Test Report issued under the responsibility of:

TEST REPORT
IEC 62116
Test procedure of islanding prevention measures for utility-interconnected photovoltaic inverters

Report Number. .... :	GZES200601936102
Date of issue .... :	23/06/2020
Total number of pages	14
Name of Testing Laboratory preparing the Report..................:	SGS-CSTC Standards Technical Services Co., Ltd. Guangzhou Branch
Applicant's name.......................... :	Shenzhen SOFAR SOLAR Co., Ltd.
Address .... :	401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen City, Guangdong Province, P.R. China
Test specification:	
Standard....................................... :	IEC/EN 62116: 2014 (Second Edition)
Test procedure.............................. :	Characteristic Examination
Non-standard test method........... :	N/A
Test Report Form No..................... :	IEC62116B
Test Report Form(s) Originator.... :	TÜV SÜD Product Service GmbH
Master TRF .... :	Dated 2014-10

This report is not valid as a CB Test Report unless signed by an approved CB Testing Laboratory and appended to a CB Test Certificate issued by an NCB in accordance with IECEE 02.

General disclaimer:

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 CB Testing Laboratory. The authenticity of this Test Report and its contents can be verified by contacting the NCB, responsible for this Test Report.

Test item description........ :	Hybrid Inverter (Three Phase)
Trade Mark .... :	SOFAR SOLAR
Manufacturer .... :	Shenzhen SOFAR SOLAR Co., Ltd.
Address .... :	401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen City, Guangdong Province, P.R. China
Model/Type reference....... :	HYD 5KTL-3PH, HYD 6KTL-3PH, HYD 8KTL-3PH; HYD 10KTL-3PH, HYD 15KTL-3PH, HYD 20KTL-3PH;
Ratings .... :	See model list in Page 7 to Page 8. **Serial Number:** SP1ES020H71002 **Firmware version:** V2.00

Responsible Testing Laboratory (as applicable), testing procedure and testing location(s):			
☐	~~CB Testing Laboratory:~~		
~~Testing location/ address ....:~~			
☐	~~Associated CB Testing Laboratory:~~		
☑	Testing procedure: TMP/CTF Stage 1:	Shenzhen SOFAR SOLAR Co., Ltd.	
Testing location/ address ....:		401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen City, Guangdong Province, P.R. China	
Tested by (name, function, signature)........:		Hugo zhang (Project Engineer)	Hugo zhang
Approved by (name, function, signature.....:		Roger Hu (Project Engineer)	Roger Hu
☐	~~Testing procedure: WMT/CTF Stage 2:~~		
☐	~~Testing procedure: SMT/CTF Stage 3 or 4:~~		

List of Attachments (including a total number of pages in each attachment):

50 Hz		
Attachment #	Description	Pages
Attachment I	Pictures of the EUT and Electrical Schemes	10 pages
Attachment II	Graphics of the Test Results	3 pages
Attachment III	Graphics of the Islanding Behavior Detection	19 pages
Attachment IV	Testing Information	9 pages

Summary of testing:

Tests performed (name of test and test clause):

All clauses except:

- Sub-clause d) of the Table 5 of the point 6.1. Voltage and frequency trips shall be adjusted according to National Standards and/or local codes.

From the result of inspection and tests performed on the submitted sample we conclude that it complies with the requirements of the Standard

Testing location:

Shenzhen SOFAR SOLAR Co., Ltd.

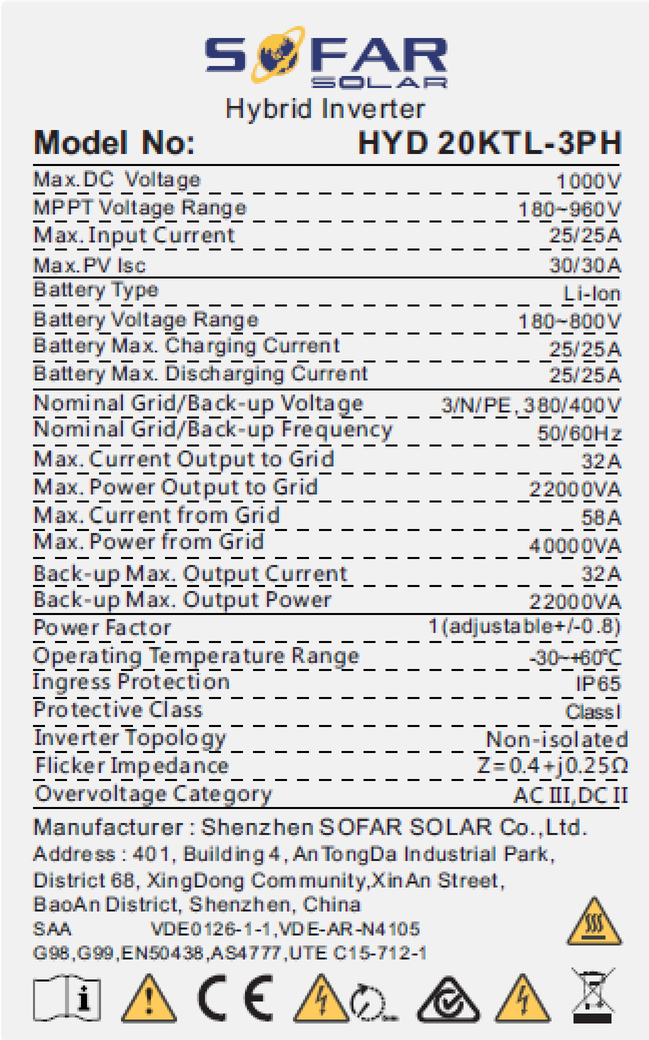
401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen City, Guangdong Province, P.R. China

(All clauses)

Summary of compliance with National Differences:

No National Differences are addressed to this test report

Copy of marking plate(representative):



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
3. Labels of other models are as the same with HYD 20KTL-3PH's except the parameters of rating.

Test item particulars ....:	Solar Grid-tied Inverter (Three Phase Inverter)
Classification of installation and use ....:	Fixed (permanent connection)
Supply Connection ....:	DC; PV
....:	AC; Grid connection
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 ....:	CTF Stage 1 procedure
Date of receipt of test item ....:	N/A
Date (s) of performance of tests ....:	From 29/05/2020 and 01/06/2020

General remarks:

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

Throughout this report a ☐ comma / ☑ point is used as the decimal separator.

Manufacturer's Declaration per sub-clause 4.2.5 of IECEE 02:

The application for obtaining a CB Test Certificate includes more than one factory location and a declaration from the Manufacturer stating that the sample(s) submitted for evaluation is (are) representative of the products from each factory has been provided ....:	☐ **Yes** ☑ **Not applicable**

When differences exist; they shall be identified in the General product information section.

Name and address of factory (ies) ....:	Dongguan SOFAR SOLAR Co.,Ltd. 1F - 6F, Building E, No. 1 JinQi Road, Bihu Industrial Park, Wulian Village, Fenggang Town, Dongguan City, Guangdong Province,P.R. China.

General product information:

Product covered by this report is grid-connected PV inverter for indoor or outdoor installation. The connection to the DC input and AC output are through connectors.

The Solar inverter converts DC voltage into AC voltage.
The input and output are protected by varistors to Earth. The unit is providing EMC filtering at the output toward mains. The unit does not provide galvanic separation from input to output (transformerless). The output is switched off redundant by the high power switching bridge and a two relays. This assures that the opening of the output circuit can operate in case of one error.

Equipment Under Testing:

- HYD 20KTL-3PH;

Variant models:

- HYD 5KTL-3PH;
- HYD 6KTL-3PH;
- HYD 8KTL-3PH;
- HYD 10KTL-3PH;
- HYD 15KTL-3PH;

Model	HYD 5KTL-3PH	HYD 6KTL-3PH	HYD 8KTL-3PH	HYD 10KTL-3PH	HYD 15KTL-3PH	HYD 20KTL-3PH
PV String Input Data						
Recommended-Max.PV power	7500Wp (6000Wp/6000 Wp)	9000Wp (6600Wp/6600 Wp)	12000Wp (6600Wp/6600 Wp)	15000Wp (7500Wp/7500 Wp)	22500Wp (11250Wp/11250 Wp)	30000Wp (15000Wp/15000 Wp)
Max. DC voltage	1000V					
Start-up operating voltage	200V					
MPPT voltage range	180V~960V					
Nominal DC voltage	600V					
Full power MPPT voltage range	250V~850V	320V~850V	360V~850V	220V~850V	350V~850V	450V~850V
Max. input current	12.5A/12.5A	12.5A/12.5A	12.5A/12.5A	25A/25A	25A/25A	25A/25A
Max. short current	15A/15A	15A/15A	15A/15A	30A/30A	30A/30A	30A/30A
Battery Input Data						
Battery voltage range	180V~800V					
Battery voltage range for full load	200V~800V	240V~800V	320V~800V	200V~800V	300V~800V	400V~800V
No. of battery input	1			2		
Nominal charging/dischar-ging power	5000W	6000W	8000W	10000W	15000W	20000W
Max. charging/dischar-ging current	25A	25A	25A	50A (25A/25A)	50A (25A/25A)	50A (25A/25A)

Peak charging/discharging current, Duration	40A, 60s	40A, 60s	40A, 60s	70A (35A/35A), 60s	70A (35A/35A), 60s	70A (35A/35A), 60s
AC Output Data (On-grid)						
Nominal AC power	5000W	6000W	8000W	10000W	15000W	20000W
Max. AC power output to utility grid	5500VA	6600VA	8800VA	11000VA	16500VA	22000VA
Max. AC power from utility grid	10000VA	12000VA	16000VA	20000VA	30000VA	40000VA
Max. AC current output to utility grid	8A	10A	13A	16A	24A	32A
Max. AC Current from utility grid	15A	17A	24A	29A	44A	58A
AC Output Data (Back-up)						
Nominal output power	5000W	6000W	8000W	10000W	15000W	20000W
Max. output power	5500VA	6600VA	8800VA	11000VA	16500VA	22000VA
Peak output power, Duration	10000VA, 60s	12000VA, 60s	16000VA, 60s	20000VA, 60s	22000VA, 60s	22000VA, 60s
Max. output current	8A	10A	13A	16A	24A	32A
Peak output current, Duration	15A, 60s	18A, 60s	24A, 60s	30A, 60s	32A, 60s	32A, 60s
Nominal output voltage	3/N/PE, 220/380Vac, 230/400Vac					
Nominal output freqency	50/60Hz					
Output power factor	~1(0.8 leading to 0.8 lagging)					
Operating temperature range	-30ºC ~60ºC					
Ingress protection	IP65					
Protective class	Class I					
Cooling method	heat sink	heat sink	heat sink	fan	fan	fan

The variants models have been included in this test report without tests because the following features don´t change regarding to the tested model:

- Same connection system and hardware topology
- Same control algorithm.
- Same Firmware Version

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Clause	Requirement + Test	Result - Remark	Verdict
4	**Testing circuit**		
	The testing circuit shown in Figure 1 is employed.		P
	Similar circuits are used for three-phase output.		P
	Parameters to be measured are shown in Table 1 and Figure 1. Parameters to be recorded in the test report are discussed in Clause 7.		P
5	**Testing equipment**		
5.1	**Measuring instruments**		**P**
	The waveform measurement/capture device is able to record the waveform from the beginning of the islanding test until the EUT ceases to energize the island.	Oscillograph and Power analyzer equipped with memory function Waveform caught from the switch open and the EUT cease to energize	P
	For multi-phase EUT, all phases are monitored.		P
	A waveform monitor designed to detect and calculate the run-on time may be used.	See Annex IV for testing equipment information	P
	For multi-phase EUT, the test and measurement equipment is recorded each phase current and each phase-to-neutral or phase-to-phase voltage, as appropriate, to determine fundamental frequency active and reactive power flow over the duration of the test.		P
	A sampling rate of 10 kHz or higher is recommended. The minimum measurement accuracy is 1 % or less of rated EUT nominal output voltage and 1 % or less of rated EUT output current	Less than 1% of the rated EUT output current	P
	Current, active power, and reactive power measurements through switch S1 used to determine the circuit balance conditions report the fundamental (50 Hz or 60 Hz) component.		P
5.2	**DC power source**		
5.2.1	**General**		**P**
	A PV array or PV array simulator (preferred) may be used. If the EUT can operate in utility-interconnected mode from a storage battery, a DC power source may be used in lieu of a battery as long as the DC power source is not the limiting device as far as the maximum EUT input current is concerned.	Chroma PV simulator used	P
	The DC power source provides voltage and current necessary to meet the testing requirements described in Clause 6.		P
5.2.2	**PV array simulator**		P
	The tests are conducted at the input voltage defined in Table 2 below, and the current is limited to 1,5 times the rated photovoltaic input current, except when specified otherwise by the test requirements.		P
	A PV array simulator is recommended, however, any type of power source may be used if it does not influence the test results.		P

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Clause	Requirement + Test	Result - Remark	Verdict
5.2.3	**Current and voltage limited DC power supply with series resistance**		N/A
	A DC power source used as the EUT input source is capable of EUT maximum input power (so as to achieve EUT maximum output power) at minimum and maximum EUT input operating voltage.		N/A
	The power source provides adjustable current and voltage limit, set to provide the desired short circuit current and open circuit voltage when combined with the series and shunt resistance described below.		N/A
	A series resistance (and, optionally, a shunt resistance) is selected to provide a fill factor within the range: Output power: Sufficient to provide maximum EUT output power and other levels specified by test conditions of table 5. Response speed: The response time of a simulator to a step in output voltage, due to a 5% load change, results in a settling of the output current to within 10% of its final value in less than 1ms. Stability: Excluding the variations caused by the EUT MPPT, simulator output power remains stable within 2 % of specified power level over the duration of the test: from the point where load balance is achieved until the island condition is cleared or the allowable run-on time is exceeded. Power factor: 0.25 to 0.8		N/A
5.2.4	**PV array**		N/A
	A PV array used as the EUT input source is capable of EUT maximum input power at minimum and maximum EUT input operating voltage.		N/A
	Testing is limited to times when the irradiance varies by no more than 2 % over the duration of the test as measured by a silicon-type pyranometer or reference device. It may be necessary to adjust the array configuration to achieve the input voltage and power levels prescribed in 6.1.		N/A
5.3	**AC power source**		
	The utility grid or other AC power source may be used as long as it meets the conditions specified in Table 4.	AC power source used meets the conditions specified	P

Table 4 – AC power source requirements

Items	Conditions
Voltage	Nominal ±2,0 %
Voltage THD	< 2,5 %
Frequency	Nominal ±0,1 Hz
Phase angle distance [1]	120 ° ± 1,5 °
[1] Three-phase case only	

5.4	**AC loads**		

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Clause	Requirement + Test	Result - Remark	Verdict
	On the AC side of the EUT, variable resistance, capacitance, and inductance are connected in parallel as loads between the EUT and the AC power source. Other sources of load, such as electronic loads, may be used if it can be shown that the source does not cause results that are different than would be obtained with passive resistors, inductors, and capacitors.	Passive loads (variable resistance, capacitance and inductance) have been connected.	P
	All AC loads are rated for and adjustable to all test conditions. The equations for Qf are based upon an ideal parallel RLC circuit. For this reason, non-inductive resistors, low loss (high Qf) inductors, and capacitors with low effective series resistance and effective series inductance are utilized in the test circuit. Iron core inductors, if used, are not exceed a current THD of 2 % when operated at nominal voltage. Load components are conservatively rated for the voltage and power levels expected. Resistor power ratings are chosen so as to minimize thermally-induced drift in esistance values during the course of the test.		P
	Active and reactive power is calculated (using the measurements provided in Table 1) in each of the R, L and C legs of the load so that these parasitic parameters (and parasitics introduced by variacs or autotransformers) are properly accounted for when calculating Qf.		P
6	**Test for single or multi-phase inverter**		
6.1	**Test procedure**	**(see appended table)**	**P**
	The test uses an RLC load, resonant at the EUT nominal frequency (50 Hz or 60 Hz) and matched to the EUT output power.		P
	For multi-phase EUT, the load is balanced across all phases and the switch S1 as in Figure 1 opens all phases		P
	This test is performed with the EUT conditions as in Table 5, where power and voltage values are given as a percent of EUT full output rating.		P
	a) Determine EUT test output power		P
	b) Adjusting the DC input source		P
	c) Turn off the EUT and open S1		P
	d) Adjust the RLC circuit to have Qf = 1.0 ±0.05		P
	e) Connect the RLC load configured in step d) to the EUT by closing S2		P
	f) Open the utility-disconnect switch S1 to initiate the test, Run-on time is recorded.		P
	g) For test condition A, adjust the real load and only one of the reactive load components to each of the load imbalance conditions shown in the shaded portion of table 6. If any of the recorded run-on times are longer than the one recorded for the rated balance condition, then the non-shaded parameter combinations also require testing.		P

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Clause	Requirement + Test	Result - Remark	Verdict
	h) For test condition B and C, adjust the only one reactive load components by approximately 1,0% per test, within a total range of 95% to 105% of the operating point. If run-on times are still increasing at the 95% or 105% points, additional 1% increments have to be taken until run-on times begin decreasing.		P
6.2	**Pass/fail criteria**		
	An EUT is considered to comply with the requirements for islanding protection when each case of recorded run-on time is less than 2 s or meets the requirements of local codes.	Run-on time is less than 2s in any case	P
7	**Documentation**		
	At a minimum, the following information is recorded and maintained in the test report.		P
	a) Specifications of EUT. Table 8 provides an example of the type of information that is provided.		P
	b) Measurement results. Table 9 provides an example of the type of information that is provided. Actual measured values is to be recorded.		P
	c) Block diagram of test circuit.		P
	d) Specifications of the test and measurement equipment. Table 10 provides an example of the type of information that is provided.		P
	e) Any test configuration or procedure details such as methods of achieving specified load and EUT output conditions.		P
	f) Any additional information required by the testing laboratory's accreditation.		P
	g) Specify the evaluation criterion from clause 6.2 that was utilized to determine if the product passed or failed the test.		P
Annex A	Islanding as it applies to PV systems(Informative)		--
A.1	General		--
A.2	Impact of distortion on islanding		--
Annex B	Test for independent islanding detection device (relay)(Informative)		--
B.1	Introduction		--
B.2	Testing circuit		--
B.3	Testing equipment		--
B.4	Testing procedure		--
B.5	Documentation		--

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Clause	Requirement + Test	Result - Remark	Verdict

6.1	**Table: tested condition and run-on time**	**P**

No.	P_{EUT} (% of EUT rating)	Reactive load (% of normial)	P_{AC}	Q_{AC}	Run-on time(ms)	P_{EUT} (KW)	Actual Q_f	V_{DC} (d.c.V)	Which load is selected to be adjusted (R or L)
Test condtion A									
1	100	100	0	0	544	20.1	1.01	808.2	--
2	100	100	-5	-5	404	20.2	1.05	808.6	R/L
3	100	100	-5	0	436	20.1	1.05	808.7	R
4	100	100	-5	+5	410	20.2	1.03	808.2	R/L
5	100	100	0	-5	482	20.1	1.02	808.8	L
6	100	100	0	+5	510	20.1	1.05	808.6	L
7	100	100	+5	-5	412	20.1	0.98	809.1	R/L
8	100	100	+5	0	442	20.2	0.96	808.3	R
9	100	100	+5	+5	414	20.1	0.96	808.5	R/L
10	100	100	-10	+10	--	--	--	--	R/L
11	100	100	-5	+10	--	--	--	--	R/L
12	100	100	0	+10	--	--	--	--	L
13	100	100	+10	+10	--	--	--	--	R/L
14	100	100	+10	+5	--	--	--	--	R/L
15	100	100	+10	0	--	--	--	--	R
16	100	100	+10	-5	--	--	--	--	R/L
17	100	100	+10	-10	--	--	--	--	R/L
18	100	100	+5	-10	--	--	--	--	R/L
19	100	100	+5	10	--	--	--	--	R/L
20	100	100	0	-10	--	--	--	--	L
21	100	100	-5	-10	--	--	--	--	R/L
22	100	100	-10	-10	--	--	--	--	R/L
23	100	100	-10	-5	--	--	--	--	R/L
24	100	100	-10	0	--	--	--	--	R/L
25	100	100	-10	+5	--	--	--	--	R/L

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Clause	Requirement + Test	Result - Remark	Verdict

Test condtion B									
10	66	66	0	0	496	13.2	1.00	571.2	--
11	66	66	0	-5	418	13.2	1.02	571.8	L
12	66	66	0	-4	430	13.2	1.02	571.7	L
13	66	66	0	-3	444	13.2	1.02	571.4	L
14	66	66	0	-2	446	13.2	1.01	572.0	L
15	66	66	0	-1	462	13.2	1.00	571.6	L
16	66	66	0	1	490	13.2	1.00	571.8	L
17	66	66	0	2	468	13.2	0.99	572.1	L
18	66	66	0	3	458	13.2	0.98	571.8	L
19	66	66	0	4	452	13.2	0.98	571.9	L
20	66	66	0	5	404	13.2	0.97	571.3	L
21	66	66	0	6	--	--	--	--	L
Test condition C									
22	33	33	0	0	518	6.6	1.00	328.3	--
23	33	33	0	-5	380	6.6	1.03	328.4	L
24	33	33	0	-4	442	6.6	1.02	328.9	L
25	33	33	0	-3	448	6.6	1.02	329.0	L
26	33	33	0	-2	466	6.6	1.01	328.5	L
27	33	33	0	-1	482	6.6	1.01	328.3	L
28	33	33	0	1	508	6.6	1.00	328.2	L
29	33	33	0	2	444	6.6	0.99	329.1	L
30	33	33	0	3	424	6.6	0.99	328.8	L
31	33	33	0	4	422	6.6	0.98	328.6	L
32	33	33	0	5	396	6.6	0.97	328.4	L
33	33	33	0	6	--	--	--	--	L

Remark:
For test condition A:
If any of the recorded run-on times are longer than the one recorded for the rated balance condition, then the non-shaded parameter combinations also require testing.
For test condition B and C:
If run-on times are still increasing at the 95 % or 105 % points, additional 1 % increments is taken until run-on times begin decreasing.

