ENA ER G100: 2016+Amd1 (2017)

Engineering recommendations G100, Issue 1 Amendment 1 2017
Technical requirements for customer export limiting schemes

Report reference No. ..... :	P2018070301	
Tested by (printed name and signature) ..... :	Daniel Keis	..... :
Approved by (printed name and signature) ..... :	Manuel Shimasaki	..... :
Date of issue ..... :	5 July 2018	

Testing Laboratory Name ..... :	EnTest Laboratories
	Test indicated as traceable only are outside the scope of the laboratories accreditation. **Accreditation number: 1273**
Address ..... :	1 Treffers Road, Wigram, Christchurch, New Zealand 8042
Testing location/procedure ..... :	NZL ☒
Other (please explain) ..... :	

Applicant's Name ..... :	Enphase Energy
Address ..... :	1420 North McDowell Boulevard, Petaluma, CA 94954, USA

Test specification

Standard ..... :	ENA ER G100: 2016+Amd1 (2017)
Test procedure ..... :	EnTest Laboratories
Non-standard test method ..... :	

Test Report Form No. ..... :	ENA ER G100: 2016+Amd1 (2017)
TRF originator. ..... :	EnTest Laboratories
Master TRF ..... :	Dated JULY 2018

Test item description ..... :	Solar Micro Inverter
Trademark ..... :	ENPHASE.
Manufacturer ..... :	Enphase Energy
Model and/or type reference ..... :	IQ7PLUS-72-X-Y-Z and IQ7-60- X-Y-Z
Rating(s) ..... :	See rating table

