TESTING FOR THE VERIFICATION OF COMPLIANCE OF PV INVERTER WITH :

ENGINEERING RECOMMENDATION G98 ISSUE 1-AMENDMENT 3 MARCH 2019,

REQUIREMENTS FOR THE CONNECTION OF FULLY TYPE TESTED MICRO-GENERATORS (UP TO AND INCLUDING 16 A PER PHASE) IN PARALLEL WITH PUBLIC LOW VOLTAGE DISTRIBUTION NETWORKS ON OR AFTER 27 APRIL 2019

Test Report Number	:	**GZES190701991201**
Type	:	
Tested Model	:	**SOFAR 3.6KTLM-G2**
Variant Models	:	**SOFAR 3KTLM-G2**

APPLICANT

Hired by	:	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.

TESTING LABORATORY

Name	:	SGS-CSTC Standards Technical Services Co., Ltd. - E&E Lab Guangzhou
Address	:	198 Kezhu Road, Scientech Park, Guangzhou Economic & Technology Development District, Guangzhou, Guangdong, China 510663
Conducted (tested) by	:	Michael Tong (Project Engineer)
Approved by	:	Roger Hu (Technical Reviewer)

Date of issue	:	**04/07/2019**
Number of pages	:	**122**

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Test Report Historical Revision:

Test Report Version	Date	Resume
GZES190101070001	27 / 05 / 2019	First issuance
GZES190701991201	04 / 07 / 2019	Update the Limited Frequency Sensitive Mode - Overfrequency test.

INDEX

1 SCOPE

SGS-CSTC Standards Technical Services Co., Ltd. - E&E Lab Guangzhou.has been contract by Shenzhen SOFAR SOLAR Co., Ltd, in order to perform the testing according the “ENGINEERING RECOMMENDATION G98 ISSUE 1 - AMENDMENT 3 March 2019, REQUIREMENTS FOR THE CONNECTION OF FULLY TYPE TESTED MICRO-GENERATORS (UP TO AND INCLUDING 16 A PER PHASE) IN PARALLEL WITH PUBLIC LOW VOLTAGE DISTRIBUTION NETWORKS ON OR AFTER 27 APRIL 2019”.

2 GENERAL INFORMATION

2.1 TESTING PERIOD AND CLIMATIC CONDITIONS

The necessary testing has been performed along 12 working days between February 22, 2019 and May 14, 2019 and at July 3, 2019.

All the tests and checks have been performed at 25 ± 5ºC, 96 kPa ± 10 kPa and 50% RH ± 10% RH).

SITE TEST

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.

2.2 EQUIPMENT UNDER TESTING

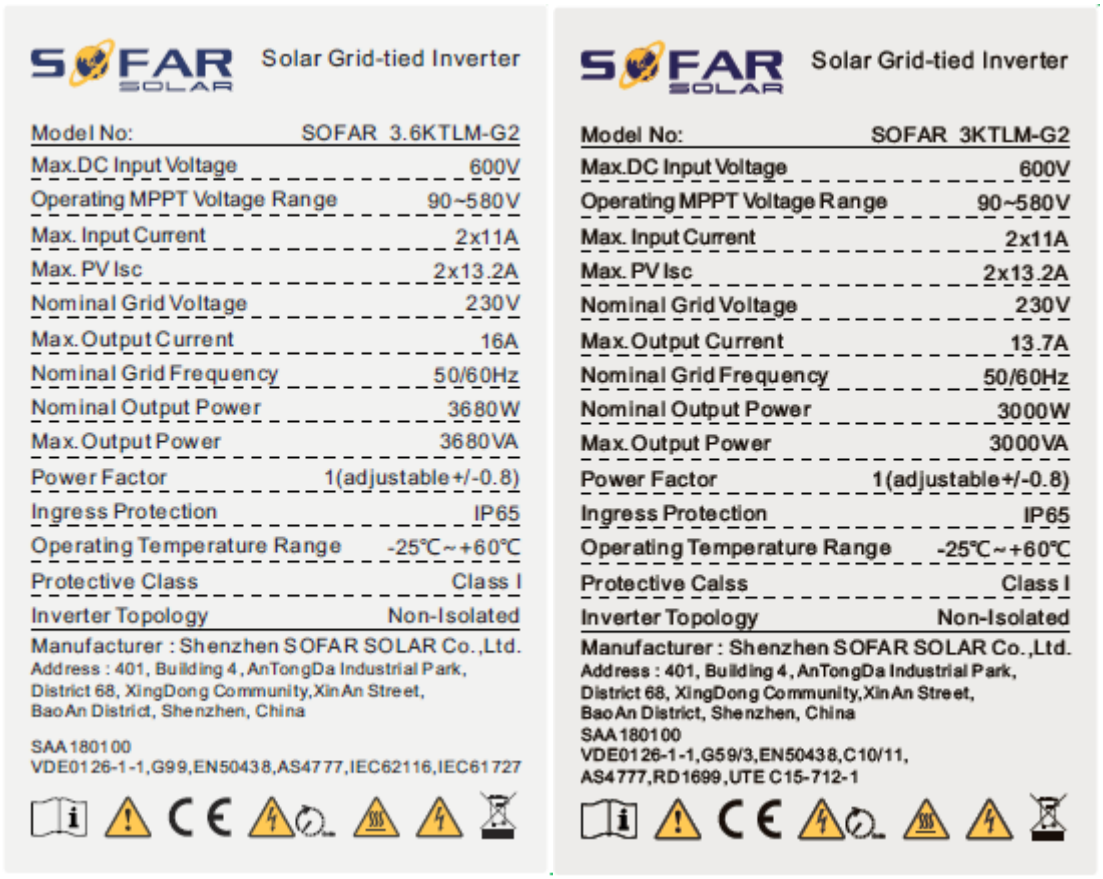
Apparatus type ..... :	Solar Grid-tied Inverter
Installation ..... :	Fixed (permanent connection)
Manufacturer ..... :	Shenzhen SOFAR SOLAR Co., Ltd.
Address ..... :	1F – 6F, Building E, No.1 JinQi Road, Bihu Industrial Park, Wulian Village, Fenggang Town, Dongguan, P.R. China.
Trade mark ..... :	SOFAR SOLAR
Model / Type reference ..... :	SOFAR 3.6KTLM-G2
Serial Number ..... :	SH1CS060JCM381
Software Version ..... :	V1.50
Rated Characteristics ..... :	DC input: 90-580V, 11/11A AC output: 230V, 50Hz, 16A, 3680VA

Date of manufacturing: 2018

Test item particulars

Input ..... :	DC
Output.....	AC
Class of protection against electric shock... :	Class I
Degree of protection against moisture ..... :	IP 65
Type of connection to the main supply ..... :	TN
Cooling group ..... :	Heat sink
Modular ..... :	No
Internal Transformer..... :	No

Copy of marking plate:



SOFAR SOLAR Solar Grid-tied Inverter

Model No:	SOFAR 3.6KTLM-G2
Max.DC Input Voltage	600V
Operating MPPT Voltage Range	90~580V
Max. Input Current	2x11A
Max. PV Isc	2x13.2A
Nominal Grid Voltage	230V
Max.Output Current	16A
Nominal Grid Frequency	50/60Hz
Nominal Output Power	3680W
Max.Output Power	3680VA
Power Factor	1(adjustable+/-0.8)
Ingress Protection	IP65
Operating Temperature Range	-25℃~+60℃
Protective Class	Class I
Inverter Topology	Non-Isolated

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

SAA180100
VDE0126-1-1,G99,EN50438,AS4777,IEC62116,IEC61727

SOFAR SOLAR Solar Grid-tied Inverter

Model No:	SOFAR 3KTLM-G2
Max.DC Input Voltage	600V
Operating MPPT Voltage Range	90~580V
Max. Input Current	2x11A
Max. PV Isc	2x13.2A
Nominal Grid Voltage	230V
Max.Output Current	13.7A
Nominal Grid Frequency	50/60Hz
Nominal Output Power	3000W
Max.Output Power	3000VA
Power Factor	1(adjustable+/-0.8)
Ingress Protection	IP65
Operating Temperature Range	-25℃~+60℃
Protective Calss	Class I
Inverter Topology	Non-Isolated

Manufacturer : Shenzhen SOFAR SOLAR Co.,Ltd.
Address : 401, Building 4, AnTongDa Industrial Park,
District 68, XingDong Community,XinAn Street,
BaoAn District, Shenzhen, China
SAA180100
VDE0126-1-1,G59/3,EN50438,C10/11,
AS4777,RD1699,UTE C15-712-1

Note:

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

Equipment Under Testing:

- **SOFAR 3.6KTLM-G2**

The variants models are:

- **SOFAR 3KTLM-G2**

The variants models are:

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.
- Output power within 2.5 and 2/3 of the EUT or Modular inverters.
- Same Firmware Version

The results obtained apply only to the particular sample tested that is the subject of the present test report. The most unfavorable result values of the verifications and tests performed are contained herein. Throughout this report a point ~~(comma)~~ is used as the decimal separator.

2.3 TEST EQUIPMENT LIST

From	No.	Equipment Name	MARK/Model No.	Equipment No.	Equipment calibration due date
Sofar Solar	1	Digital oscilloscope	Agilent / DSO5014A	MY50070266	2020-02-12
	2	Current clamp	FLUKE / i1000s	29503223	2020-02-12
	3	Current clamp	FLUKE / i1000s	30413441	2020-02-12
	4	Current clamp	FLUKE / i1000s	30413448	2020-02-12
	5	Differential probe	Sanhua / SI-9110	111541	2020-02-12
	6	Differential probe	Sanhua / SI-9110	152627	2020-02-12
	7	Differential probe	Sanhua / SI-9110	111134	2020-02-12
	8	Power analyzer	ZLG / PA3000	PA3005-P0005-1246	2020-02-12
	9	Temperature & Humidity meter	Anymetre/ TH101B	201030245220	2020-02-12
	10	Power analyzer	Yokogawa / WT3000	91N610888	2020-02-12
	11	Digital oscilloscope	KEYSIGHT / DSOX3024T	MY57251898	2020-02-12
SGS	12	True RMS Multimeter	Fluke / 289C	SHES100602 (15100038)	2020-01-06

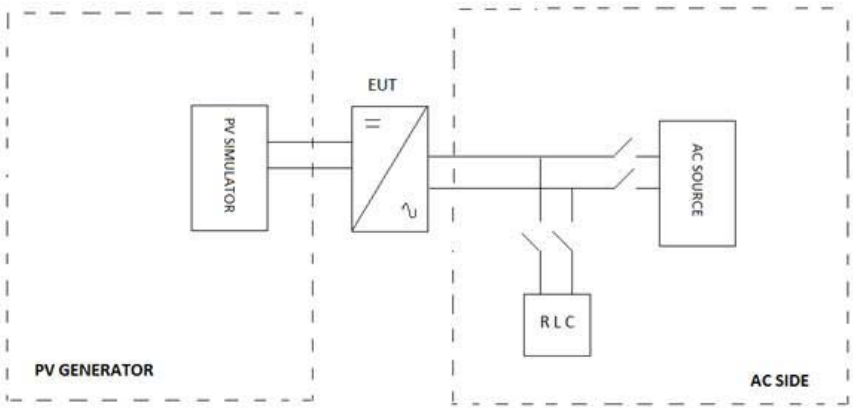
2.4 MEASUREMENT UNCERTAINTY

Associated uncertainties through measurements showed in this this report are the maximum allowable uncertainties.

Magnitude	Uncertainty
Voltage measurement	±0.05 %
Current measurement	±0.05 %
Frequency measurement	±0.001 Hz
Time measurement	±0.001s
Power measurement	±0.5 %
Phase Angle	±0.1º
Temperature	±3º C
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.	

2.5 TEST SET UP OF THE DIFFERENT STANDARD

Below is the simplified construction of the test set up.



Different equipment has been used to take measures as it shows in chapter 2.3. Current and voltage clamps have been connected to the inverter input / output for all the tests.
All the tests described in the following pages have used this specified test setup.

The test bench used includes:

No.	Equipment Name	MARK/Model No.	Equipment No,
1	AC Source	Parwa / PVS7030T	16100790
2	PV Array Simulator	Chroma 62150H	BZ-EP-L002
3	RLC Load	ACLT-38160H	BZ-DGD-L003

2.6 Definitions

EUT	Equipment Under Testing	Hz	Hertz
A	Ampere	V	Volt
VAr	Volt-Ampere reactive	W	Watt
EMC	Electromagnetic Compatibility	p.u	Per unit
Un	Nominal Voltage	Pn	Nominal Active Power
In	Nominal Current	Qn	Nominal Reactive Power
Ia	Active Current	Sn	Nominal Apparent Power
Ir	Reactive Current	THD	Total Harmonic Distortion
I_h	Harmonic Current	TDD	Total Demand Distortion
PWHD	Partial Weighted Harmonic Distortion	PLT	Severity of Flicker Long-Term
		d(t)	Variation of Voltage
PST	Severity of Flicker Short-Term	OV	Over Voltage
d max	Maximum Absolute Value of Voltage Variation	OF	Over Frequency
UV	Under Voltage	UF	Under Frequency

3 RESUME OF TEST RESULTS

INTERPRETATION KEYS

Test object does meet the requirement ..... **P** Pass
Test object does not meet the requirement..... **F** Fails
Test case does not apply to the test object ..... **N/A** Not applicable
To make a reference to a table or an annex. ..... See additional sheet
To indicate that the test has not been realized ..... **N/R** Not realized

STANDAARD CLAUSE	STANDARD REQUIREMENTS		RESULT
	G98 Issue 1 Amendment 3 March 2019		
	TEST	REMARKS	
EN 50438 D.3.1.	Operating Range		P
EREC G98 Annex A1 A1.3.1	Harmonics		P
EREC G98 Annex A1 A1.3.3	Voltage fluctuations and Flicker		P
EN 50438 Annex D.3.10	DC injection		P
EN 50538 Annex D.3.4.1	Power factor		P
EREC G98 Annex A1 A.1.2.3	Frequency tests		P
EREC G98 Annex A1 A.1.2.2	Voltage tests		P
BS EN 62116	Loss of Mains test		P
EREC G98 Annex A1 A.1.2.6	Frequency change, Vector Shift Stability test		P
EREC G98 Annex A1 A.1.2.6	Frequency change, RoCoF Stability test		P
EN 50438 Annex D.3.3	Overfrequency test		P
EN 50438 Annex D.3.2	Power output with falling frequency test		P
EN 50438 Annex A12	Re-connection timer.		P
EREC G98 Annex A1 A.1.3.5	Fault level contribution		P
EREC G98 Annex A1 A.1.3.6	Self-Monitoring solid state switching	No solid state switching devices	N/A
EREC G98 Annex A1 A.1.3.7	Electromagnetic Compatibility (EMC)		P

4 TEST RESULTS

4.1 Operating Range

This test should be carried out as specified in EN 50438 D.3.1.

Active Power shall be recorded every second. The tests will verify that the Micro-generator can operate within the required ranges for the specified period of time.

The Interface Protection shall be disabled during the tests.

In case of a PV Micro-generator the PV primary source may be replaced by a DC source.

In case of a full converter Micro-generator (eg wind) the primary source and the prime mover Inverter/rectifier may be replaced by a DC source.

In case of a DFIG Micro-generator the mechanical drive system may be replaced by a test bench motor.

Test 1:

Voltage = 85% of nominal (195.5 V)

Frequency = 47.5 Hz

Power factor = 1

Period of test 90 minutes

Test 2:

Voltage = 110% of nominal (253 V).

Frequency = 51.5 Hz

Power factor = 1

Period of test 90 minutes

Test 3:

Voltage = 110% of nominal (253 V).