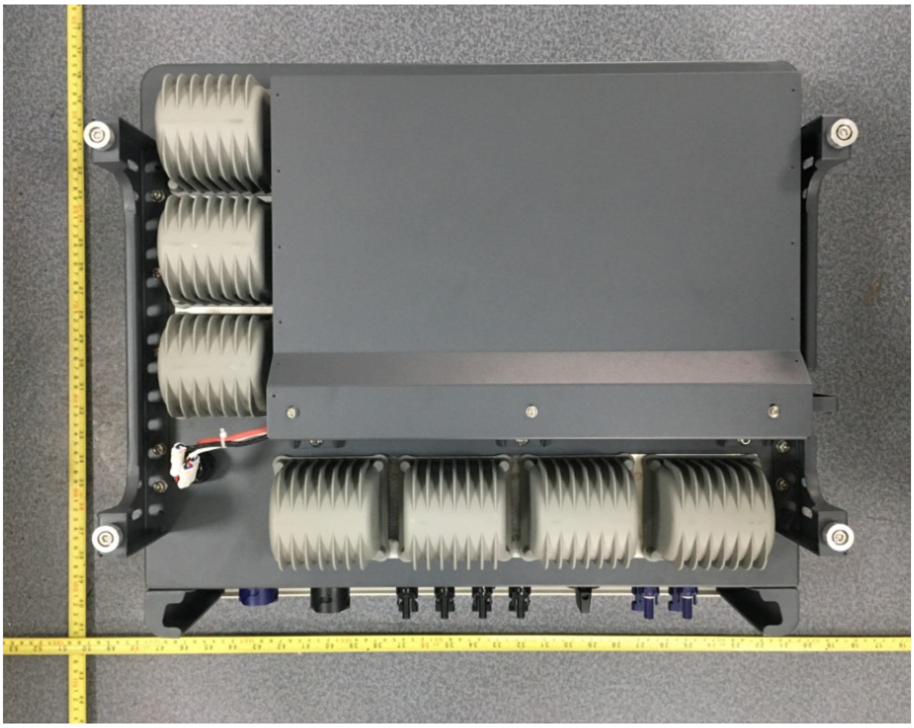
--- End of test report---

ATTACHMENT I

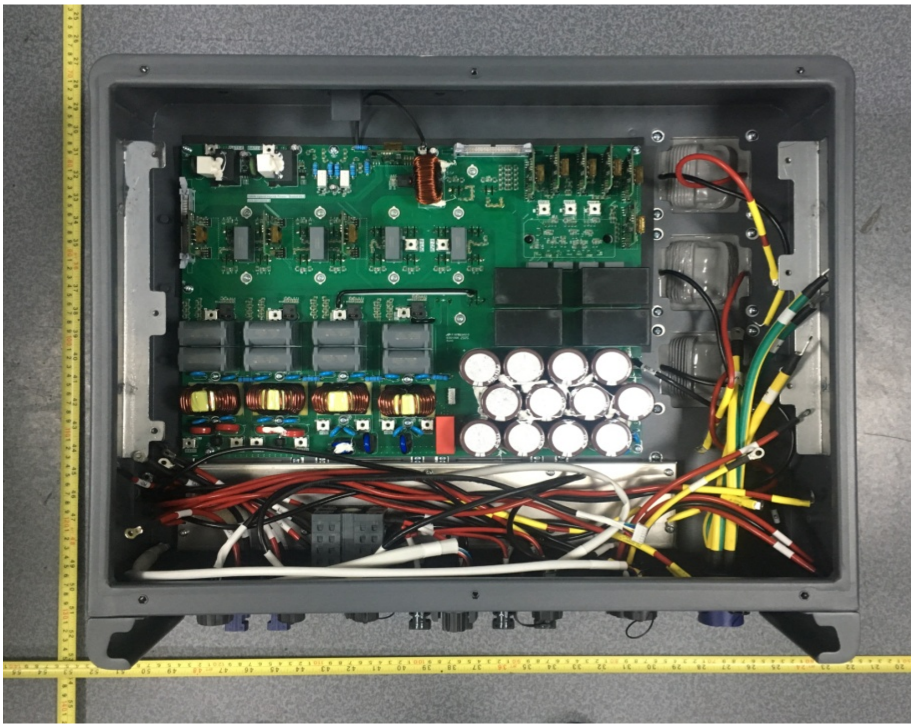
(Pictures of the EUT and Electrical Schemes)

1 PICTURES

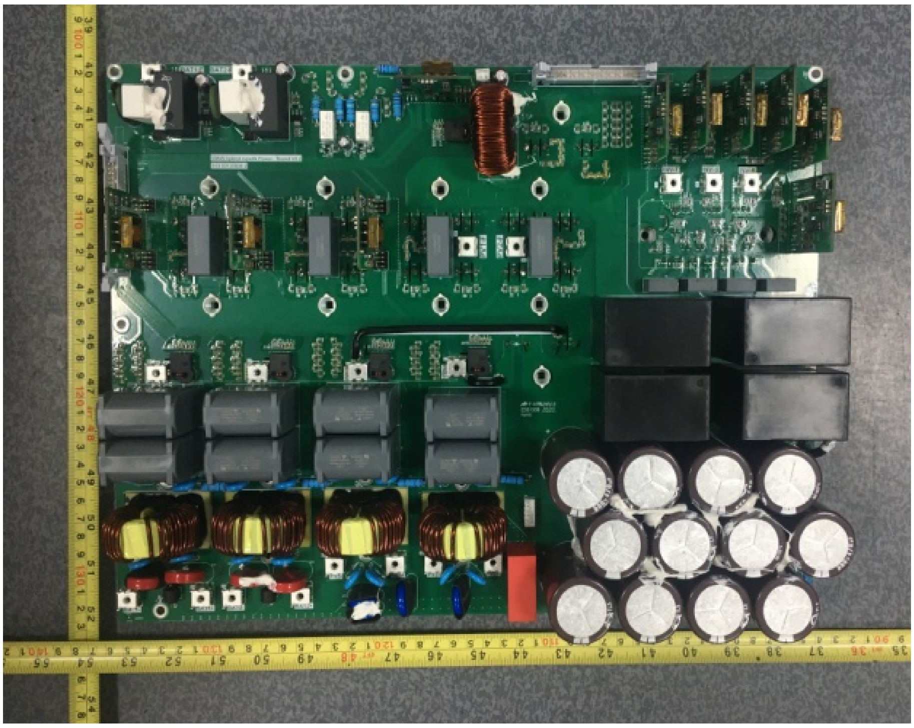
Front view

Back view


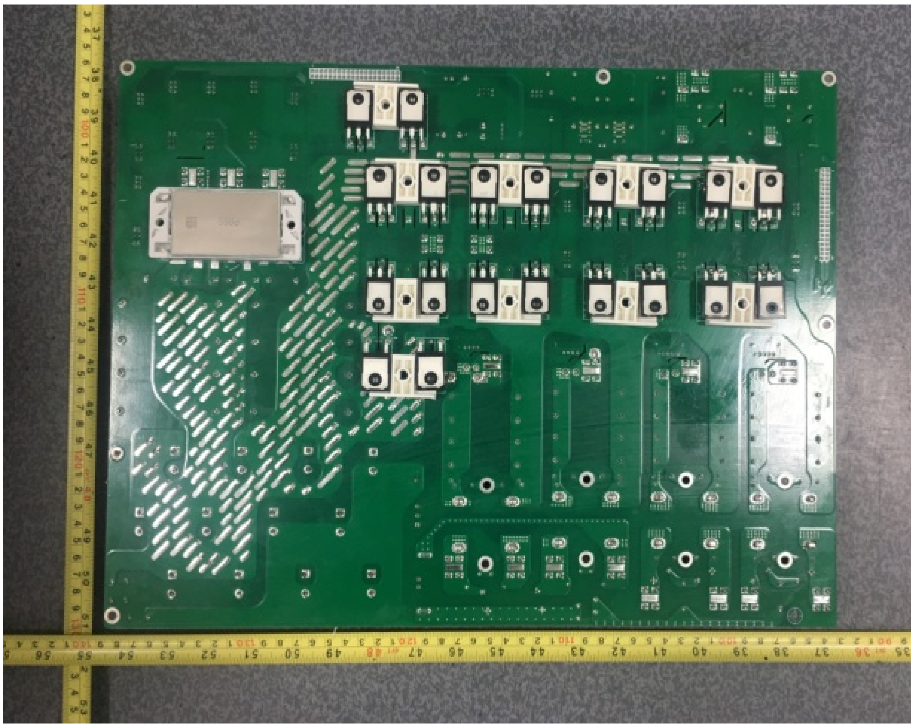
Internal View 1

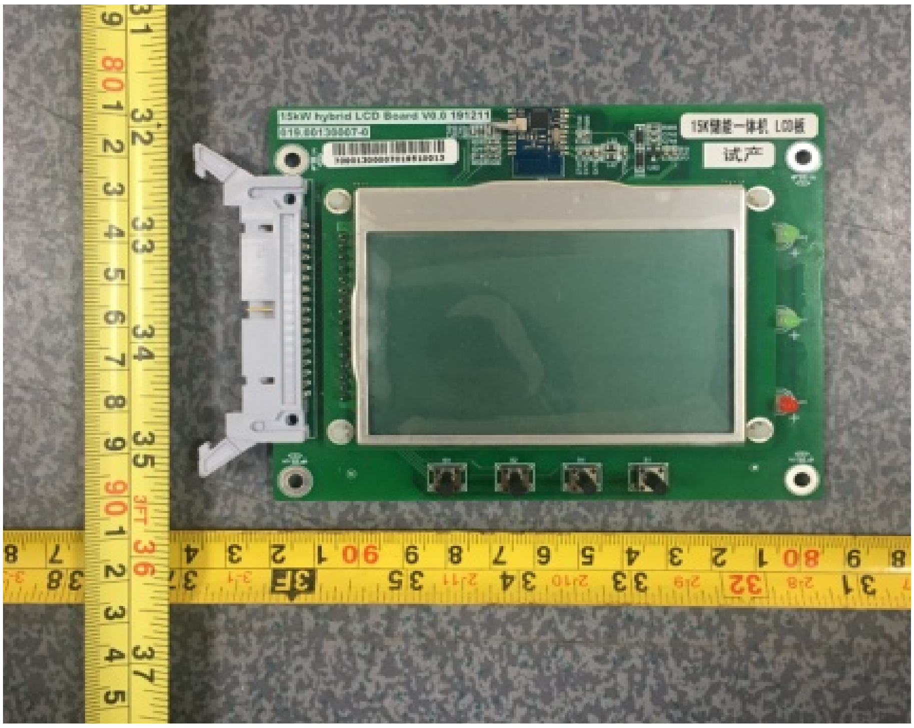
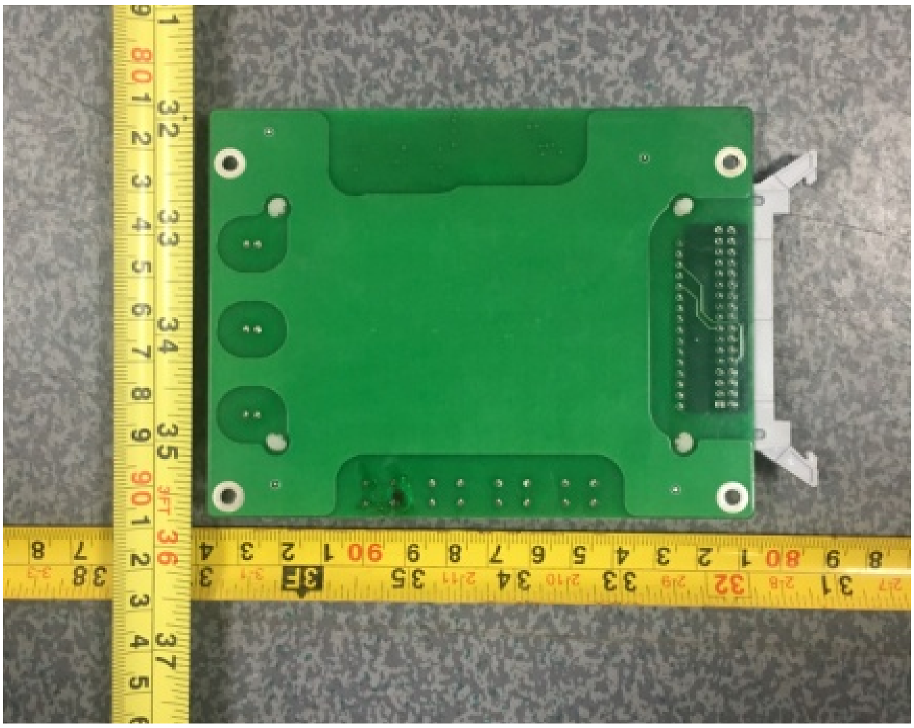
Internal View 2


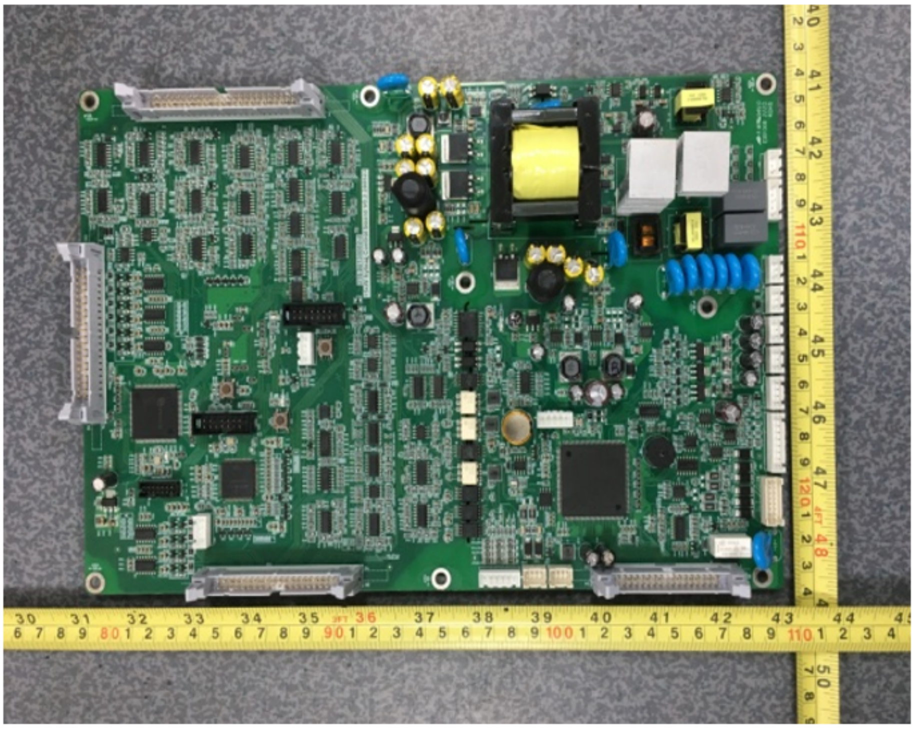
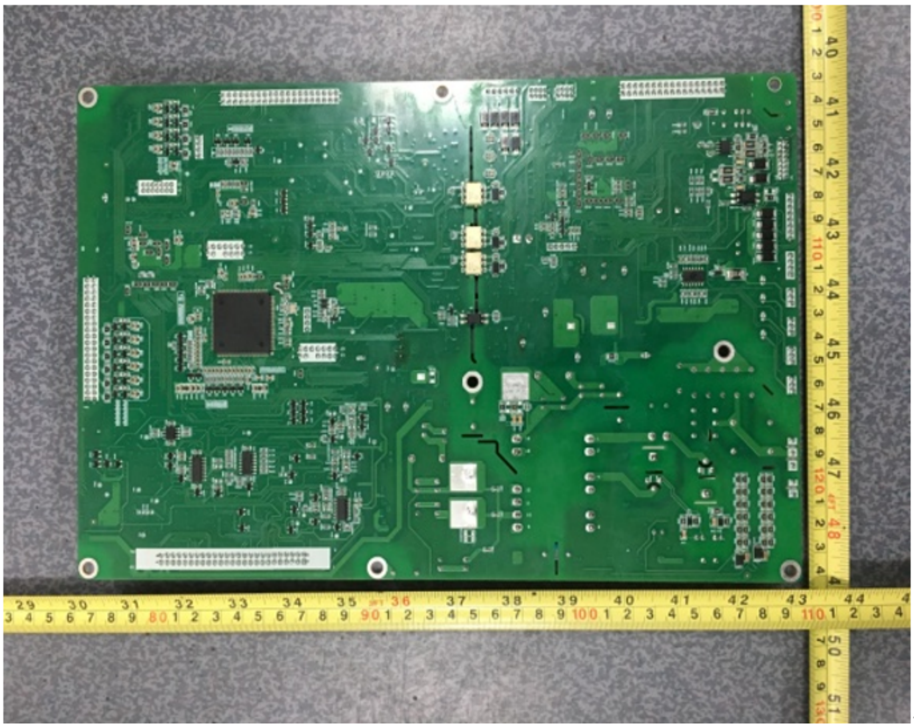
Front side of Power board

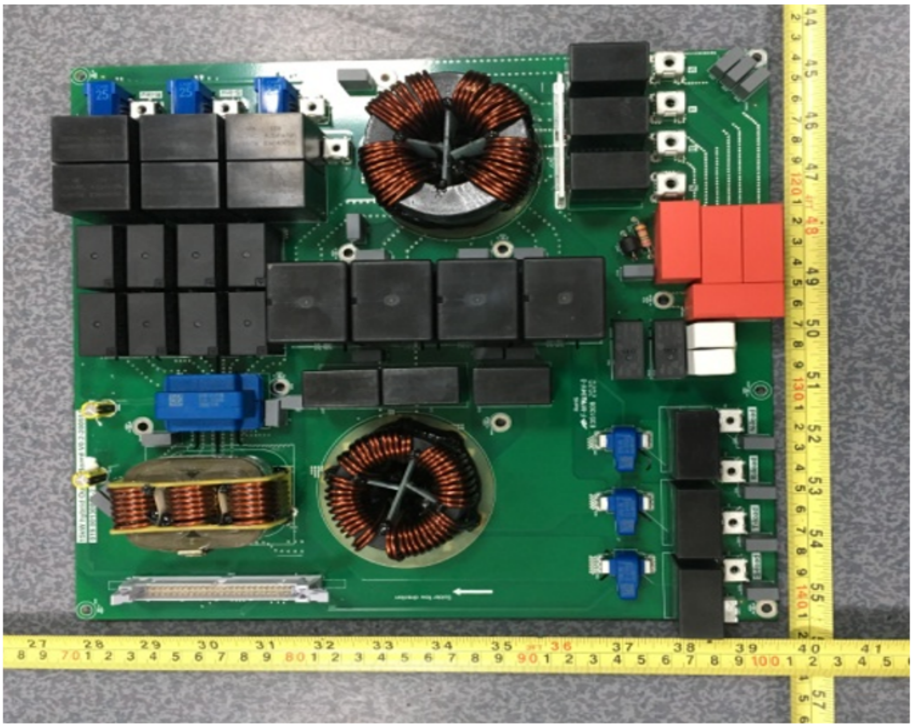
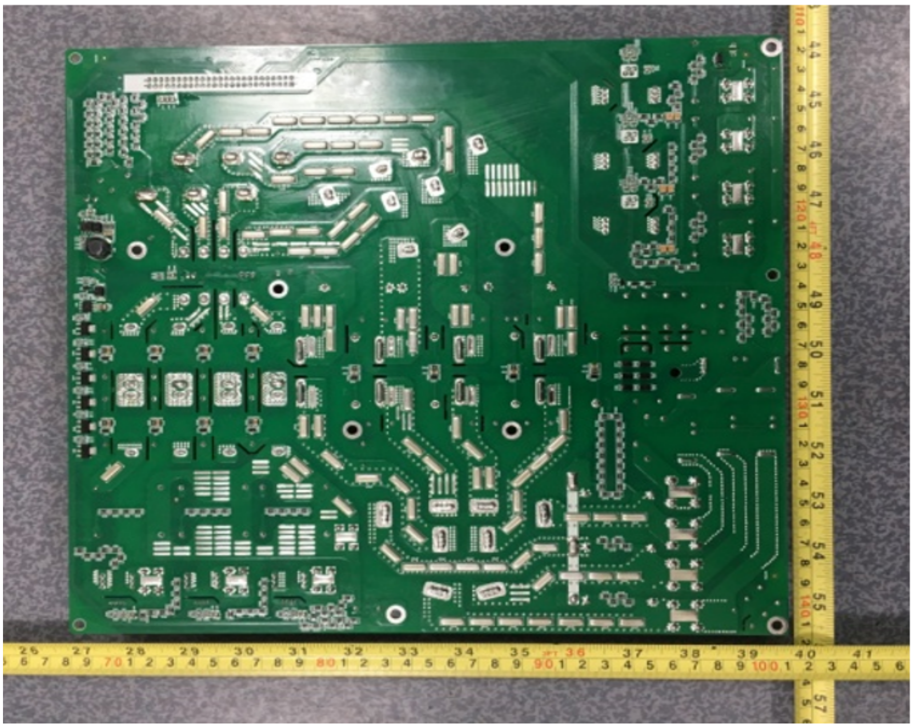