Copy of marking plate

Model: **IQ7PLUS-72-X-INT**

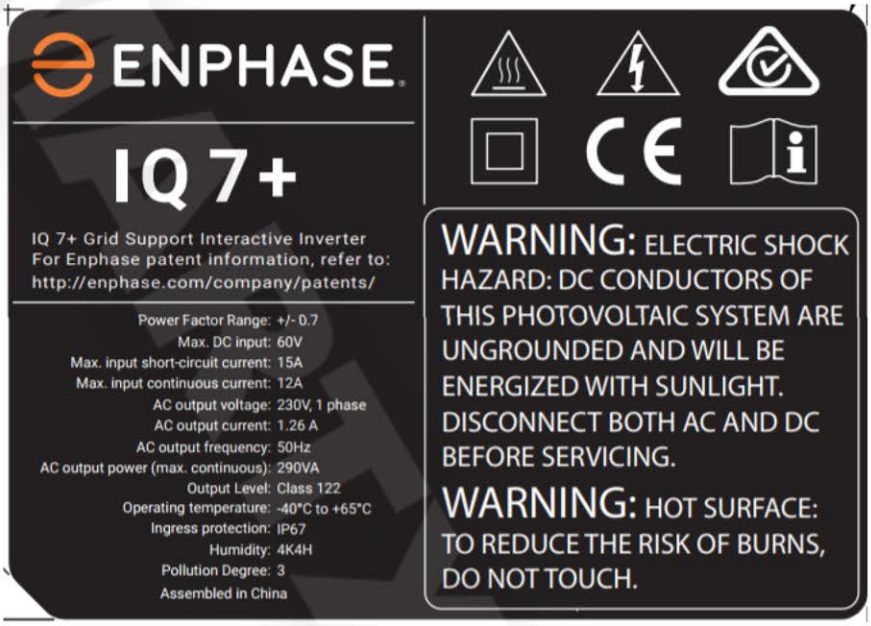

Figure 1: IQ7PLUS marking plate

Model: **IQ7-60-X-INT**

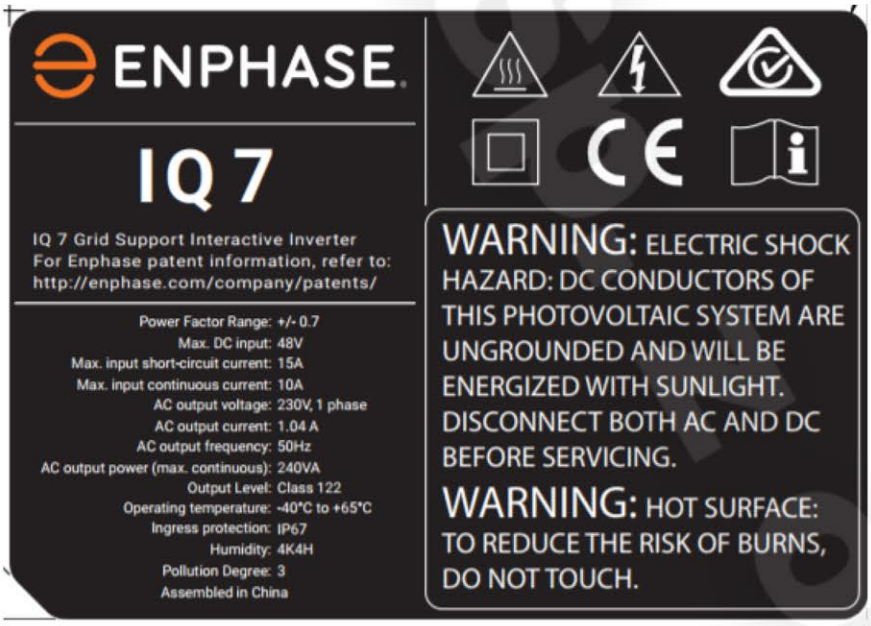

Figure 2: IQ7 marking plate

Copy of marking plate

Model: **IQ7PLUS-ACM-INT**

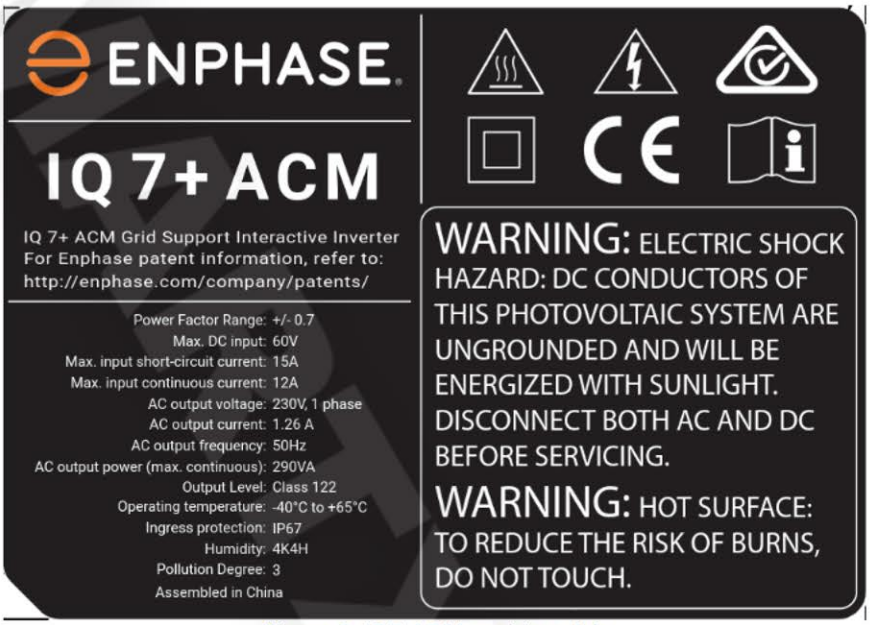

Figure 3: IQ7 ACM marking plate

Model: **IQ7-ACM-INT**

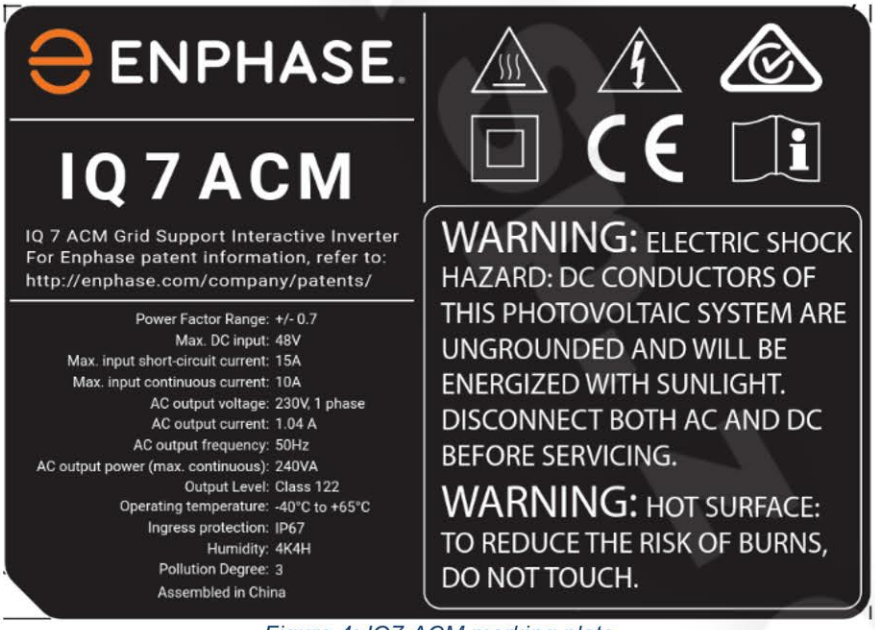

Figure 4: IQ7 ACM marking plate

SUMMARY OF COMPLIANCE WITH ENA ER G100: 2016+Amd1 (2017)

All tests passed the requirements of the ENA ER G100: 2016+Amd1 (2017) standard within the required limits and within the equipment uncertainties.

The system consisting of Photovoltaic Micro-inverters, model numbers IQ7PLUS-72-X-Y-Z and IQ7-60-X-Y-Z and Q-RELAY-1P-INT **COMPLIED** with the tested clauses of ENA ER G100: 2016+Amd1 (2017).

Possible test case verdicts:

- test case does not apply to the test object ..... : N/A
- test object does meet the requirement ..... : P(Pass)
- test object does not meet the requirement ..... : F(Fail)

Testing ..... :

Date of receipt of test item ..... : July 2018

Date (s) of performance of tests ..... : July 2018

General remarks:

1. The test results presented in this report relate only to the object tested.
2. This report shall not be reproduced, except in full, without the written approval of the Issuing testing laboratory.
3. If the measured result complies up to the limit of acceptance, the result shall be reported along with our uncertainty of measurement. e.g. results to state window of uncertainty.
4. "(see Enclosure #)" refers to additional information appended to the report.
5. "(see appended table)" refers to a table appended to the report.
6. EMC report:
    a. E2018041801 including: BS EN 61000-6-2: 2005, BS EN 61000-6-3: 2007, BS EN 50065-1: 2011, BS EN 50065-2-2: 2003, BS EN 61000-3-2: 2014, BS EN 61000-3-3: 2013-
7. Safety reports:
    a. S2018043001 including: IEC BS/EN 62109-1 and IEC BS/EN 62109-2

General product information:

The EUT (Equipment Under Test), known as Photovoltaic Micro-inverters, model numbers IQ7PLUS and IQ7 were supplied for testing to ENA ER G100: 2016+Amd1 (2017) by Enphase Energy Inc of 1420 North McDowell Boulevard, Petaluma, CA 94954, USA.

Worst case uncertainty of Measurements

Parameter	Range	Instrument accuracy of Measuring Range
Voltage		
- Up to 1000 V	up to 1 kHz	±1,5 %
	1kHz up to 5 kHz	±2 %
	5 kHz up to 20 kHz	±3 %
	20 kHz and above	±5 %
- 1000 V and above	dc up to 20 kHz	±3 %
	20 kHz and above	±5 %
Current		
- Up to 5 A	up to 60 Hz	±1,5 %
	above 60 Hz up to 5 kHz	±2,5 %
	5 kHz up to 20 kHz	±3,5 %
	20 kHz and above	±5 %
- Above 5 A	up to 5 kHz	±2,5 %
	5 kHz up to 20 kHz	±3,5 %
	20 kHz and above	± %
Leakage (Touch) current[1]	50 Hz up to 60 Hz	±3,5 %
	greater 60 Hz up to 5 kHz	±5 %
	greater 5 kHz up to 100 kHz	±10 %
	greater 100 kHz up to 1 MHz	under consideration
Power (50/60 Hz)	up to 3 kW	±3 %
	above 3 kW	±5 %
Power Factor (50/60 Hz)		±0,05
Frequency	up to 10 kHz	±0,2 %
Resistance	1 mW up to 100 mΩ and above 1 MΩ up to 1 TΩ	±5 %
	above 1 TΩ	±10 %
	for all other cases	±3 %
Temperature [2,3]		
	- 35°C to below 100° C	±2° C
	100° C up to 500° C	±3 %
	below - 35°C ± 3°C	±3° C
Time	10 ms up to 200 ms	±5 %
	200 ms up to 1 s	±10 ms
	1 s and above	±1 %
Linear dimensions	up to 1 mm	±0,05 mm
	1 mm up to 25 mm	±0,1 mm
	25 mm and above	±0,5 %
Mass	above 10 g and up to 100 g	±1 %
	100 g up to 5 kg	±2 %
	5 kg and above	±5 %
Force	for all values	±6 %
Mechanical energy	for all values ± 10%	±10 %
Torque		±10%
Angles		±1 degree
Relative humidity	30% to 95% RH	±6% RH
Barometric air pressure		±10 kPa

1. The stated tolerances apply to the total tolerance of the leakage (touch) current circuit and metering Instrument.
2. Thermocouple not included in the Instrument accuracy of measuring range. Thermocouples type “T” premium grade, are recommended.
3. Not for measurements related to relative humidity.

Model rating table:

Specification	Units	IQ7PLUS	IQ7
Rated output active power	W	290	240
Output apparent power	VA	290	240
Nominal output voltage	V_{rms}	230	230
Output voltage range	V_{rms}	211-264	211-264
Nominal output frequency	Hz	50	50
Output frequency range	Hz	47-51	47-51
AC output current	A_{rms}	1.26	1.04
Maximum output current	A_{rms}	1.37	1.14
EN50530 efficiency	%	96.5	96.5
Full power MPPT input voltage range	V	27-45	27-37
Input operating range	V	16-60	16-48
Input current limit region	V	16-27	16-27
Input frequency	Hz	DC	DC
Input maximum continuous current	A	12	10
DC LSC input maximum	A	15	15
Ingress protection		IP67	IP67
Environmental category		Outdoor	Outdoor
Wet locations		suitable	suitable
Pollution degree		PD3	PD3
Ambient temperature		-40C to +65C	-40C to +65C
Relative humidity		4K4H	4K4H
Maximum altitude		Not rated	Not rated
Overvoltage category		OVC III	OVC III

Models IQ7-60-X-Y-Z and IQ7PLUS-72-X-Y-Z are similar except as indicated above.
Model nomenclature details:
X = 2, 5 or B
- 2 = Multicontact PV connector
- 5 = Amphenol PV connector
- B = Friends PV connector

Y = blank or ACM (X marking not required)
Z = blank or any letter for country of intended installation (eg: US for North America, INT for International)

The EUT AC connector was to be connected to a Q cable and connected to fixed-wiring in accordance with ENA ER G100: 2016+Amd1 (2017) and the National Wiring Rules AS/NZS 3000. f

Mode and control of the inverter can be performed via PLC (Power Line Communication) with an external control gateway named EnvoyS.