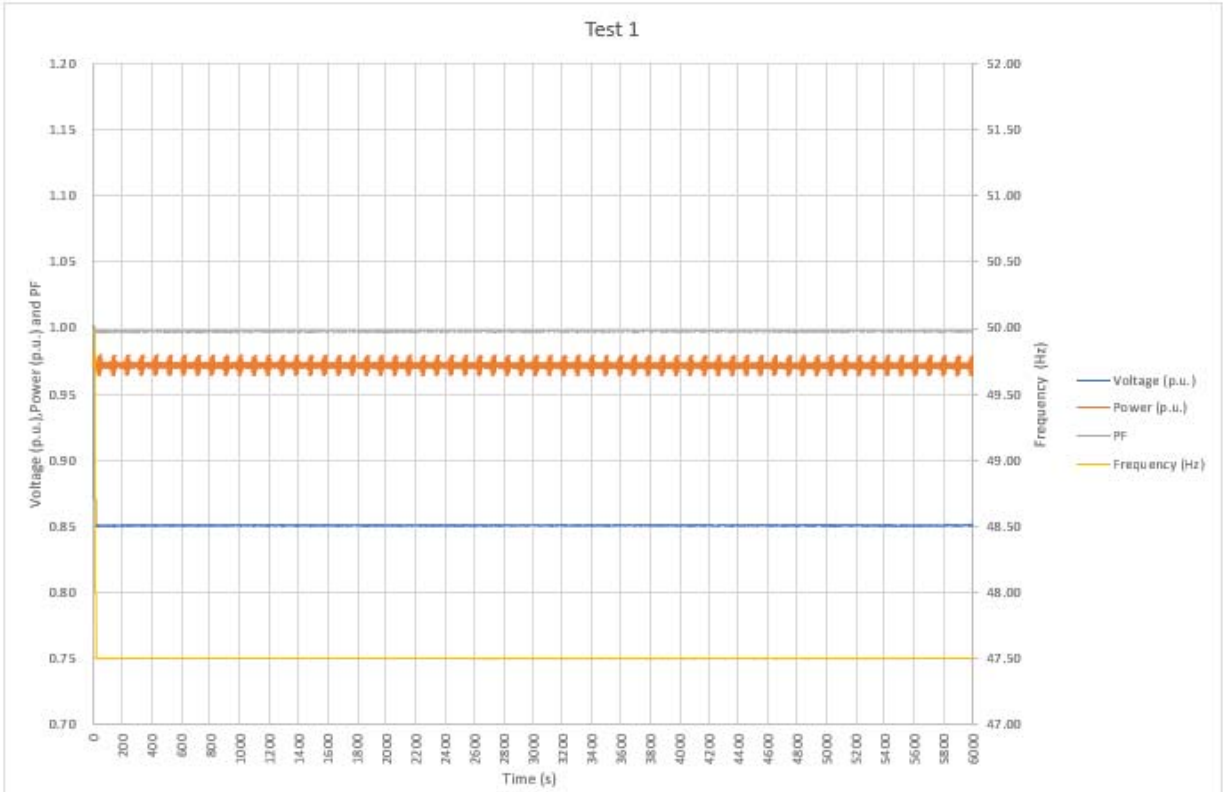
Frequency = 52.0 Hz

Power factor = 1

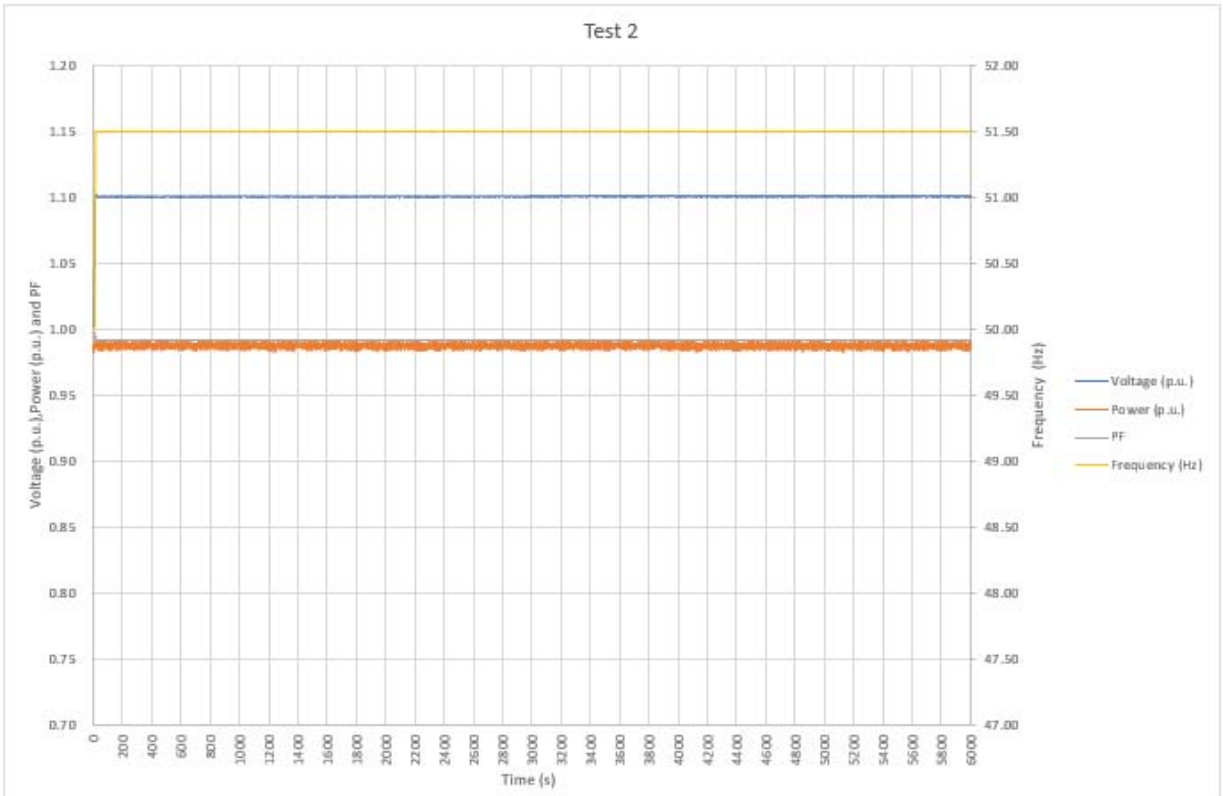
Period of test 15 minutes

Test results are graphically shown in following pages.

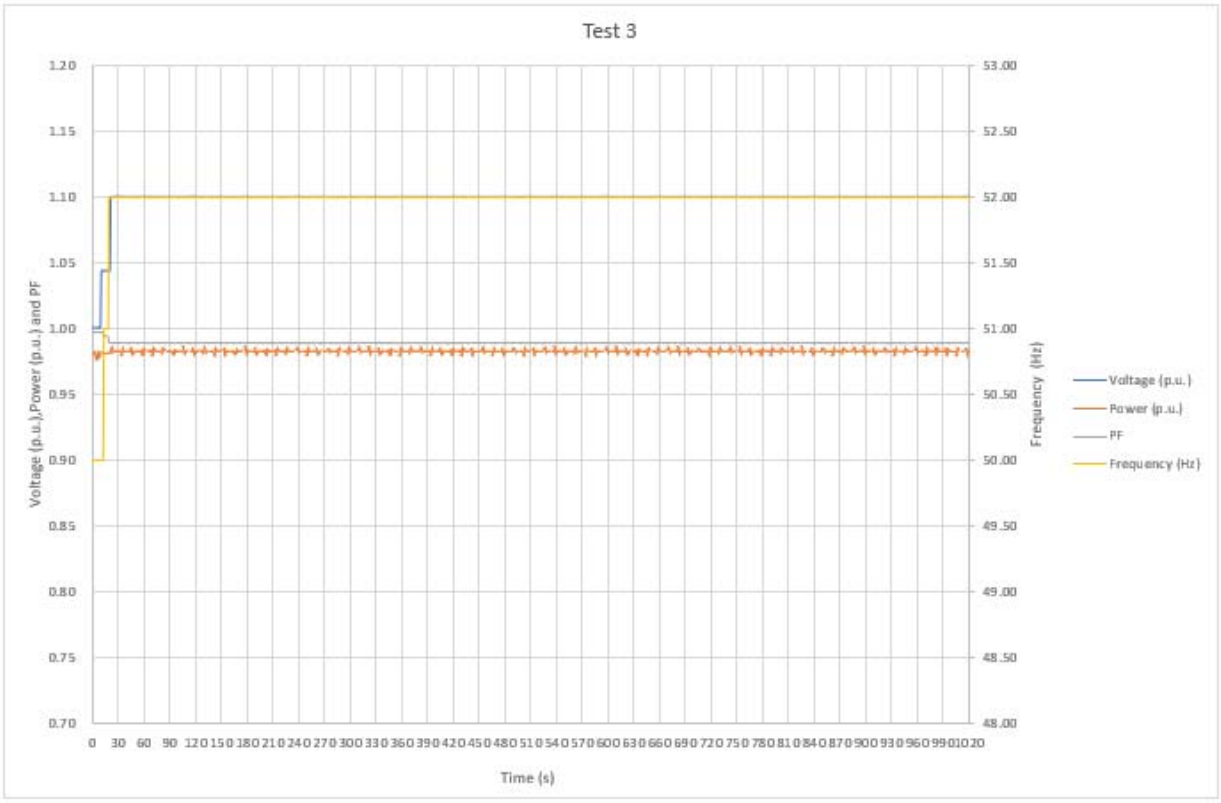
Test 1


Test 1
Voltage (p.u.),Power (p.u.) and PF
Frequency (Hz)
Time (s)
Voltage (p.u.)
Power (p.u.)
PF
Frequency (Hz)

Test 2


Test 2
Voltage (p.u.),Power (p.u.) and PF
Frequency (Hz)
Time (s)
Voltage (p.u.)
Power (p.u.)
PF
Frequency (Hz)

Test 3


Test 3
Voltage (p.u.),Power (p.u.) and PF
Frequency (Hz)
Time (s)
Voltage (p.u.)
Power (p.u.)
PF
Frequency (Hz)

4.2 POWER QUALITY

4.2.1 Current Harmonics

The tests should be carried out as specified in BS EN 61000-3-2 and can be undertaken with a fixed source of energy at two power levels firstly between 45 and 55% and at 100% of Registered Capacity. The test requirements are specified in Annex A1 A.1.3.1 (Inverter connected) or Annex A2 A.2.3.1 (Synchronous).

Measures have been repeated at 50%P_n and 100%P_n.

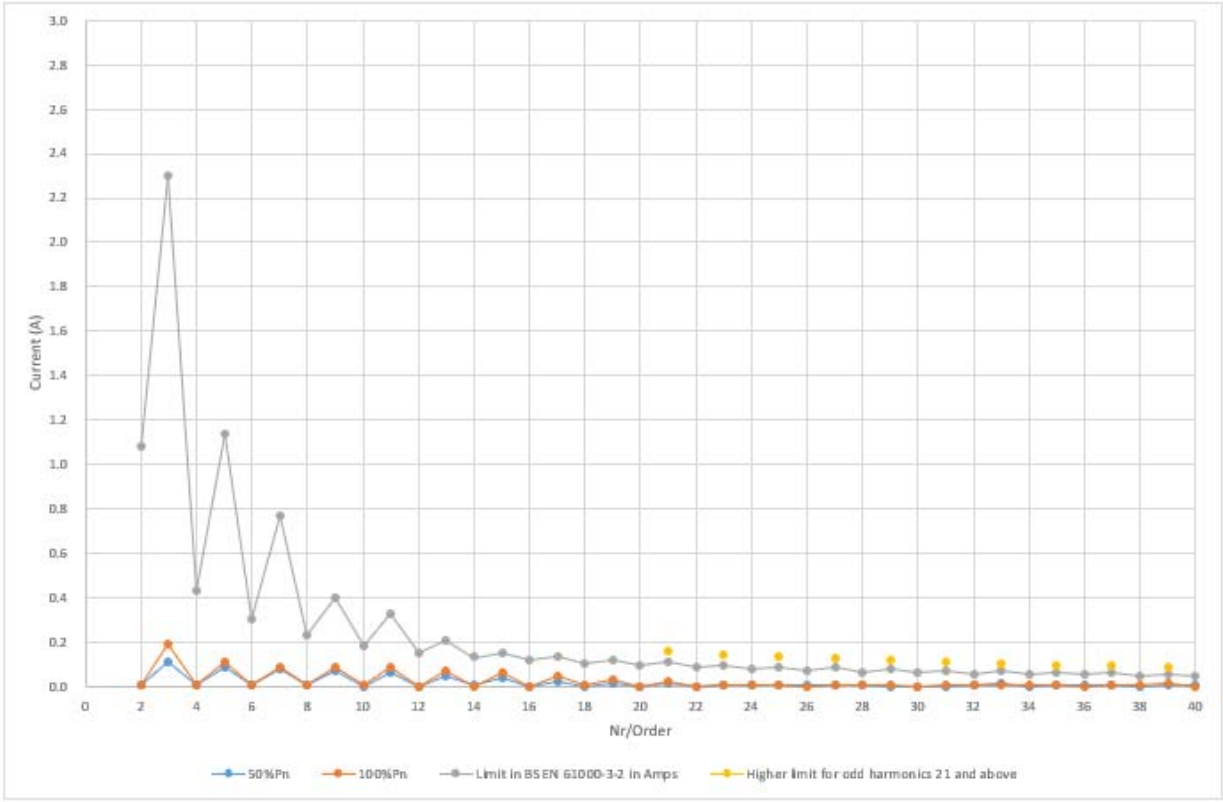
Following tables show the test results:

Micro-generator rating per phase (rpp)			3.68	kW		
Harmonic	At 45-55% of **Registered Capacity**		100% of **Registered Capacity**			
	Measured Value MV in Amps	Ih(%)	Measured Value MV in Amps	Ih(%)	Limit in BS EN 61000-3-2 in Amps	Higher limit for odd harmonics 21 and above
2	0.003	0.019	0.005	0.031	1.080	
3	0.114	0.713	0.194	1.213	2.300	
4	0.004	0.025	0.003	0.019	0.430	
5	0.086	0.538	0.111	0.694	1.140	
6	0.004	0.025	0.004	0.025	0.300	
7	0.078	0.488	0.085	0.531	0.770	
8	0.003	0.019	0.004	0.025	0.230	
9	0.067	0.419	0.084	0.525	0.400	
10	0.002	0.013	0.004	0.025	0.184	
11	0.062	0.388	0.087	0.544	0.330	
12	0.002	0.013	0.002	0.013	0.153	
13	0.047	0.294	0.071	0.444	0.210	
14	0.003	0.019	0.002	0.013	0.131	
15	0.038	0.238	0.060	0.375	0.150	
16	0.002	0.013	0.002	0.013	0.115	
17	0.026	0.163	0.043	0.269	0.132	

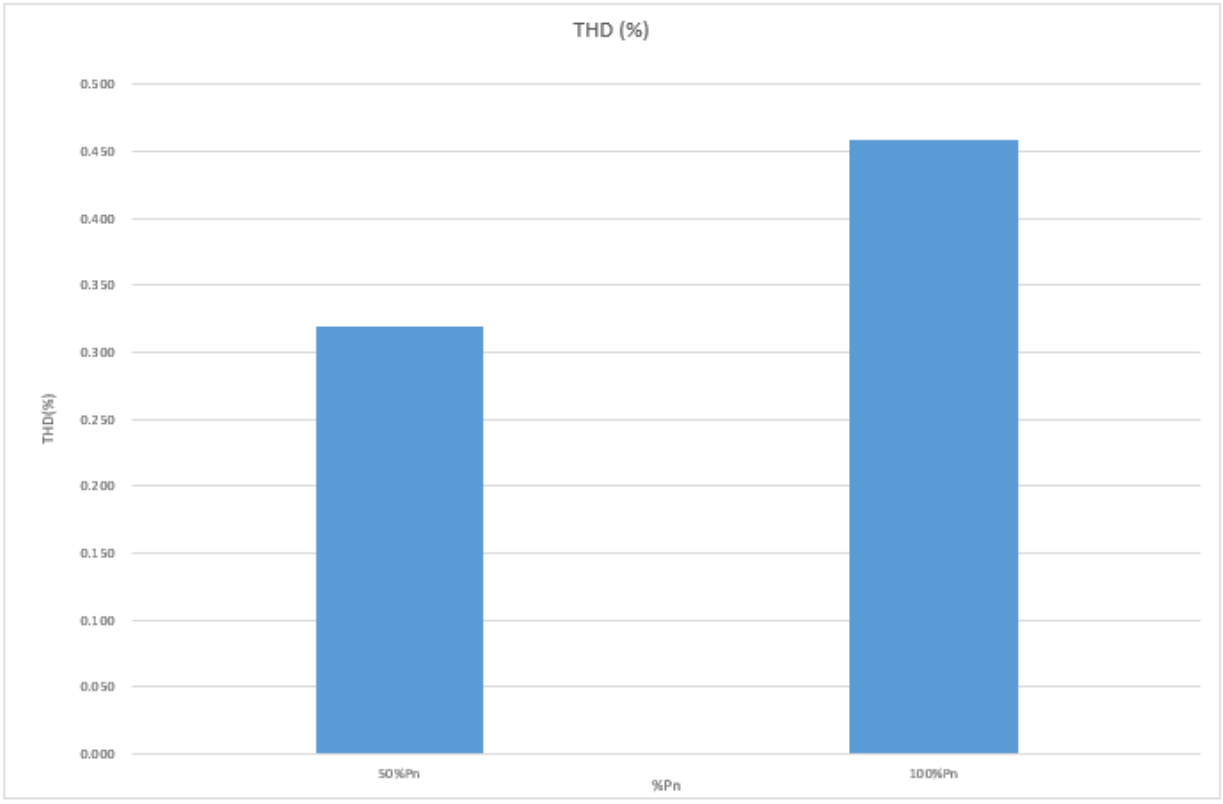
18	0.002	0.013	0.003	0.019	0.102	
19	0.013	0.081	0.030	0.188	0.118	
20	0.002	0.013	0.002	0.013	0.092	
21	0.012	0.075	0.025	0.156	0.107	0.160
22	0.002	0.013	0.002	0.013	0.084	
23	0.006	0.038	0.009	0.056	0.098	0.147
24	0.004	0.025	0.004	0.025	0.077	
25	0.004	0.025	0.009	0.056	0.090	0.135
26	0.003	0.019	0.002	0.013	0.071	
27	0.007	0.044	0.007	0.044	0.083	0.124
28	0.003	0.019	0.004	0.025	0.066	
29	0.002	0.013	0.005	0.031	0.078	0.117
30	0.002	0.013	0.002	0.013	0.061	
31	0.002	0.013	0.010	0.063	0.073	0.109
32	0.005	0.031	0.003	0.019	0.058	
33	0.011	0.069	0.009	0.056	0.068	0.102
34	0.001	0.006	0.003	0.019	0.054	
35	0.006	0.038	0.007	0.044	0.064	0.096
36	0.003	0.019	0.002	0.013	0.051	
37	0.003	0.019	0.007	0.044	0.061	0.091
38	0.002	0.013	0.006	0.038	0.048	
39	0.003	0.019	0.014	0.088	0.058	0.087
40	0.004	0.025	0.002	0.013	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.

