	0.0043	0.0047	0.0016	0.0023	0.0039
5.7	0.0043	0.0016	0.0031	0.0051	0.0047	0.0035	0.0039	0.0043	0.0039	0.0039	0.0047
5.9	0.0035	0.0035	0.0023	0.0039	0.0039	0.0031	0.0043	0.0043	0.0016	0.0039	0.0047
6.1	0.0051	0.0027	0.0016	0.0043	0.0039	0.0043	0.0023	0.0039	0.0027	0.0035	0.0051
6.3	0.0031	0.0019	0.0019	0.0031	0.0035	0.0043	0.0035	0.0035	0.0031	0.0043	0.0043
6.5	0.0043	0.0039	0.0043	0.0019	0.0031	0.0027	0.0043	0.0019	0.0043	0.0039	0.0054
6.7	0.0043	0.0027	0.0035	0.0047	0.0043	0.0051	0.0066	0.0047	0.0039	0.0051	0.0043
6.9	0.0058	0.0023	0.0035	0.0070	0.0039	0.0039	0.0051	0.0070	0.0031	0.0047	0.0070
7.1	0.0047	0.0043	0.0047	0.0035	0.0031	0.0066	0.0062	0.0035	0.0043	0.0070	0.0066
7.3	0.0058	0.0035	0.0039	0.0027	0.0054	0.0051	0.0082	0.0070	0.0051	0.0051	0.0074
7.5	0.0031	0.0058	0.0074	0.0023	0.0066	0.0066	0.0066	0.0035	0.0074	0.0066	0.0097
7.7	0.0039	0.0082	0.0043	0.0027	0.0054	0.0074	0.0097	0.0027	0.0089	0.0082	0.0109
7.9	0.0120	0.0128	0.0093	0.0027	0.0120	0.0245	0.0159	0.0043	0.0326	0.0229	0.0253
8.1	0.0093	0.0140	0.0152	0.0039	0.0222	0.0187	0.0202	0.0031	0.0295	0.0264	0.0315
8.3	0.0074	0.0054	0.0039	0.0051	0.0058	0.0085	0.0051	0.0039	0.0089	0.0058	0.0117
8.5	0.0047	0.0097	0.0078	0.0054	0.0082	0.0062	0.0066	0.0027	0.0070	0.0074	0.0093
8.7	0.0070	0.0082	0.0074	0.0051	0.0066	0.0066	0.0051	0.0066	0.0109	0.0058	0.0101
8.9	0.0027	0.0085	0.0070	0.0159	0.0058	0.0082	0.0019	0.0190	0.0054	0.0043	0.0058

Appendix 1- Test Result

F.4 Requirements for the test report for the NS protection

Extract from test report for unit certificate: 180903074GZU-001

Determination of electrical properties

☒ NS protection as integrated NS protection

Type of NS protection: Integration	**Other manufacturer's data**
Software/ firmware version: V1.00	**Assigned to PGU type:** **Integrated interface switch**
Manufacturer: Shenzhen SOFAR SOLAR Co., Ltd.	**Manufacturer:** Panasonic Corporation **Type:** ALFG2PF121 **Rating**: 33A,277VAC **Alternative Manufacturer:** XIAMEN HONGFA ELECTROACOUSTIC CO LTD **Type:** HF161F-W/12-HT **Rating**: 31A, 250VAC