There was reinforced isolation between the SELV DC input and the hazardous voltage AC output.

Firmware version:
520-00082-r01-v02.12.02

ENA ER G100: 2016+Amd1 (2017)			
Clause	Requirements – Tests	Results - Remark	Verdict

5	**REQUIREMENTS**		**P**
5.1	**Export Limitation Scheme Design**		**P**
	An Export Limitation Scheme measures the Active Power at points within the Customer's installation and then uses this information to either restrict generation output and/or balance the Customers demand in order to prevent the export from to the Distribution System from exceeding the Agreed Export Capacity.	*Handled by the EnvoyS*	P
	An ELS may include a secondary feature to restrict generation export when the voltage at the Connection Point exceeds the Statutory Voltage Limits. If this feature is required, the DNO shall specify this at the quotation / offer stage.	*Voltage limits and Volt Watt functions are propagated by the Envoy to the Inverters*	P
	In order for the installation of an ELS to be an acceptable solution, the DNO must be satisfied that the control schemes will meet the requirements of section 5.6 under all circumstances.		Noted
	It should be noted that the Agreed Export Capacity is expressed as an Active Power value (in kW or MW). In addition to this Agreed Export Capacity, DNOs will specify an export Power Factor or Power Factor range at the Connection Point, as applicable. The ELS shall be designed to measure and limit the Active Power only since the Power Factor and hence the Apparent Power and Reactive Power should be controlled by the Customer to satisfy the requirements of the Connection Agreement.		Noted
	The ELS may be formed of discrete units, as shown in Appendix B, or integrated into a single packaged scheme. Where discrete units are used they should preferably be interconnected using metallic or fibre optic cables. Alternatively the units may be interconnected using secure radio links but where this is the case these links shall be licensed (by OFCOM) and have a planned availability of 99.9% or higher. Irrespective of the media used for interconnecting between the discrete units, if the communication path fails the generation output shall be reduced to a nominal value stipulated by the DNO within a set response time (see section 5.5) to prevent the Agreed Export Capacity from being exceeded.	*Power line communications is used between Envoy and inverters*	P
	ELSs installed at Power Stations with an aggregate Generating Unit capacity exceeding 16A (i.e. 3.68kW) per phase must be fail-safe and must ensure that the Agreed Export Limit is not exceeded if any single component, including the communication links between the discrete units, fail or lose their power supply.	*Fail-safe passed testing*	P

ENA ER G100: 2016+Amd1 (2017)			
Clause	Requirements – Tests	Results - Remark	Verdict
	Once installed and commissioned, the scheme settings should not be capable of being readily altered by the Customer and shall only be changed with the written agreement of the DNO.	*Envoy setting as password protected and cannot be changed by the customer*	P
	The exported power at the Connection Point may be managed by increasing the Customer's demand within the Customers installation; however the ELS must be able to turn down/reduce the generated power or disconnect one of more Generation Units if the demand is not available.	*This is handled by the export limiting function*	P
	Additional reverse power protection shall be installed at all HV metered connections to back-up the ELS. See section 5.5 for further detail.	*Not HV*	N/A
	For LV Connection Points, a reverse power protection relay is only required if the DNO deems the ELS not to be fail-safe.	*Fail-safe passed testing*	N/A
	A description of the scheme, its settings, and a single line diagram shall be permanently displayed on site.		Noted
5.2	**Maximum Power Station Capacity**		**P**
	An ELS will take a finite time (as specified in section 5.5.) to operate and restrict the site export. During this period the exported power may be above the Agreed Export Capacity which could cause equipment current ratings, over-current protection settings, fuse ratings or Statutory Voltage Limits to be temporarily exceeded.	*Power is limited within 5 seconds*	P
	The DNO will carry out an assessment at the design stage to determine the maximum acceptable Power Station Capacity above which either thermal limits, protection settings / fuse ratings or equipment voltage limits could be exceeded. Further guidance on these aspects is provided below.		Noted
5.2.1	**Equipment Thermal Limit Assessment**		**Noted**
	Plant and equipment (e.g. switchgear, transformers, cables and overhead lines etc.) is normally capable of withstanding short periods of moderate overloading. In most cases thermal limits will not be exceeded due to detection and operation of the ELS and, where fitted, the reverse power protection.		Noted
5.2.2	**Protection Assessment**		**Noted**

ENA ER G100: 2016+Amd1 (2017)			
Clause	Requirements – Tests	Results - Remark	Verdict
	In order to prevent mal-operation of cut-out fuses and/or over-current protection and other protection equipment the Power Station Capacity shall typically be no greater than 1.25 x Agreed Import Capacity or 1.25 x Agreed Export Capacity, whichever is the higher. At some sites it may be possible for a DNO to agree a higher value depending upon the protection requirements and the Minimum Demand.		Noted
	Where the site does not have an Agreed Import Capacity or Agreed Export Capacity the protection assessment shall be based on the DNO's cut-out fuse rating or the over-current protection settings applied to the metering circuit breaker (operating at Nominal Voltage). In the absence of other information, the DNOs cut-out fuse should be assumed to be 60A.		Noted
5.2.3	**Voltage Assessment**		**P**
	The Power Station Capacity shall be restricted to prevent DNO equipment voltage ratings from being exceeded during the detection and operation time of the ELS. It is recommended that the highest network voltage is no greater than the Statutory Voltage Limit + 1% (of the Nominal Voltage) before the ELS operates.	*Statutory Voltage Limit will not be exceeded*	P
	For LV networks, the Declared Voltage is 230V (phase to neutral) and the DNO's upper Statutory Voltage Limit is = 230V + 10% = 253V. "Where a Power Station Capacity does not exceed 32A per phase and consists solely of Type Tested SSEGs a voltage assessment is not required. In all other circumstances the maximum Power Station Capacity should be restricted in order to prevent the network voltage exceeding 253V + (1% of 230V) = 255.3V.	*Inverters are type tested to G83/2-1 and G59/3-4*	P
	For HV networks an upper voltage limit is defined by the DNO to ensure the voltage at LV Connection Points remains within Statutory Voltage Limits. For example, where a DNO specifies an upper voltage limit of 11.3kV (phase to phase) for an HV network, the maximum Power Station Capacity must be restricted to prevent the highest network voltage exceeding 11.3kV + (1% of 11kV) = 11.41kV.	*Not HV*	N/A
5.2.4	**Other Restrictions**		**Noted**
	It is possible that other factors may restrict the maximum Power Station Capacity at the site, for example fault level contribution, or possible transmission system related restrictions. Where this is the case the DNO shall notify the Customer of the reason for the restriction.		Noted

ENA ER G100: 2016+Amd1 (2017)			
Clause	Requirements – Tests	Results - Remark	Verdict
	Examples of how the maximum Power Station Capacity is calculated are included Appendix D.		Noted
5.3	**Maximum Capacity of Actively Controlled Demand**		**P**
	Where the Agreed Export Capacity is limited by actively controlling flexible on-site demand the Agreed Import Capacity could be exceeded if the generation is suddenly disconnected (e.g. if the EREC G59 interface protection operates). This could potentially cause equipment thermal limits and / or rapid voltage change limits to be exceeded. In order to prevent these issues the maximum demand of the site, including the actively controlled demand, shall not exceed 1.25 x the Agreed Import Capacity of the site.	*Complies with Export limiting requirements*	P
	Where a site with an LV Connection Point does not have an Agreed Import Capacity the rating of the cut-out fuse or the over-current protection settings applied to the metering circuit breaker (operating at Nominal Voltage) shall be used instead. In the absence of other data a 60A cut-out fuse shall be assumed.		Noted
5.4	**Power Quality**		**P**
	All installations must comply with the power quality requirements defined in	*See general remarks 6 and 7*	P
	• ENA Engineering Recommendation P28	*Flicker*	P
	• ENA Engineering Recommendation P29	*Voltage unbalance*	P
	• ENA Engineering Recommendation G5	*Harmonics*	P
	In accordance with the above documents, with BS7671 (The IET Wiring Regulations) and the Distribution Code, Customers shall discuss and agree the connection of any potentially disturbing equipment with the DNO.		Noted
	In addition to the connected load and generation, the ELS may also create voltage disturbances and voltage distortion.		Noted
	An ELS that quickly decreases or trips the generation or that quickly increases or decreases demand may give rise to rapid voltage changes and / or flicker. In such cases the Customer shall provide the DNO information on the maximum change in current or power, the characteristics of the change (e.g. step change, ramped change etc.). If the current is ramped up or down the maximum ramp rate and ramp duration shall also be provided. EREC P28 normally restricts rapid voltage changes to a maximum of 3%.		P