Current Harmonics



THD



4.2.2 Voltage fluctuations and Flicker

These tests should be undertaken in accordance with EREC G98 Annex A1 A.1.3.3 (Inverter connected) or Annex A2 A.2.3.3 (Synchronous).

The measurements of voltage fluctuations have been measured according to the standard, at 100 % of the nominal power value of the inverter.

The test impedance is recorded in the table below:

Test Impedance	R	0.4	Ω	X	0.25	Ω
Standard Impedance	R	0.4	Ω	X	0.25	Ω
Maximum Impedance	R	0.4	Ω	X	0.25	Ω

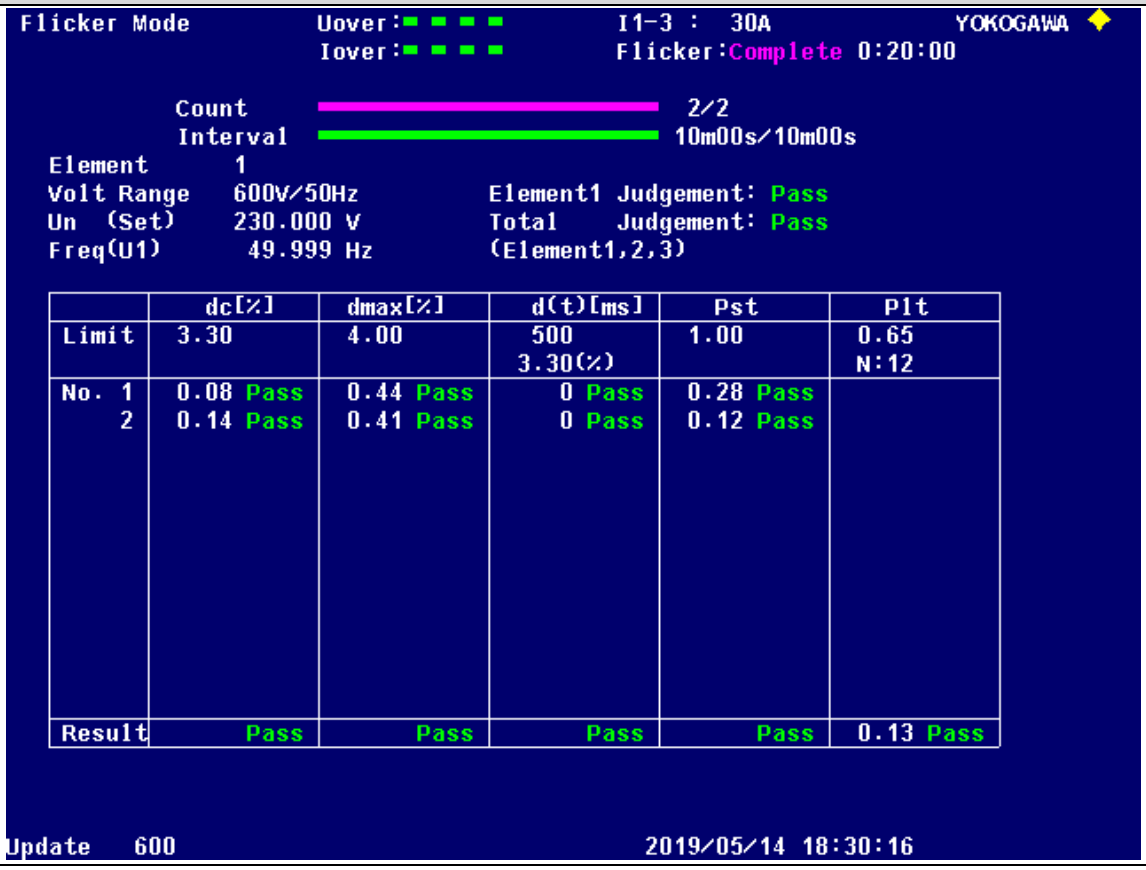
Starting operation and Stopping operation			
Pbin (%)	**100%**		
	Limit	**Starting measured values**	**Stopping measured values**
PST	≤ 1	0.28	0.12
PLT	≤ 0.65	0.13	0.13
dc	≤ 3.30%	0.08	0.14
d(t)	≤ 3.30%	0	0
dmax	4%	0.44%	0.41%

As it can be seen in the next screenshots, this test has two steps:

1. Starting operation
2. Stopping operation

All values are the most unfavorable of the two steps.

Starting operation and Stopping operation
100% Pn



Running operation 2 hours		
Pbin (%)	100%	
	Limit	Measured values
PST	≤ 1	0.38
PLT	≤ 0.65	0.29
dc	≤ 3.30%	0.57%
d(t)	≤ 3.30%	0
dmax	4%	1.96%

As it can be seen in the next screenshots is running operation. The values took of Pst and Plt are the most unfavorable of the twelve steps.

Running operation

100% Pn

Flicker Mode Uover:▬ ▬ ▬ ▬ YOKOGAWA ◆
Iover:▬ ▬ ▬ ▬ Flicker:Complete 2:00:00

Count ▬▬▬▬▬▬▬▬▬▬▬▬ 12/12
Interval ▬▬▬▬▬▬▬▬▬▬▬▬ 10m00s/10m00s

Element 1
Volt Range 300V/50Hz Element1 Judgement: Pass
Un (Set) 230.000 V Total Judgement: Pass
Freq(U1) 49.969 Hz (Element1)

	dc[%]	dmax[%]	d(t)[ms]	Pst	Plt
Limit	3.30	4.00	500 3.30(%)	1.00	0.65 N:12
No. 1	0.08 Pass	1.06 Pass	0 Pass	0.27 Pass	
2	0.30 Pass	1.19 Pass	0 Pass	0.31 Pass	
3	0.31 Pass	1.75 Pass	0 Pass	0.31 Pass	
4	0.11 Pass	1.75 Pass	0 Pass	0.31 Pass	
5	0.26 Pass	1.50 Pass	0 Pass	0.28 Pass	
6	0.33 Pass	1.60 Pass	0 Pass	0.38 Pass	
7	0.11 Pass	1.10 Pass	0 Pass	0.26 Pass	
8	0.34 Pass	0.95 Pass	0 Pass	0.24 Pass	
9	0.57 Pass	1.22 Pass	0 Pass	0.26 Pass	
10	0.48 Pass	1.96 Pass	0 Pass	0.35 Pass	
11	0.22 Pass	0.53 Pass	0 Pass	0.19 Pass	
12	0.23 Pass	0.81 Pass	0 Pass	0.20 Pass	
Result	Pass	Pass	Pass	Pass	0.29 Pass

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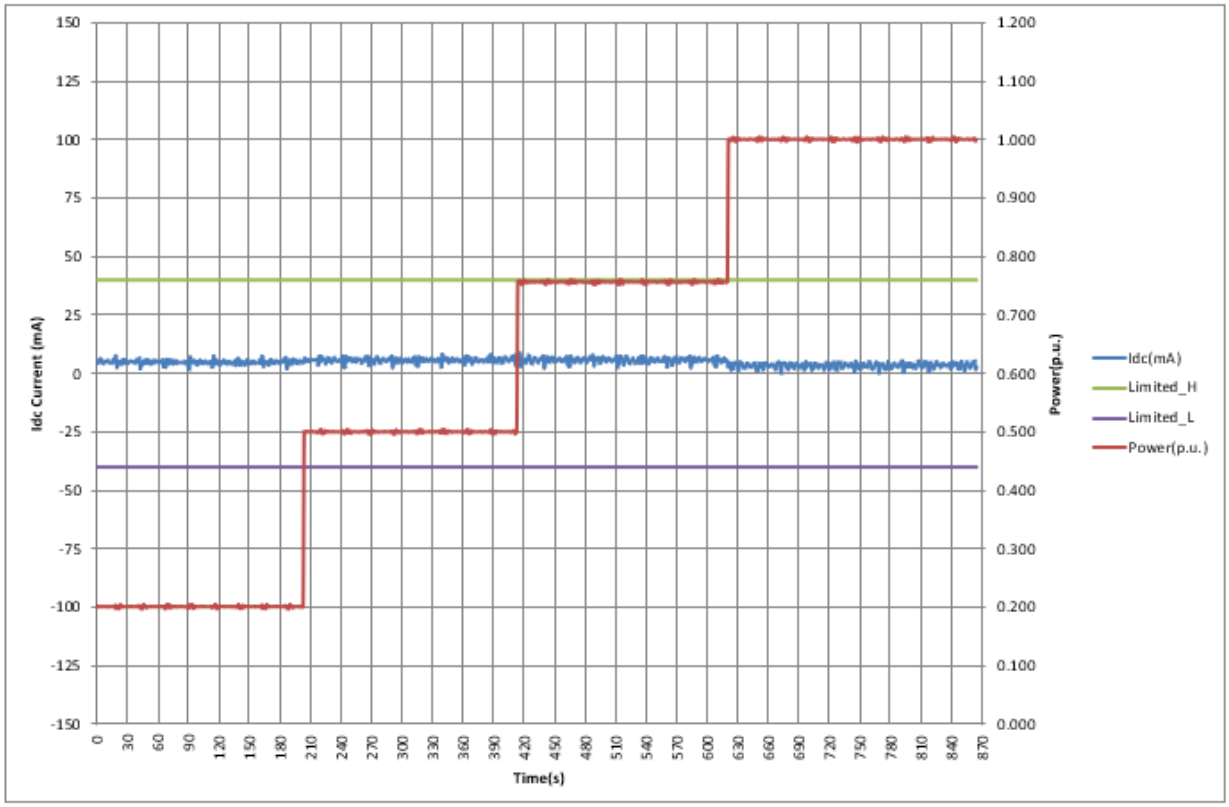
4.2.3 DC Injection

The DC component shall be measured under steady-state conditions for the following power levels: 20 %, 50 %, 75 %, and 100 % of nominal power with a tolerance of ± 5 % of nominal power and as far as adjustable for the tested micro-generator. These tests should be undertaken in accordance with Annex A1.3.4.

Following tables show the test results:

Power quality – DC injection: This test should be carried out in accordance with EN 50438 Annex D.3.10				
Test power level	20%	50%	75%	100%
Recorded value in Amps	0.005	0.006	0.006	0.003
as % of rated AC current	0.03%	0.04%	0.04%	0.02%
Limit	0.25%	0.25%	0.25%	0.25%

DC injection test result



4.2.4 Power Factor

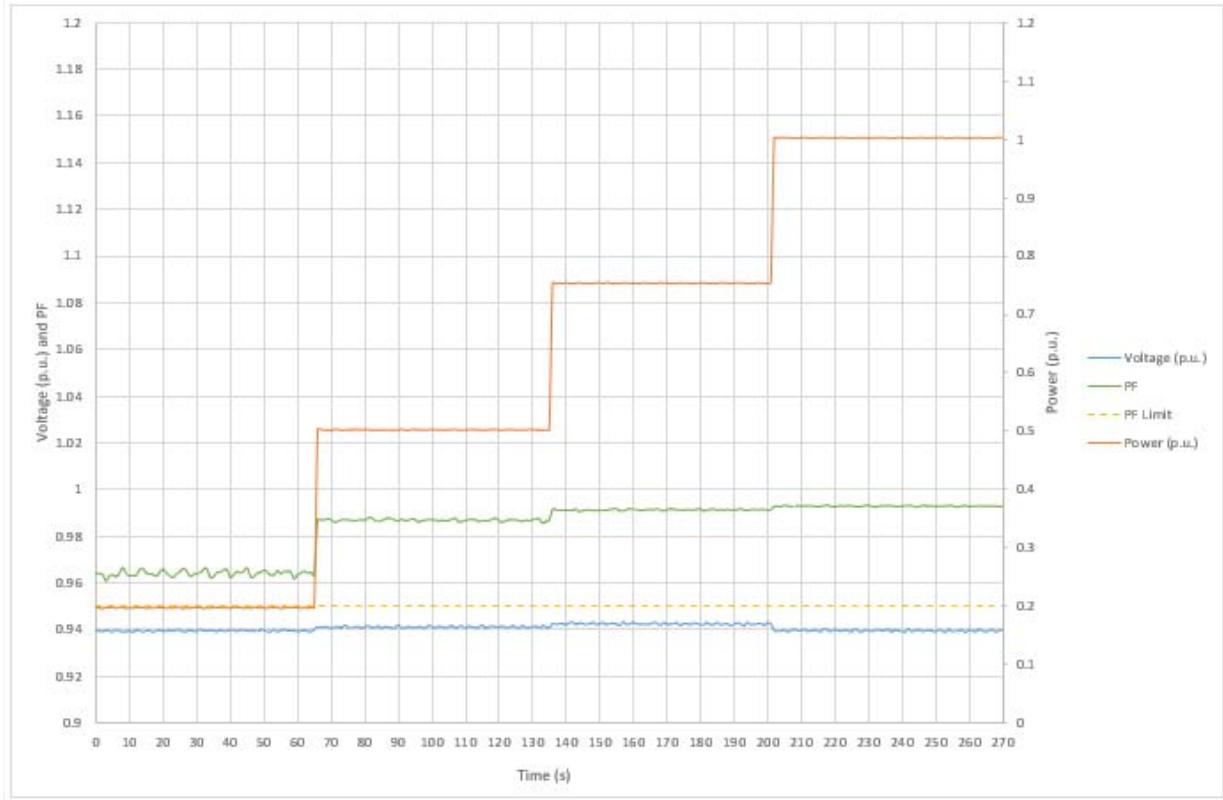
This test shall be carried out in accordance with EN 50538 Annex D.3.4.1 but with nominal voltage -6% and +10%. Voltage to be maintained within ±1.5% of the stated level during the test.