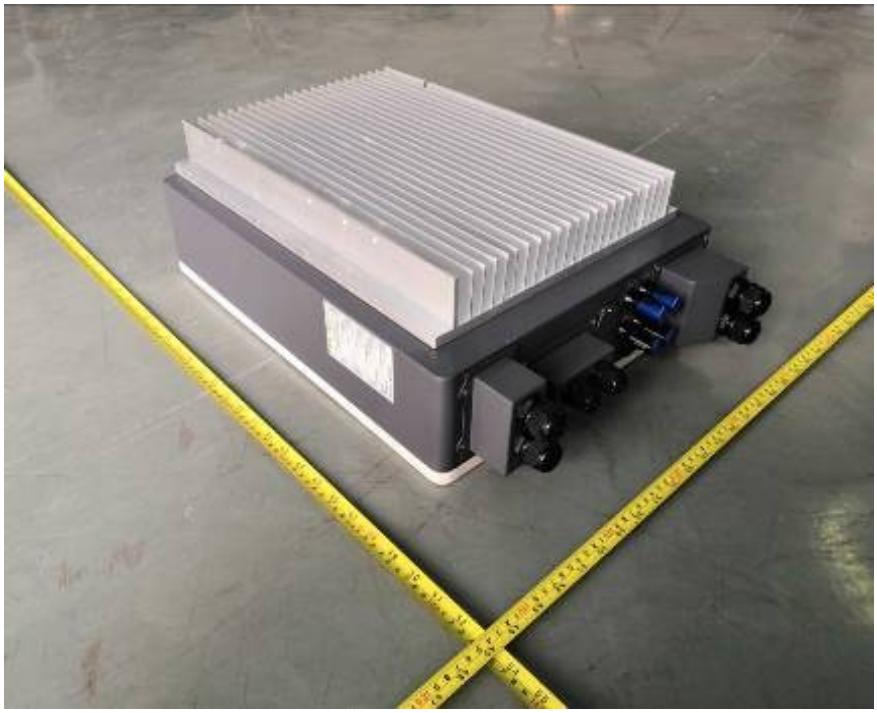
Measuring period:

Protection function	Setting value	Tripping value (Vac)			Break time (ms)		
		1st	2nd	3rd	1st	2nd	3rd
Voltage drop protection *U* <	0.77 U_n	--	--	--	--	--	--
Voltage drop protection *U* <	0.8 U_n	185.75	185.61	185.73	149.5	148.5	172.5
Rise-in-voltage protection *U* >	1.1 U_n	--	--	--	516s*		
Rise-in-voltage protection *U* >>	1.15 U_n	263.12	263.13	263.18	175.0	173.5	166.0
Rise-in-voltage protection *U* >>	1.18 U_n	--	--	--	--	--	--
Frequency decrease protection *f* <	47.5 Hz	47.50	47.50	47.50	157.5	156.0	154.5
Frequency increase protection *f* >	51.5 Hz	51.48	51.48	51.48	138.5	136.5	152.0
Proper time of interface switch		20ms					

The break time (sum of tripping time NS protection plus proper time of interface switch) shall not exceed 200ms.
The verification of the full functional chain "NS protection – Interface switch" has yield to intended disconnection.
* Results of the protection of the Increase in voltage as 10-min moving average