ENA ER G100: 2016+Amd1 (2017)			
Clause	Requirements – Tests	Results - Remark	Verdict
	An ELS that relies on power electronics (e.g. converters etc.) to control the load shall also provide information demonstrating compliance with relevant harmonics standards (e.g. BSEN 61000-3-2 and/or BSEN 61000-3-12) or provide data on the harmonic current produced by the ELS in accordance with ENA EREC G5.	*Harmonics passed as per G83 and G59*	P
5.5	**Accuracy and Response Rates**		**P**
	The overall accuracy of ELS with regard to measurement and control of Active Power and, where applicable, voltage, shall be determined by the manufacturer of the system and published within its operating manual. These tolerances shall, as far as possible, take account of sensing / measurement errors, processing errors, communication errors and control errors. Consideration shall also be given to environmental factors (e.g. the expected ambient temperature range).	*Refer to product data sheets*	P
	The settings applied to the ELS shall take account of the published tolerances to ensure the required export limits and voltage limits are maintained. For example, if an ELS is required to limit the export to 100kW and it has an overall tolerance of +/-5% at this value, it shall be set to limit the Active Power to 95kW (i.e. 95% of the required value).		Noted
	The ELS must detect an excursion and reduce the export to the Agreed Export Capacity or less within 5 seconds.	*See appendix A for results*	P
	Where communication delays (between the ELS and the Generating Units and actively controlled demand) mean that the 5 second operating time may not be satisfied, a back-up system shall be installed that detects an excursion and operates within 5 seconds. In such circumstances the back-up system should be programmed to act at the Agreed Export Capacity and the ELS at a lower value. This backup system should have an Active Power accuracy of +/-3% or better.	*Complied with the 5 second requirement*	P
	For example, for a site with a nominal 50kW export limit, the ELS system could be set to 48kW, with a back-up disconnection device set at 50kW; under normal operation, the dynamic system will keep the site limited to 48kW export, but should the export peak over 50kW, the generation will be disconnected within 5 seconds by device back-up disconnection system. Where an ELS relies on a backup disconnection systems to achieve the 5 seconds limit the arrangement must satisfy the power quality requirements, including the EREC P28 rapid voltage change and flicker requirements.		Noted

ENA ER G100: 2016+Amd1 (2017)			
Clause	Requirements – Tests	Results - Remark	Verdict
	For all High Voltage metered connections, protection (known as reverse power protection) shall disconnect the Generating Unit if the exported power exceeds the Agreed Export Capacity for more than 5 seconds. It shall be the responsibility of the Customer to specify and satisfy the relevant DNO that the protection meets this requirement.	Not HV	N/A
5.6	**Excursions**		**P**
	The Active Power may, under abnormal conditions, temporarily exceed the Agreed Export Capacity. The ELS shall be designed so that under normal operating conditions the thermal limits and Statutory Voltage Limits are not exceeded.	*Refer to general remarks 7*	P
	In recognising that the ELS may have a delayed response under abnormal conditions, up to 5 seconds response time is assumed to allow the ELS to bring the export equal to, or below the Agreed Export Capacity. Where frequent excursions of the Agreed Export Capacity take place under normal operating conditions, the DNO may request that the Active Power thresholds are lowered to reduce the number and the magnitude of the excursions.	*Complies with 5 second response time and Inverters Frequency Watt capability*	P
	The Connection Agreement may need to be amended in the event of an excursion to the Agreed Export Capacity.		Noted
	Breeches of the Agreed Export Capacity may result in the Connection Agreement being withdrawn or further monitoring and/or remote control being installed at the Customers' cost.		Noted
6	**Application and Acceptance**		**Noted**
	Customers shall provide information on the proposed ELS to enable DNOs to make an assessment on the risk to the network. A flowchart on the acceptability criteria is shown in Appendix C.		Noted
	The following information shall be provided with the ELS application:		Noted
	• Single Line Diagram of ELS		Noted
	• Explanation of ELS operation		Noted
	• Description of any fail-safe functionality (interruption of sensor signals, disconnection of load, loss of power, internal fault detection etc.)		Noted

ENA ER G100: 2016+Amd1 (2017)			
Clause	Requirements – Tests	Results - Remark	Verdict

7	**Witness Testing and Commissioning**		**P**
	The following section only applies to ELSs at installations with an aggregate Generating Unit capacity exceeding 16A (3.68kW) per phase.		Noted
7.1	**General**		**Noted**
	The Customer is responsible for demonstrating that the ELS complies with the requirements detailed in this document.		Noted
	Where the ELS is used at a site with a combined on-site generation capacity of 50kW or less, the DNO may, at its discretion, not require to witness the Fail Safe operation. For larger installations DNOs normally witness the tests on the ELS.		Noted
	Where the ELS commissioning tests are witnessed by the DNO it is expected that this will be carried out in the same visit as the generation commissioning tests are witnessed.		Noted
	In order to safely and effectively test an ELS, it is necessary to be able to simulate instances where the ELS is expected to operate.		Noted
	A means of ensuring the applied settings are tamper proof will need to be demonstrated. A copy of any additional settings associated with the ELS shall be displayed on site alongside any EREC G59 protection settings.		Noted
7.2	**Preventing the export limit being exceeded during setup/testing**		**P**
	Care shall be taken whilst testing and commissioning the ELS so that the Agreed Export Capacity or the Agreed Import Capacity is not breeched so as to not put the distribution network at risk. This may involve setting the export limit to a lower threshold for demonstration purposes.		P
	A combination of the following measures should be considered to ensure that Agreed Export Capacity or the Agreed Import Capacity is not exceeded during setup/testing:		P
	• Temporarily programming the export limit value to zero, or setting it to 50% (or less) than the true export limit	*Zero export profile can be loaded for testing*	P
	• Restricting the maximum output of the generation (e.g. on a PV system with multiple inverters, turning off a number of the inverters)		P
	• Operating a temporary load or load bank		P
	If ELS settings need to be changed in order to demonstrate operation, then they must be restored and confirmed once testing is complete.	*Profile needs to be updated to agreed limits after testing*	Noted

ENA ER G100: 2016+Amd1 (2017)			
Clause	Requirements – Tests	Results - Remark	Verdict