The following table shows the test results at required voltage levels:

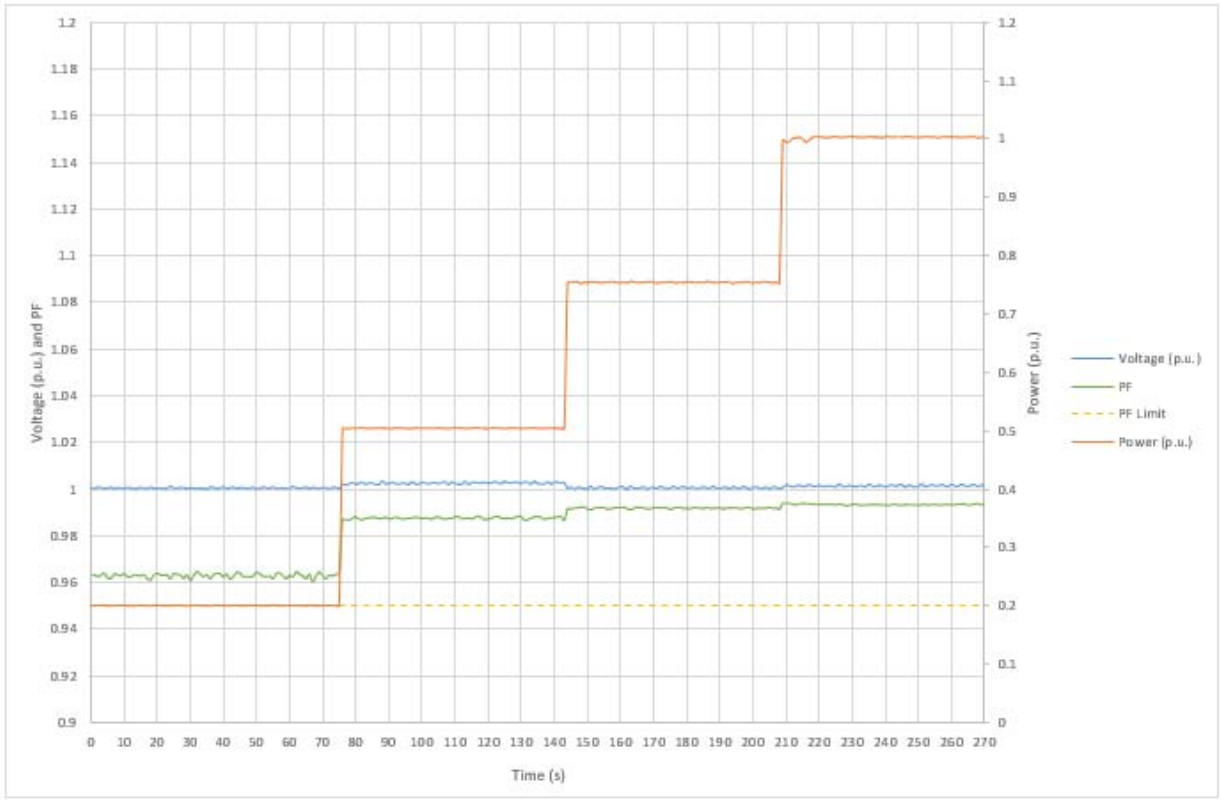
	216.2 V	230 V	253 V
20% of **Registered Capacity**	0.96	0.96	0.97
50% of **Registered Capacity**	0.99	0.99	0.99
75% of **Registered Capacity**	0.99	0.99	0.99
100% of **Registered Capacity**	0.99	0.99	0.99
Limit	>0.95	>0.95	>0.95

Test results are graphically shown below.

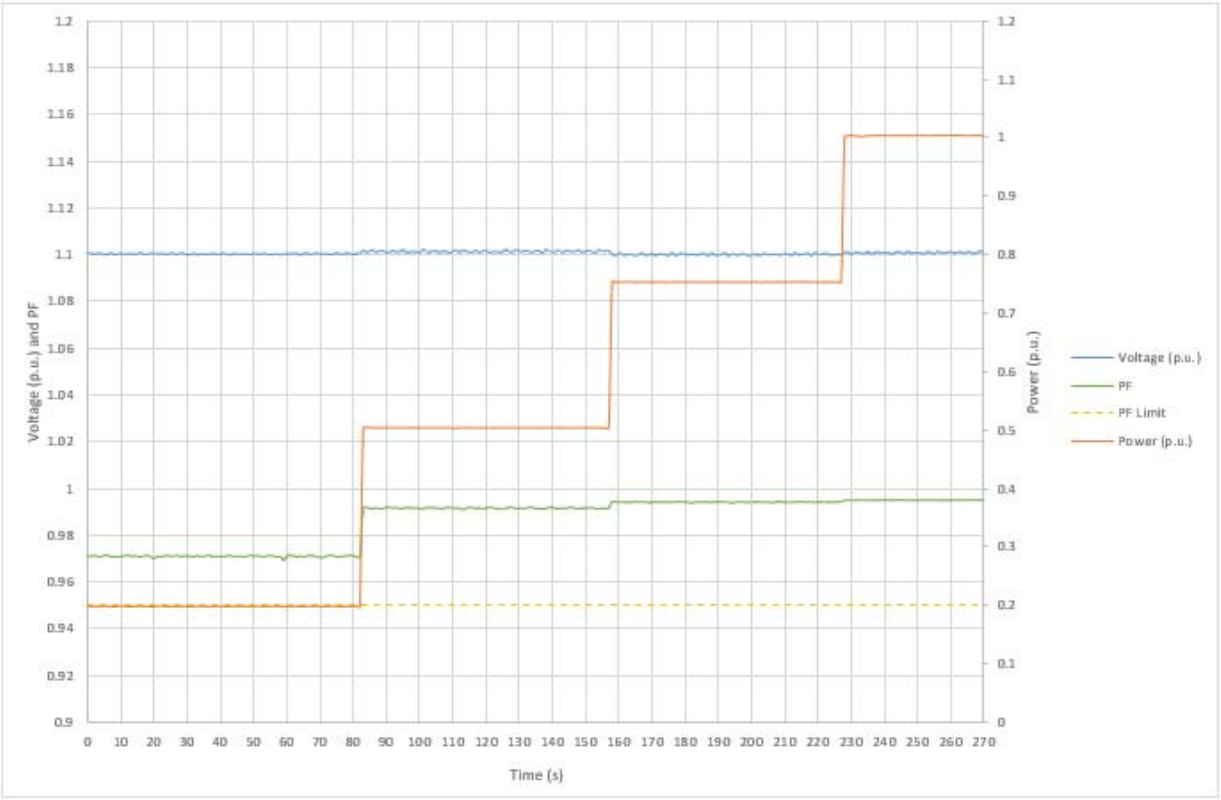
Power Factor 216.2V



Power Factor 230V



Power Factor 253V



4.3 PROTECTION

4.3.1 Frequency tests

These tests should be carried out in accordance with EN 50438 Annex D.2.4 and the notes in EREC G98 Annex A1 A.1.2.3 (Inverter connected) or Annex A2 A.2.2.3 (Synchronous).

To establish a trip frequency, the test frequency should be applied in a slow ramp rate of less than 0.1 Hz/s, or if this is not possible in steps of 0.05 Hz for a duration that is longer than the trip time delay.

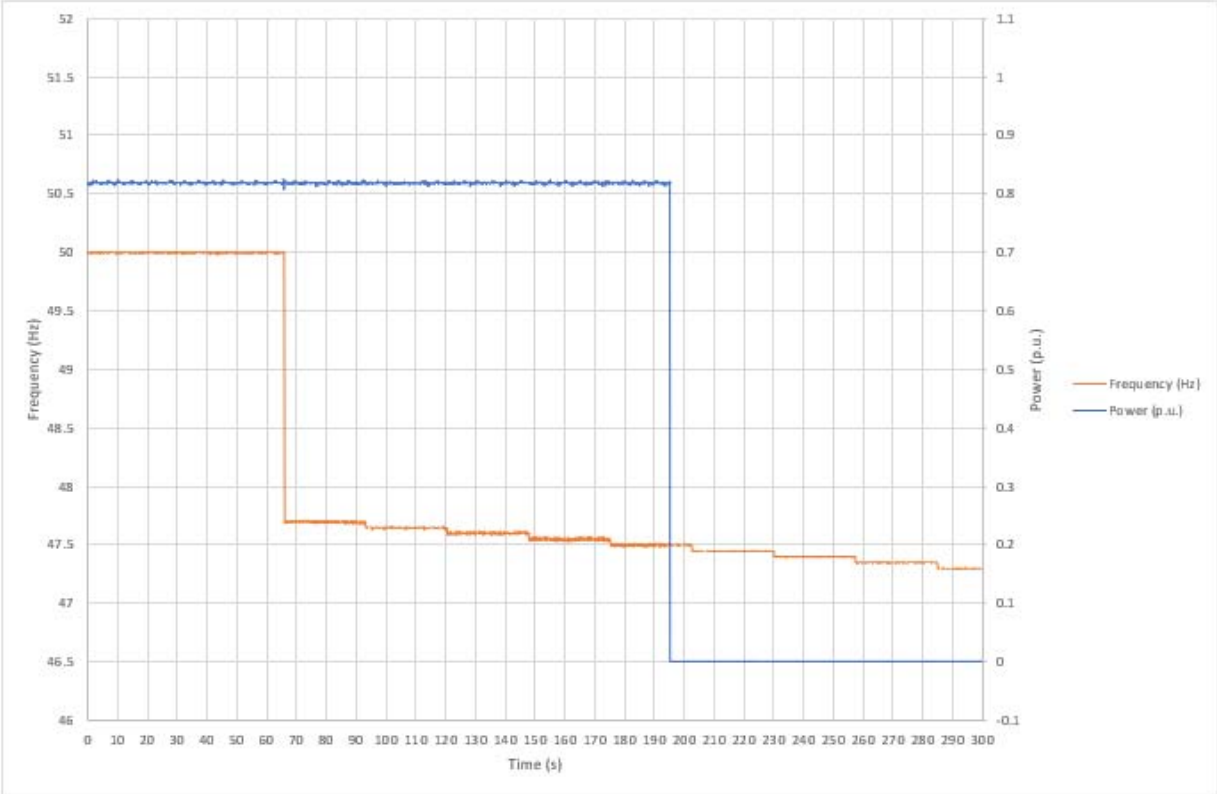
To establish the trip time, the test frequency should be applied starting from 0.3 Hz below or above the recorded trip frequency and should be changed to 0.3 Hz above or below the recorded trip frequency in a single step. For each trip setting five tests shall be carried out.

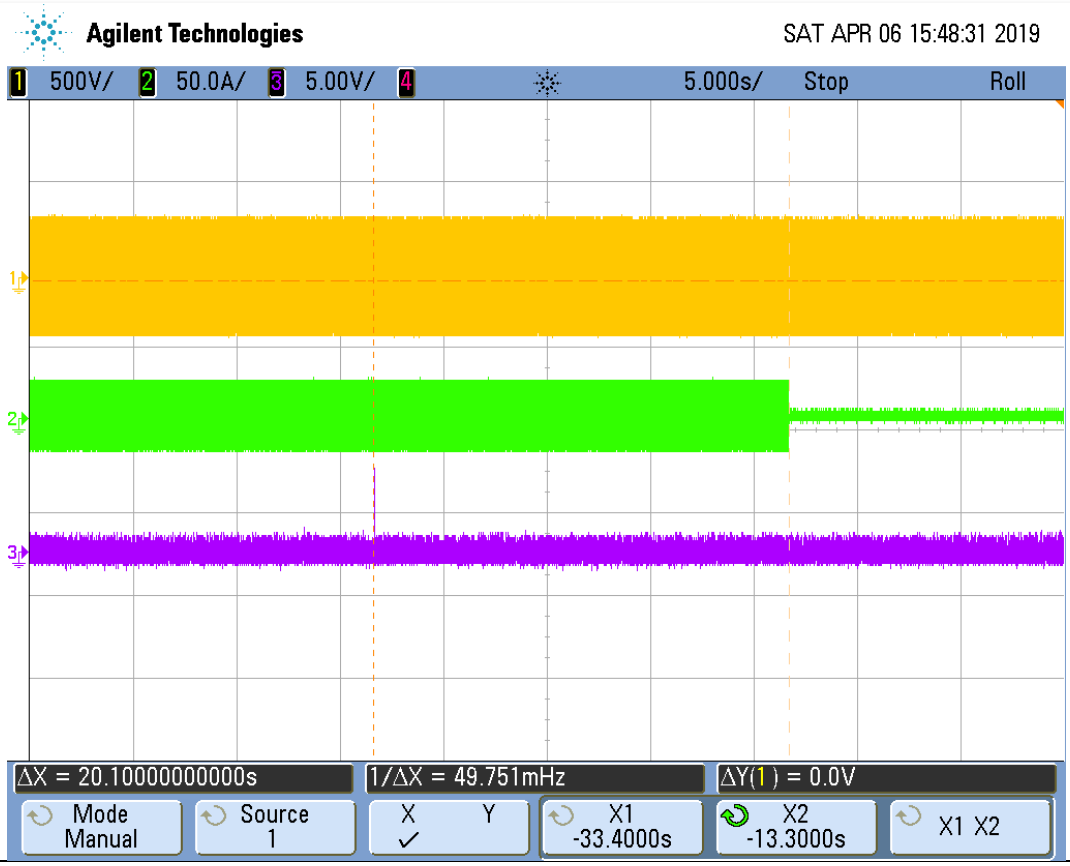
Following tables show the test results:

Function	Setting		Trip test (5 times)		"No trip tests"	
	Frequency	Time delay	Frequency (Hz)	Time delay (s)	Frequency /time	Confirm no trip
U/F stage 1	47.5 Hz	20 s	47.5	20.100	47.7 Hz / 25 s	Pass
			47.5	20.150		
			47.5	20.120		
			47.5	20.065		
			47.5	20.100		
U/F stage 2	47 Hz	0.5 s	47.0	0.528	47.2 Hz / 19.98 s	Pass
			47.0	0.514		
			47.0	0.512		
			47.0	0.524		
			47.0	0.524		
					46.8 Hz / 0.48 s	Pass
O/F stage 1	52 Hz	0.5 s	52.0	0.530	51.8 Hz / 89.98 s	Pass
			52.0	0.526		
			52.0	0.536		
			52.0	0.520		
			52.0	0.534		
					52.2 Hz / 0.48 s	Pass

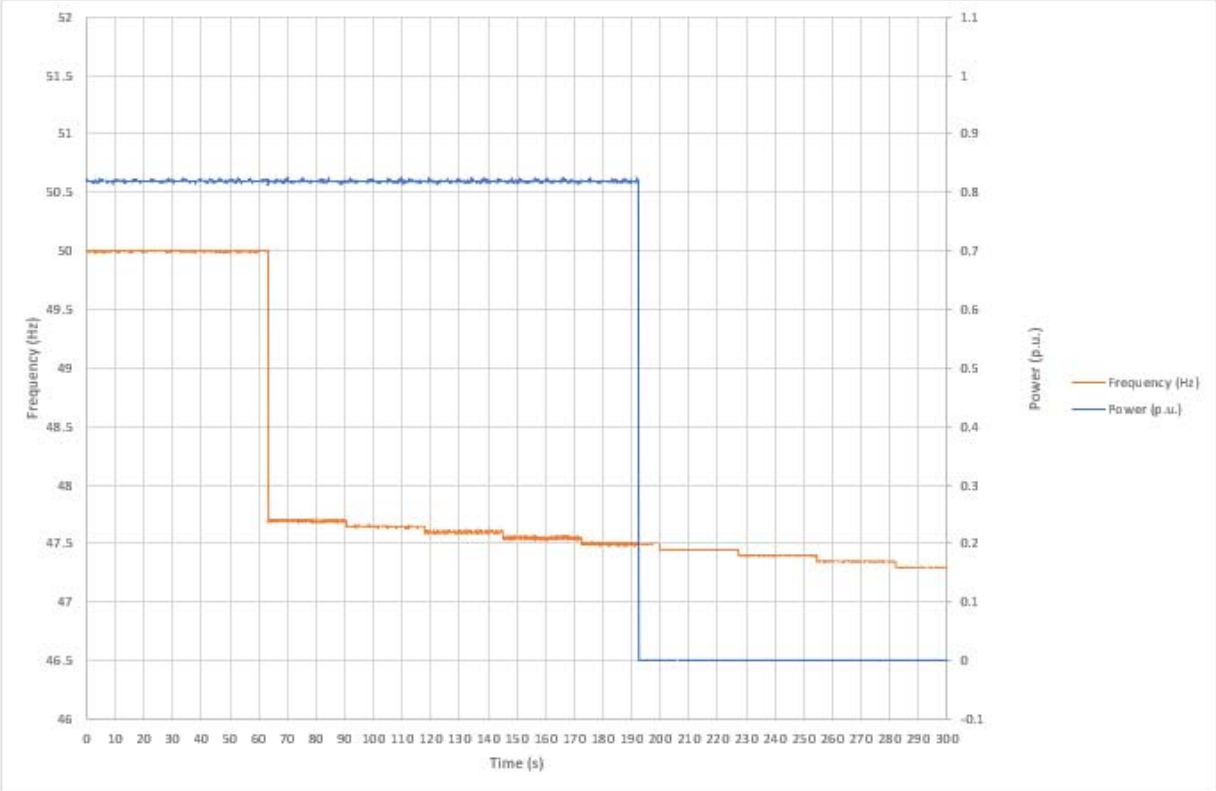
Test results are graphically shown below.