Back side of Power board



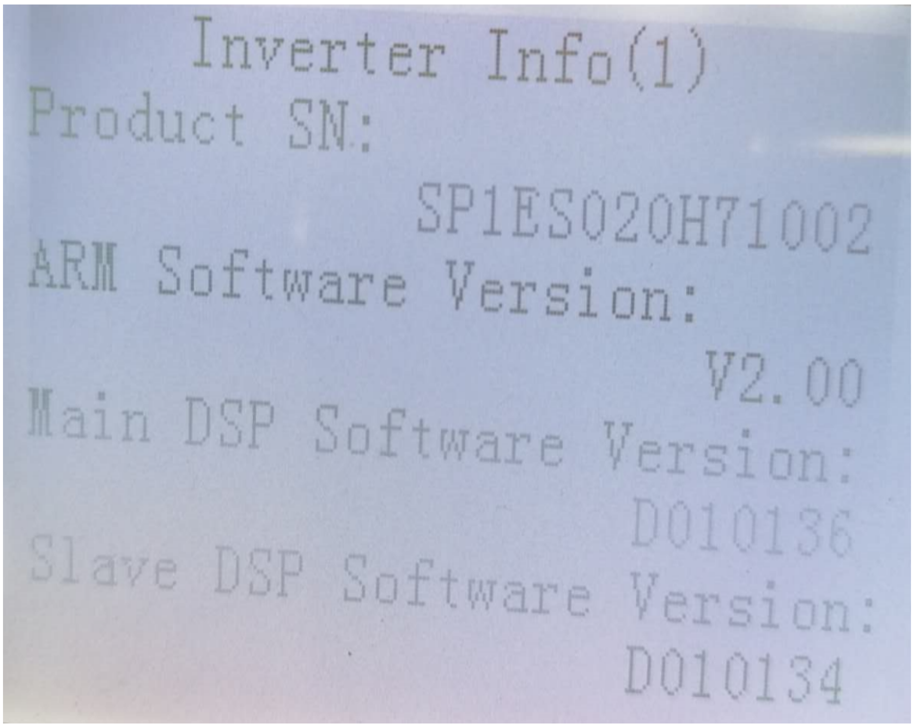
Front side of Display board

Back side of Display board


Front side of Control board

Back side of Control board


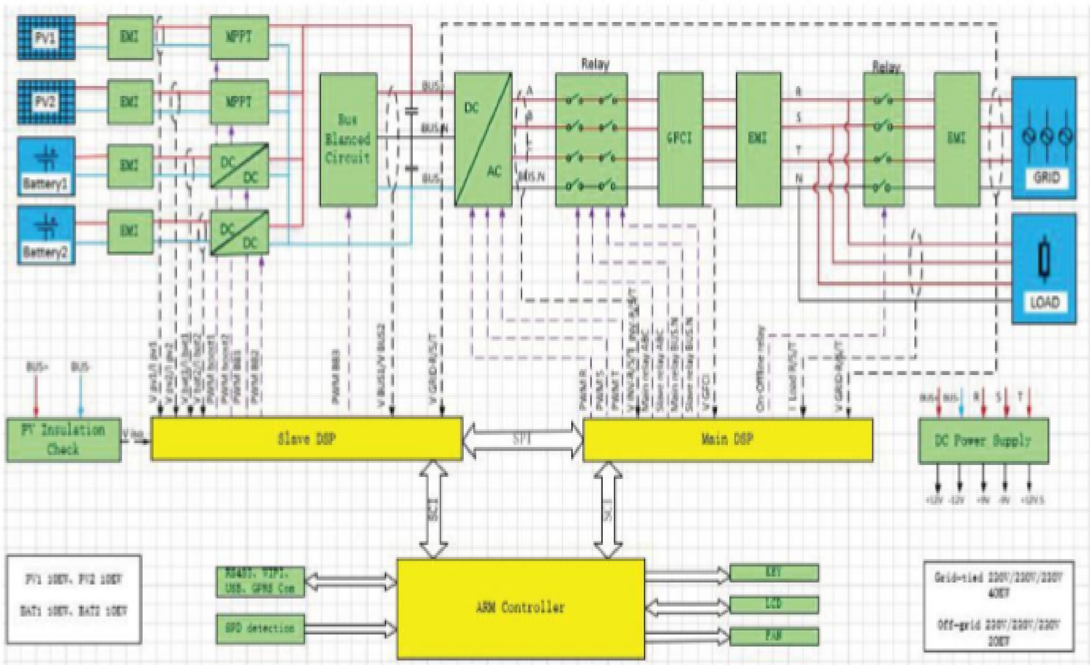
Front side of Output board front

Back side of Output board front


Grounding

Connection interface


Serial Number and Software Version


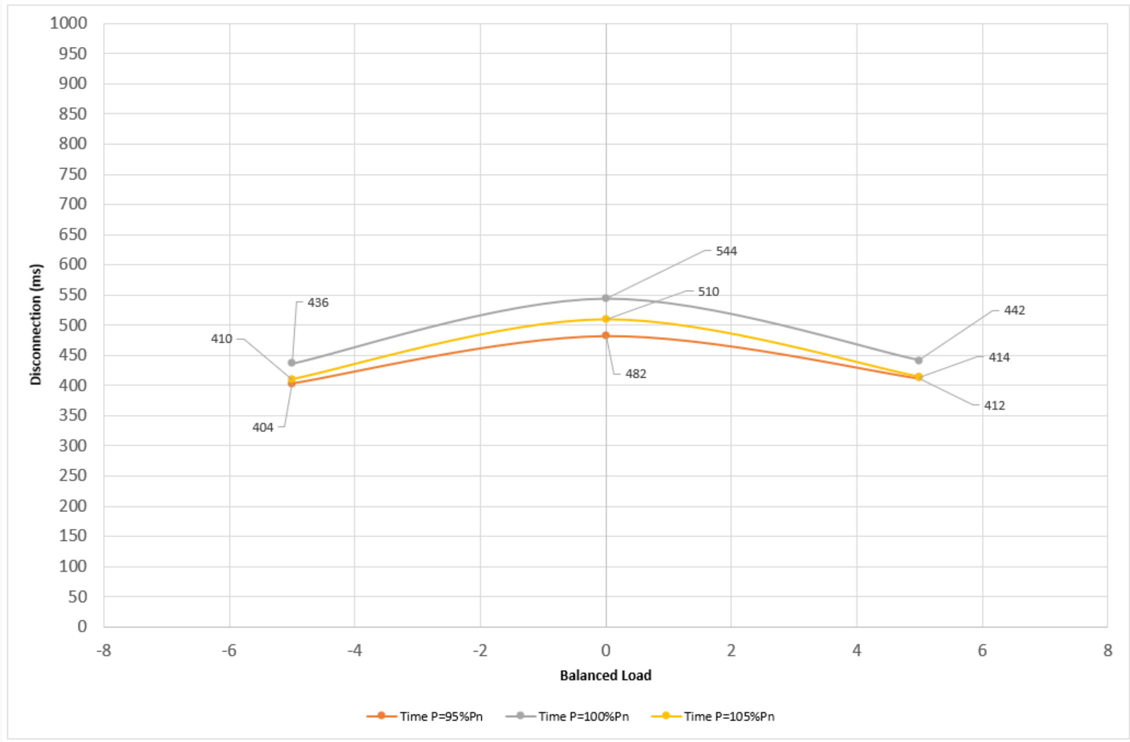
2 ELECTRICAL SCHEMES



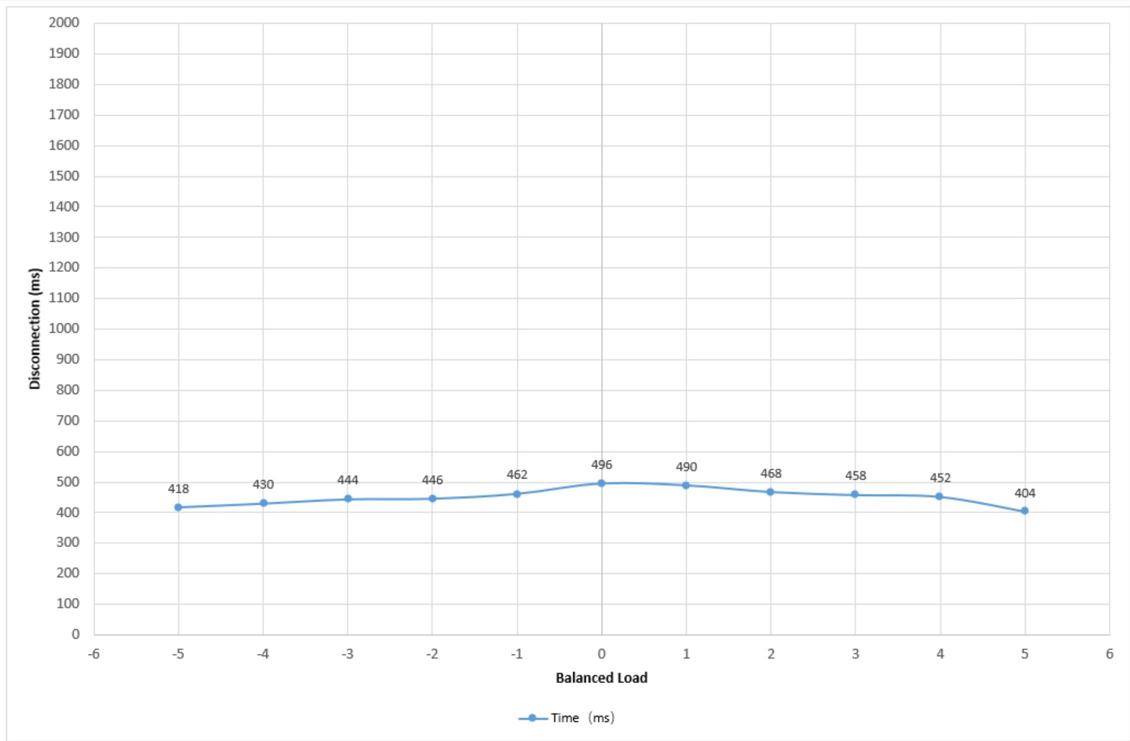
ATTACHMENT II

(GRAPHICS OF THE TEST RESULTS)

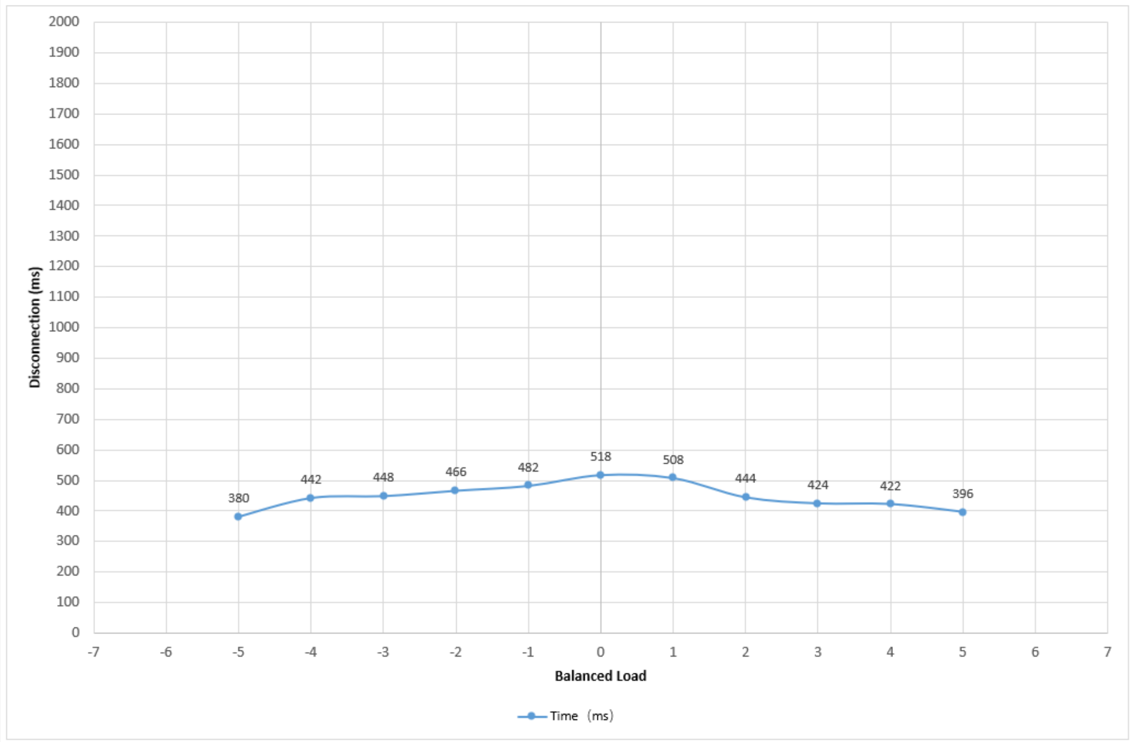
Test Condition A



Test Condition B



Test Condition C



ATTACHMENT III

(GRAPHICS OF THE ISLANDING BEHAVIOR DETECTION)

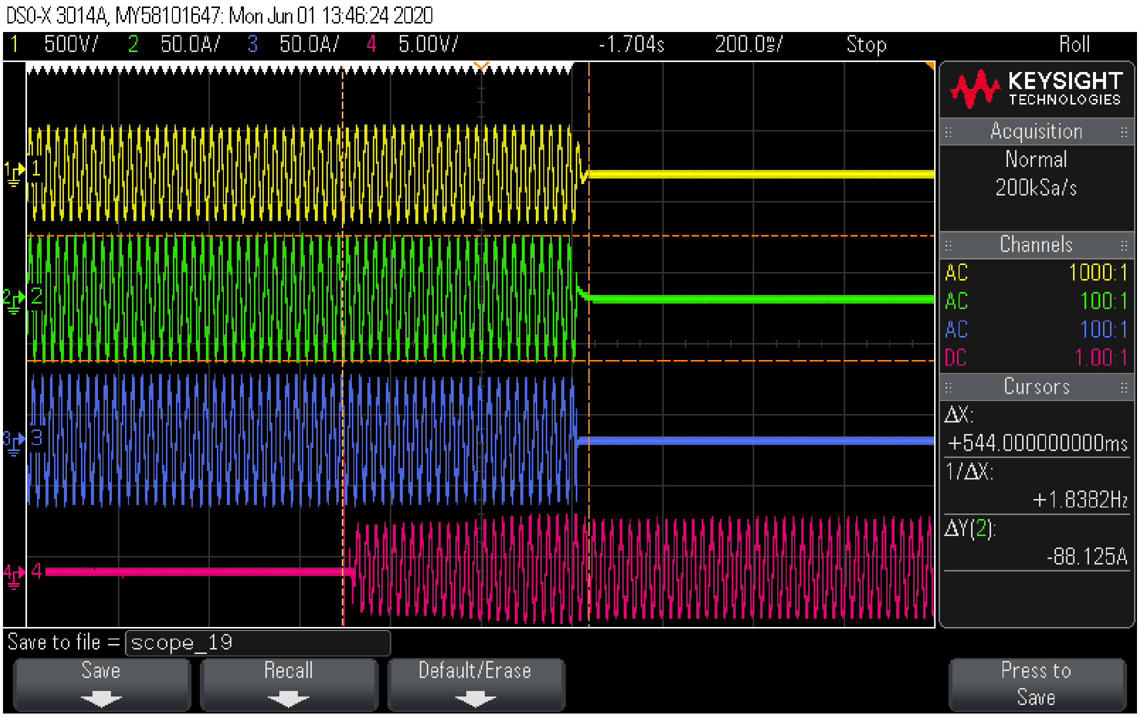
1 DEFINITIONS

M It represents the % change in active load from nominal output power

N It represents the % change in reactive load from nominal output power

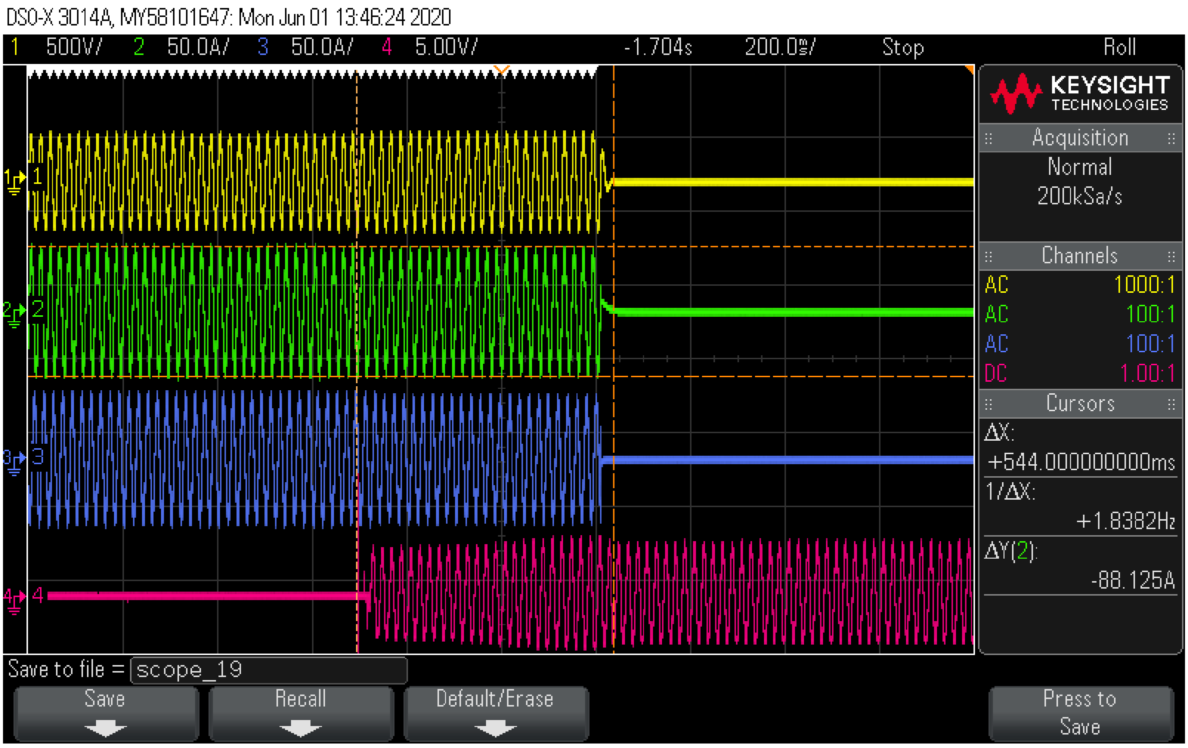
2 LEGEND

Legend

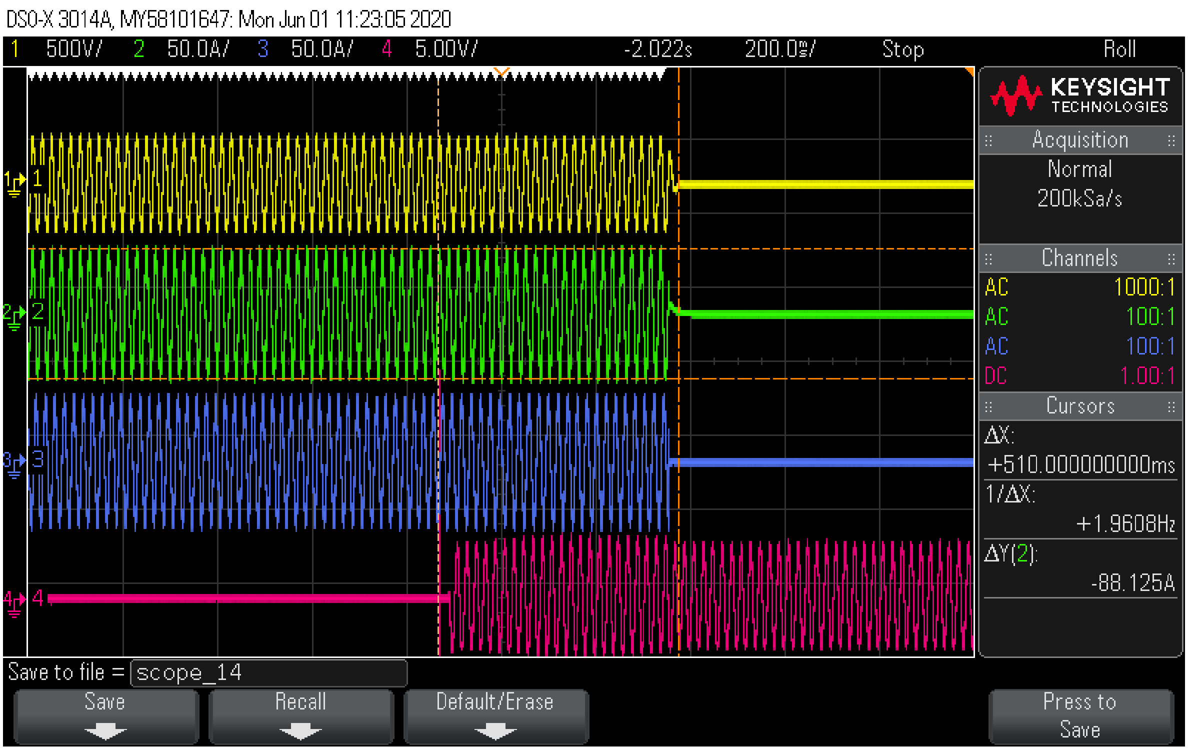


Colour	Label	Definition
	CH1	Output current
	CH2	Output current
	CH3	Output current
	CH4	Grid Switch