Appendix 2: Photos

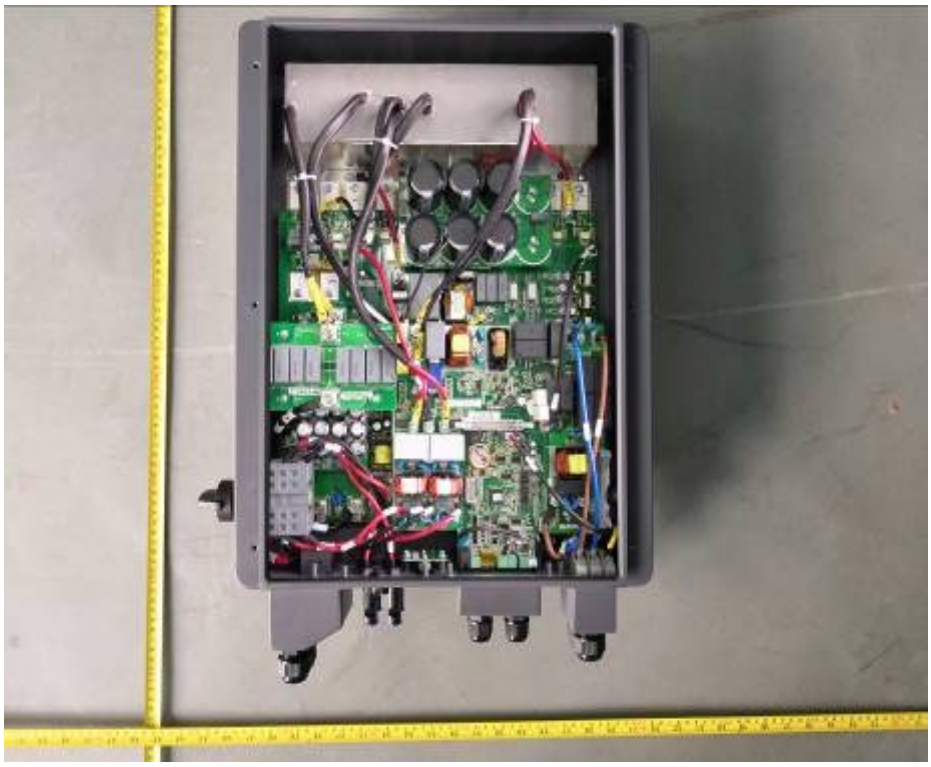
Overview



Bottom view

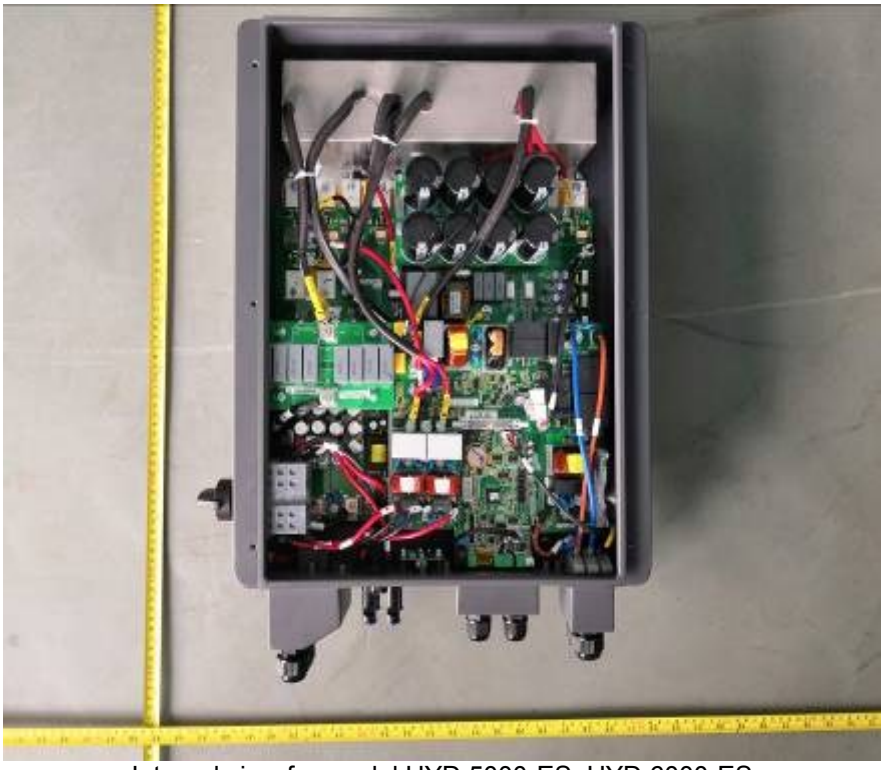
Appendix 2: Photos

Connection view

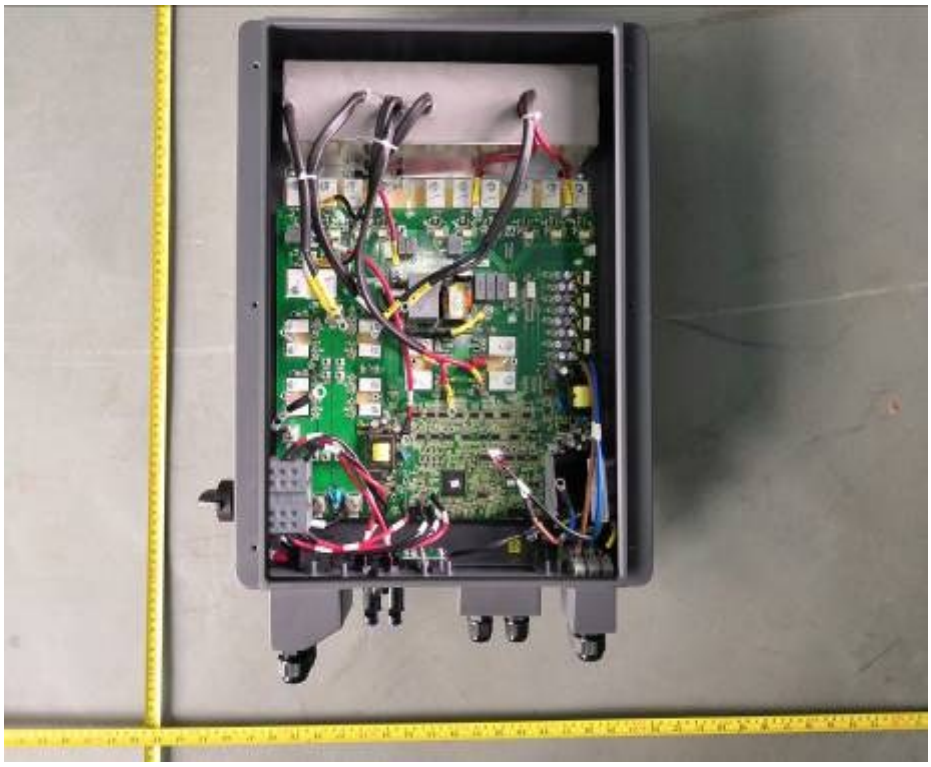