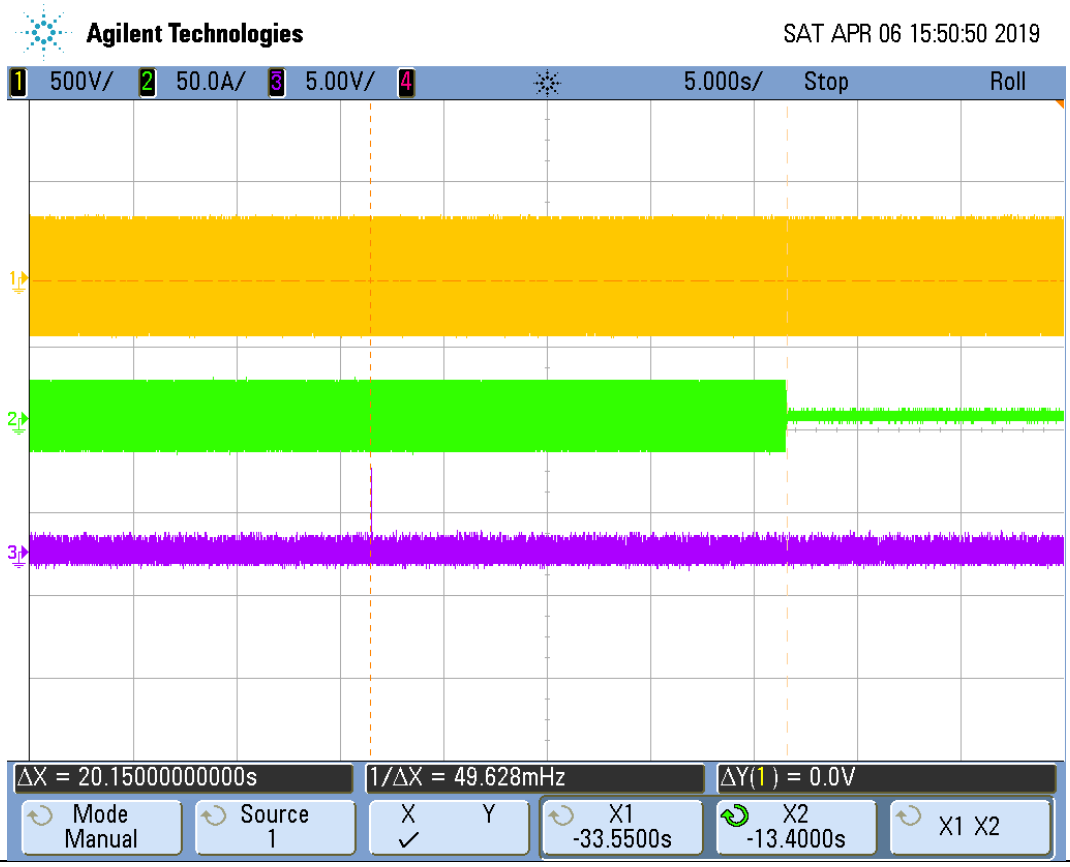
U/F stage 1


Frequency (Hz)
Power (p.u.)
Time (s)
Frequency (Hz)
Power (p.u.)

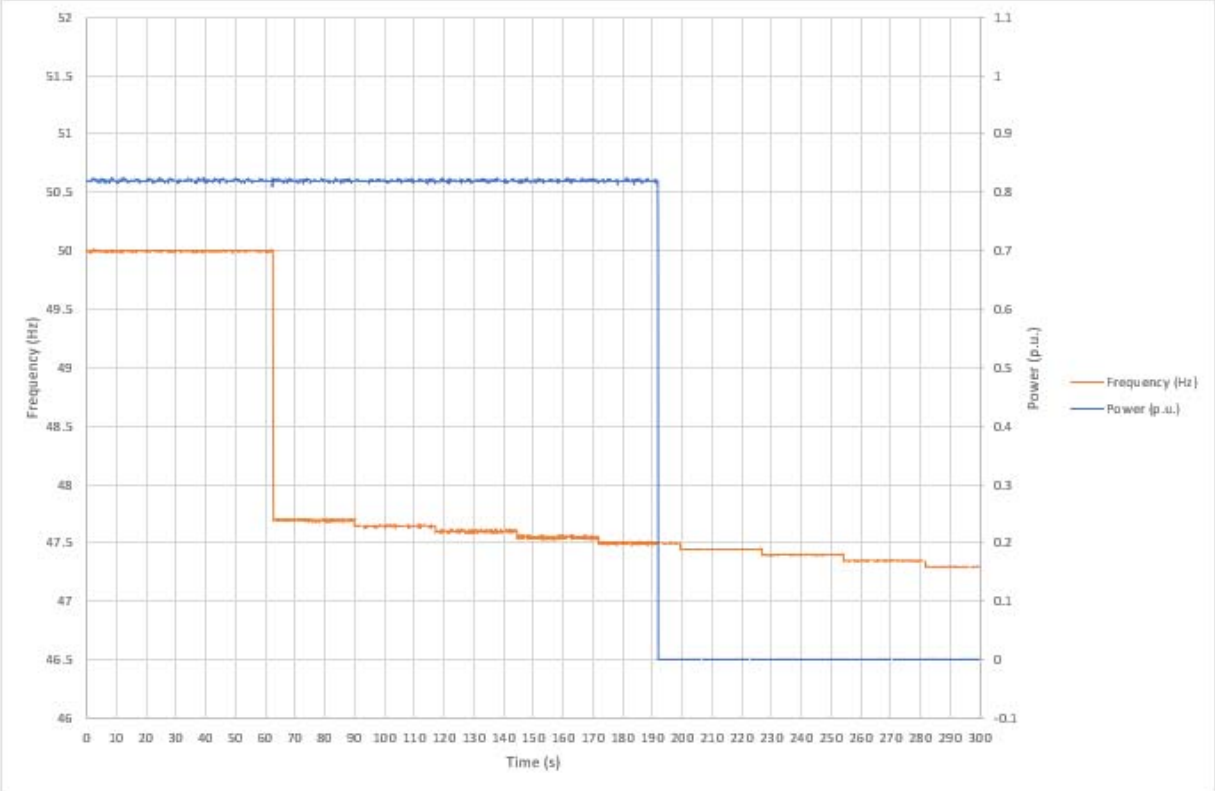

Agilent Technologies
SAT APR 06 15:48:31 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4 5.000s/ Stop Roll
ΔX = 20.100000000000s
1/ΔX = 49.751mHz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -33.4000s
X2 -13.3000s
X1 X2

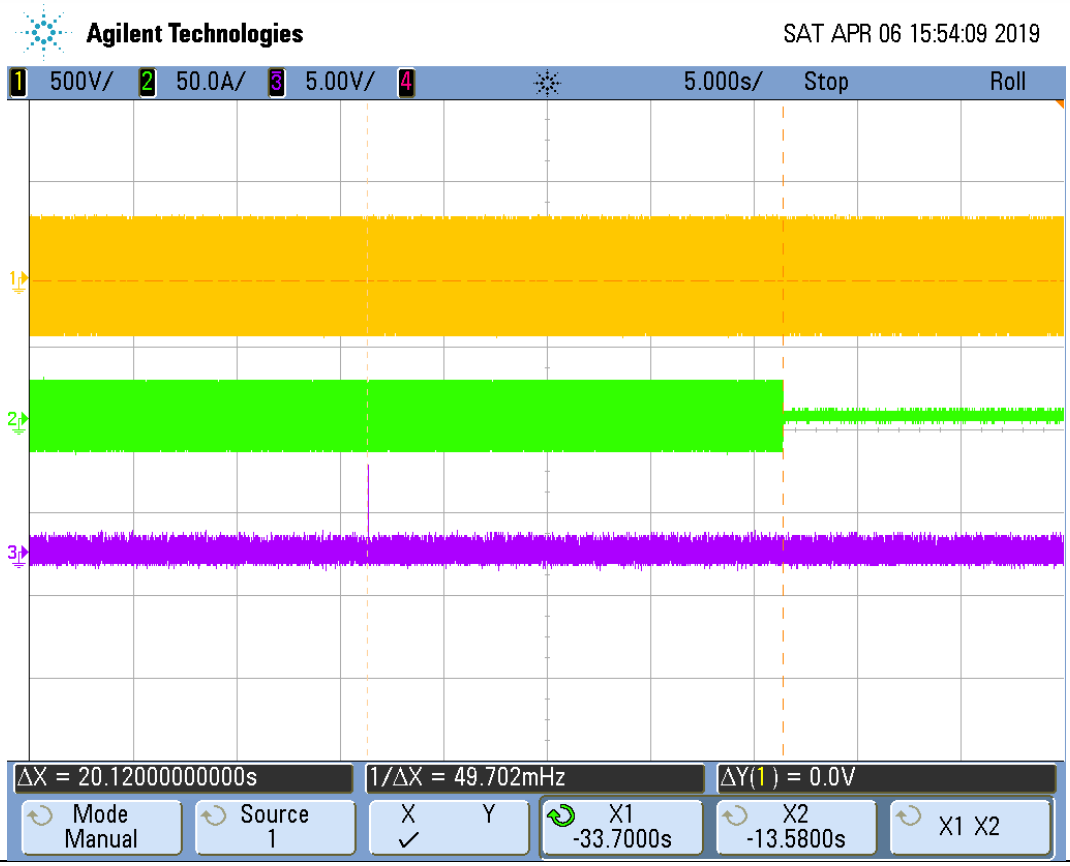
U/F stage 1


Frequency (Hz)
Power (p.u.)
Time (s)
Frequency (Hz)
Power (p.u.)

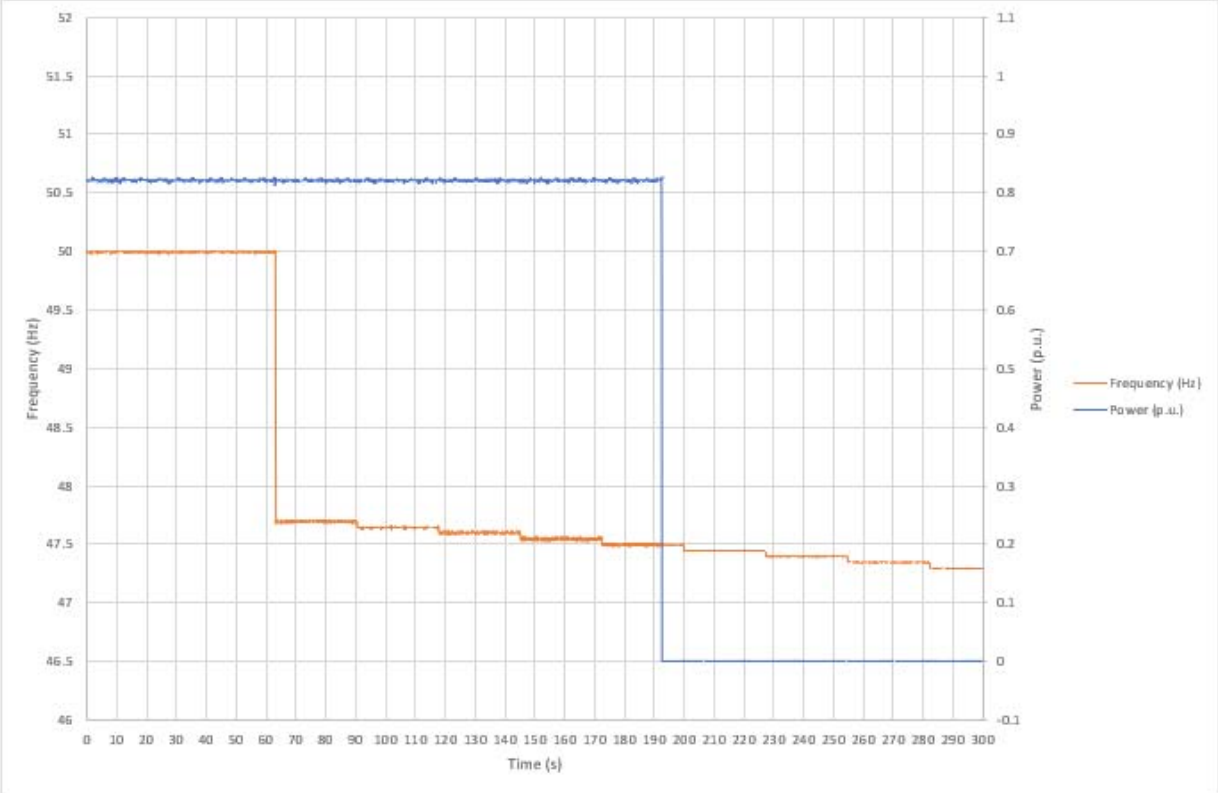

Agilent Technologies
SAT APR 06 15:50:50 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4 5.000s/ Stop Roll
ΔX = 20.15000000000s
1/ΔX = 49.628mHz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -33.5500s
X2 -13.4000s
X1 X2

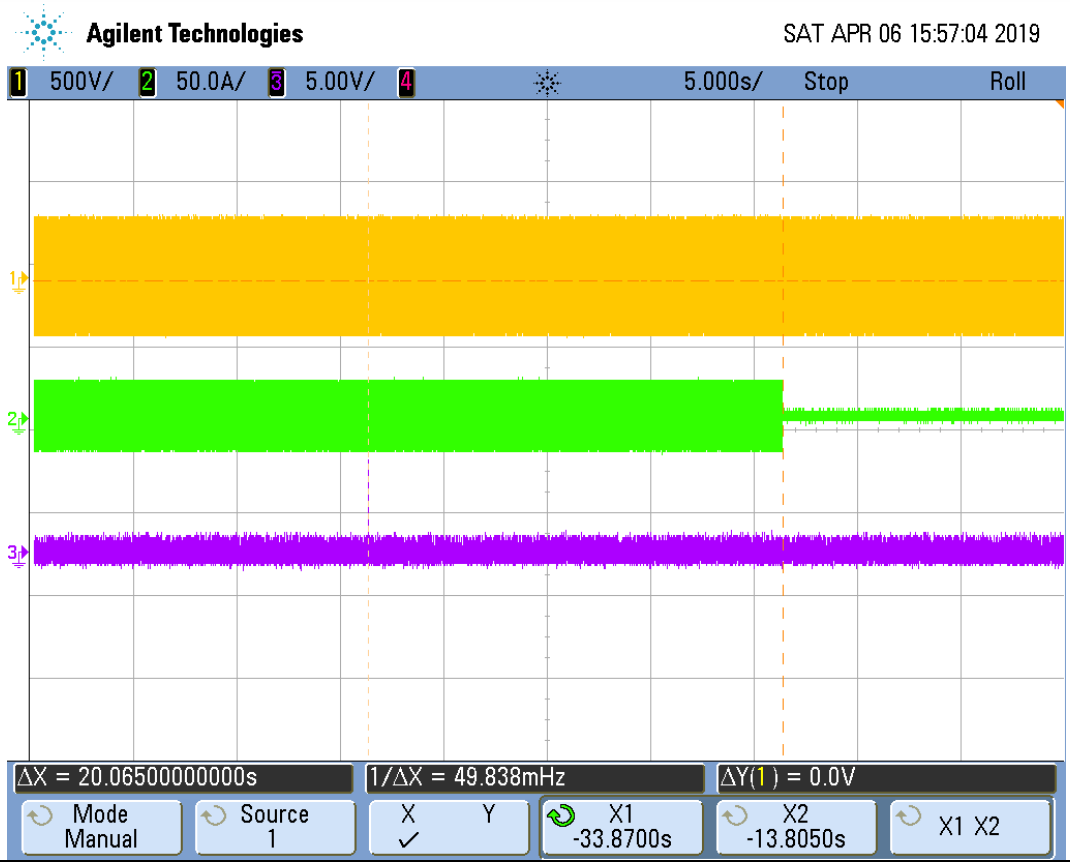
U/F stage 1


Frequency (Hz)
Power (p.u.)
Time (s)
Frequency (Hz)
Power (p.u.)