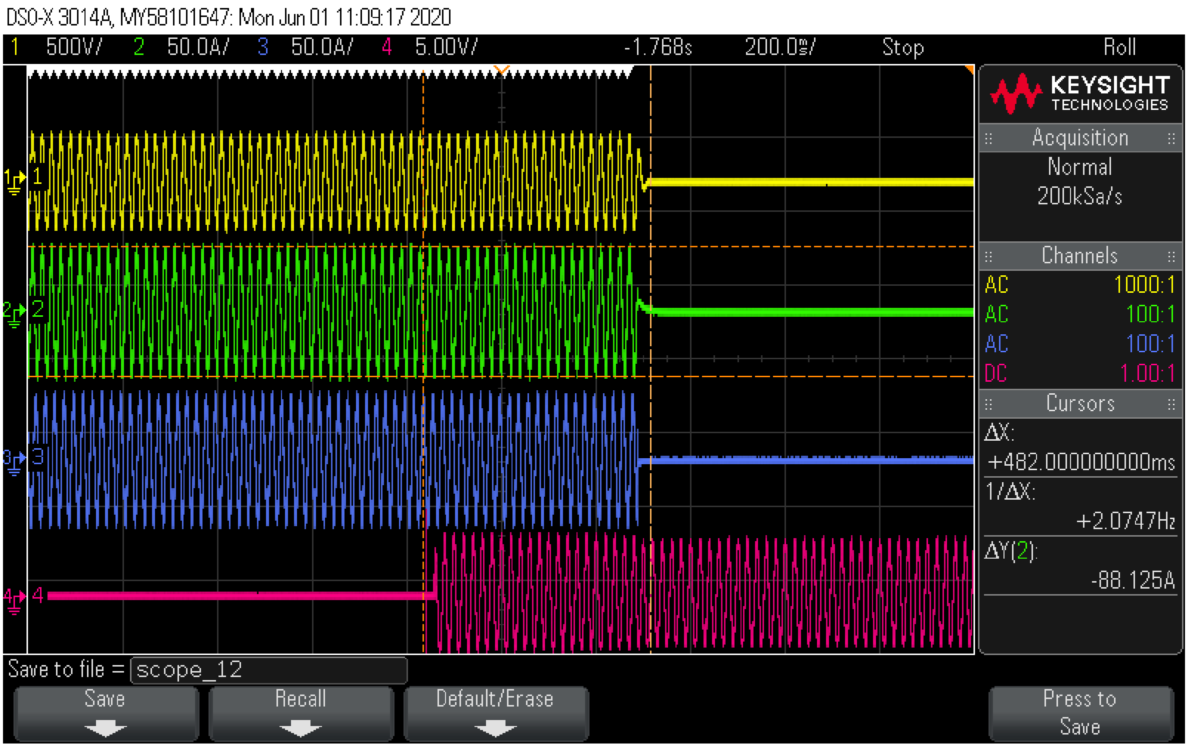
Test A(50Hz)	M(%)=0 & N(%)=0



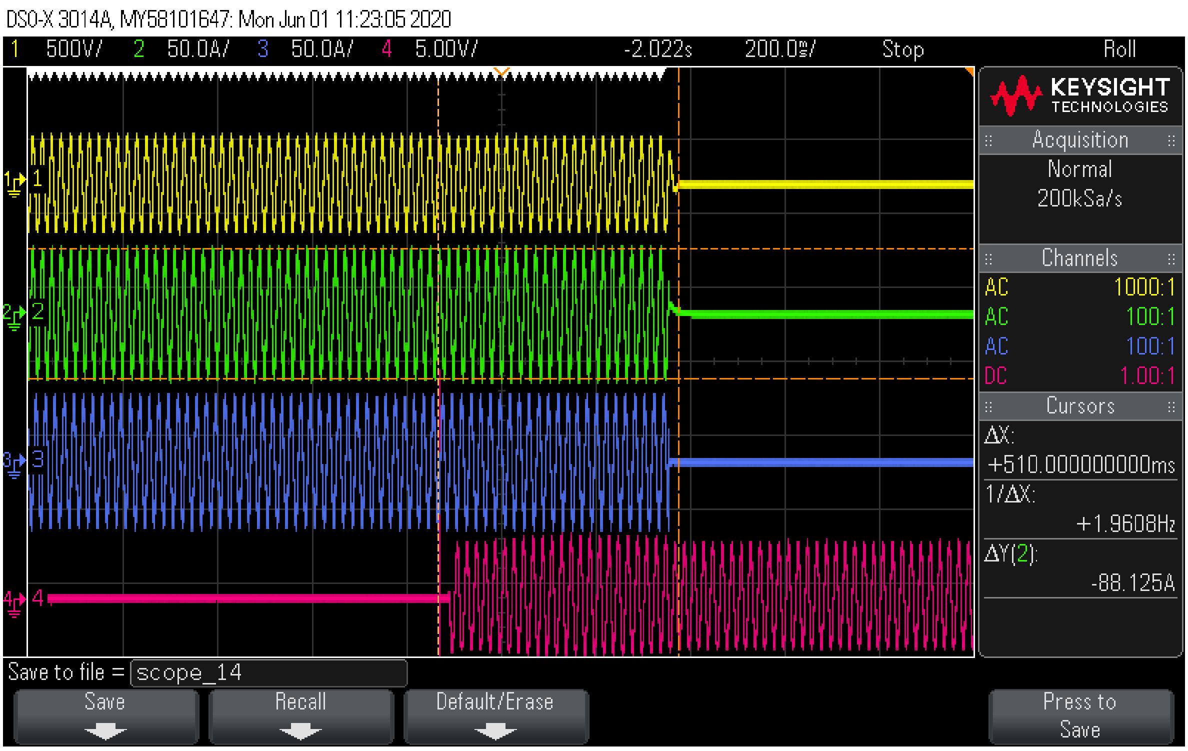
Test A(50Hz)	M(%)=0 & N(%)=+5



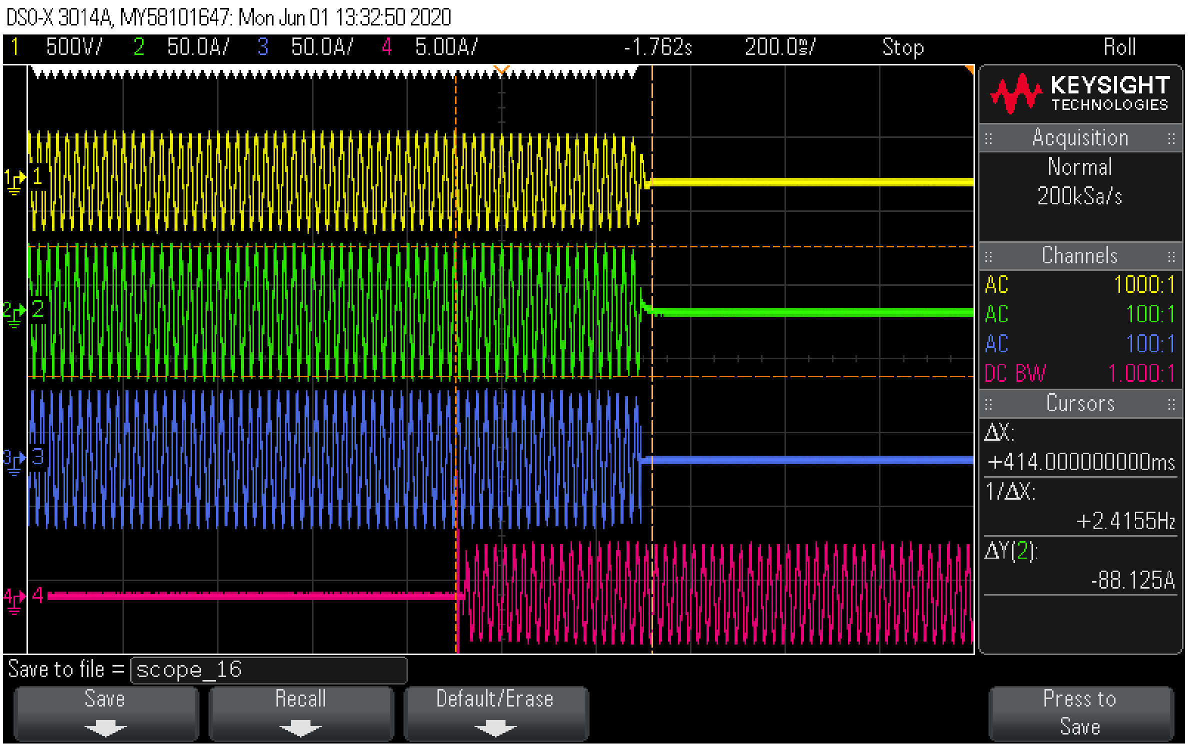
Test A(50Hz)	M(%)=0 & N(%)=-5



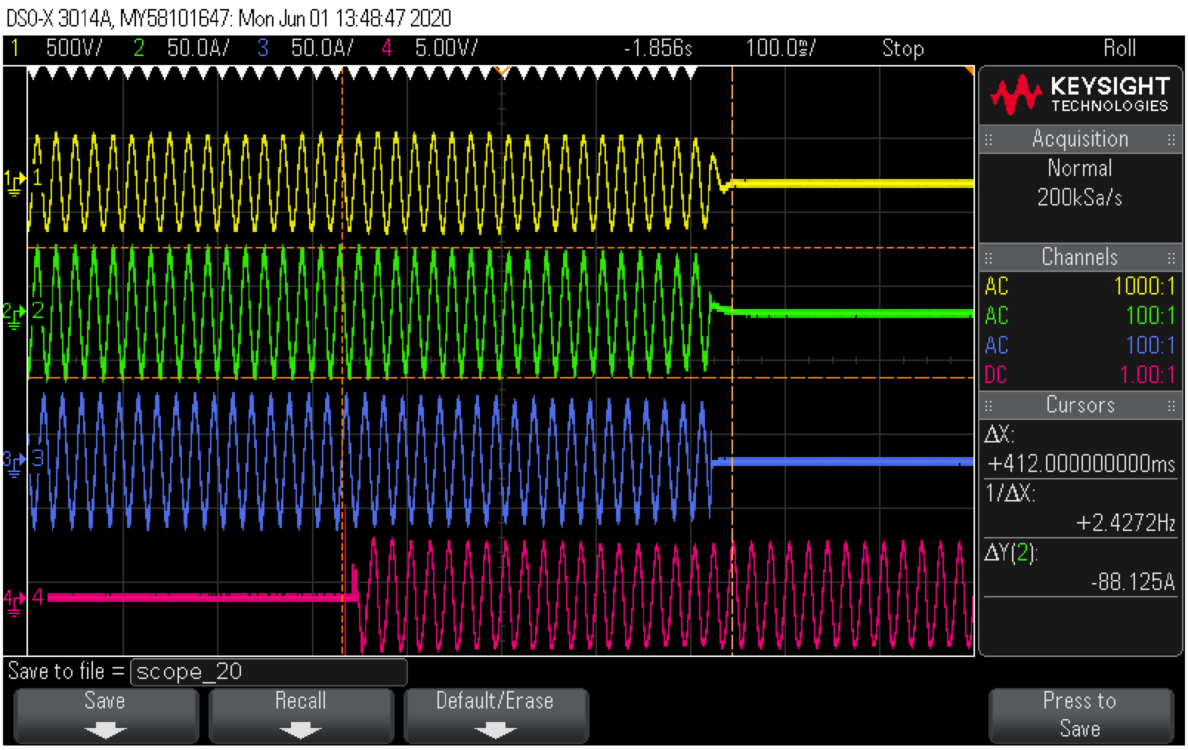
Test A(50Hz)	M(%)=+5 & N(%)=0



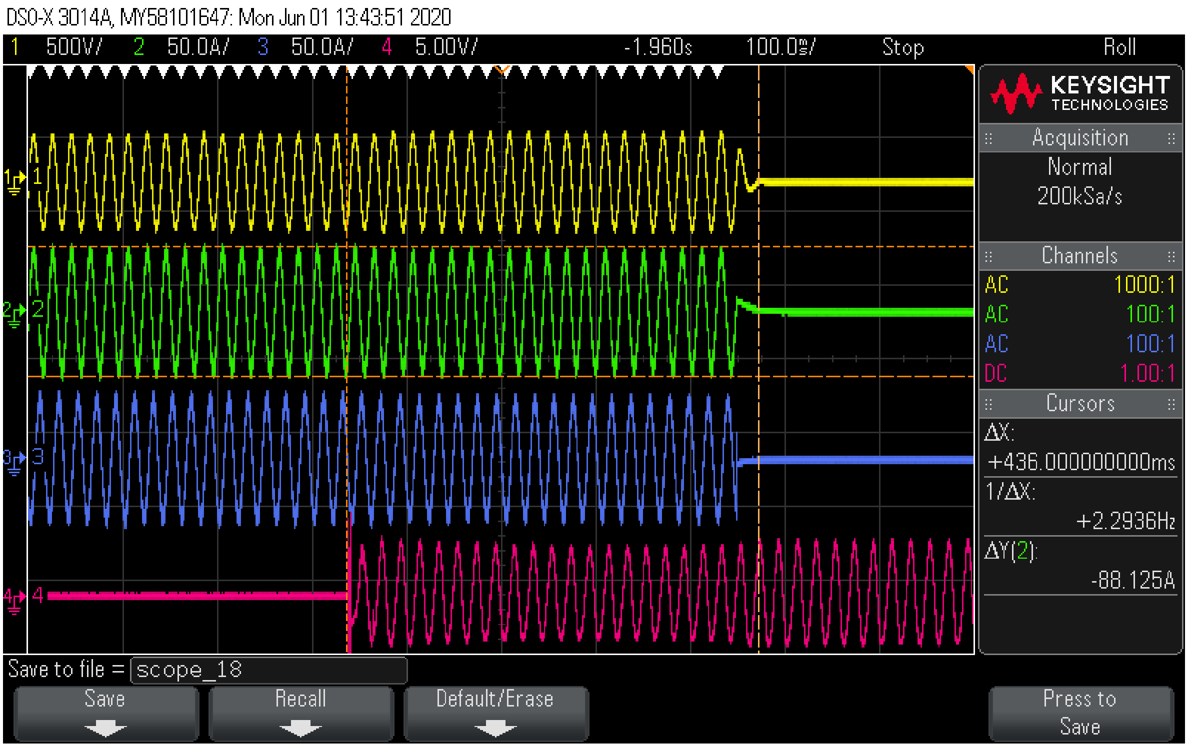
Test A(50Hz)	M(%)=+5 & N(%)=+5



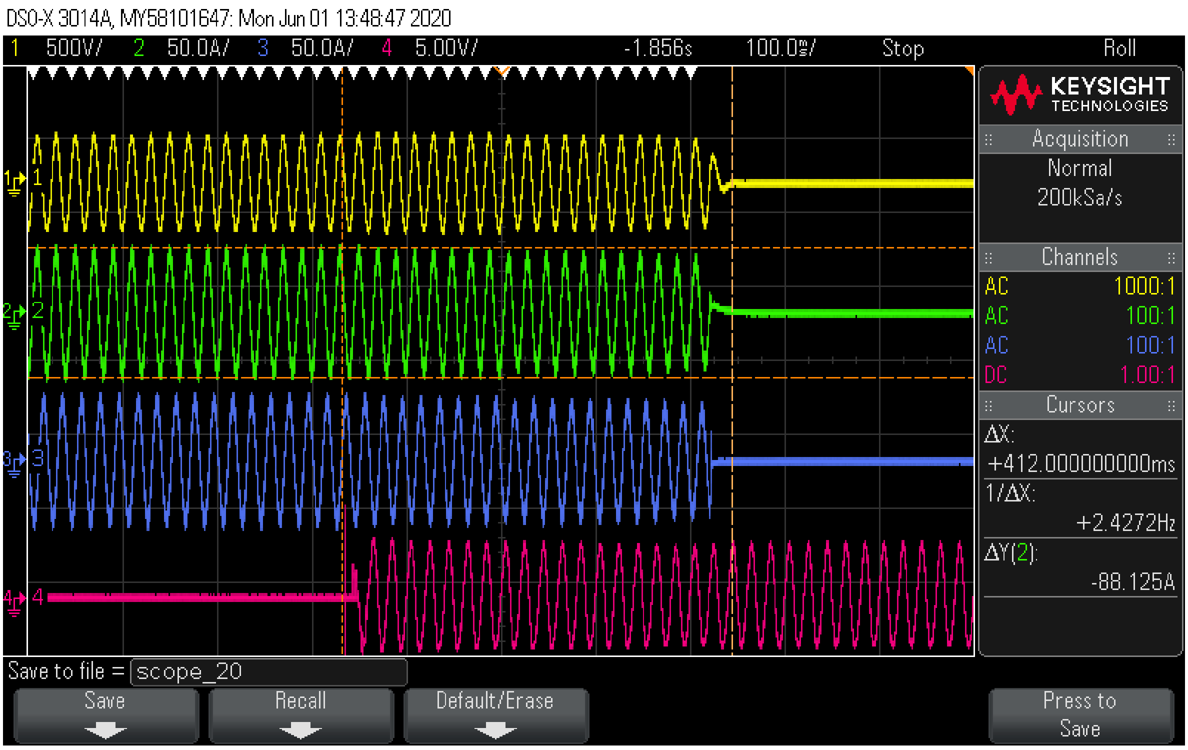
Test A(50Hz)	M(%)=+5 & N(%)=-5



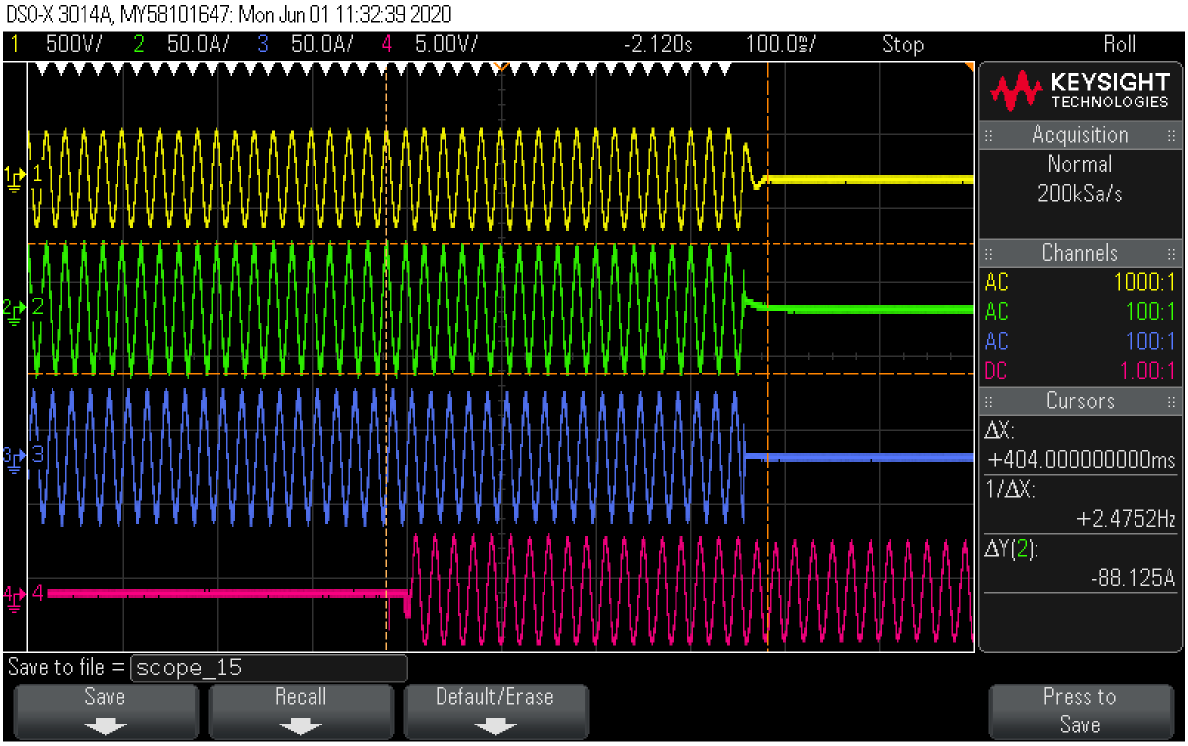
Test A(50Hz)	M(%)=-5 & N(%)=0



