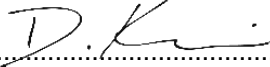


ENA G83-2-1

Recommendations for the connection of type tested small-scale embedded generators (up to 16A per phase) in parallel with low-voltage distribution systems

Report reference No.: P2018062802

Tested by
 (printed name and signature): Daniel Keis



Approved by
 (printed name and signature): Manuel Shimasaki



Date of issue: 28 June 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: NZ

Other (please explain)

Applicant's Name: Enphase Energy

Address: 1420 North McDowell Boulevard, Petaluma, CA 94954, USA.

Test specification

Standard: ENA G83-2-1

Test procedure: EnTEST Laboratories

Non-standard test method


Test Report Form No.: ENA G83-2-1

TRF originator: EnTEST Laboratories

Master TRF: June 2018

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Test item description: Solar Micro Inverter

Trademark:  **ENPHASE.**

Manufacturer: Enphase Energy

Model and/or type reference: IQ7-60- X-Y-Z

Rating(s): See rating table

Copy of marking plate

Model: IQ7-60-X-INT

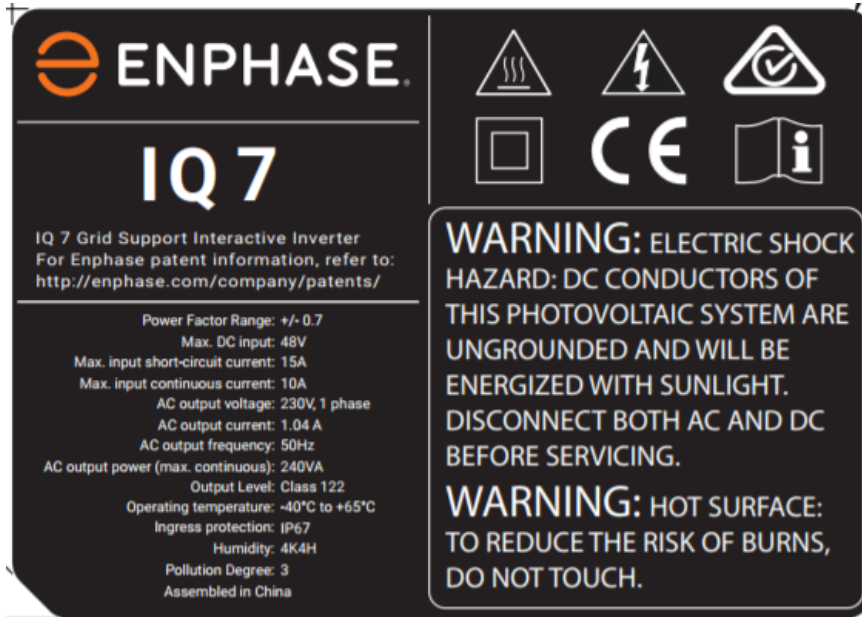


Figure 1: IQ7 marking plate

Model: IQ7-ACM-INT

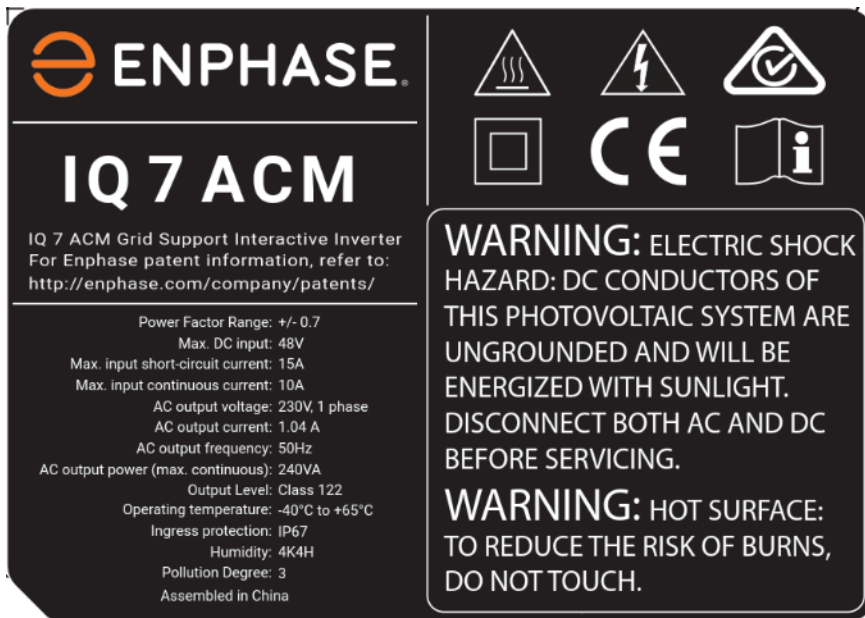


Figure 2: IQ7 ACM marking plate

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) current¹	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 mΩ 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.