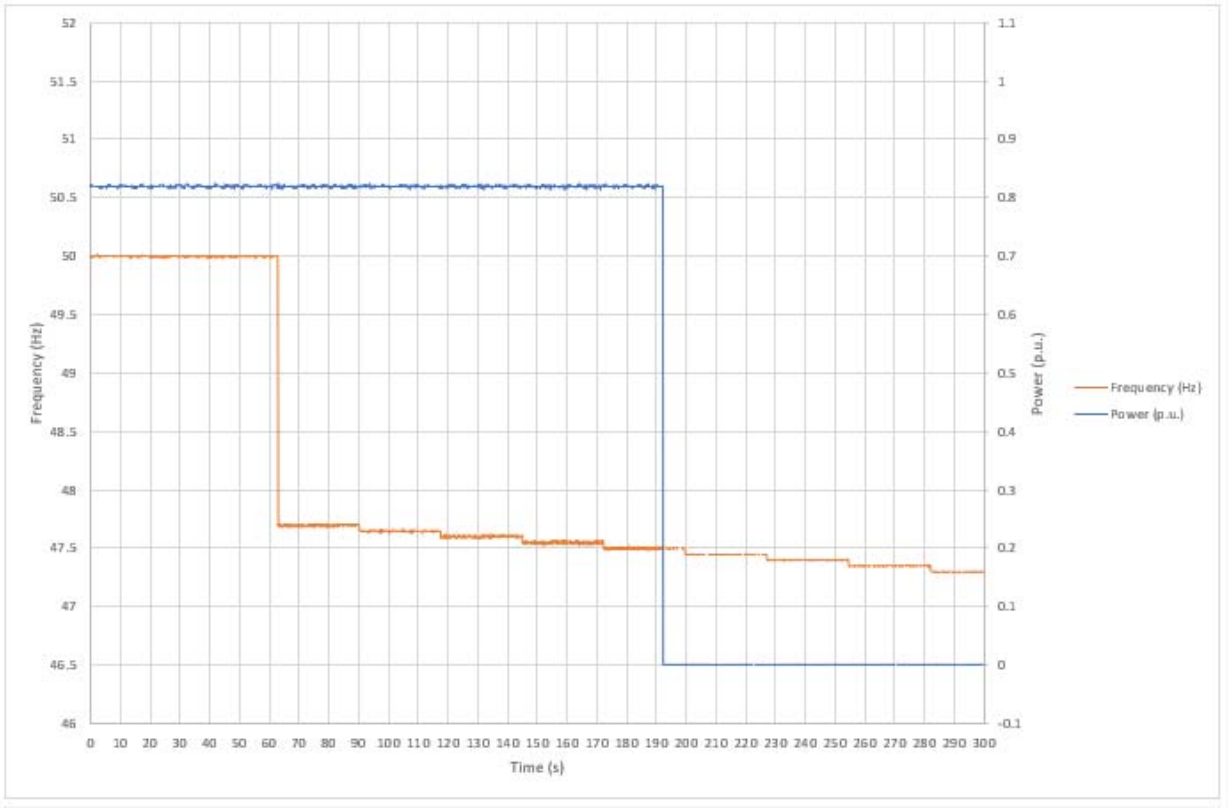

Agilent Technologies
SAT APR 06 15:54:09 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4 5.000s/ Stop Roll
ΔX = 20.12000000000s
1/ΔX = 49.702mHz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -33.7000s
X2 -13.5800s
X1 X2

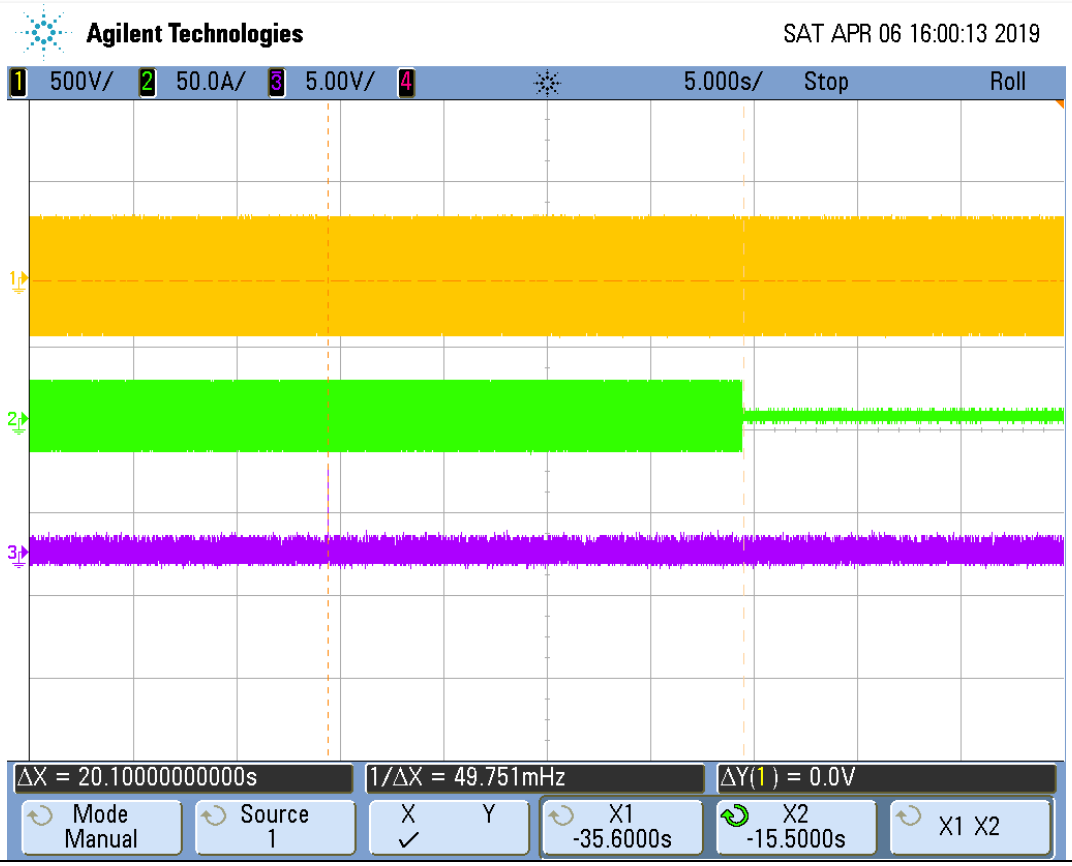
U/F stage 1


Frequency (Hz)
Power (p.u.)
Time (s)
Frequency (Hz)
Power (p.u.)

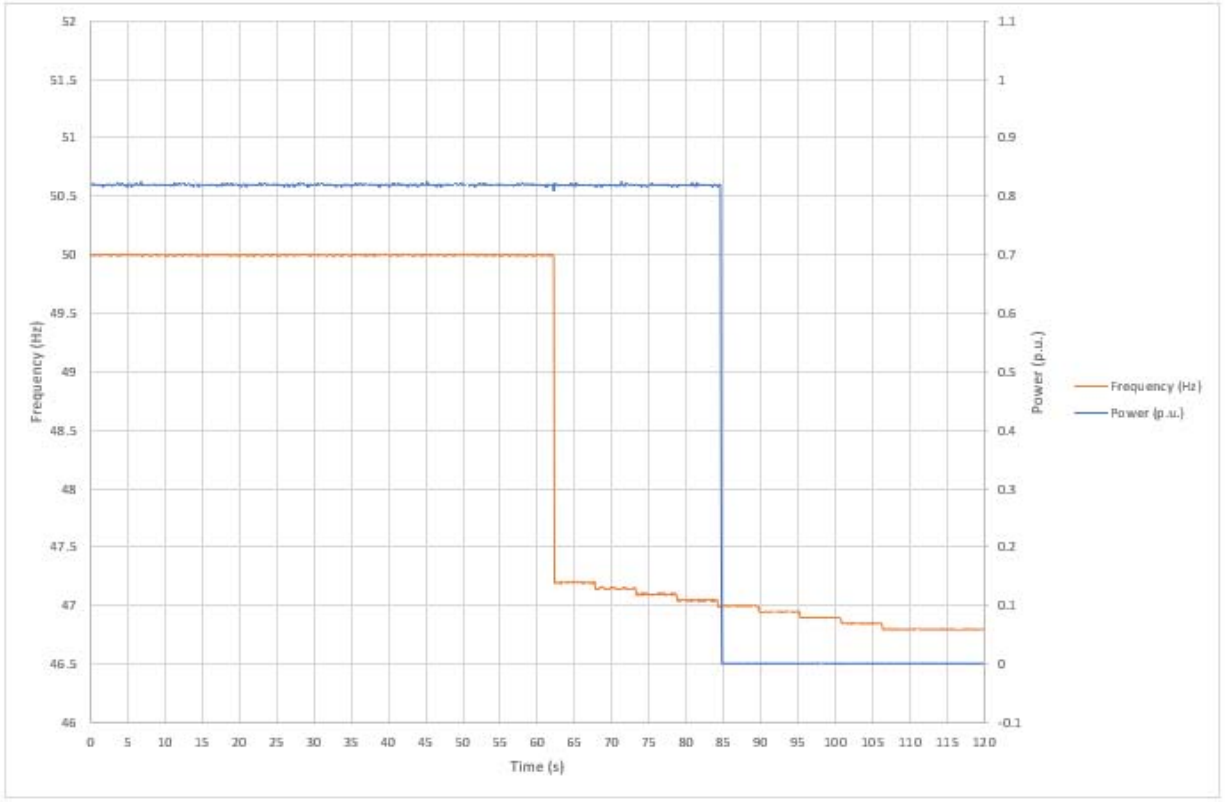

Agilent Technologies
SAT APR 06 15:57:04 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4 5.000s/ Stop Roll
ΔX = 20.06500000000s
1/ΔX = 49.838mHz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -33.8700s
X2 -13.8050s
X1 X2

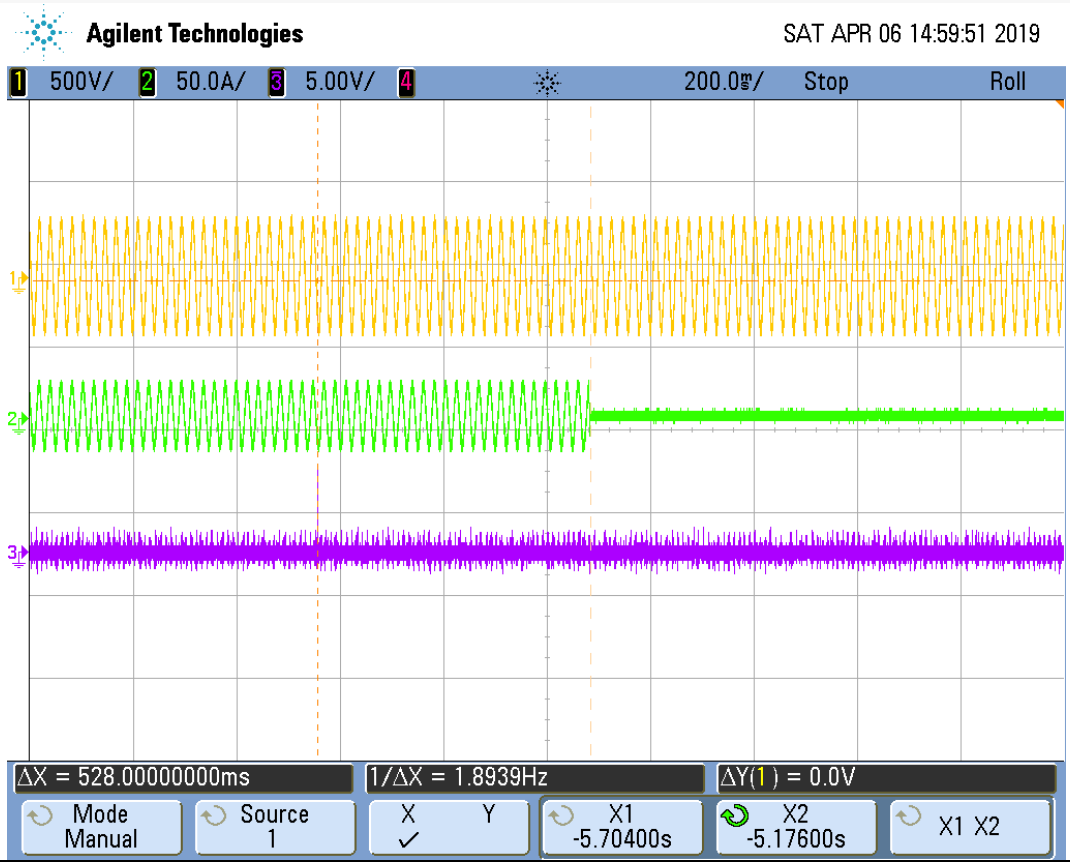
U/F stage 1


Frequency (Hz)
Power (p.u.)
Time (s)
Frequency (Hz)
Power (p.u.)

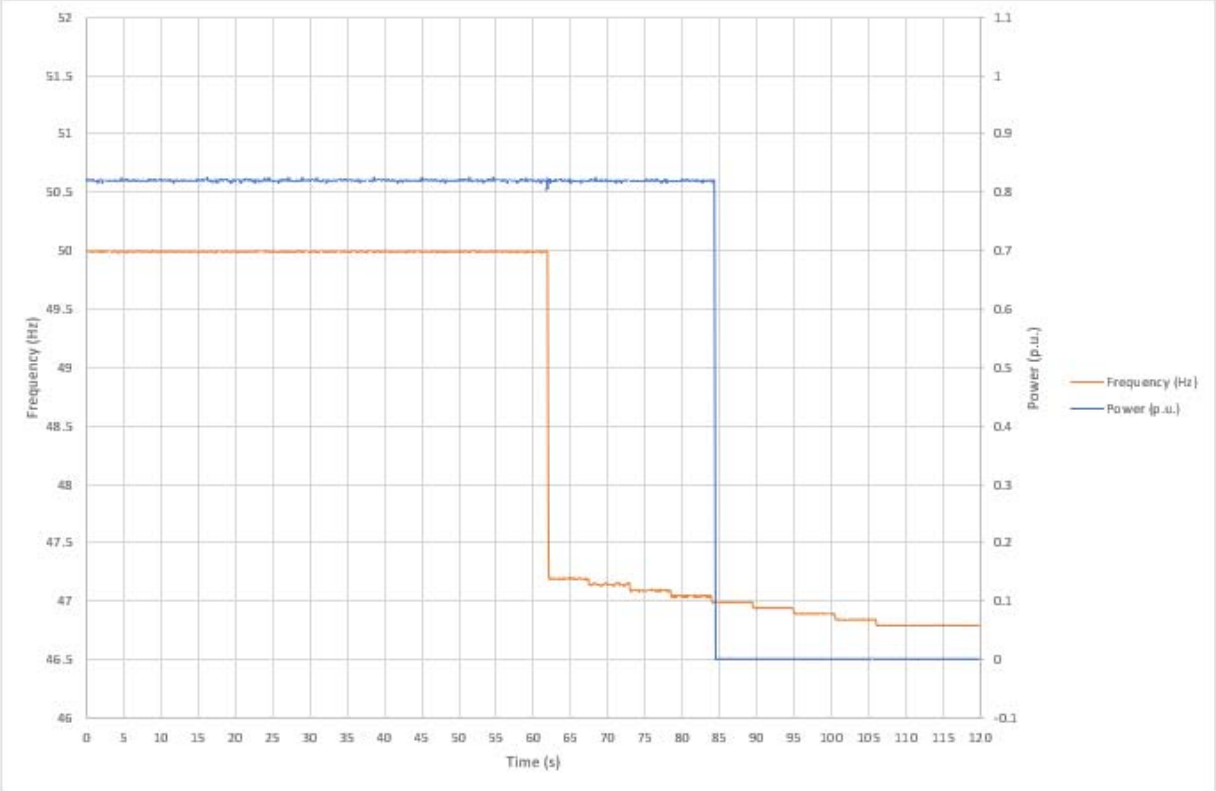

Agilent Technologies
SAT APR 06 16:00:13 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4
5.000s/ Stop Roll
ΔX = 20.10000000000s
1/ΔX = 49.751mHz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -35.6000s
X2 -15.5000s
X1 X2

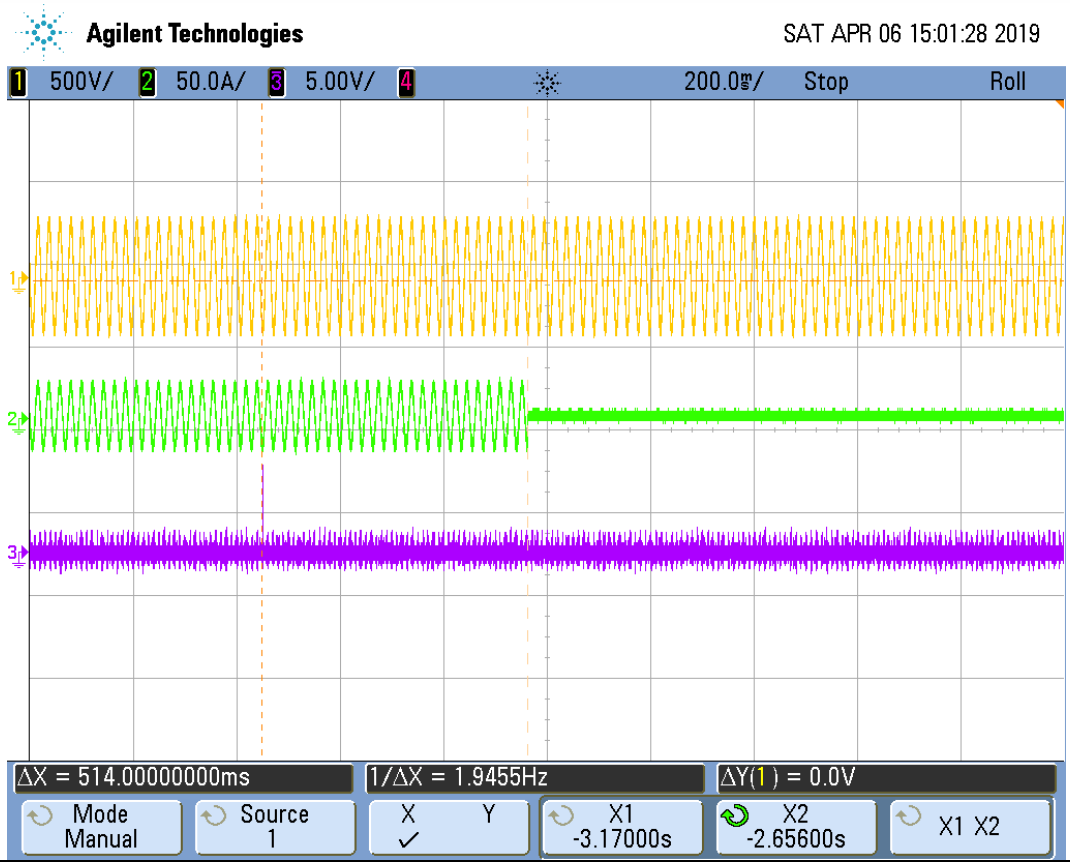
U/F stage 2


Frequency (Hz)
Power (p.u.)
Time (s)
Frequency (Hz)
Power (p.u.)