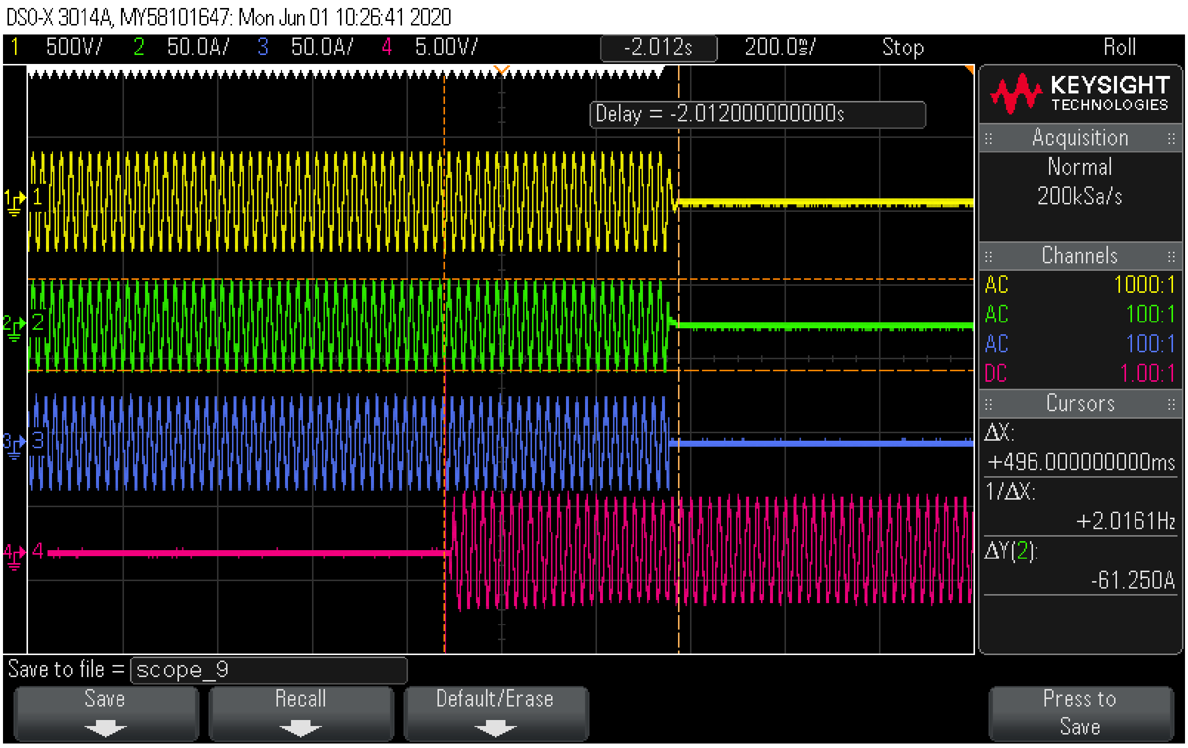
Test A(50Hz)	M(%)=-5 & N(%)=+5



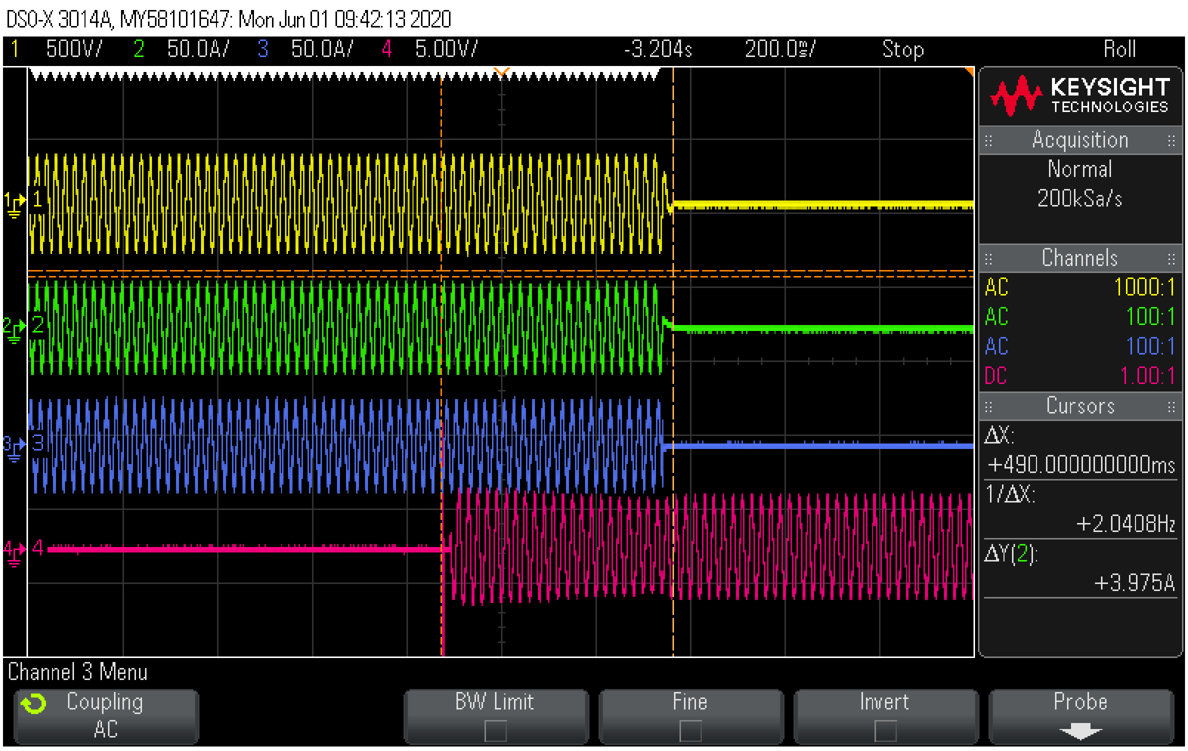
Test A(50Hz)	M(%)=-5 & N(%)=-5



Test B(50Hz)	M(%)=0 & N(%)=0

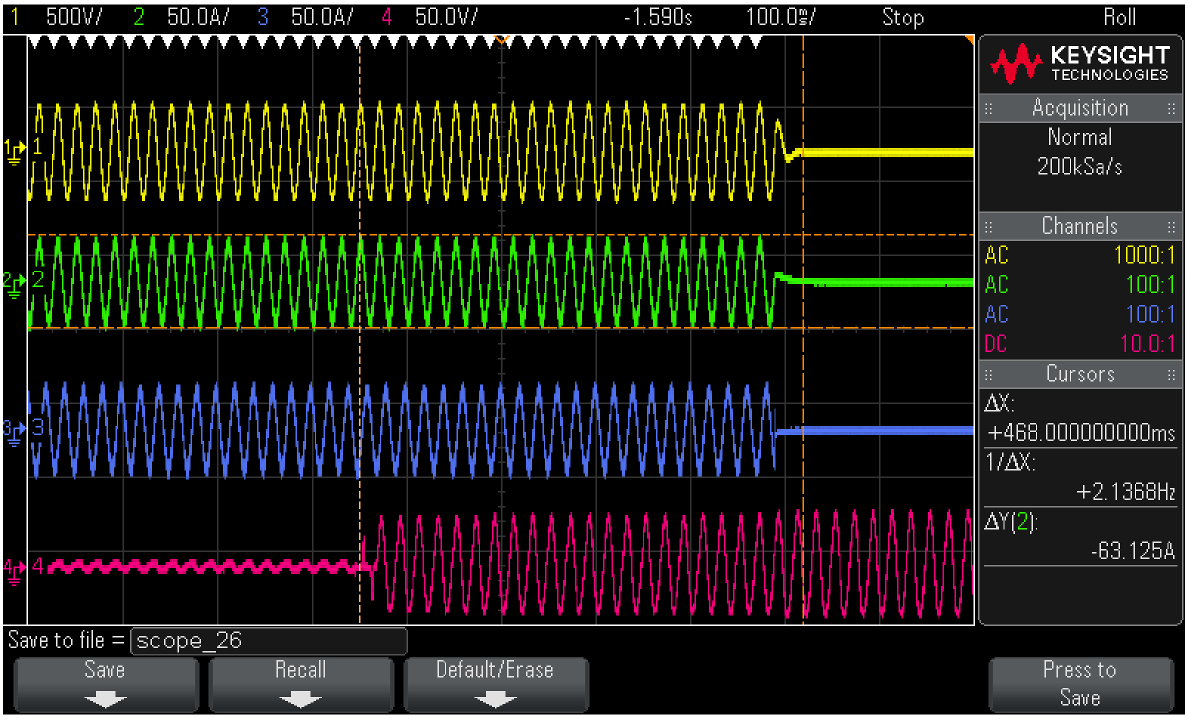


Test B(50Hz)	M(%)=0 & N(%)=+1



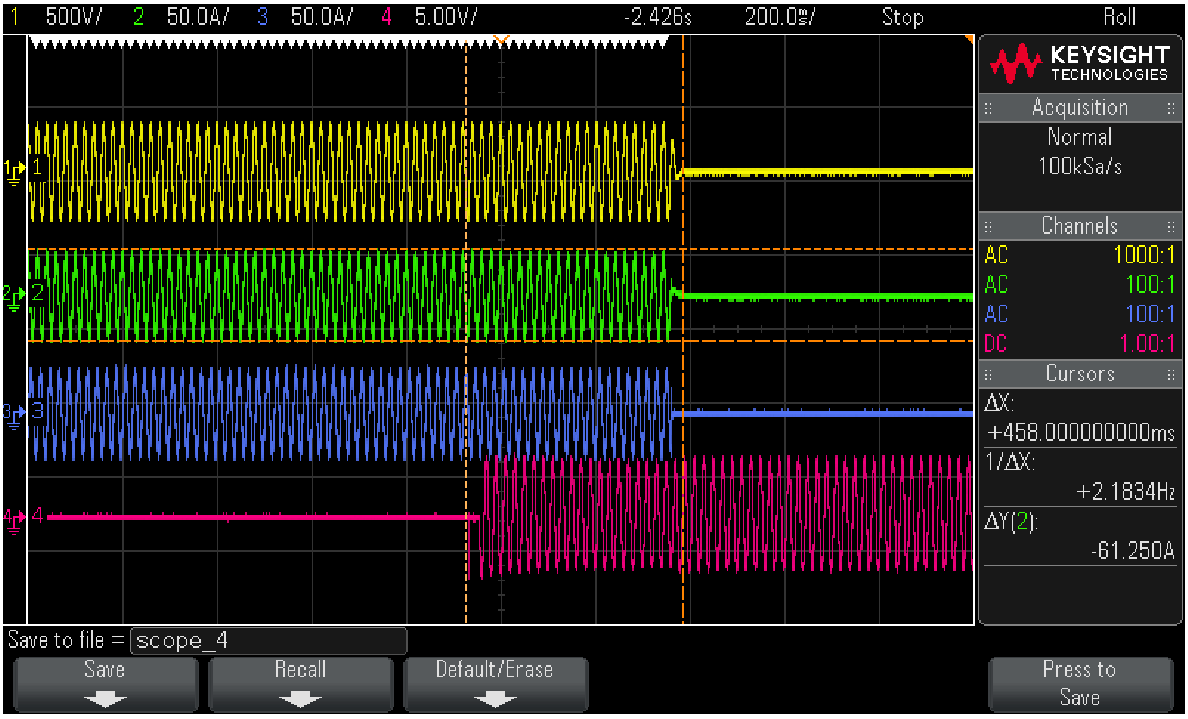
Test B(50Hz)	M(%)=0 & N(%)=+2

DSO-X 3014A, MY58101647: Mon Jun 01 14:10:42 2020

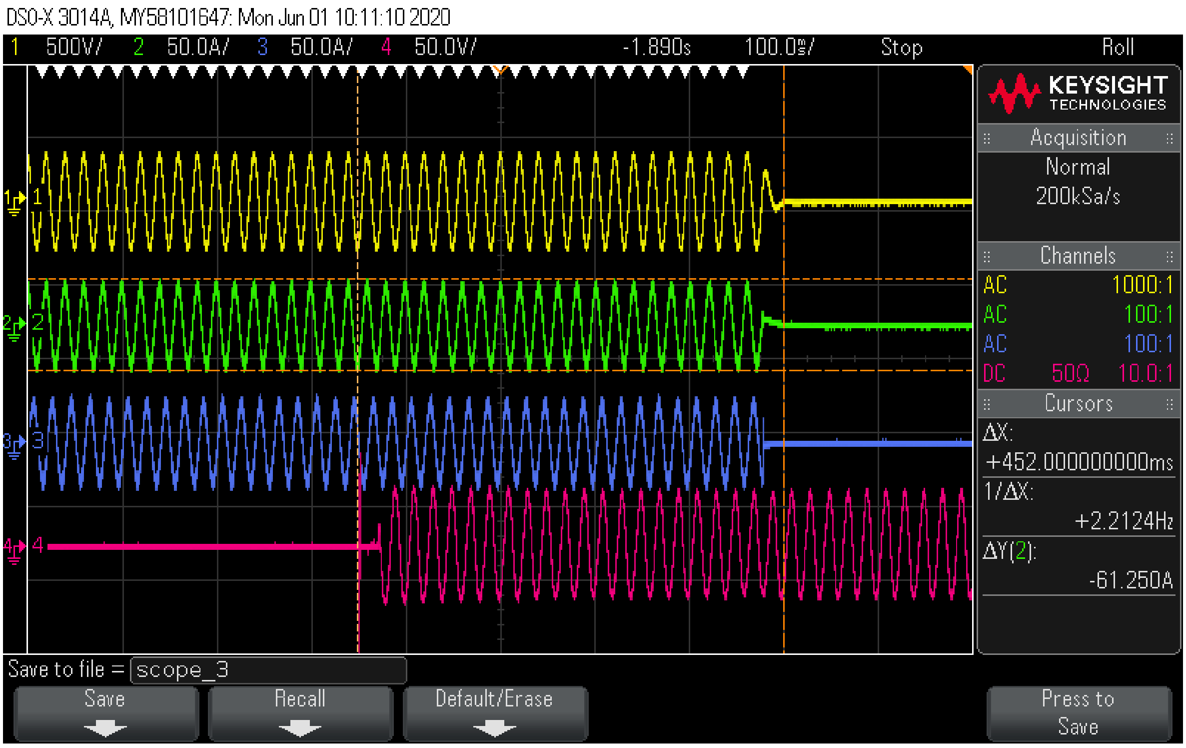


Test B(50Hz)	M(%)=0 & N(%)=+3

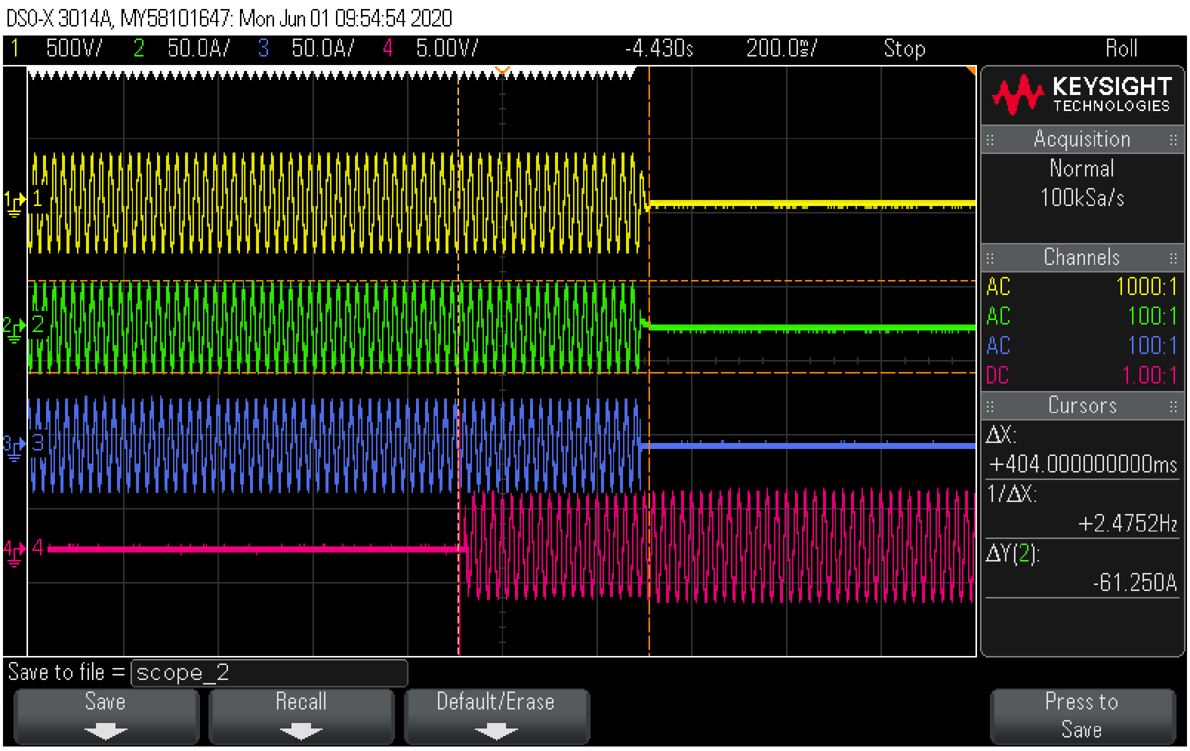
DSO-X 3014A, MY58101647: Mon Jun 01 10:13:38 2020