SUMMARY OF COMPLIANCE WITH ENA G83-2-1

All tests passed the requirements of the ENA G83-2-1 within the required limits and within the equipment uncertainties.

The Photovoltaic Micro-inverters, model numbers IQ7-60-X-Y-Z **COMPLIED** with the applicable clauses of ENA G83-2-1

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..... : April 2018
Date (s) of completion of tests..... : April – June 2018

General remarks:

1. The test results presented in this report relate only to the objects 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.

General product information:

The EUT (Equipment Under Test), known as Photovoltaic Micro-inverters, model number IQ7 was supplied for testing to ENA G83-2-1 by Enphase Energy Inc of 1420 North McDowell Boulevard, Petaluma, CA 94954, USA.

Model rating table:

Specification	Units	IQ7
Rated output active power	W	240
Output apparent power	VA	240
Nominal output voltage	V _{rms}	230
Output voltage range	V _{rms}	230 / 184 to 276
Nominal output frequency	Hz	50
Output frequency range	Hz	45-55
AC output current	A _{rms}	1.04
EN50530 efficiency	%	96.5
Full power MPPT input voltage range	V	27-37
Input operating range	V	16-48
Input current limit region	V	16-27
Input frequency	Hz	DC
Input maximum continuous current	A	10
DC LSC input maximum	A	15
Ingress protection		IP67
Environmental category		Outdoor
Wet locations		suitable
Pollution degree		PD3
Ambient temperature		-40C to +65C
Relative humidity		4K4H
Maximum altitude		Not rated
Overvoltage category		OVC III

IQ7-60-X-Y-Z 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)

Firmware version:

520-00082-r01-v02.12.02

ENA G83-2-1
APPENDIX A: Table of Results

Appendix 4 Type Verification Test Report

Type Approval and manufacturer/supplier declaration of compliance with the requirements of Engineering Recommendation G83/2-1.			
SSEG Type reference number		IQ7-60-2-INT, IQ7-60-5-INT IQ7-60-B-INT IQ7-60-ACM-INT	
SSEG Type		Microinverter	
System Supplier name		Enphase Energy Inc	
Address		1420, N. McDowell Blvd Petaluma, CA 94954, USA	
Tel	(877) 797-4743	Fax	
E:mail	dkeis@enphaseenergy.com	Web site	enphase.com
Maximum rated capacity, use separate sheet if more than one connection option.	Connection Option		
	≤ 3.68	kW single phase, single, split or three phase system	
	≤ 3.68 (x3)	kW three phase	
		kW two phases in three phase system	
	kW two phases split phase system		
SSEG manufacturer/supplier declaration. I certify on behalf of the company named above as a manufacturer/supplier of Small Scale Embedded Generators, that all products manufactured/supplied by the company with the above SSEG Type reference number will be manufactured and tested to ensure that they perform as stated in this Type Verification Test Report, prior to shipment to site and that no site modifications are required to ensure that the product meets all the requirements of G83/2-1.			
Signed		On behalf of	
<p>Note that testing can be done by the manufacturer of an individual component, by an external test house, or by the supplier of the complete system, or any combination of them as appropriate. Where parts of the testing are carried out by persons or organisations other than the supplier then the supplier shall keep copies of all test records and results supplied to them to verify that the testing has been carried out by people with sufficient technical competency to carry out the tests.</p>			

ENA G83-2-1
APPENDIX A: Table of Results

Power Quality. Harmonics. The requirement is specified in section 5.4.1, test procedure in Annex A or B 1.4.1