Internal view for model HYD 4000-ES, HYD 3600-ES, HYD 3000-ES

Appendix 2: Photos



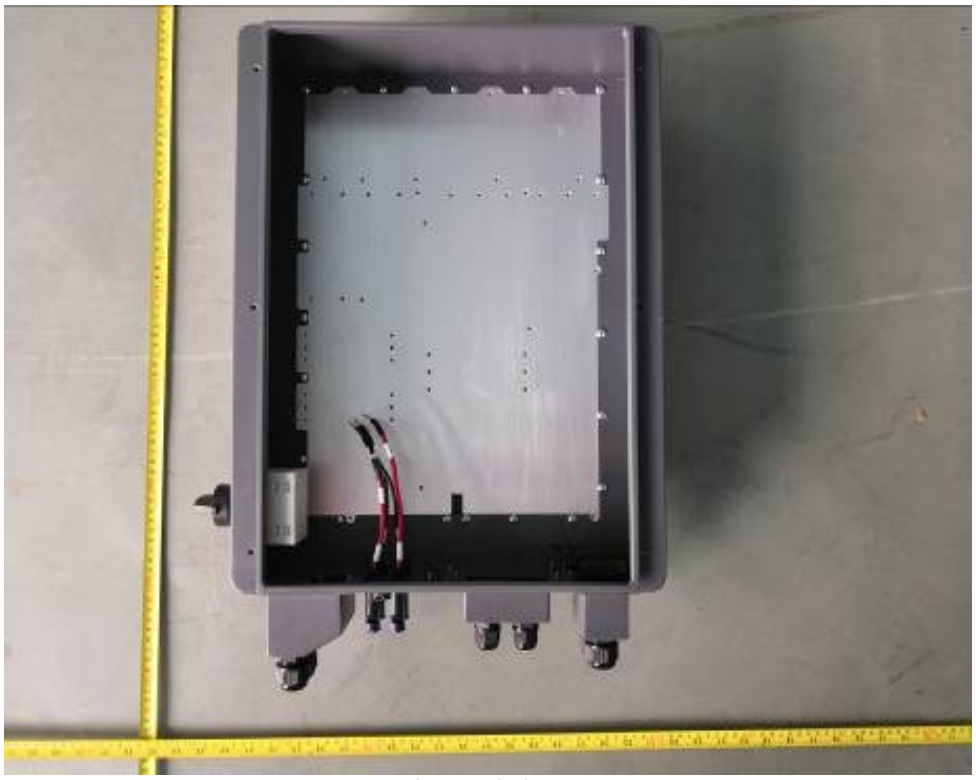
Internal view for model HYD 5000-ES, HYD 6000-ES