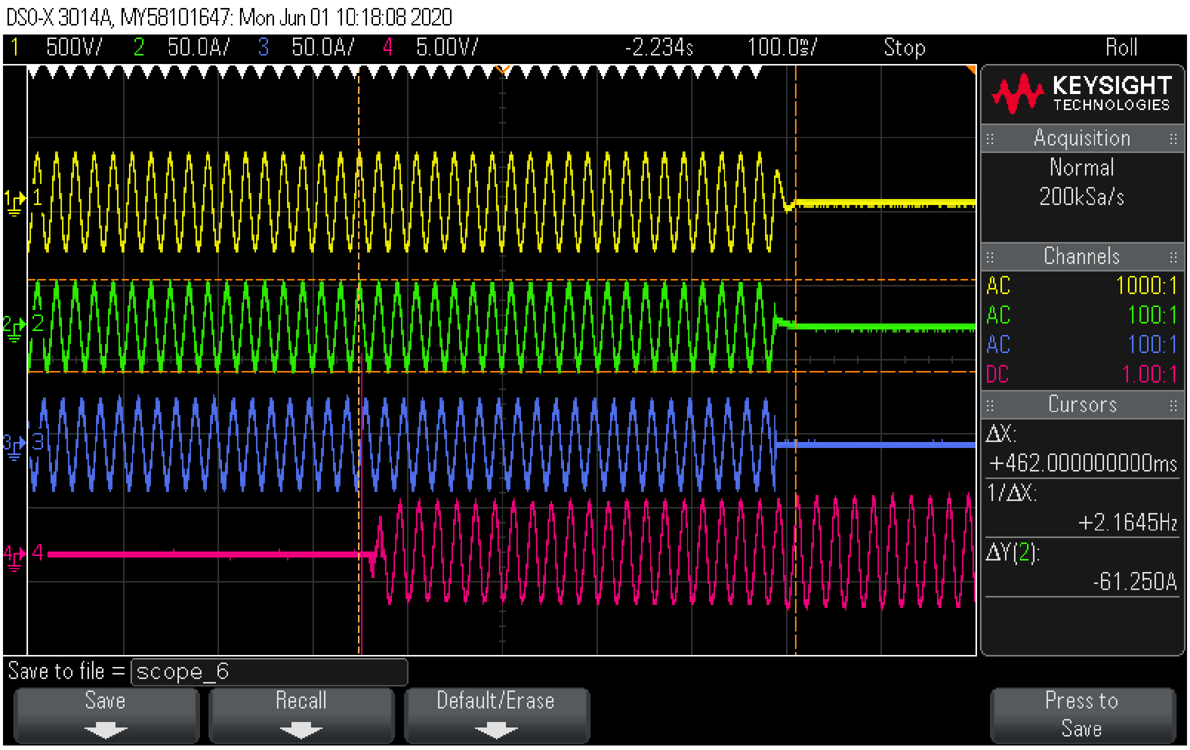
Test B(50Hz)	M(%)=0 & N(%)=+4



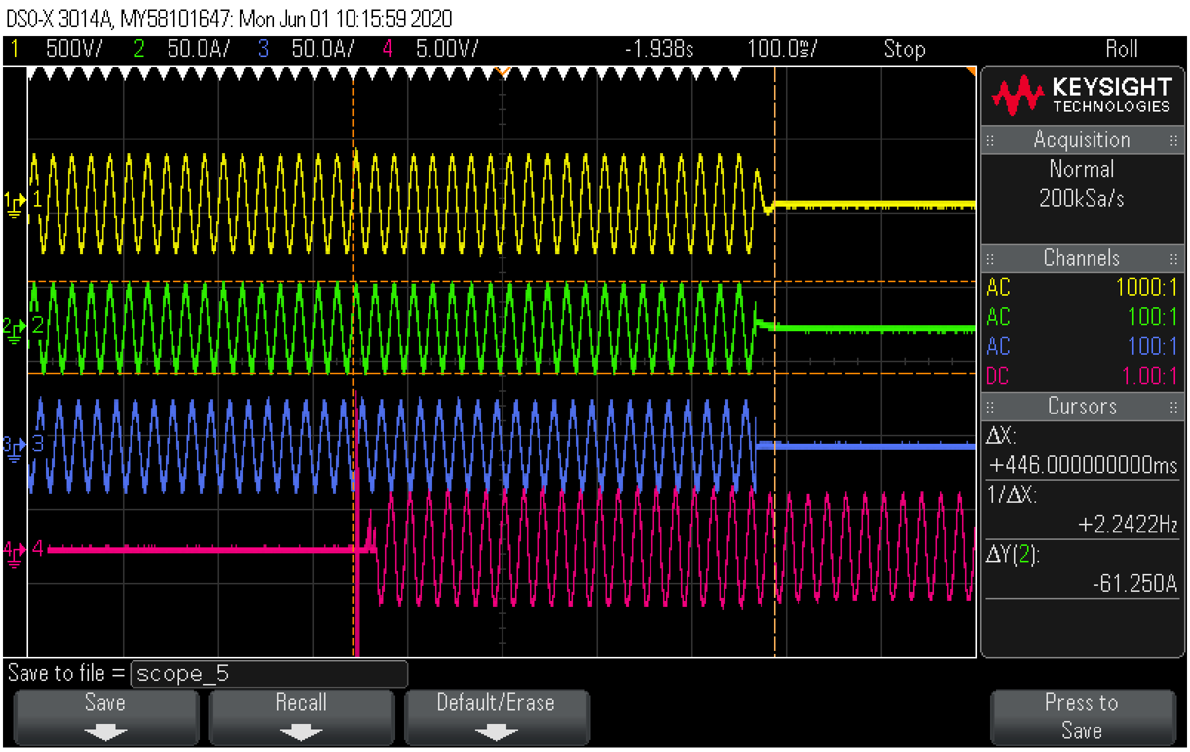
Test B(50Hz)	M(%)=0 & N(%)=+5



Test B(50Hz)	M(%)=0 & N(%)=-1

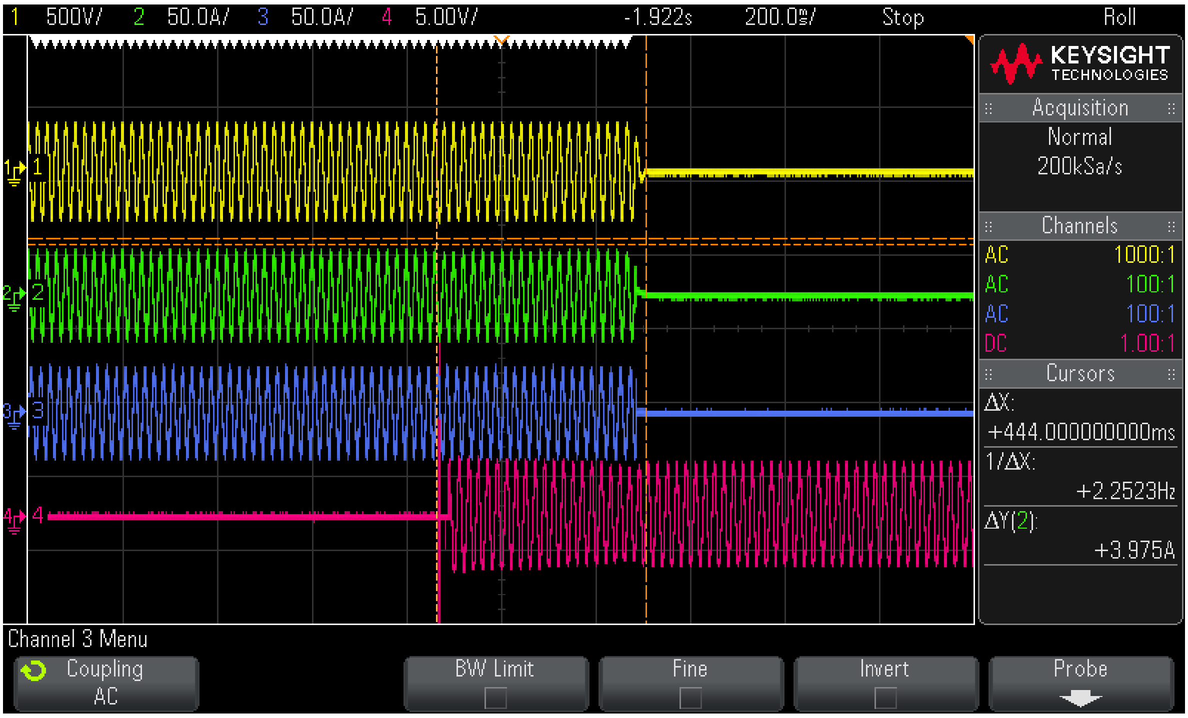


Test B(50Hz)	M(%)=0 & N(%)=-2



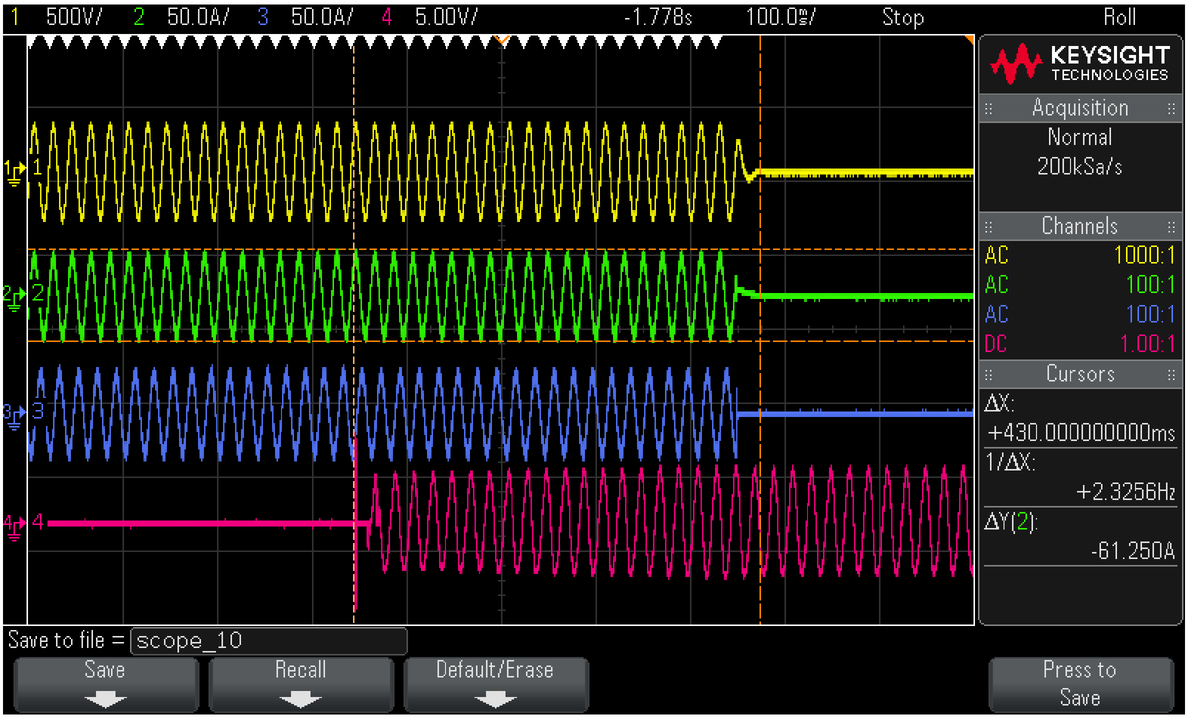
Test B(50Hz)	M(%)=0 & N(%)=-3

DSO-X 3014A, MY58101647: Mon Jun 01 09:44:33 2020

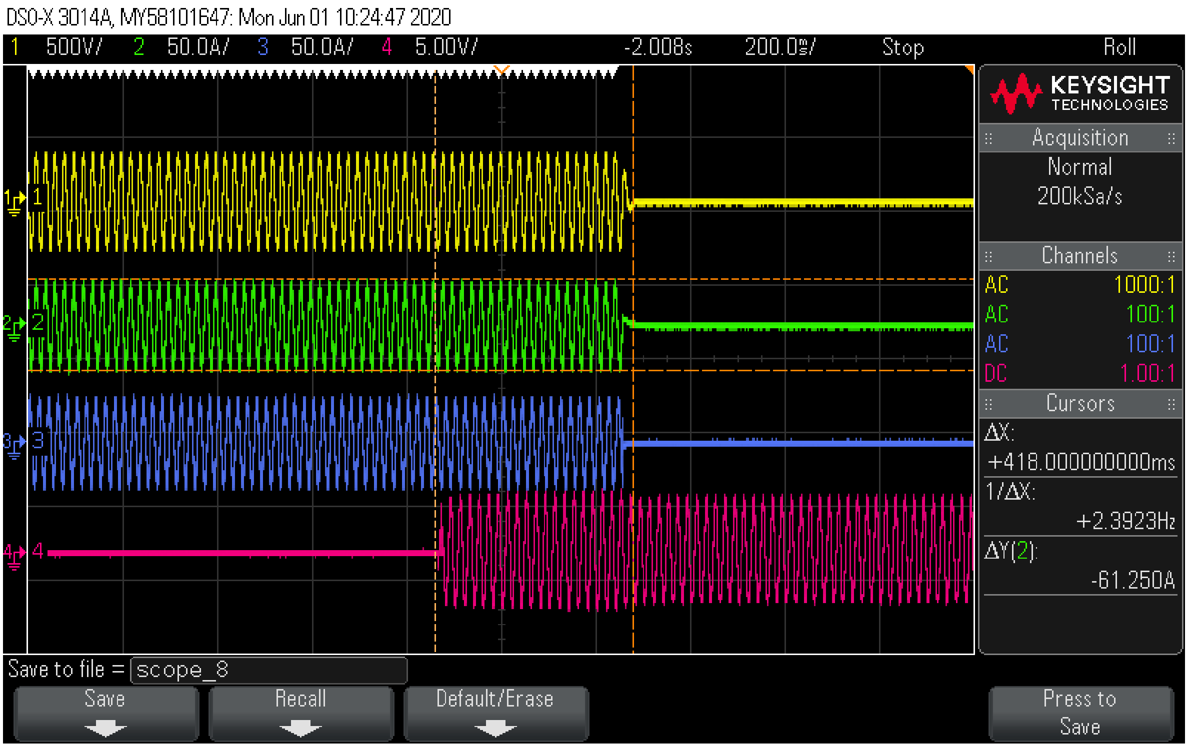


Test B(50Hz)	M(%)=0 & N(%)=-4

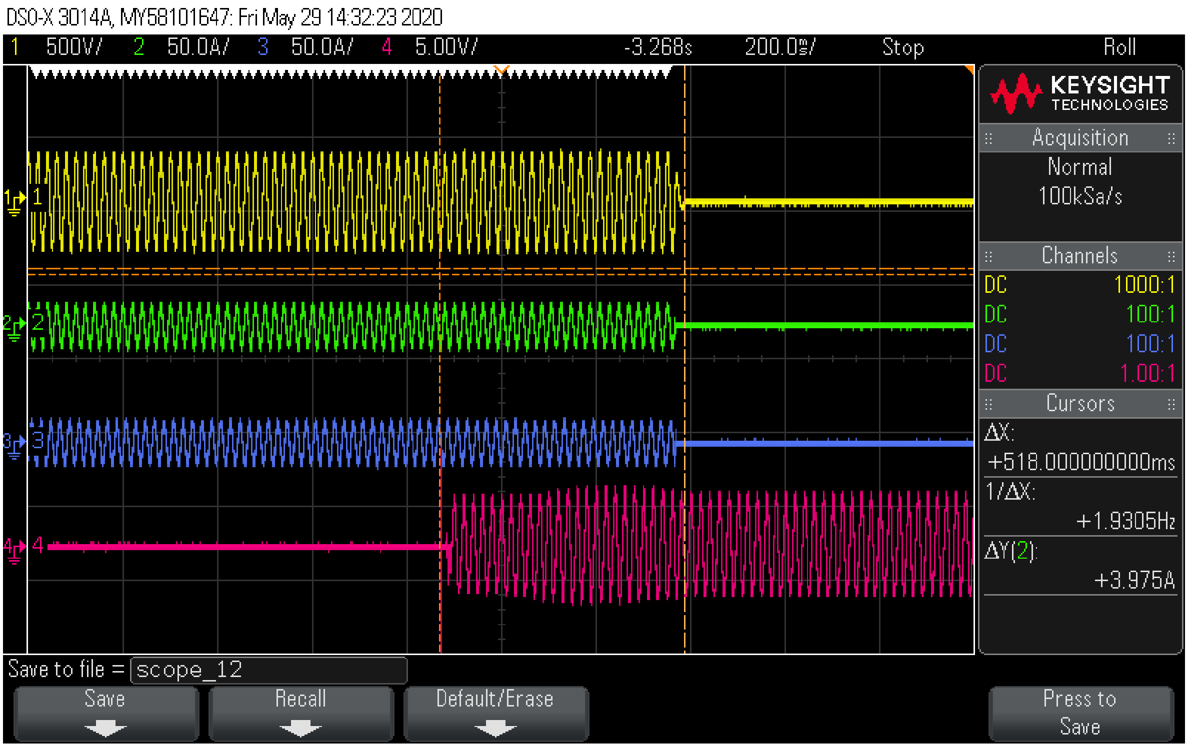
DSO-X 3014A, MY58101647: Mon Jun 01 10:28:53 2020