SSEG rating per phase (rpp)				2.199	kW		NV=MV*3.68/rpp	
Harmonic	50%	of rated output		100%	of rated output		Limit in BS EN 61000-3-2 in Amps	Higher limit for odd harmonics 21 and above
	Measured Value (MV) in Amps	Normalised Value (NV) in Amps	P or F	Measured Value (MV) in Amps	Normalised Value (NV) in Amps	P or F		
2	0.0094	0.0157	P	0.0198	0.0331	P	1.08	
3	0.0178	0.0298	P	0.0265	0.0443	P	2.3	
4	0.0006	0.0010	P	0.0005	0.0008	P	0.43	
5	0.1425	0.2385	P	0.2999	0.5019	P	1.14	
6	0.0005	0.0008	P	0.0006	0.0010	P	0.3	
7	0.0146	0.0244	P	0.0035	0.0059	P	0.77	
8	0.0005	0.0008	P	0.0007	0.0012	P	0.23	
9	0.0128	0.0214	P	0.0047	0.0079	P	0.4	
10	0.0005	0.0008	P	0.0006	0.0010	P	0.184	
11	0.0124	0.0208	P	0.0107	0.0179	P	0.33	
12	0.0005	0.0008	P	0.0008	0.0013	P	0.153	
13	0.0089	0.0149	P	0.0096	0.0161	P	0.21	
14	0.0007	0.0012	P	0.0005	0.0008	P	0.131	
15	0.0081	0.0136	P	0.0108	0.0181	P	0.15	
16	0.0004	0.0007	P	0.0007	0.0012	P	0.115	
17	0.0083	0.0139	P	0.0116	0.0194	P	0.132	
18	0.0005	0.0008	P	0.0004	0.0007	P	0.102	
19	0.0089	0.0149	P	0.0087	0.0146	P	0.118	
20	0.0009	0.0015	P	0.0009	0.0015	P	0.092	
21	0.0093	0.0156	P	0.0106	0.0177	P	0.107	0.16
22	0.0005	0.0008	P	0.0004	0.0007	P	0.084	
23	0.0044	0.0074	P	0.0085	0.0142	P	0.098	0.147
24	0.0006	0.0010	P	0.0005	0.0008	P	0.077	
25	0.0036	0.0060	P	0.0091	0.0152	P	0.09	0.135
26	0.0004	0.0007	P	0.0005	0.0008	P	0.071	
27	0.0054	0.0090	P	0.0092	0.0154	P	0.083	0.124
28	0.0006	0.0010	P	0.0008	0.0013	P	0.066	
29	0.0032	0.0054	P	0.0066	0.0110	P	0.078	0.117
30	0.0006	0.0010	P	0.0009	0.0015	P	0.061	
31	0.0070	0.0117	P	0.0076	0.0127	P	0.073	0.109
32	0.0006	0.0010	P	0.0008	0.0013	P	0.058	
33	0.0043	0.0072	P	0.0048	0.0080	P	0.068	0.102
34	0.0006	0.0010	P	0.0011	0.0018	P	0.054	
35	0.0039	0.0065	P	0.0024	0.0040	P	0.064	0.096
36	0.0004	0.0007	P	0.0008	0.0013	P	0.051	
37	0.0058	0.0097	P	0.0030	0.0050	P	0.061	0.091
38	0.0006	0.0010	P	0.0011	0.0018	P	0.048	
39	0.0022	0.0037	P	0.0015	0.0025	P	0.058	0.087
40	0.0018	0.0030	P	0.0022	0.0037	P	0.046	

Note the higher limits for odd harmonics 21 and above are only allowable under certain conditions, if these higher limits are utilised please state the exemption used as detailed in part 6.2.3.4 of BS EN 61000-3-2 in the box below.

ENA G83-2-1
APPENDIX A: Table of Results

Power Quality. Voltage fluctuations and Flicker. The requirement is specified in section 5.4.2, test procedure in Annex A or B 1.4.3								
Traceable results only	Starting			Stopping			Running	
	d_{max}	d_c	$d(t)$	d_{max}	d_c	$d(t)$	P_{st}	P_{it} 2 hours
Measured Values	0	0	0	0	0	0	0.08	0.07
Normalised to standard impedance and 3.68kW for multiple units	0	0	0	0	0	0	0.048	0.041
Limits set under BSEN 61000-3-2	4%	3.3%	3.3% 500ms	4%	3.3%	3.3% 500ms	1.0	0.65
Test start date		16-May-2018		Test end date		16-May-2018		
Test location		1 Treffers Rd, Wigram, Christchurch, NZ						