Internal view

Appendix 2: Photos

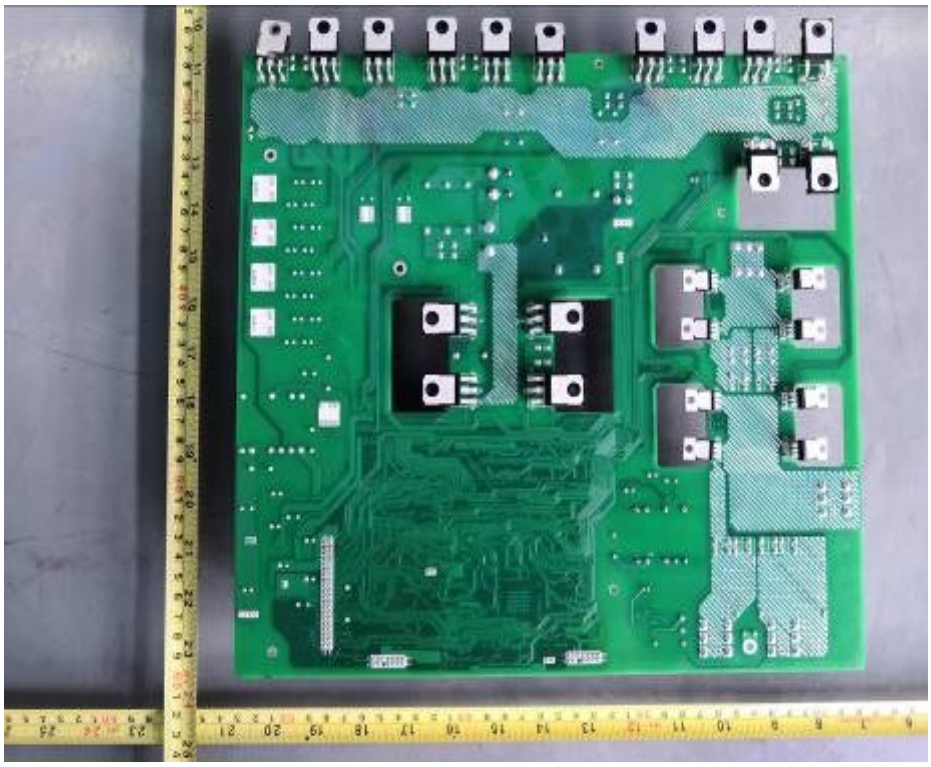
Earthing view



Internal view

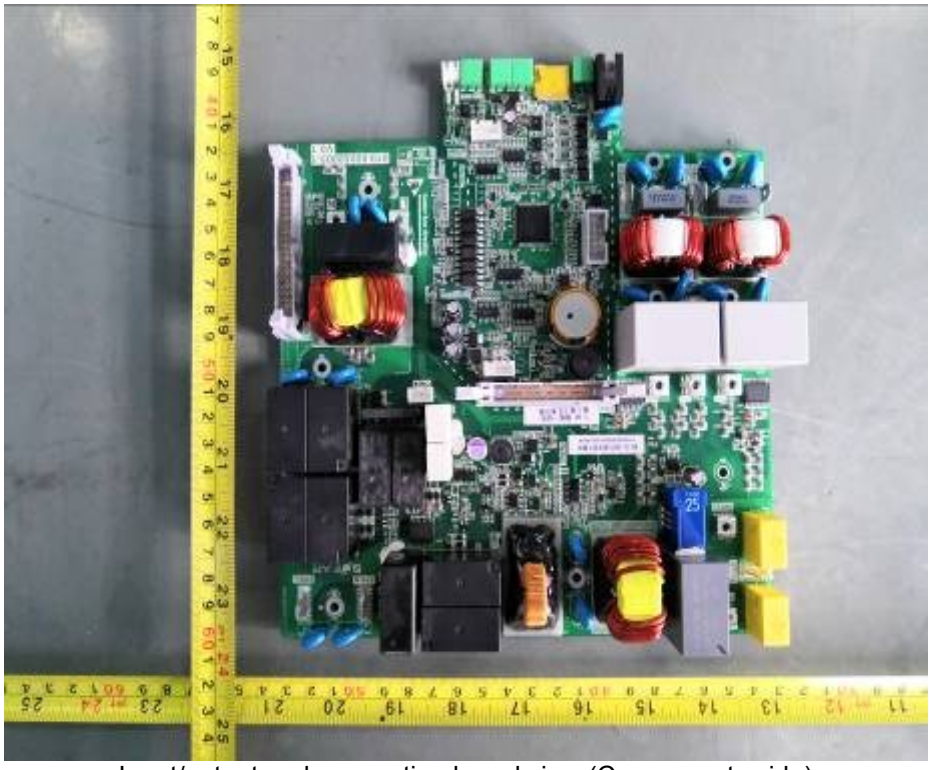
Appendix 2: Photos

Power board view (Components side)

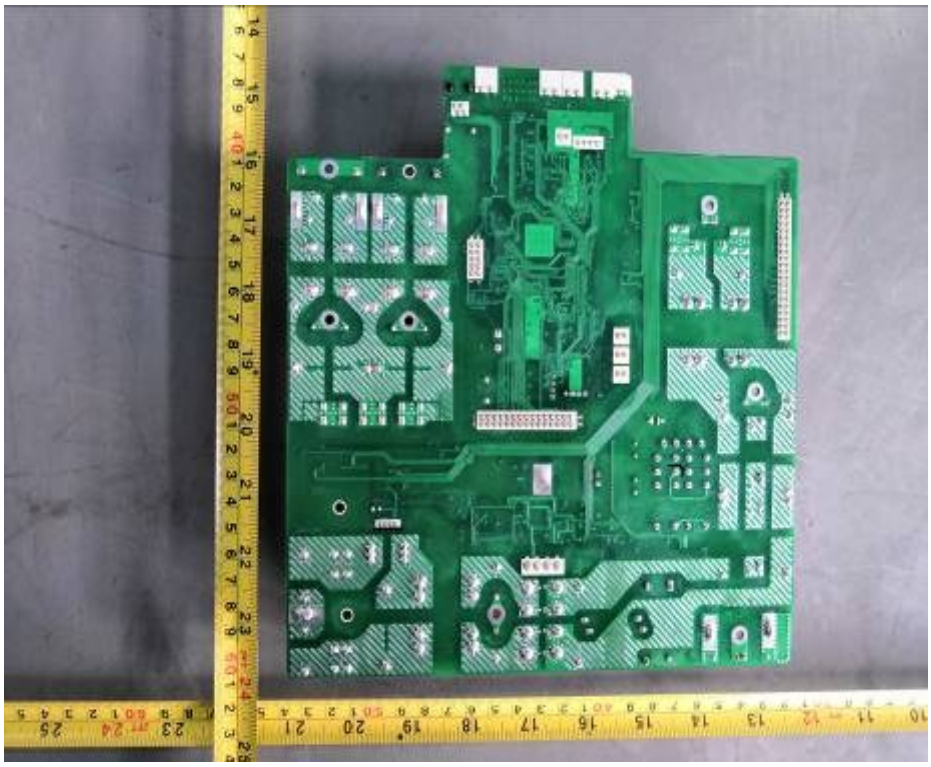


Power board view (Soldered side)

Appendix 2: Photos



Input/output and connection board view (Components side)



Input/output and connection board view (Soldered side)

Appendix 4: Equipment lists

Equipment Description:				
Number:	**Equipment No.**	**Name**	**Brand**	**Model**
01	SA200-01	Power analyzer	YOKOWAWA / ZLG	WT3000 / PA6000
02	SA200-04	DC Power	--	DCST-800-120
03	SA200-05	AC Power	--	ACST-L-33075
04	SA050-33	Oscillograph	YOKOWAWA	DL850
05	SA002-17	Withstand voltage tester	KIKVSUI	T0S5052
06	SA023-08	Earthing resistor tester	OS	CS9950L
07	SA016-13	Programmable temperature and humidity test chamber	--	WGD/SJ-40408
08	SA200-02	RLC Load	--	ACLT-4830H

----------End of Report----------