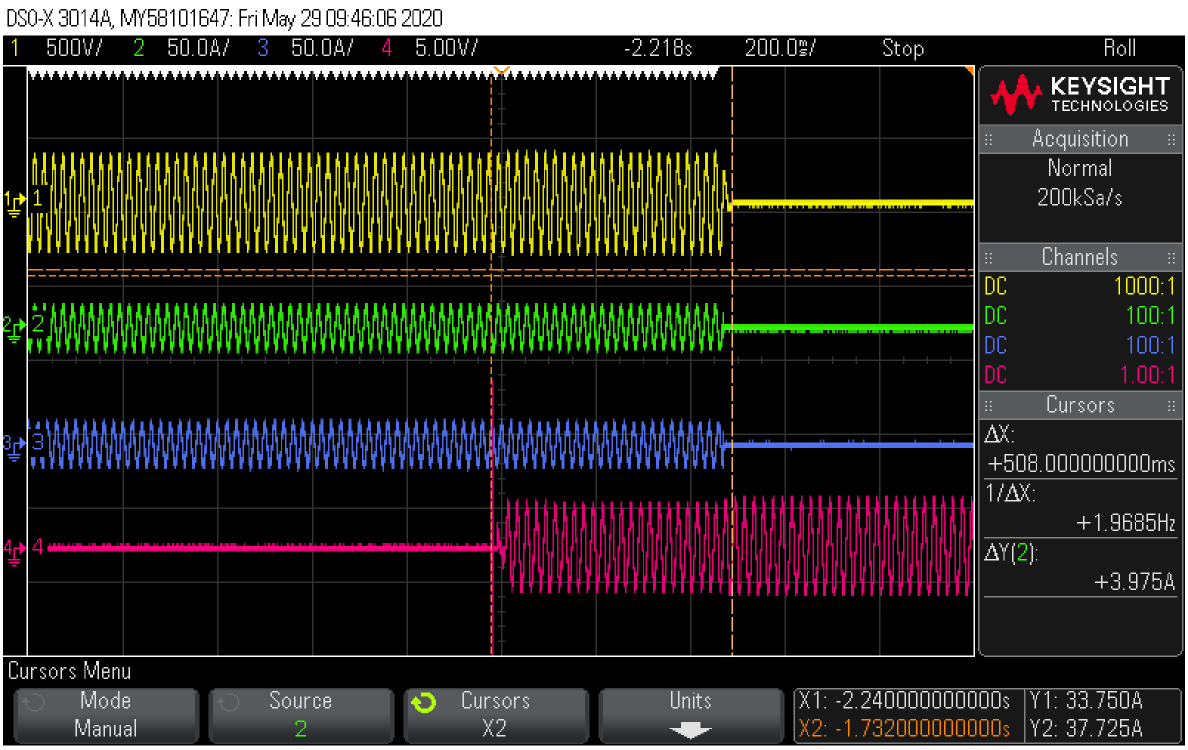
Test B(50Hz)	M(%)=0 & N(%)=-5



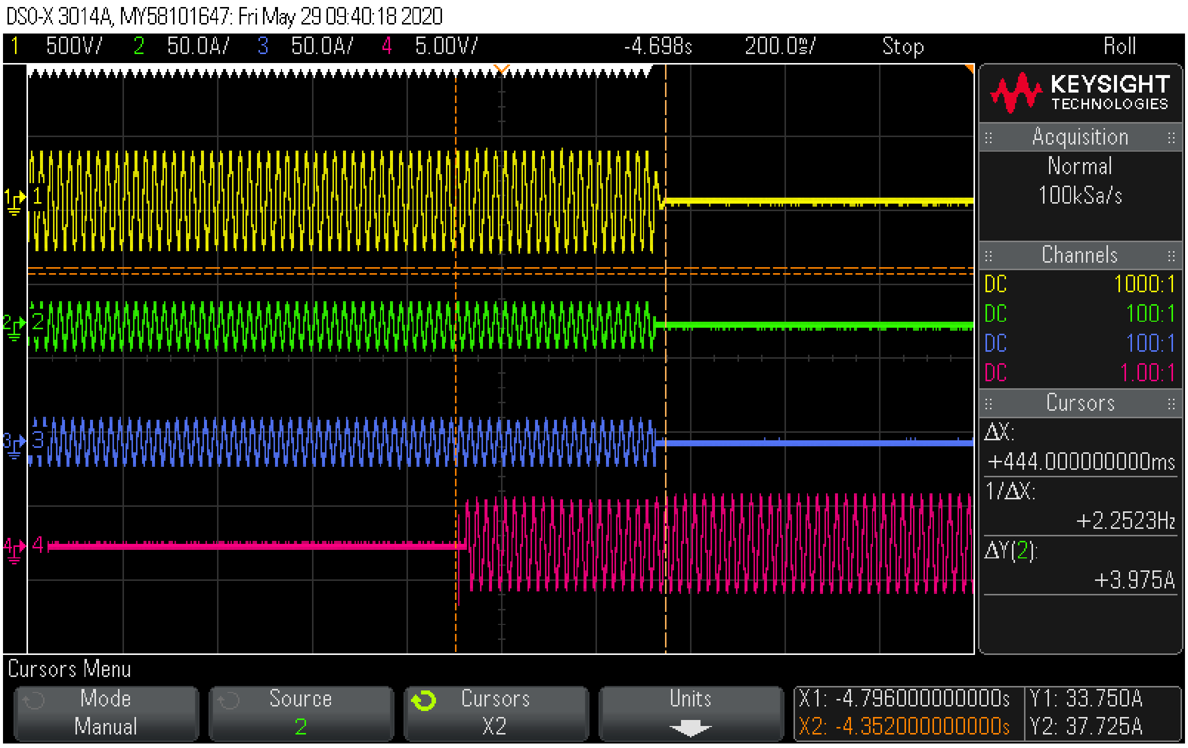
Test C(50Hz)	M(%)=0 & N(%)=0



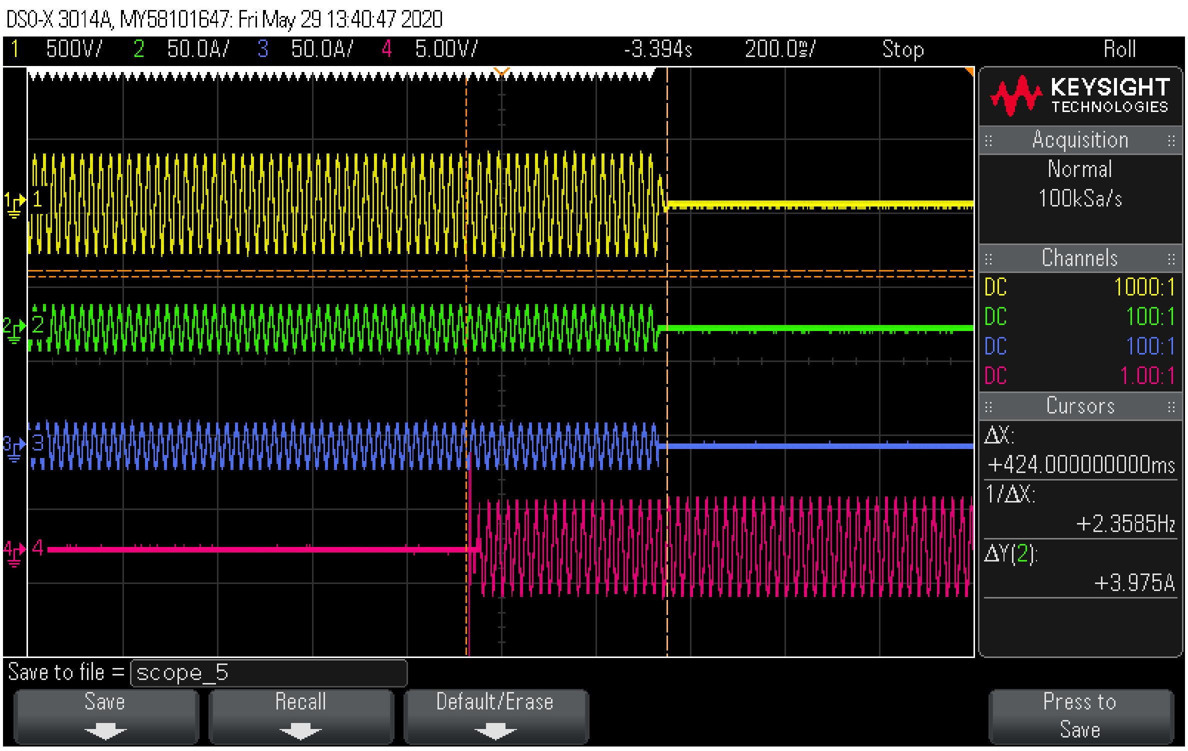
Test C(50Hz)	M(%)=0 & N(%)=+1



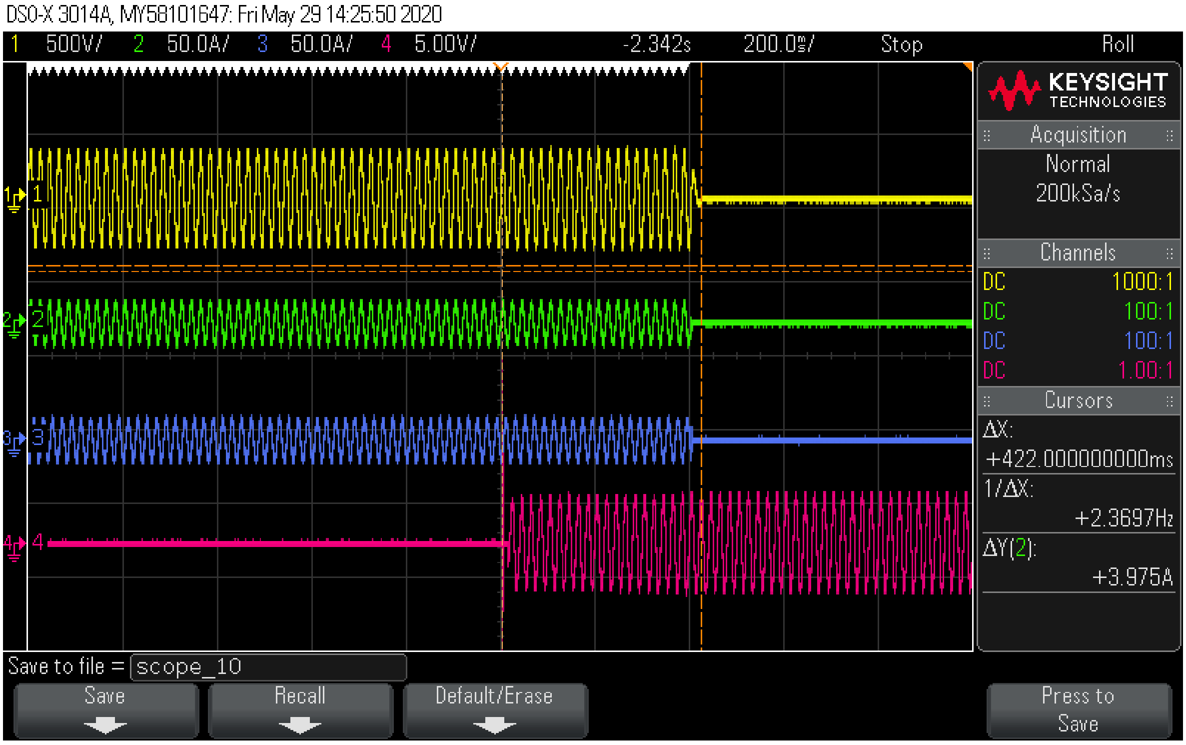
Test C(50Hz)	M(%)=0 & N(%)=+2



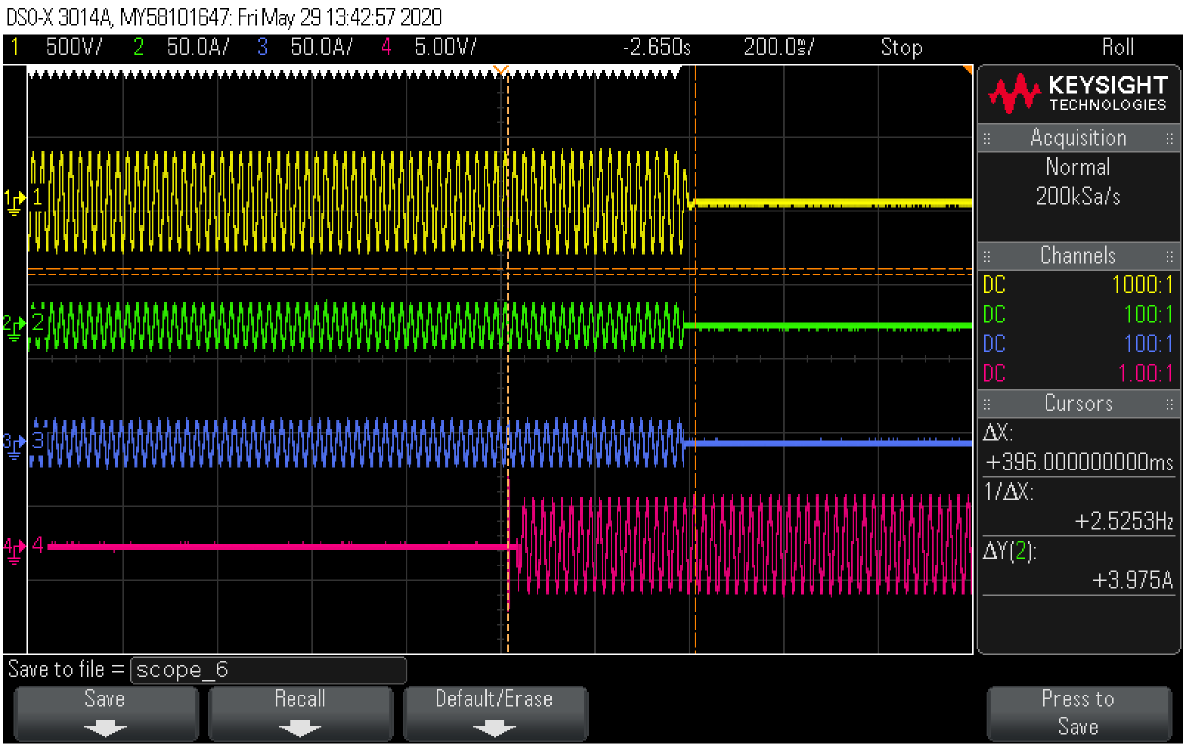
Test C(50Hz)	M(%)=0 & N(%)=+3



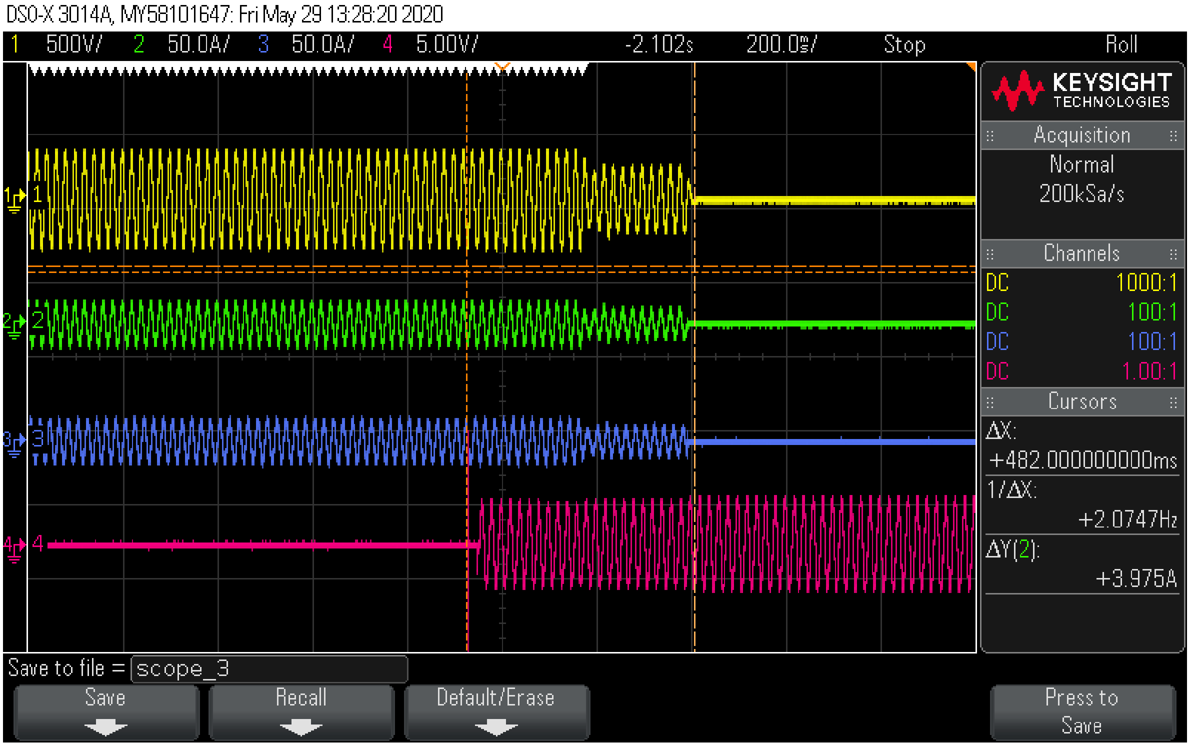
Test C(50Hz)	M(%)=0 & N(%)=+4



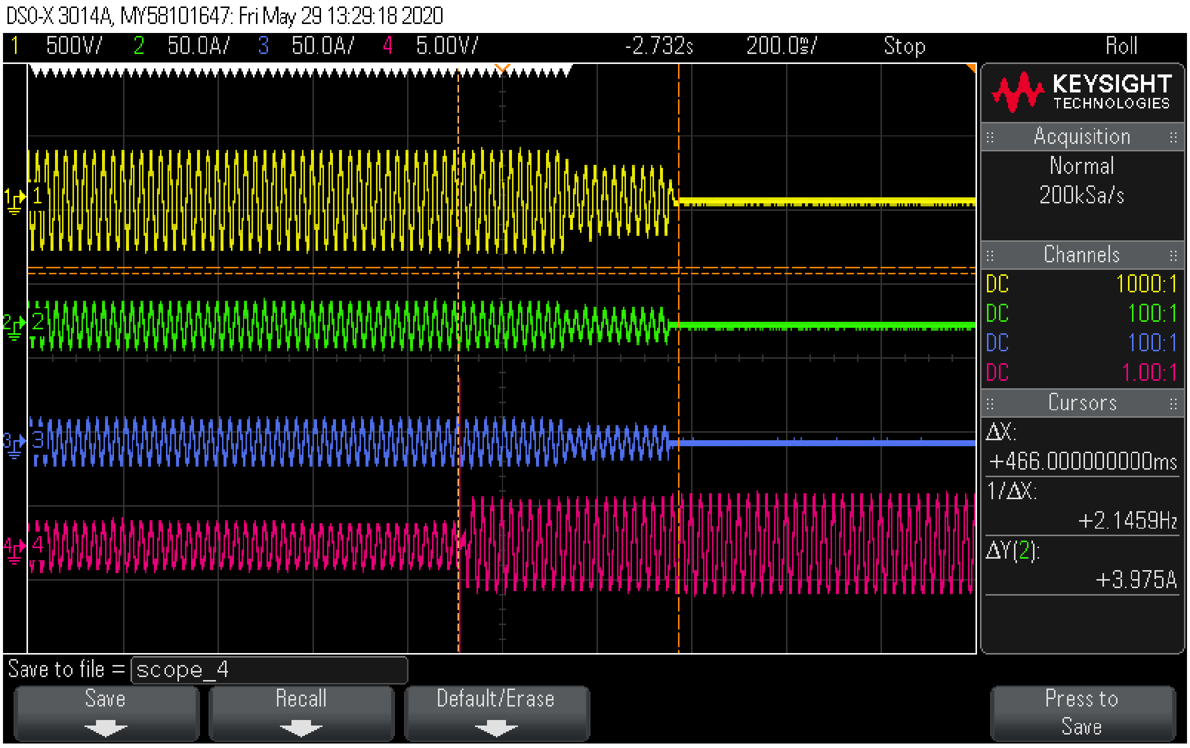
Test C(50Hz)	M(%)=0 & N(%)=+5



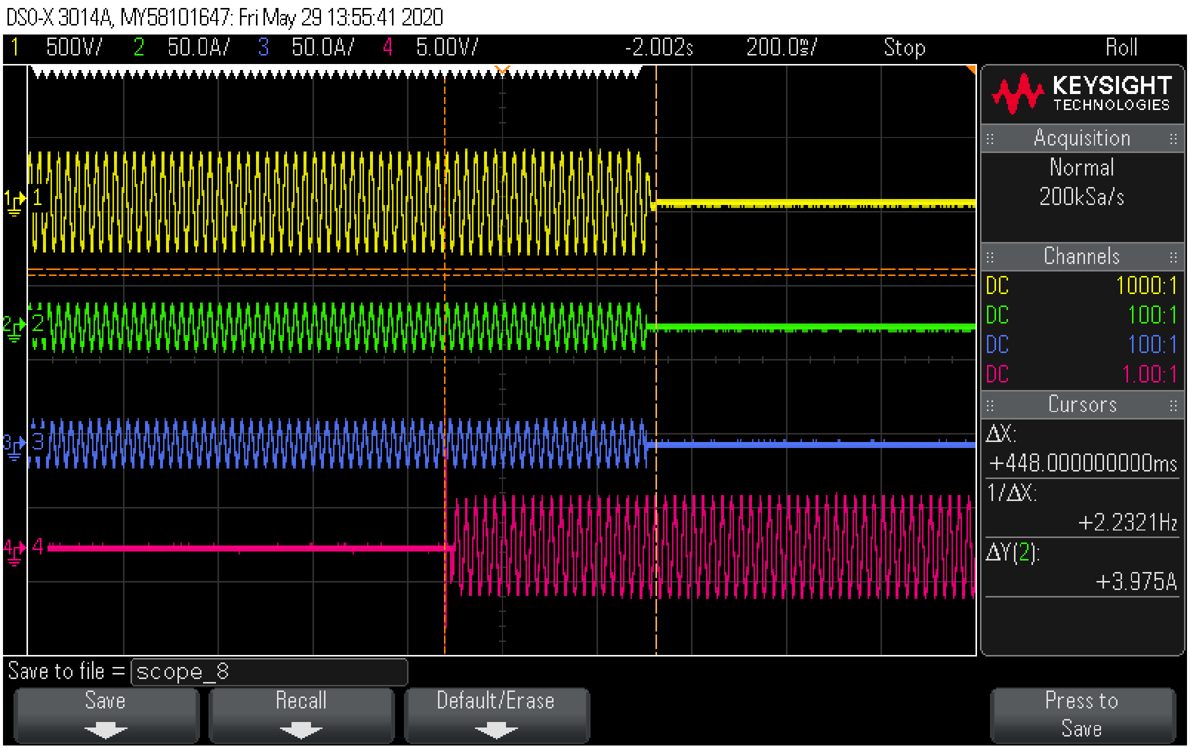
Test C(50Hz)	M(%)=0 & N(%)=-1



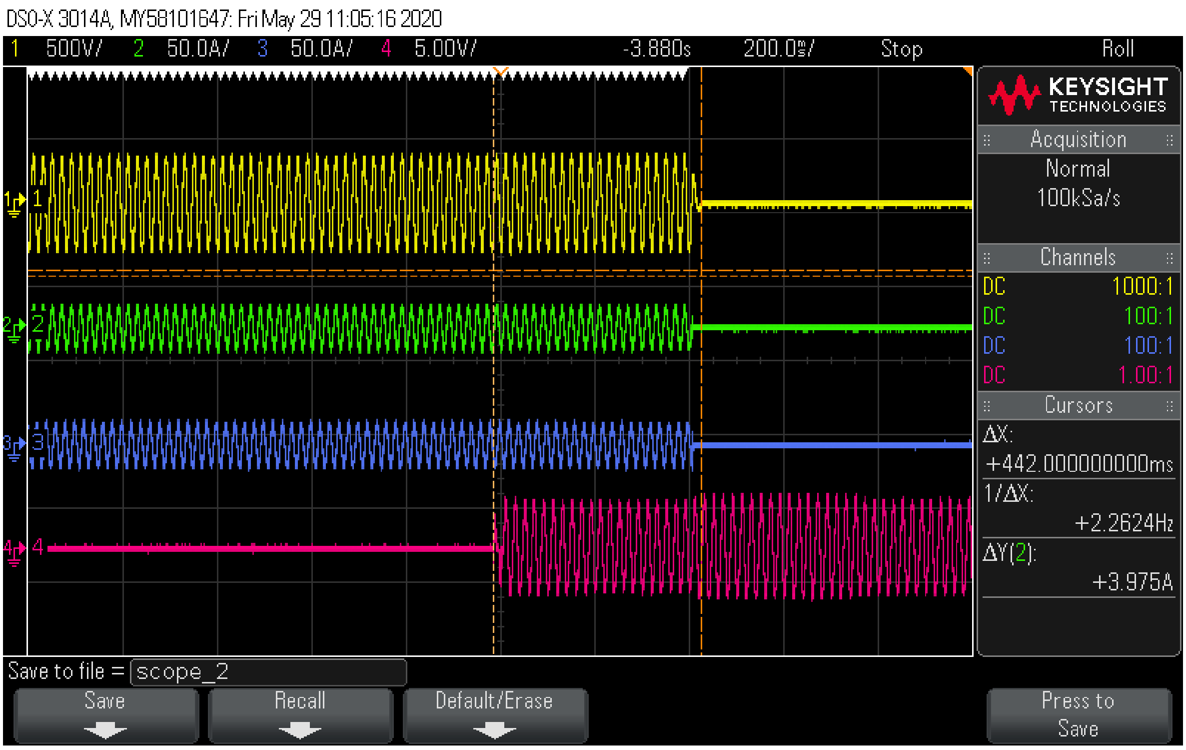
Test C(50Hz)	M(%)=0 & N(%)=-2



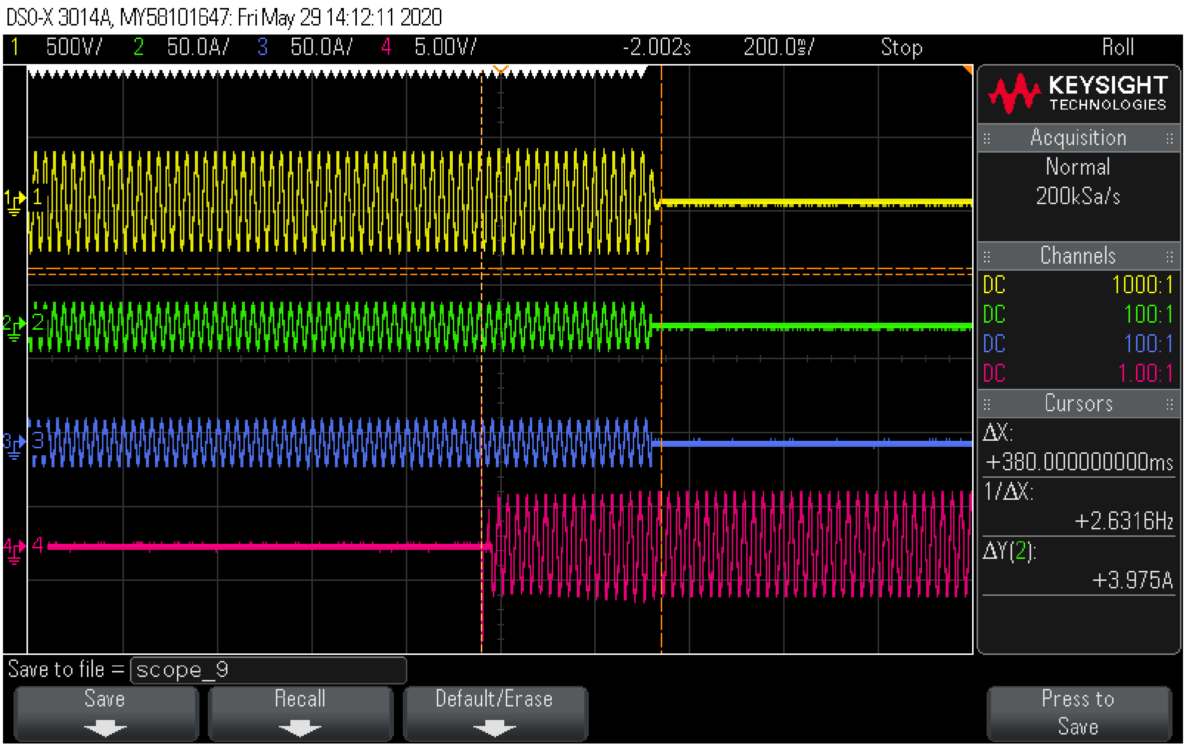
Test C(50Hz)	M(%)=0 & N(%)=-3



Test C(50Hz)	M(%)=0 & N(%)=-4



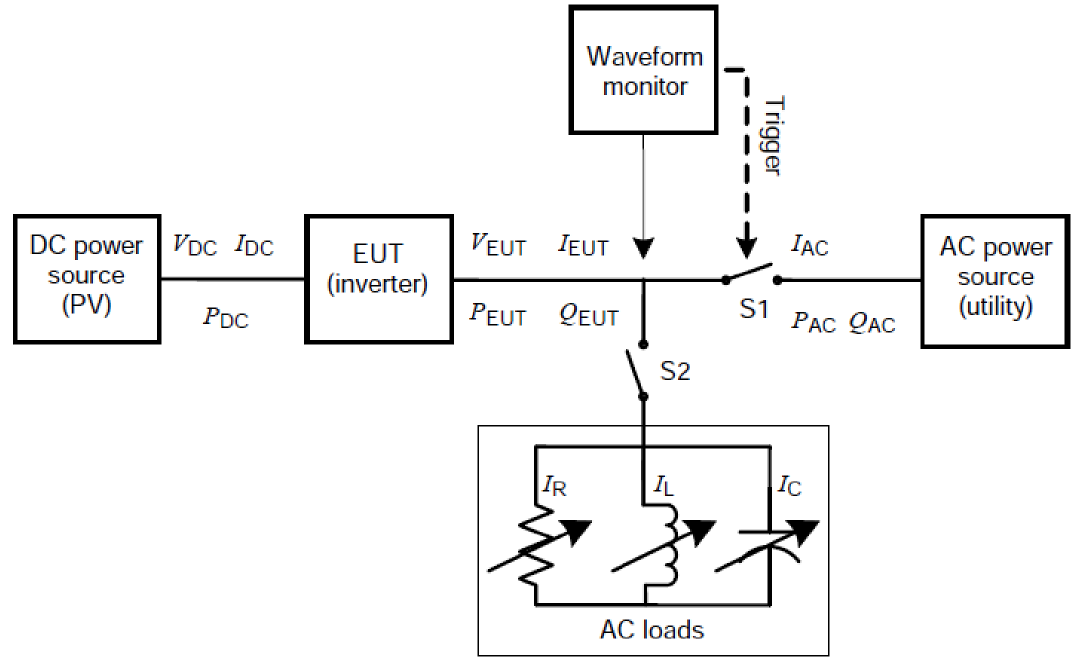
Test C(50Hz)	M(%)=0 & N(%)=-5



ATTACHMENT IV

(Testing information)

1 TESTING CIRCUIT



Current and voltage clamps have been connected to the inverter input/output for all the tests.

All the tests and checks have been performed in accordance with the reference standard under testing.

2 TESTING EQUIPMENT

From	No.	Equipment Name	Model No.	Equipment No.	Calibration Date	Equipment calibration due date
Sofar Solar	1	Digital oscilloscope	MD03024	MY58491772	2020/04/24	2021/04/23
	2	Voltage probe	SI-9110	111152	2020/1/14	2021/1/13
	3	Voltage probe	SI-9110	152627	2020/01/14	2021/01/13
	4	Voltage probe	SI-9110	111134	2020/01/14	2021/01/13
	5	Power analyzer	PA5000H	C8202909082002 110001	2020/03/02	2021/03/01
	6	Current probe	CP1000A	C181000922	2020/01/14	2021/01/13
	7	Current probe	CP1000A	C181000925	2020/01/14	2021/01/13
	8	Current probe	CP1000A	C181000929	2020/01/14	2021/01/13
	9	Temperature & Humidity meter	TH101B	ZB-WSDJ-001	2020/01/14	2021/01/13
SGS	10	True RMS Multimeter	Fluke / 187	GZE012-8	2019/12/05	2020/12/04

Items	Specifications
1) PV array simulator	
a) Voltage range	0 – 1000Vdc (0.01V step)
b) Current range	0 – 40A (0.01A step)
2) AC power source	
a) Output wiring	Three phase
b) Output capacity	100KVA
c) Output voltage	10-300Vrms
d) Output frequency	45-65Hz
e) Voltage stability	± 100ppm/℃
f) Output voltage distortion	0.05% max.
3) Digital meter	
a) Voltage range	0 – 1000Vdc, 0 – 600Vrms
b) Current range	0 – 30A
c) Frequency range (accuracy)	0.2%
d) Measurement items	Voltage (V) Current (A) Active power (W) Reactive power (Var) Volt-ampere (VA) Power factor (PF) Frequency (Hz) Electric energy (Wh)
4) Waveform recorder	
a) Sampling speed	1M/s
b) Recording device	Memory record and USB reading
c) Time accuracy	± 500ppm
5) AC load	
a) Resistive load	Maximum voltage: 300Vrms Current range: 0 – 100A Capacity: 100KW
b) Inductive load	Maximum voltage: 300Vrms Current range: 0 – 100A Capacity: 100KVA
c) Capacitive load	Maximum voltage: 300Vrms Current range: 0 – 100A Capacity: 100KVA

3 MEASUREMENT UNCERTAINTY

	Voltage measurement uncertainty	±1.5 %
	Current measurement uncertainty	±2.0 %
	Frequency measurement uncertainty	±0.2 %
	Time measurement uncertainty	±0.2 %
	Power measurement uncertainty	±2.5 %
	Phase Angle	±1º
	cosφ	±0.01
Note1: Measurements uncertainties showed in this table are maximum allowable uncertainties. The measurement uncertainties associated with other parameters measured during the tests are in the laboratory at disposal of the solicitant. Note2: Where the standard requires lower uncertainties that those in this table. Most restrictive uncertainty has been considered.		

4 MEASUREMENT OF AC SOURCE USED FOR TEST

Items	Desired	Measured	Deviation	Limited
Phase A Voltage(V)	230	229.8	0.2	±2%
Phase B Voltage(V)	230	229.8	0.2	±2%
Phase C Voltage(V)	230	230	0	±2%
Voltage THD (%)	<2.5%	0.03	2.47	<2.5%
Frequency	50	50	0	±0.1Hz
Phase angle distance Phase A to Phase B	120°	119.9°	0.1°	± 1.5°
Phase angle distance Phase A to Phase C	240°	240.0°	0.0°	± 1.5°

AC source voltage harmonics (Phase A)

(Phase A)

Normal Mode   Uover:■ ■ ■ ■   Update:500msec EAMP   YOKOGAWA ◆
Iover:■ ■ ■ ■   Integ:Reset

change items

PLL	U1
Freq	49.997 Hz
Urms1	229.935 V
Irms1	0.0000 A
P1	0.0000kW
S1	0.0000kVA
Q1	0.0000kvar
λ1	Error
φ1	Error
Uthd1	0.027 %
Ithd1	99.608 %
Pthd1	0.075 %
Uthf1	0.026 %
Ithf1	148.594 %
Utif1	1.199
Itif1	---O F---

Or.	U1 [V]	hdf[%]	Or.	U1 [V]	hdf[%]
	229.935		dc	---------	--------
1	229.927	100.000	2	0.020	0.009
3	0.039	0.017	4	0.004	0.002
5	0.014	0.006	6	0.002	0.001
7	0.007	0.003	8	0.002	0.001
9	0.010	0.004	10	0.008	0.004
11	0.008	0.003	12	0.002	0.001
13	0.005	0.002	14	0.002	0.001
15	0.001	0.000	16	0.003	0.002
17	0.006	0.003	18	0.005	0.002
19	0.002	0.001	20	0.002	0.001
21	0.006	0.003	22	0.002	0.001
23	0.003	0.001	24	0.017	0.008
25	0.005	0.002	26	0.015	0.006
27	0.010	0.004	28	0.005	0.002
29	0.001	0.000	30	0.003	0.001
31	0.002	0.001	32	0.005	0.002
33	0.000	0.000	34	0.006	0.003
35	0.002	0.001	36	0.003	0.001
37	0.003	0.001	38	0.002	0.001
39	0.001	0.000	40	0.003	0.001

Σ A(3P4W)
U1 600Vrms
I1 30Arms
U2 600Vrms
I2 30Arms
U3 600Vrms
I3 30Arms

Element4
U4 600Vrms
I4 30Arms

Integ:Reset
Time
-----:--:--
Timer
0:03:00

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Normal Mode   Uover:■ ■ ■ ■   Update:500msec EAMP   YOKOGAWA ◆
Iover:■ ■ ■ ■   Integ:Reset

change items

PLL	U1
Freq	49.997 Hz
Urms1	229.935 V
Irms1	0.0000 A
P1	0.0000kW
S1	0.0000kVA
Q1	0.0000kvar
λ1	Error
φ1	Error
Uthd1	0.027 %
Ithd1	99.608 %
Pthd1	0.075 %
Uthf1	0.026 %
Ithf1	148.594 %
Utif1	1.199
Itif1	---O F---

Or.	U1 [V]	hdf[%]	Or.	U1 [V]	hdf[%]
	229.935		dc	---------	--------
41	0.004	0.002	42	0.004	0.002
43	0.002	0.001	44	0.003	0.001
45	0.004	0.002	46	0.005	0.002
47	0.003	0.001	48	0.008	0.003
49	0.007	0.003	50	0.007	0.003
51	0.005	0.002	52	0.005	0.002
53	0.002	0.001	54	0.003	0.001
55	0.003	0.001	56	0.004	0.002