Power quality. DC injection. The requirement is specified in section 5.5, test procedure in Annex A or B 1.4.4			
Test power level	10%	55%	100%
Recorded value	0.0004	0.0002	0.0016
as % of rated AC current	0.005%	0.002%	0.018%
Limit	0.25%	0.25%	0.25%

Power Quality. Power factor. The requirement is specified in section 5.6, test procedure in Annex A or B 1.4.2				
	216.2V	230V	253V	Measured at three voltage levels and at full output. Voltage to be maintained within $\pm 1.5\%$ of the stated level during the test.
Measured value	1.00	1.00	1.00	
Limit	>0.95	>0.95	>0.95	

ENA G83-2-1
APPENDIX A: Table of Results

Protection. Frequency tests The requirement is specified in section 5.3.1, test procedure in Annex A or B 1.3.3						
Function	Setting		Trip test		"No trip tests"	
	Frequency	Time delay	Frequency	Time delay	Frequency /time	Confirm no trip
U/F stage 1	47.5Hz	20s	47.52 Hz	20.27 s	47.7Hz 25s	Confirmed
U/F stage 2	47Hz	0.5s	47.02 Hz	0.57 s	47.2Hz 19.98s	Confirmed
					46.8Hz 0.48s	Confirmed
O/F stage 1	51.5Hz	90s	51.48 Hz	91.25 s	51.3Hz 95s	Confirmed
O/F stage 2	52Hz	0.5s	51.98 Hz	0.57 s	51.8Hz 89.98s	Confirmed
					52.2Hz 0.48s	Confirmed

Protection. Voltage tests The requirement is specified in section 5.3.1, test procedure in Annex A or B 1.3.2						
Function	Setting		Trip test		"No trip tests"	
	Voltage	Time delay	Voltage	Time delay	Voltage /time	Confirm no trip
U/V stage 1	200.1V	2.5s	200.7 V	2.56 s	204.1V 3.5s	Confirmed
U/V stage 2	184V	0.5s	183.8 V	0.56 s	188V 2.48s	Confirmed
					180V 0.48s	Confirmed
O/V stage 1	262.2V	1.0s	262.6 V	1.06 s	258.2V 2.0s	Confirmed
O/V stage 2	273.7V	0.5s	273.8 V	0.56 s	269.7V 0.98s	Confirmed
					277.7V 0.48s	Confirmed

Note for Voltage tests the Voltage required to trip is the setting $\pm 3.45V$. The time delay can be measured at a larger deviation than the minimum required to operate the protection. The No trip tests need to be carried out at the setting $\pm 4V$ and for the relevant times as shown in the table above to ensure that the protection will not trip in error.

ENA G83-2-1
APPENDIX A: Table of Results

Protection. Loss of Mains test. The requirement is specified in section 5.3.2, test procedure in Annex A or B 1.3.4						
To be carried out at three output power levels with a tolerance of plus or minus 5% in Test Power levels.						
Test Power	10%	55%	100%	10%	55%	100%
Balancing load on islanded network	95% of SSEG output	95% of SSEG output	95% of SSEG output	105% of SSEG output	105% of SSEG output	105% of SSEG output
Trip time. Limit is 0.5 seconds	3.6 ms	3.2 ms	6.0 ms	3.6 ms	3.6 ms	6.0 ms
For Multi phase SSEGs confirm that the device shuts down correctly after the removal of a single fuse as well as operation of all phases.						
Test Power	10%	55%	100%	10%	55%	100%
Balancing load on islanded network	95% of SSEG output	95% of SSEG output	95% of SSEG output	105% of SSEG output	105% of SSEG output	105% of SSEG output
Trip time. Ph1 fuse removed	302 ms	444 ms	316 ms	384 ms	328 ms	282 ms
Test Power	10%	55%	100%	10%	55%	100%
Balancing load on islanded network	95% of SSEG output	95% of SSEG output	95% of SSEG output	105% of SSEG output	105% of SSEG output	105% of SSEG output
Trip time. Ph2 fuse removed	364 ms	410 ms	436 ms	454 ms	302 ms	410 ms
Test Power	10%	55%	100%	10%	55%	100%
Balancing load on islanded network	95% of SSEG output	95% of SSEG output	95% of SSEG output	105% of SSEG output	105% of SSEG output	105% of SSEG output
Trip time. Ph3 fuse removed	294 ms	304 ms	400 ms	300 ms	462 ms	322 ms
Note for technologies which have a substantial shut down time this can be added to the 0.5 seconds in establishing that the trip occurred in less than 0.5s. Maximum shut down time could therefore be up to 1.0 seconds for these technologies.						
Indicate additional shut down time included in above results.					0 ms	
Note as an alternative, inverters can be tested to BS EN 62116. The following sub set of tests should be recorded in the following table.						
Test Power and imbalance	33% -5% Q Test 22	66% -5% Q Test 12	100% -5% P Test 5	33% +5% Q Test 31	66% +5% Q Test 21	100% +5% P Test 10
Trip time. Limit is 0.5s	94 ms	181 ms	170 ms	110 ms	96 ms	170 ms