7.3	**Commissioning Sequence**		**Noted**
	ELS commissioning should only be undertaken after the generation commissioning has been successfully completed.		Noted
	In order to ensure system safety, the following commissioning sequence shall be followed. This should be performed in the sequence indicated and the process should only proceed to the next stage once the preceding stage has been successfully undertaken:		Noted
	The Customer shall provide all relevant scheme drawings and information to enable safe, informed commissioning of the ELS.		Noted
7.4	**Fail-safe tests**		**P**
	"Fail safe tests are not required at installations where all of the Generating Units are Type Tested SSEGs, with a Power Station Capacity of not more than 7.36kW per phase (i.e. 32A per phase at 230V) and an Export Capacity of not more than 3.68kW per phase (i.e. 16A per phase at 230V)."		P
	The purpose of the Fail-Safe tests is to ensure that should any part of the ELS fail, the Active Power exported across the Connection Point will drop to the Agreed Export Capacity or less within the specified time.		P
	There are three potential options to reducing the Active Power.		P
	1. The Generation Units switches off completely	*Reduces power to 0 W*	P
	2. A section of the Generating Units may remain operating as long as the aggregate capacity of the Generating Units remaining operational is equal or less than the Agreed Export Capacity.		P
	3. All Generating Units may operate at a restricted output as long as the aggregate export from the Generating Units remaining operational is equal or less than the Agreed Export Capacity.		P
	The Fail-Safe test process comprises a sequence of tests on each individual piece of equipment forming the ELS. Each piece of equipment needs to have, where relevant, its communication and its power supply cables removed as separate tests.		P
	At no time during the Fail-Safe test sequence should the Active Power rise above the programmed export limit for a duration longer than the specified reaction time.		P

ENA ER G100: 2016+Amd1 (2017)			
Clause	Requirements – Tests	Results - Remark	Verdict
	NOTE: Some power supplies may take a short while to power down (due to power stored in capacitors). This will cause a slight delay in the response time of the system. In such cases the reaction time is measured from the point at which the unit powers down, not the point at which the power supply is disconnected.		Noted
7.5	**Test Sequence**		**Noted**
	The following table describes a typical test sequence. Not all systems will have all of the components listed and others may have additional components that need to be included in the list. An example can be found at Appendix B. The system shall be restored after each test below.	*Removed power to Envoy*	Noted
7.6	**Functional tests**		**P**
	In order to safely and effectively test an ELS, it is necessary to be able to simulate instances where the ELS is expected to operate. Two different means may be employed to simulate system operation.		Noted
	1. Manual control over the loads operating on the site; or		P
	2. Injection testing using a calibrated test set		Noted
	The method adopted will depend on the nature of the site. On larger sites with multiple distributed loads (e.g. an office, factory or school), injection testing will be the only practical option.		Noted
	Particular attention should be paid to the correct orientation of the PMU current monitoring connections (including CT orientation) during testing.		Noted
7.6.1	**Functional testing – manual load control**		**P**
	Three site factors can be adjusted and a generic test method could be:		P
	1. The export limit is adjusted (set to zero or a percentage of the final figure)		P
	2. The site loads are manually increased / decreased		P
	3. The output from the Generation Units is manually increased / decreased		P
	Pass-Fail criteria: During the test sequence the power exported from the site does not rise above the programmed export capacity for a duration longer than the specified reaction time.		P
7.6.2	**Functional testing – Injection testing**		**N/A**

ENA ER G100: 2016+Amd1 (2017)			
Clause	Requirements – Tests	Results - Remark	Verdict
	Export limit conditions can be simulated by temporarily connecting the PMU to a calibrated injection test set.		N/A
	When using an injection test set, there is no feedback loop between the ELS and the injection test set. This has two significant implications for the test process:		N/A
	1. As soon as the ELS begins to operate, because it sees no corresponding decrease in export levels, the control loop will keep running until the Generation Units output is reduced to the programmed export capacity or below.		N/A
	2. To ensure that the ELS is reacting by the correct amount and within an acceptable time period, a step change needs be applied by the test set to the PMU.		N/A
	The following test sequence should be performed: (Table 2)		N/A
	The procedure for performing the test is as follows:		N/A
	• Initially apply 100% of nominal voltage and inject current (at unity power factor) to mimic an exported Active Power equivalent to of 95% of the export limit setting. Check that the ELS does not operate.		N/A
	• Step up the current to give an export Active Power equivalent to 105% of the export Active Power limit (for Test A), Check that change in export level is “seen” by the PMU.		N/A
	• Check that the Active Power exported by the generation reduces to a value at least 5% below the export limit setting within the specified reaction time. The test shall be repeated at the maximum statutory voltage (i.e. at 110% of nominal voltage at LV connections or at 106% at HV connections) and also at the minimum statutory voltage limit (i.e. 94% of nominal voltage for both LV and HV connections).		N/A
	• All the above tests shall also be repeated for step increases from 95% to 110% of the export limit and from 95% to 120% of the export limit as detailed in Table 2.		N/A
	When injection testing is complete, the correct orientation of any current monitoring connections (including CT orientations) which may have removed for the test must be checked and verified as correct.		N/A

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Clause	Requirements – Tests	Results - Remark	Verdict
	If settings need to be changed in order to demonstrate operation, then they must be restored and confirmed once testing is complete.		N/A
Appendix A	**Information Request**		**Noted**
Appendix B	**Export Limitation Scheme Installation and Commissioning Tests**		**Noted**
Appendix C	**Export Limitation Scheme Diagram**		**Noted**
Appendix D	**Export Limitation Scheme Application Flow Chart**		**Noted**
Appendix E	**Power Station Capacity Examples**		**Noted**
Appendix F	**AC Power and Direction of Power Flow**		**Noted**

ENA ER G100: 2016+Amd1 (2017)
APPENDIX A: Table of Results

TABLE OF RESULTS

7.4	Fail-safe tests	P

The only requirement for fail-safe is if the Envoy (PMU) losses power:

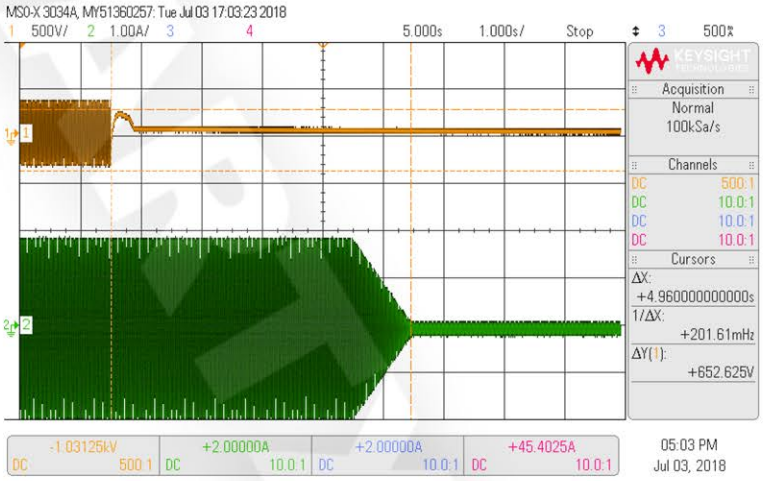

Figure 5: Fail-safe test on single phase system

Single phase system stops producing power within 5 seconds of Envoy losing power.
Measured value = 4.96 seconds

Fail-safe verified on 1.8kW system:

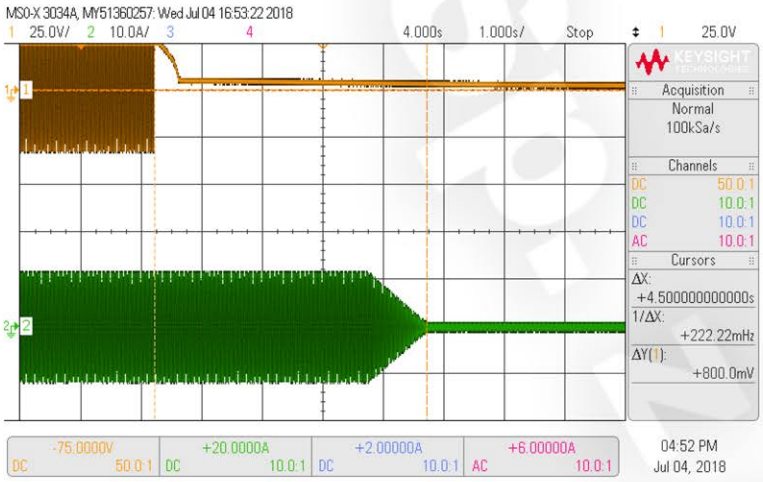

Figure 6:Fail-safe test on 1.8kW single phase system

Single phase system stops producing power within 5 seconds of Envoy losing power.
Measured value = 4.5 seconds