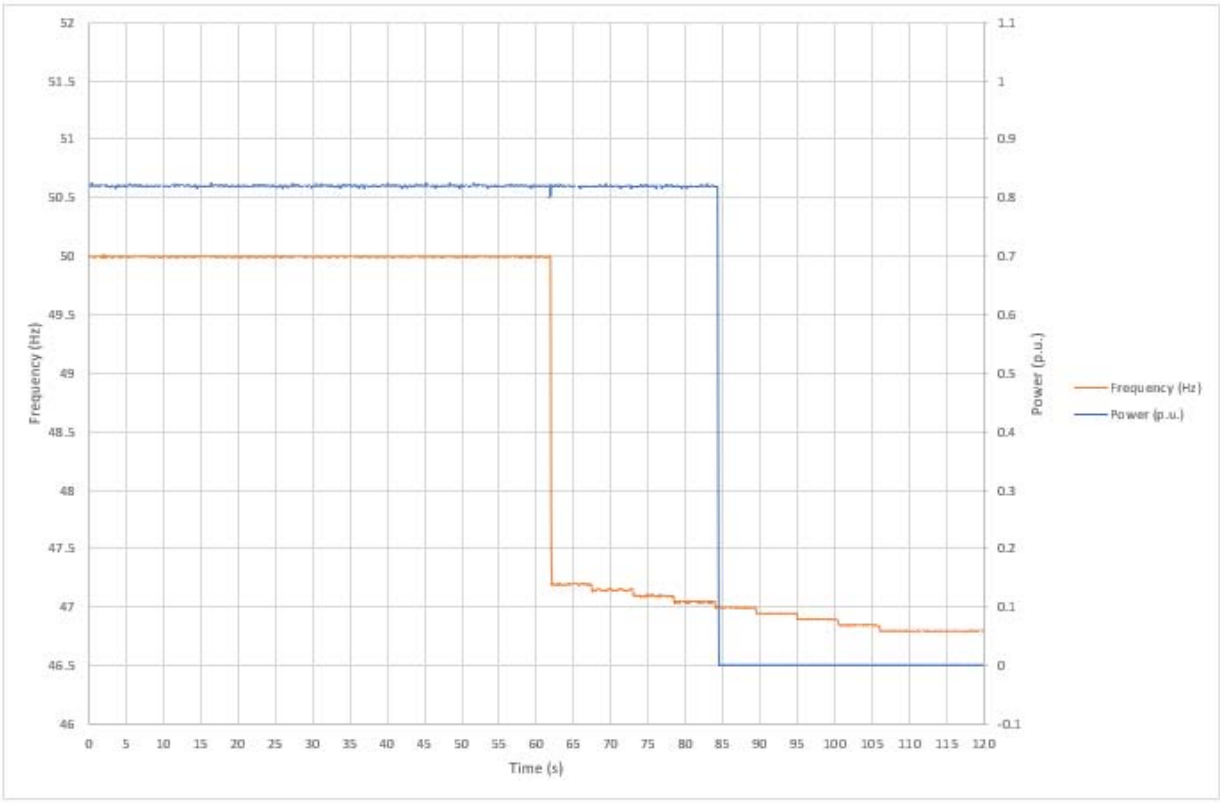

Agilent Technologies
SAT APR 06 14:59:51 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4 200.0ms/ Stop Roll
ΔX = 528.00000000ms
1/ΔX = 1.8939Hz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -5.70400s
X2 -5.17600s
X1 X2

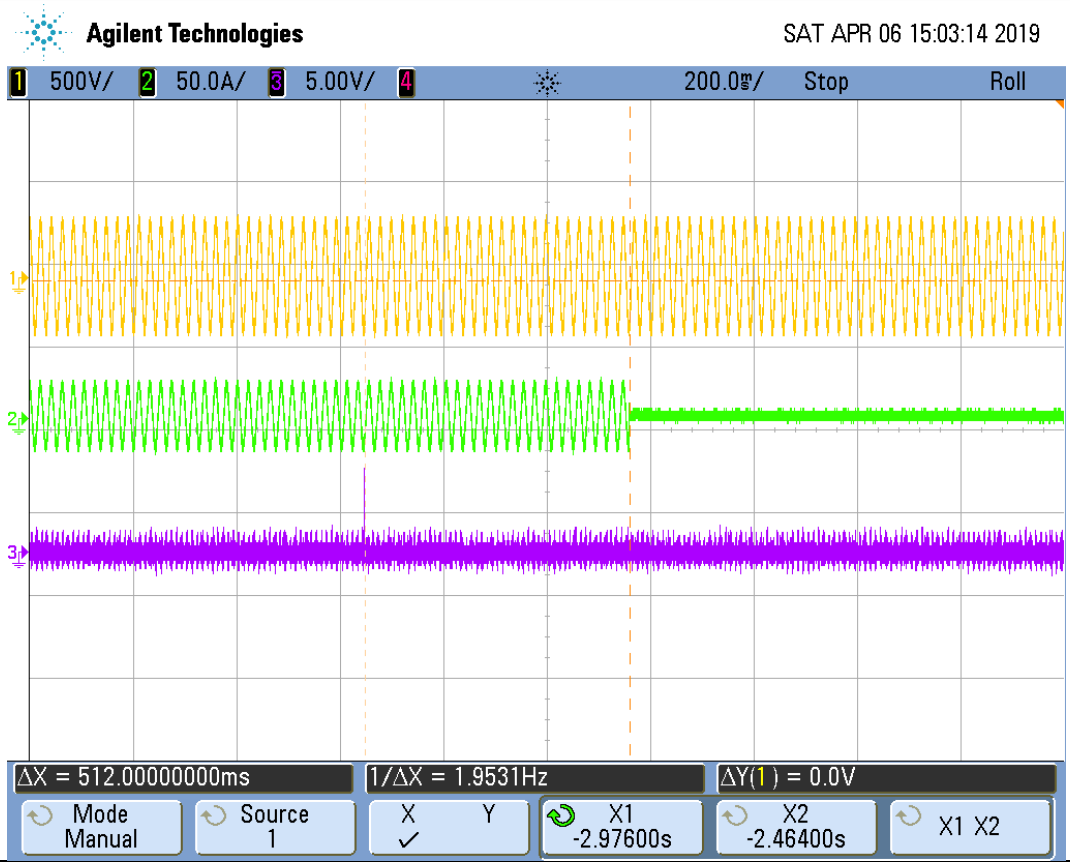
U/F stage 2


Frequency (Hz)
Power (p.u.)
Time (s)
Frequency (Hz)
Power (p.u.)

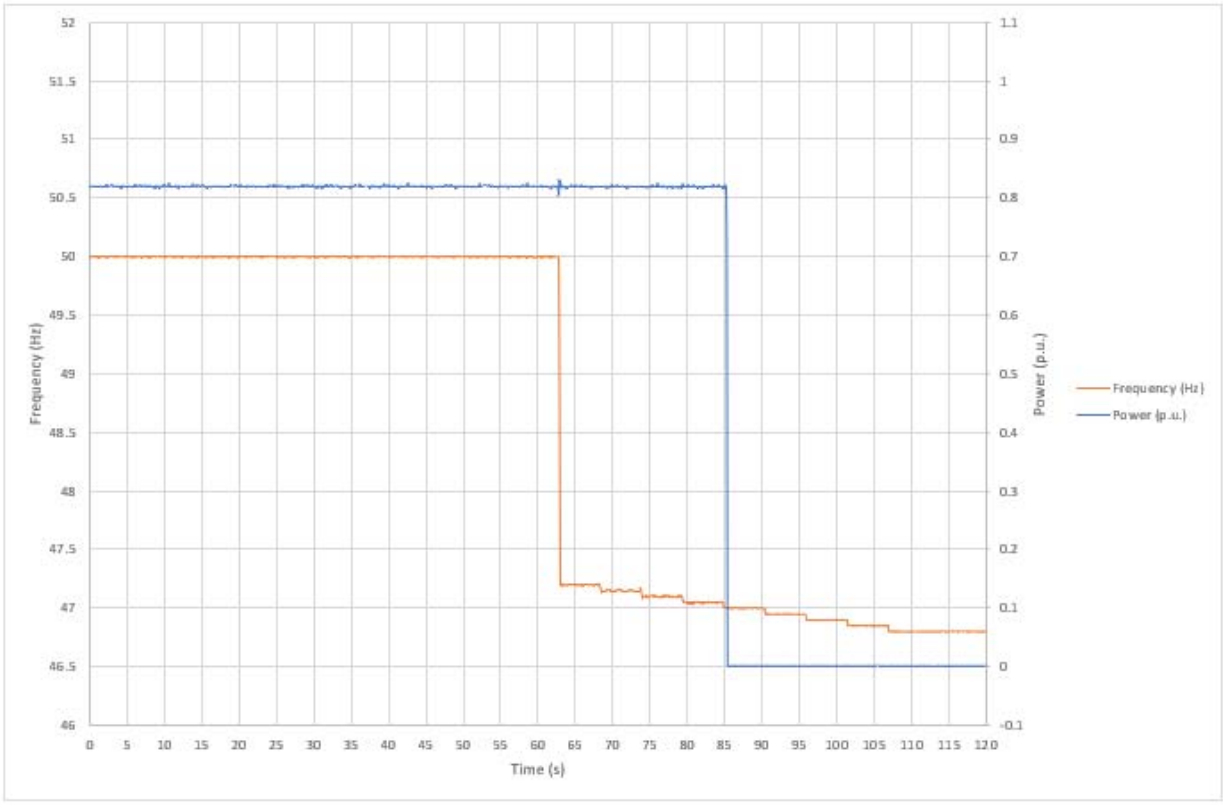

Agilent Technologies
SAT APR 06 15:01:28 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4 200.0ms/ Stop Roll
ΔX = 514.00000000ms
1/ΔX = 1.9455Hz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -3.17000s
X2 -2.65600s
X1 X2

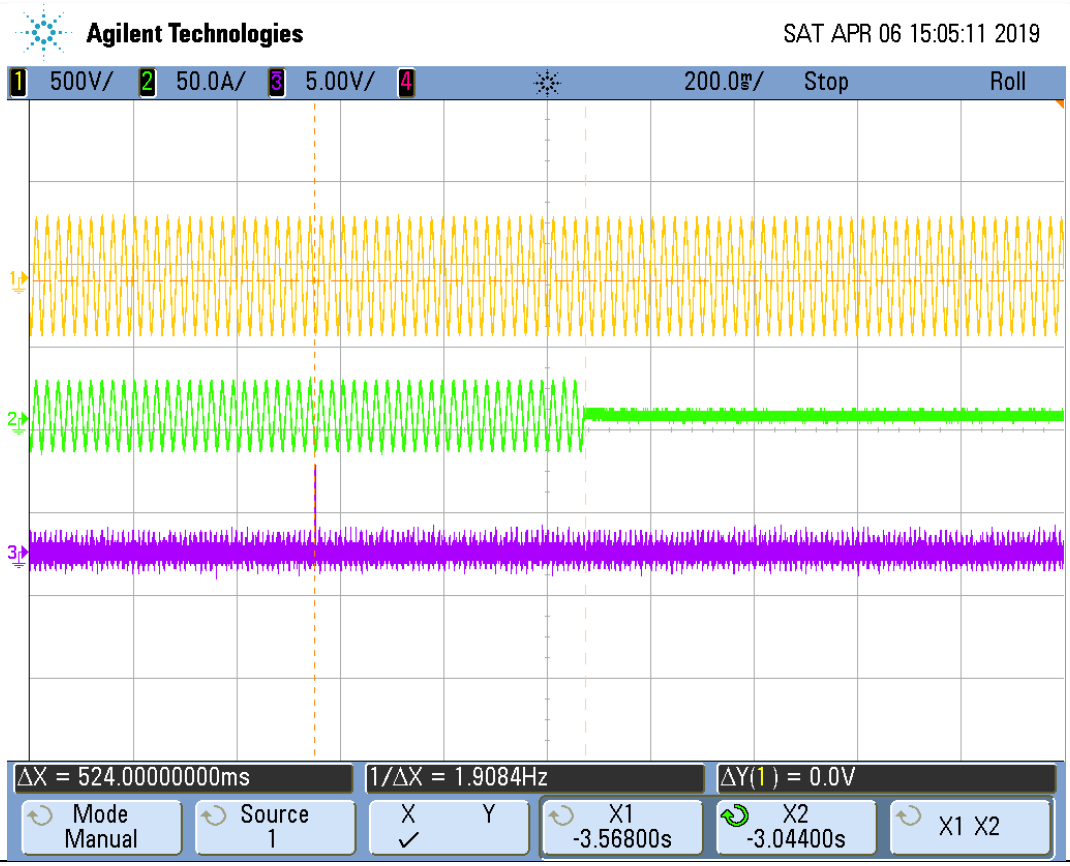
U/F stage 2


Frequency (Hz)
Power (p.u.)
Time (s)
Frequency (Hz)
Power (p.u.)

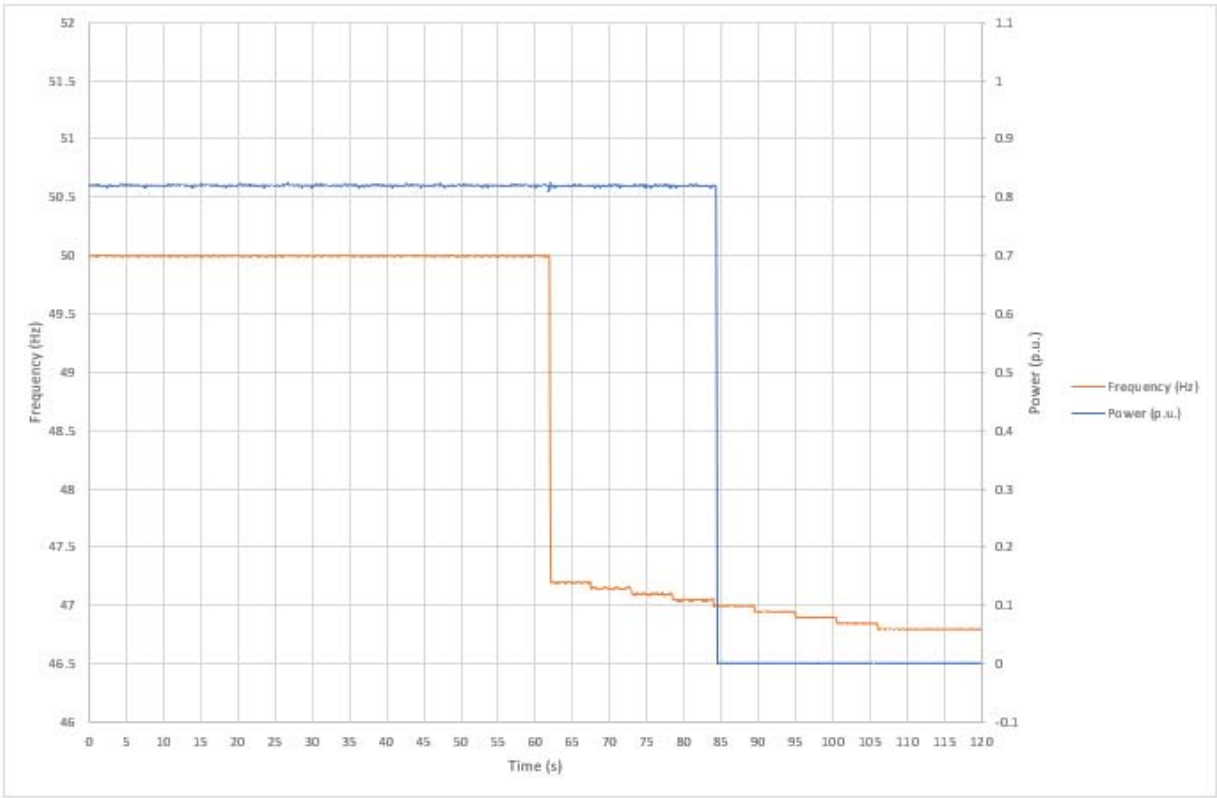

Agilent Technologies
SAT APR 06 15:03:14 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4 200.0ms/ Stop Roll
ΔX = 512.00000000ms
1/ΔX = 1.9531Hz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -2.97600s
X2 -2.46400s
X1 X2