ENA G83-2-1
APPENDIX A: Table of Results

Protection. Frequency change, Vector Shift Stability test The requirement is specified in section 5.3.3, test procedure in Annex A or B 1.3.6				
	Start Frequency	Change	End Frequency	Confirm no trip
Positive Vector Shift	49.5Hz	+50 degrees		Confirmed
Negative Vector Shift	50.5Hz	- 50 degrees		Confirmed

Protection. Frequency change, RoCoF Stability test The requirement is specified in section 5.3.3, test procedure in Annex A or B 1.3.6			
Ramp range	Test frequency ramp:	Test Duration	Confirm no trip
49.0Hz to 51.0Hz	+0.95Hzs ⁻¹	2.1s	Confirmed
51.0Hz to 49.0Hz	-0.95Hzs ⁻¹	2.1s	Confirmed

Protection. Re-connection timer. The requirement is specified in section 5.3.4, test procedure in Annex A or B 1.3.5						
Test should prove that the reconnection sequence starts after a minimum delay of 20 seconds for restoration of voltage and frequency to within the stage 1 settings of table 1.						
Time delay setting	Measured delay		Checks on no reconnection when voltage or frequency is brought to just outside stage 1 limits of table 1.			
20s	27s		At 266.2V	At 196.1V	At 47.4Hz	At 51.6Hz
Confirmation that the SSEG does not re-connect.			Confirmed	Confirmed	Confirmed	Confirmed

Fault level contribution. The requirement is specified in section 5.7, test procedure in Annex A or B 1.4.6						
For a directly coupled SSEG			For a Inverter SSEG			
Parameter	Symbol	Value	Time after fault	Volts	Amps	
Peak Short Circuit current	i_p	5.78	20ms	0	0	
Initial Value of aperiodic current	A	3.29	100ms	0	0	
Initial symmetrical short-circuit current*	I_k	2.48	250ms	0	0	
Decaying (aperiodic) component of short circuit current*	i_{DC}	0	500ms	0	0	
Reactance/Resistance Ratio of source*	X/R	2.5	Time to trip	0.01	In seconds	

ENA G83-2-1
APPENDIX A: Table of Results

Self-Monitoring solid state switching The requirement is specified in section 5.3.1, No specified test requirements.	Yes/or NA
It has been verified that in the event of the solid state switching device failing to disconnect the SSEG, the voltage on the output side of the switching device is reduced to a value below 50 volts within 0.5 seconds.	Yes

Additional comments

ENA G83-2-1
APPENDIX B: Photographic record of sample

IQ7 Photos:

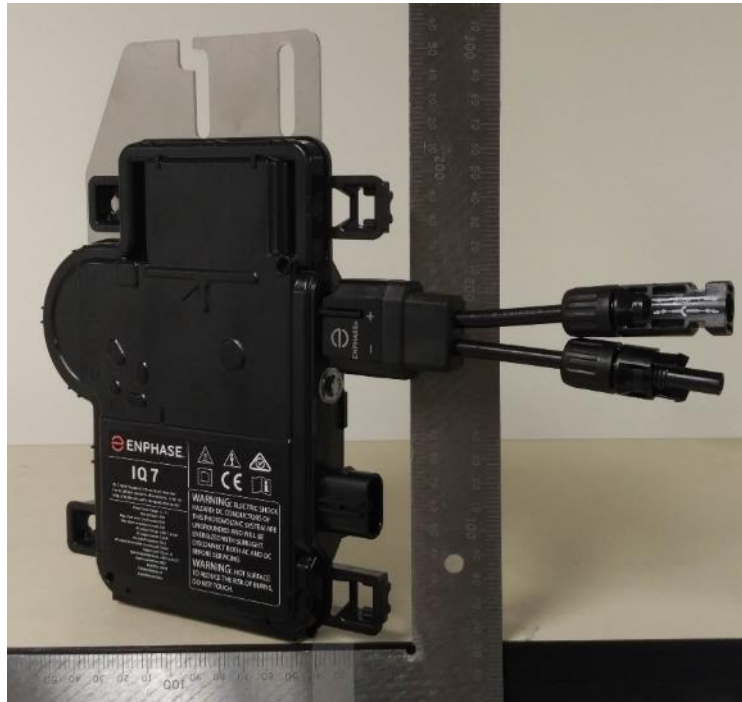


Figure 3: IQ7 general view



Figure 4: IQ7 Bottom

ENA G83-2-1
APPENDIX B: Photographic record of sample

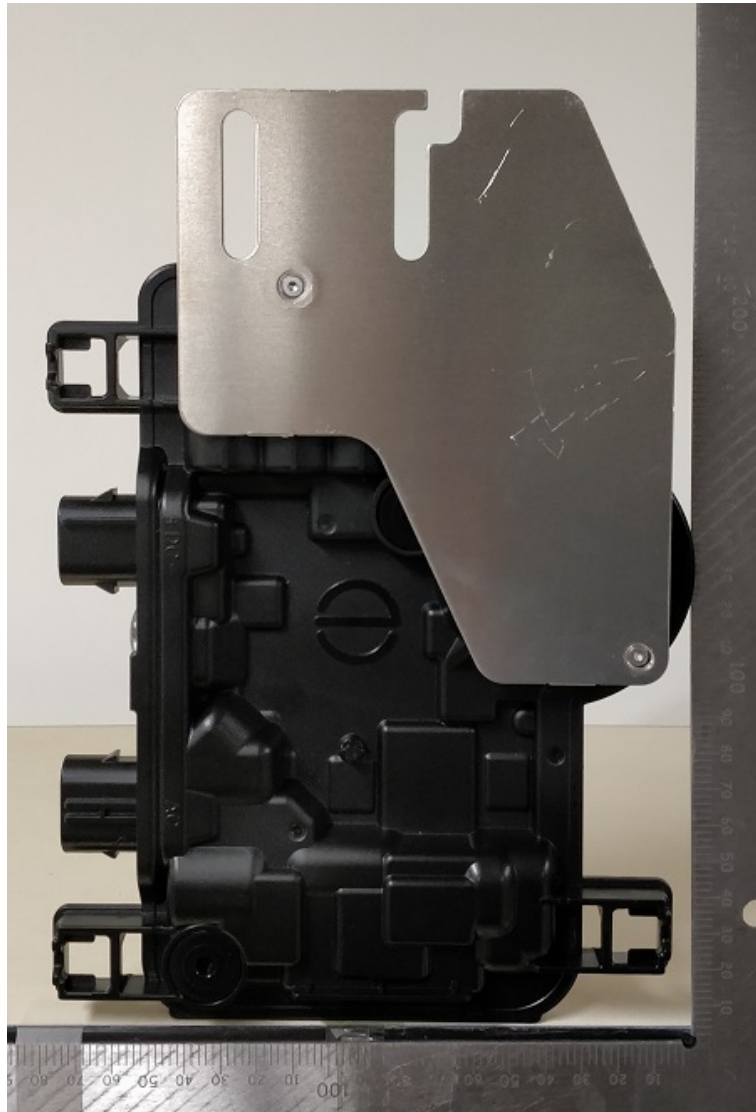


Figure 5: IQ7 Top



Figure 6: IQ7 Cable side

ENA G83-2-1
APPENDIX B: Photographic record of sample



Figure 7: IQ7 Right side



Figure 8: IQ7 Label side



Figure 9: IQ7 Mounting plate side

End of report