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APPENDIX A: Table of Results

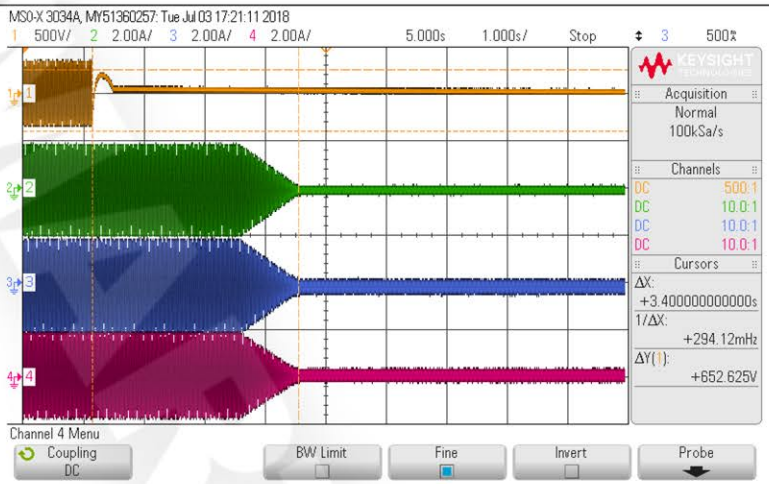

Figure 7: Fail safe on three phase system

Three phase system stops producing power within 5 seconds of Envoy losing power.
Measured value = 3.4 seconds

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APPENDIX A: Table of Results

7.6	**Functional tests**	P

Functional testing – manual load control used:

1) Export limit was set to 114 W
2) Resistive load was set to 300 W to allow full production of inverter.
3) Resistive load was changed to 25 W and reaction time was measured:
4) Power reduced to 100 W export

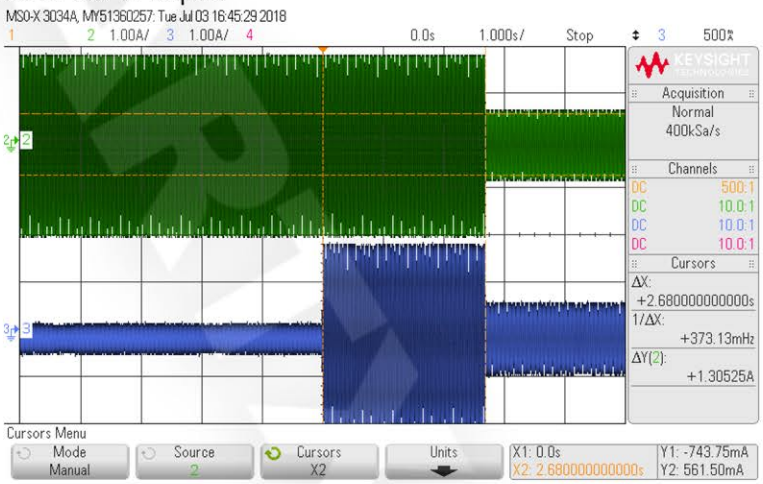

Figure 8: Functional test on single phase system

Green waveform is inverter current
Blue waveform is grid current
Measured value = 2.68 seconds

Export limiting tested on a 1.8kW system:

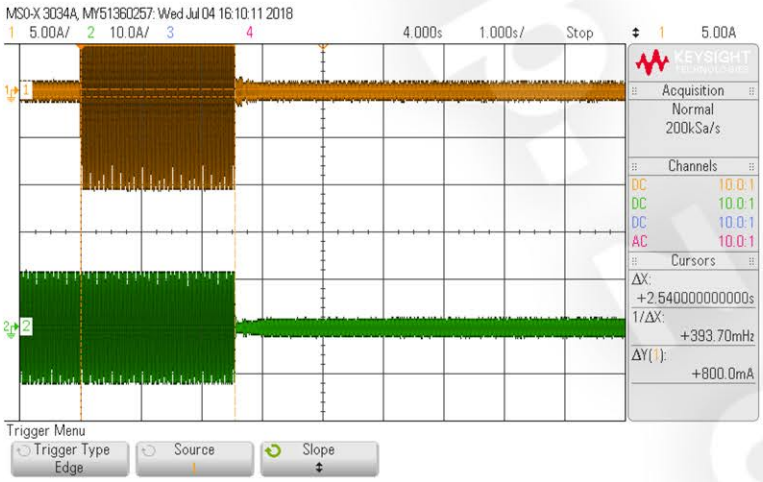

Figure 9: Functional test on 1.8kW single phase system

Green waveform is combined inverter current
Orange waveform is grid current
Measured value = 2.54 seconds

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APPENDIX A: Table of Results

1) Export limit was set to 114 W
2) Resistive load was set to 300 W on all three phases to allow full production of inverter.
3) Resistive load was changed to 25 W on all three phases and reaction time was measured:

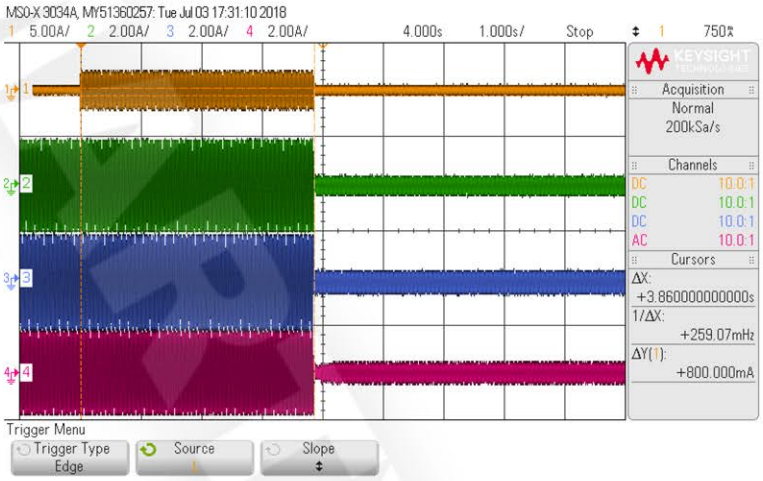

Figure 10: Functional test on three phase system adjusting all phases

Orange waveform is grid current.
Green waveform is Phase 1current.
Blue waveform is Phase 2 current.
Pink waveform is Phase 3 current.
Measured value = 3.86 seconds

1) Export limit was set to 114 W
2) Resistive load was set to 300 W on all three phases to allow full production of inverter.
3) Resistive load was changed to 25 W on phase 1 and reaction time was measured:

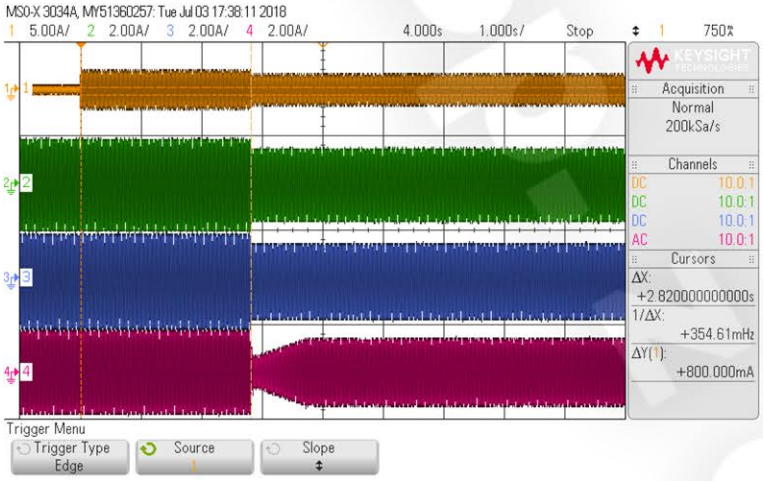

Figure 11: Functional test on three phase system adjusting phase 1

Orange waveform is Phase 1 grid current.
Green waveform is Phase 1current.
Blue waveform is Phase 2 current.
Pink waveform is Phase 3 current.
Measured value = 2.82 seconds

1) Export limit was set to 114 W
2) Resistive load was set to 300 W on all three phases to allow full production of inverter.
3) Resistive load was changed to 25 W on phase 2 and reaction time was measured:

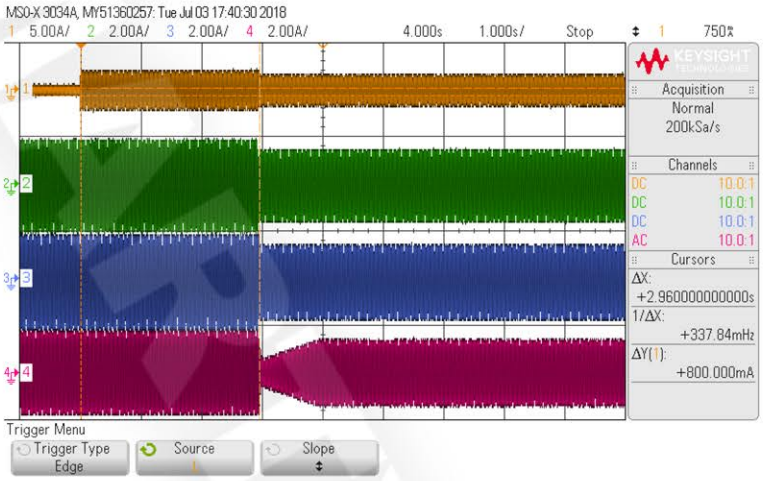

Figure 12: Functional test on three phase system adjusting phase 2

Orange waveform is Phase 2 grid current.
Green waveform is Phase 1current.
Blue waveform is Phase 2 current.
Pink waveform is Phase 3 current.
Measured value = 2.96 seconds

1) Export limit was set to 114 W
2) Resistive load was set to 300 W on all three phases to allow full production of inverter.
3) Resistive load was changed to 25 W on phase 3 and reaction time was measured:

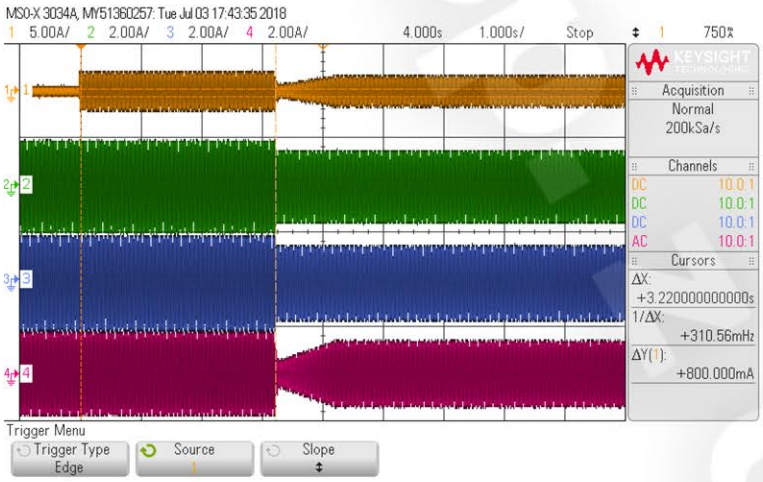

Figure 13: Functional test on three phase system adjusting phase 3

Orange waveform is Phase 3 grid current.
Green waveform is Phase 1 current.
Blue waveform is Phase 2 current.
Pink waveform is Phase 3 current.
Measured value = 3.22 seconds

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APPENDIX A: Table of Results

1) Export limit was set to 114 W
2) Resistive load was set to 25 W on all three phases to show reduced production of inverter.
3) Resistive load was changed to 300 W on all three phases and ramp up reaction time was measured:

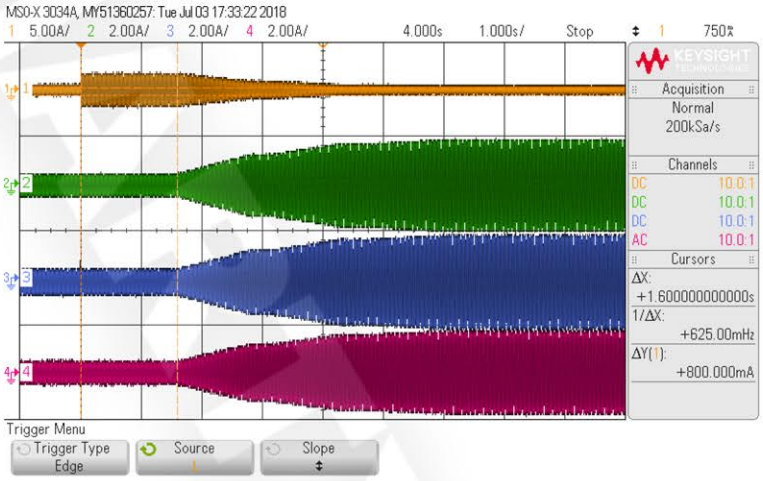

Figure 14: Return to full power after all loads are reengaged

Orange waveform is grid current.
Green waveform is Phase 1current.
Blue waveform is Phase 2 current.
Pink waveform is Phase 3 current.
Measured value = 1.6 seconds before power ramps up.

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Appendix B: Photographic Record of Sample

Photographic Record of Sample

IQ7PLUS Photos:

Figure 15: IQ7PLUS general view

Figure 16: IQ7PLUS bottom

ENA ER G100: 2016+Amd1 (2017)
Appendix B: Photographic Record of Sample

Figure 17: IQ7PLUS top

Figure 18: IQ7PLUS connector side

ENA ER G100: 2016+Amd1 (2017)
Appendix B: Photographic Record of Sample

Figure 19: IQ7PLUS right side

Figure 20: IQ7PLUS label side

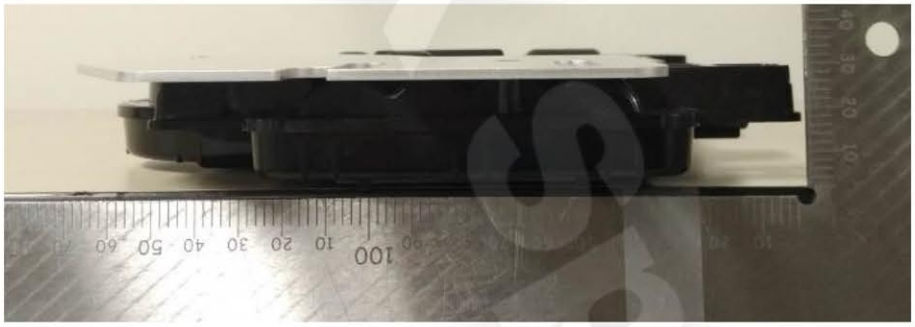

Figure 21: IQ7PLUS mounting plate side

ENA ER G100: 2016+Amd1 (2017)
Appendix B: Photographic Record of Sample

IQ7 Photos:

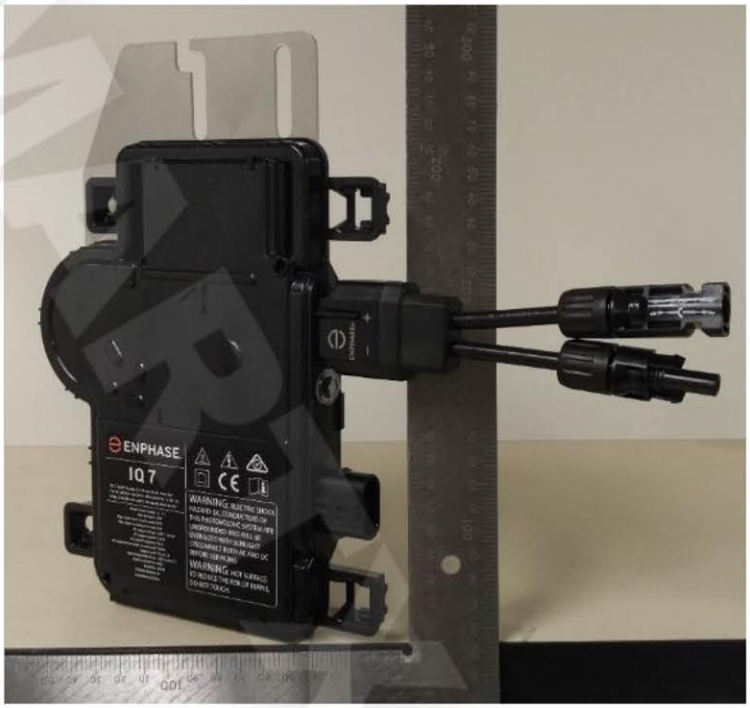

Figure 22: IQ7 general view

Figure 23: IQ7 bottom

ENA ER G100: 2016+Amd1 (2017)
Appendix B: Photographic Record of Sample

Figure 24: IQ7 top

Figure 25: IQ7 cable side

ENA ER G100: 2016+Amd1 (2017)
Appendix B: Photographic Record of Sample

Figure 26: IQ7 right side

Figure 27: IQ7 label side

Figure 28: IQ7 mounting plate side

ENA ER G100: 2016+Amd1 (2017)

Appendix C: Equipment Calibration

List of measurement units used for investigation

Type	Model No	Calibration date	Expiration date	Fixtures-No.
20 CH MULTIPLEXER CARD (with SAF-DAT-01)	34901A	9/03/2018	9/03/2019	SAF-MUX-02
20 CH MULTIPLEXER CARD (with SAF-DAT-01)	34901A	9/03/2018	9/03/2019	SAF-MUX-01
20 CH MULTIPLEXER CARD (with SAF-DAT-02)	34901A	12/03/2018	12/03/2019	SAF-MUX-04
20 CH MULTIPLEXER CARD (with SAF-DAT-02)	34901A	12/03/2018	12/03/2019	SAF-MUX-03
AC POWER SOURCE	MX30	NCR	NCR	SAF-PSU-02
AC POWER SOURCE	MX30	NCR	NCR	SAF-PSU-03
AC Source	320AMXT-UPC32E	NCR	NCR	SAF-PSU-01
Current Probe	TCP303	20/03/2017	19/03/2020	SAF-TCP-01
Current Probe	TCP303	17/03/2017	16/03/2020	SAF-TCP-02
Current Probe	TCP202A	5/03/2018	4/03/2021	SAF-TCP-03
Current Probe	N2783B	8/08/2017	7/08/2020	SAF-TCP-05
Current Probe	1147A	8/08/2017	7/08/2020	SAF-TCP-07
Current Probe	1147A	9/08/2017	8/08/2020	SAF-TCP-08
Current Probe	N2783B	NCR	NCR	SAF-TCP-04
Current Probe	1147A	NCR	NCR	SAF-TCP-06
Current Probe Power Supply	N2779A	NCR	NCR	SAF-CPA-03
Current Probe Power Supply	N2779A	NCR	NCR	SAF-CPA-04
DATA AQUISITION / SWITCH UNIT	34970A	6/03/2018	6/03/2019	SAF-DAT-01
DATA AQUISITION / SWITCH UNIT	34970A	12/03/2018	12/03/2019	SAF-DAT-02
DATA AQUISITION / SWITCH UNIT	34970A	NCR	NCR	SAF-DAT-03
Demand Response Enabling Device (AS/NZS 4777.2-2015 Appendix I)		NCR	NCR	SAF-DRD-01
Digital Micrometer	MDC-25SX	23/05/2017	23/05/2022	SAF-MIC-01
Digital Multimeter	34461A	19/02/2018	19/02/2019	SAF-DMM-01
Digital Multimeter	34461A	6/03/2018	6/03/2019	SAF-DMM-02
Handheld Digital Multimeter with current clamp	U1242C	For indication only	For indication only	SAF-DMM-03
Hi Pot Tester	08256	26/02/2018	26/02/2019	SAF-HPT-01
Modular SAS Mainframe	E4360A	NCR	NCR	SAF-SAS-01
Modular SAS Mainframe	E4360A	NCR	NCR	SAF-SAS-04
Modular SAS Mainframe	E4360A	NCR	NCR	SAF-SAS-07
Modular SAS Mainframe	E4360A	NCR	NCR	SAF-SAS-10
Modular SAS Mainframe	E4360A	NCR	NCR	SAF-SAS-13
Oscilloscope	TDS3034C	5/03/2018	5/03/2019	SAF-OSC-01
Oscilloscope	TDS3034C	5/03/2018	5/03/2019	SAF-OSC-02
Oscilloscope	DSO-X 3034A	11/05/2018	11/05/2019	SAF-OSC-03
Oscilloscope	MSO-X 3034A	8/08/2017	8/08/2018	SAF-OSC-04
Power Quality Analyzer	WT3004E	19/01/2018	19/01/2019	SAF-PQA-01
Power Quality Analyzer	WT1806	10/05/2018	10/05/2019	SAF-PQA-02
Power Quality Analyzer	WT1800	1/06/2018	1/06/2019	SAF-PQA-03
Power Quality Analyzer	WT3000	15/06/2018	15/06/2019	SAF-PQA-04
RLC Load for Anti-Islanding	ACLT-3802H	18/06/2018	18/06/2019	SAF-RLC-01
Solar Array Simulator (in SAF-SAS-01)	E4361A	NCR	NCR	SAF-SAS-02
Solar Array Simulator (in SAF-SAS-01)	E4361A	NCR	NCR	SAF-SAS-03
Solar Array Simulator (in SAF-SAS-04)	E4361A	NCR	NCR	SAF-SAS-05
Solar Array Simulator (in SAF-SAS-04)	E4361A	NCR	NCR	SAF-SAS-06
Solar Array Simulator (in SAF-SAS-07)	E4361A	NCR	NCR	SAF-SAS-08
Solar Array Simulator (in SAF-SAS-07)	E4361A	NCR	NCR	SAF-SAS-09
Solar Array Simulator (in SAF-SAS-10)	E4361A	8/03/2018	8/03/2019	SAF-SAS-11
Solar Array Simulator (in SAF-SAS-10)	E4361A	8/03/2018	8/03/2019	SAF-SAS-12
Solar Array Simulator (in SAF-SAS-13)	E4361A	NCR	NCR	SAF-SAS-14
Solar Array Simulator (in SAF-SAS-13)	E4361A	NCR	NCR	SAF-SAS-15
Reference Impedance network	IEC61000-3	NCR	NCR	SAF-RIN-01

End of report