57	0.001	0.001	58	0.004	0.002
59	0.004	0.002	60	0.002	0.001
61	---------	--------	62	---------	--------
63	---------	--------	64	---------	--------
65	---------	--------	66	---------	--------
67	---------	--------	68	---------	--------
69	---------	--------	70	---------	--------
71	---------	--------	72	---------	--------
73	---------	--------	74	---------	--------
75	---------	--------	76	---------	--------
77	---------	--------	78	---------	--------
79	---------	--------	80	---------	--------

Σ A(3P4W)
U1 600Vrms
I1 30Arms
U2 600Vrms
I2 30Arms
U3 600Vrms
I3 30Arms

Element4
U4 600Vrms
I4 30Arms

Integ:Reset
Time
-----:--:--
Timer
0:03:00

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(Phase B)

Normal Mode Uover:■■■■ I1-3 : 30Arms YOKOGAWA ◆
Iover:■■■■ Integ:Reset

change items
PLL U1
Freq 50.002 Hz

Urms2 229.833 V
Irms2 0.0000 A
P2 -0.0000kW
S2 0.0000kVA
Q2 0.0000kvar
λ2 Error
φ2 Error
Uthd2 0.027 %
Ithd2 99.655 %
Pthd2 0.029 %
Uthf2 0.023 %
Ithf2 149.869 %
Utif2 1.117
Itif2 ---O F---

Or.	U2 [V]	hdf[%]	Or.	U2 [V]	hdf[%]
	229.833		dc	---------	--------
1	229.827	100.000	2	0.010	0.004
3	0.048	0.021	4	0.005	0.002
5	0.016	0.007	6	0.006	0.003
7	0.008	0.003	8	0.005	0.002
9	0.007	0.003	10	0.004	0.002
11	0.003	0.001	12	0.004	0.002
13	0.007	0.003	14	0.004	0.002
15	0.001	0.000	16	0.002	0.001
17	0.007	0.003	18	0.001	0.000
19	0.002	0.001	20	0.006	0.003
21	0.001	0.000	22	0.000	0.000
23	0.002	0.001	24	0.005	0.002
25	0.009	0.004	26	0.004	0.002
27	0.002	0.001	28	0.004	0.002
29	0.002	0.001	30	0.002	0.001
31	0.003	0.001	32	0.002	0.001
33	0.008	0.004	34	0.002	0.001
35	0.004	0.002	36	0.003	0.001
37	0.001	0.000	38	0.005	0.002
39	0.003	0.001	40	0.003	0.001

Σ A(3P4W)
U1 600Vrms
I1 30Arms
U2 600Vrms
I2 30Arms
U3 600Vrms
I3 30Arms

Element4
U4 600Vrms
I4 30Arms

Integ:Reset
Time
-----:--:--
Timer
0:03:00

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Normal Mode Uover:■■■■ I1-3 : 30Arms YOKOGAWA ◆
Iover:■■■■ Integ:Reset

change items
PLL U1
Freq 50.002 Hz

Urms2 229.833 V
Irms2 0.0000 A
P2 -0.0000kW
S2 0.0000kVA
Q2 0.0000kvar
λ2 Error
φ2 Error
Uthd2 0.027 %
Ithd2 99.655 %
Pthd2 0.029 %
Uthf2 0.023 %
Ithf2 149.869 %
Utif2 1.117
Itif2 ---O F---

Or.	U2 [V]	hdf[%]	Or.	U2 [V]	hdf[%]
	229.833		dc	---------	--------
41	0.006	0.002	42	0.003	0.001
43	0.003	0.001	44	0.003	0.001
45	0.007	0.003	46	0.005	0.002
47	0.004	0.002	48	0.001	0.000
49	0.008	0.003	50	0.004	0.002
51	0.006	0.003	52	0.002	0.001
53	0.006	0.003	54	0.004	0.002
55	0.004	0.002	56	0.003	0.001
57	0.002	0.001	58	0.007	0.003
59	0.007	0.003	60	0.003	0.001
61	---------	--------	62	---------	--------
63	---------	--------	64	---------	--------
65	---------	--------	66	---------	--------
67	---------	--------	68	---------	--------
69	---------	--------	70	---------	--------
71	---------	--------	72	---------	--------
73	---------	--------	74	---------	--------
75	---------	--------	76	---------	--------
77	---------	--------	78	---------	--------
79	---------	--------	80	---------	--------

Σ A(3P4W)
U1 600Vrms
I1 30Arms
U2 600Vrms
I2 30Arms
U3 600Vrms
I3 30Arms

Element4
U4 600Vrms
I4 30Arms

Integ:Reset
Time
-----:--:--
Timer
0:03:00

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(PhaseC)

Normal Mode Uover:■ ■ ■ ■ I1-3 : 30Arms YOKOGAWA ◆
Iover:■ ■ ■ ■ Integ:Reset

change items

PLL	U1
Freq	50.002 Hz
Urms3	229.951 V
Irms3	0.0000 A
P3	0.0000kW
S3	0.0000kVA
Q3	0.0000kvar
λ3	Error
φ3	Error
Uthd3	0.027 %
Ithd3	98.724 %
Pthd3	0.010 %
Uthf3	0.024 %
Ithf3	155.307 %
Utif3	1.155
Itif3	---O F---

Or.	U3 [V]	hdf[%]	Or.	U3 [V]	hdf[%]
	229.951		dc	---------	--------
1	229.950	100.000	2	0.034	0.015
3	0.037	0.016	4	0.006	0.003
5	0.016	0.007	6	0.001	0.000
7	0.010	0.004	8	0.001	0.001
9	0.003	0.001	10	0.001	0.000
11	0.003	0.001	12	0.001	0.001
13	0.003	0.001	14	0.003	0.001
15	0.001	0.000	16	0.001	0.001
17	0.005	0.002	18	0.004	0.002
19	0.007	0.003	20	0.003	0.001
21	0.007	0.003	22	0.004	0.002
23	0.003	0.001	24	0.003	0.001
25	0.003	0.001	26	0.004	0.002
27	0.010	0.005	28	0.003	0.001
29	0.004	0.002	30	0.003	0.001
31	0.003	0.001	32	0.003	0.001
33	0.008	0.003	34	0.003	0.001
35	0.003	0.001	36	0.001	0.001
37	0.002	0.001	38	0.002	0.001
39	0.002	0.001	40	0.001	0.001

Σ A(3P4W)
U1 600Vrms
I1 30Arms
U2 600Vrms
I2 30Arms
U3 600Vrms
I3 30Arms

Element4
U4 600Vrms
I4 30Arms

Integ:Reset
Time
-----:--:--
Timer
0:03:00

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Normal Mode Uover:■ ■ ■ ■ I1-3 : 30Arms YOKOGAWA ◆
Iover:■ ■ ■ ■ Integ:Reset

change items

PLL	U1
Freq	50.002 Hz
Urms3	229.951 V
Irms3	0.0000 A
P3	0.0000kW
S3	0.0000kVA
Q3	0.0000kvar
λ3	Error
φ3	Error
Uthd3	0.027 %
Ithd3	98.724 %
Pthd3	0.010 %
Uthf3	0.024 %
Ithf3	155.307 %
Utif3	1.155
Itif3	---O F---

Or.	U3 [V]	hdf[%]	Or.	U3 [V]	hdf[%]
	229.951		dc	---------	--------
41	0.004	0.002	42	0.003	0.001
43	0.004	0.002	44	0.007	0.003
45	0.010	0.004	46	0.003	0.001
47	0.007	0.003	48	0.006	0.002
49	0.005	0.002	50	0.003	0.001
51	0.003	0.001	52	0.005	0.002
53	0.002	0.001	54	0.006	0.003
55	0.003	0.001	56	0.001	0.000
57	0.005	0.002	58	0.008	0.003
59	0.004	0.002	60	0.003	0.001
61	---------	--------	62	---------	--------
63	---------	--------	64	---------	--------
65	---------	--------	66	---------	--------
67	---------	--------	68	---------	--------
69	---------	--------	70	---------	--------
71	---------	--------	72	---------	--------
73	---------	--------	74	---------	--------
75	---------	--------	76	---------	--------
77	---------	--------	78	---------	--------
79	---------	--------	80	---------	--------

Σ A(3P4W)
U1 600Vrms
I1 30Arms
U2 600Vrms
I2 30Arms
U3 600Vrms
I3 30Arms

Element4
U4 600Vrms
I4 30Arms

Integ:Reset
Time
-----:--:--
Timer
0:03:00

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Phase angle distance