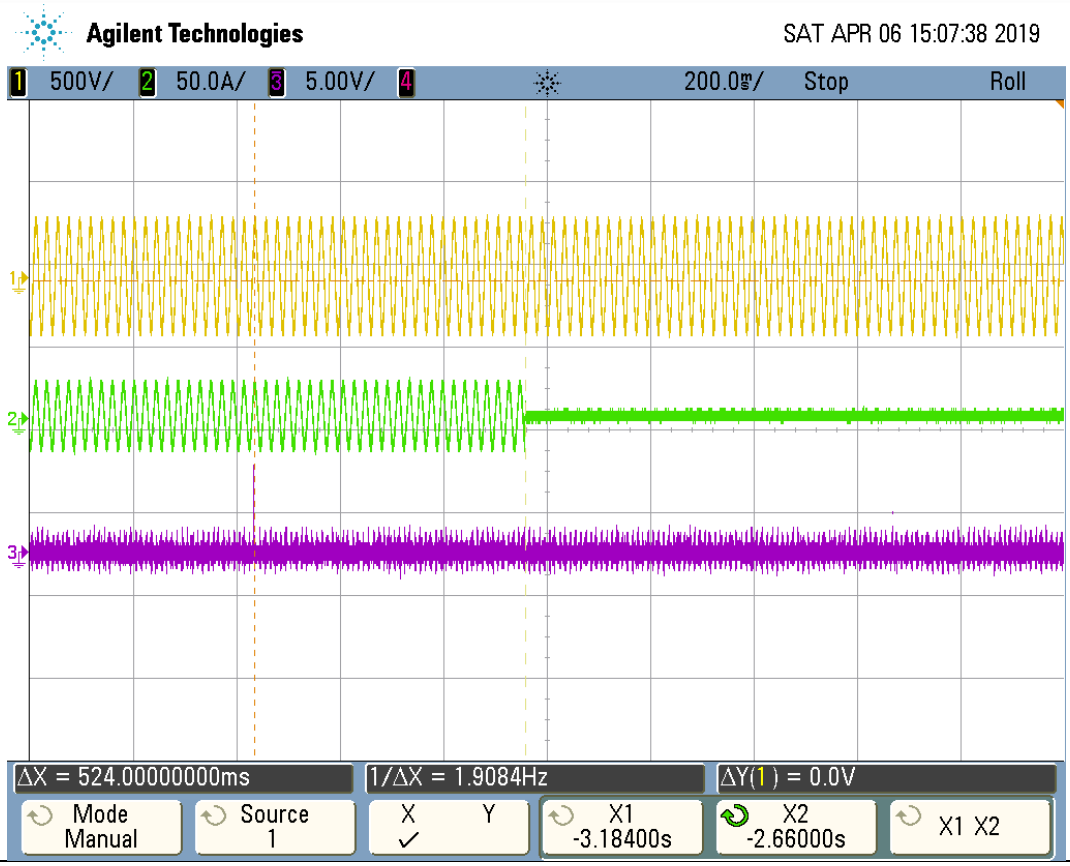
U/F stage 2


Frequency (Hz)
Power (p.u.)
Time (s)
Frequency (Hz)
Power (p.u.)

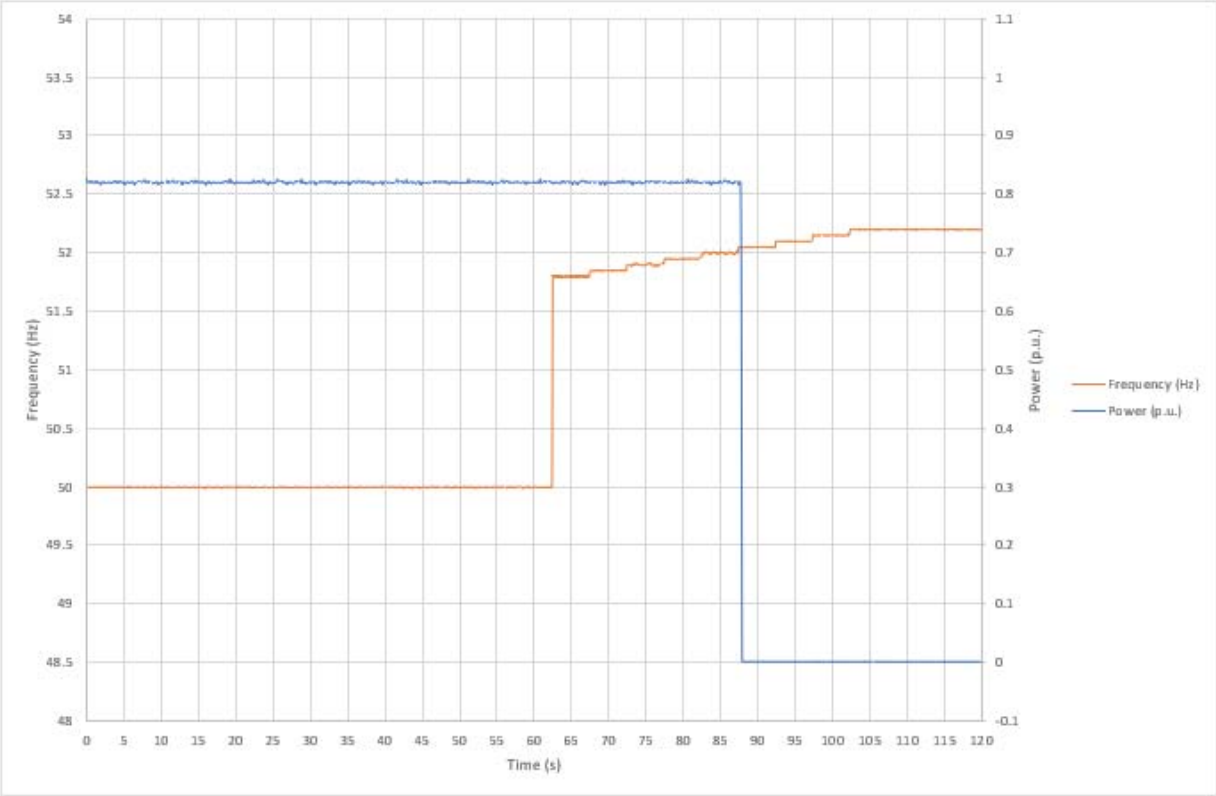

Agilent Technologies
SAT APR 06 15:05:11 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4 200.0ms/ Stop Roll
ΔX = 524.00000000ms
1/ΔX = 1.9084Hz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -3.56800s
X2 -3.04400s
X1 X2

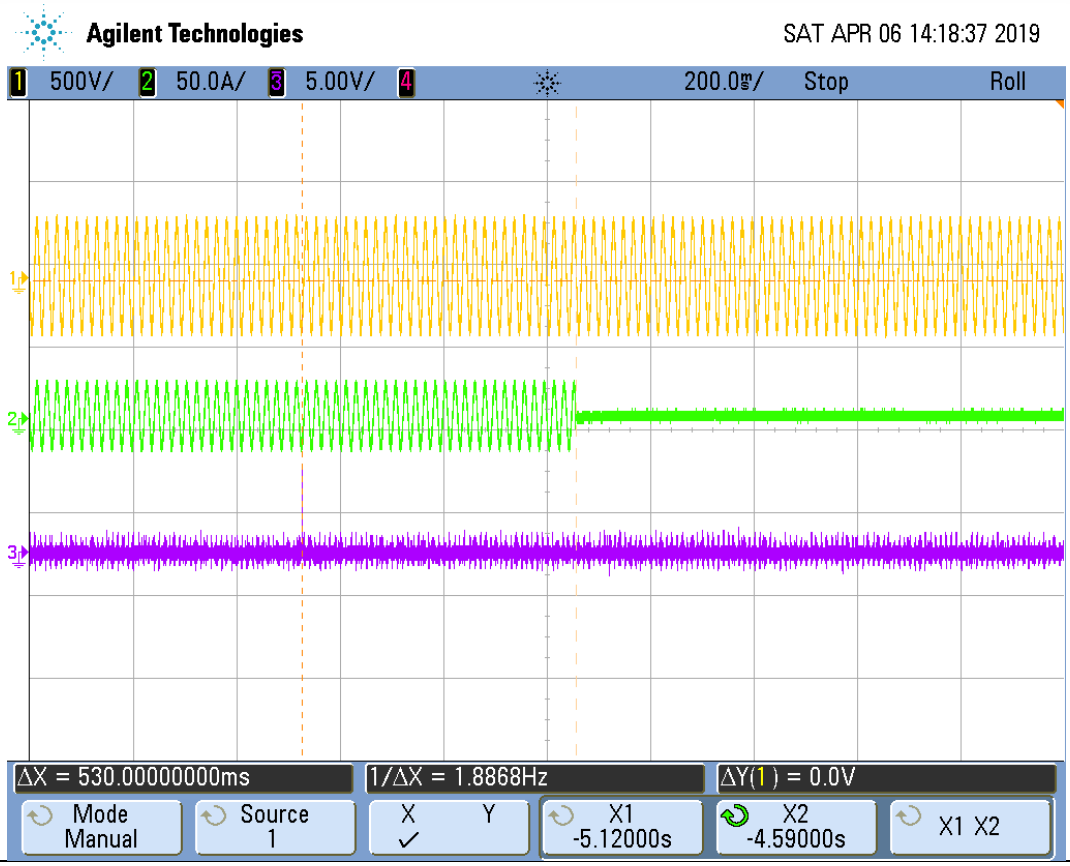
U/F stage 2


Frequency (Hz)
Power (p.u.)
Time (s)
Frequency (Hz)
Power (p.u.)

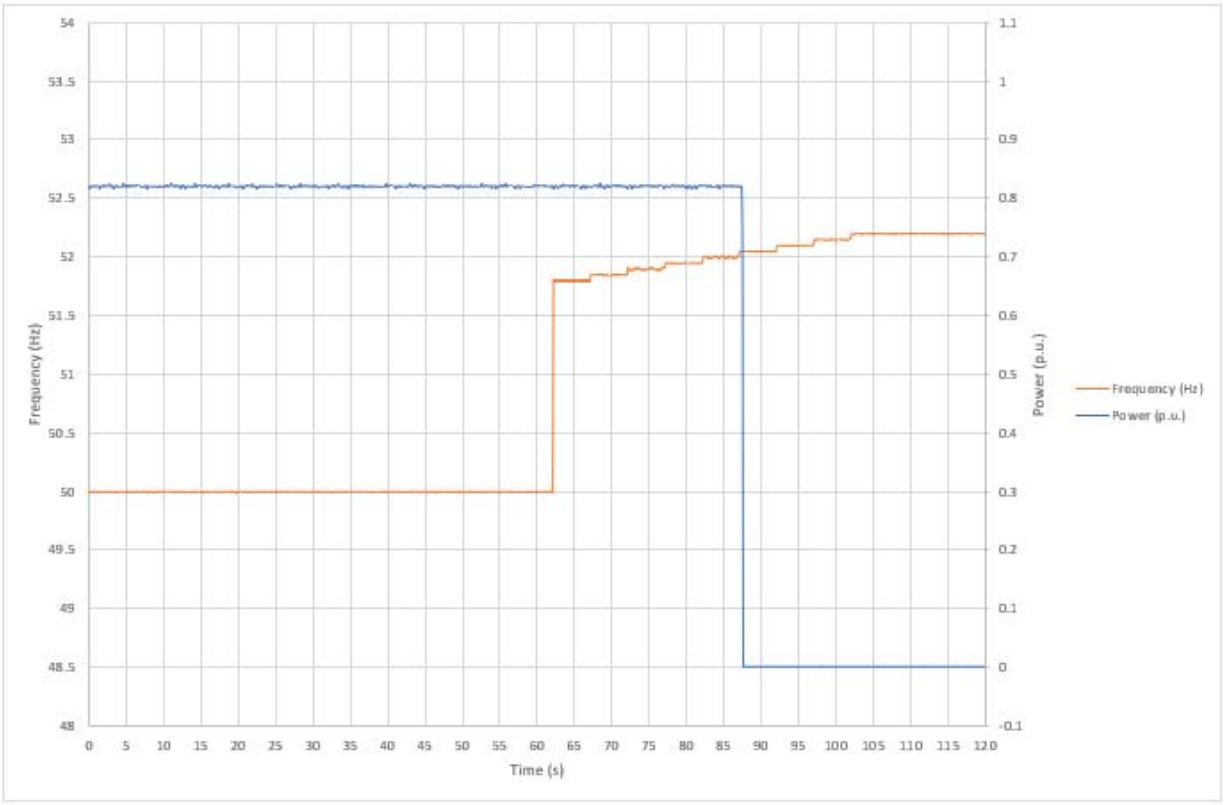

Agilent Technologies
SAT APR 06 15:07:38 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4 200.0ms/ Stop Roll
ΔX = 524.00000000ms
1/ΔX = 1.9084Hz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -3.18400s
X2 -2.66000s
X1 X2

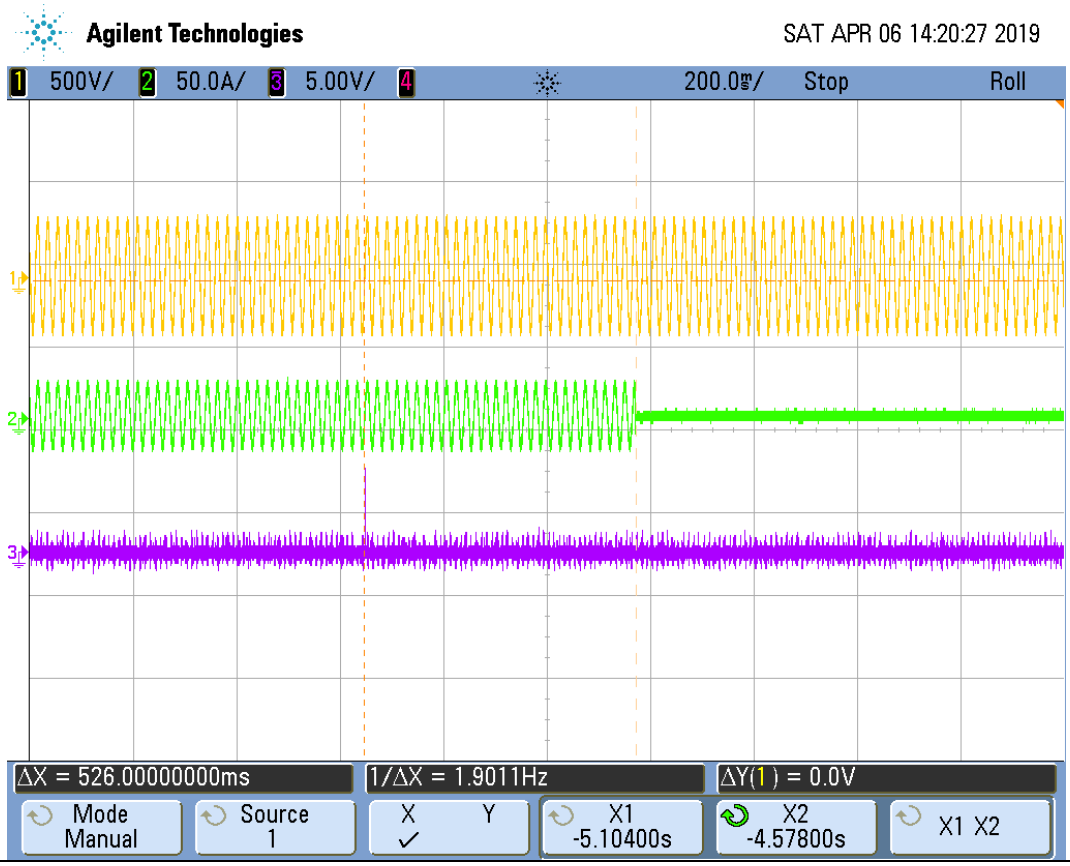
O/F stage 1


Frequency (Hz)
Power (p.u.)
Time (s)
Frequency (Hz)
Power (p.u.)

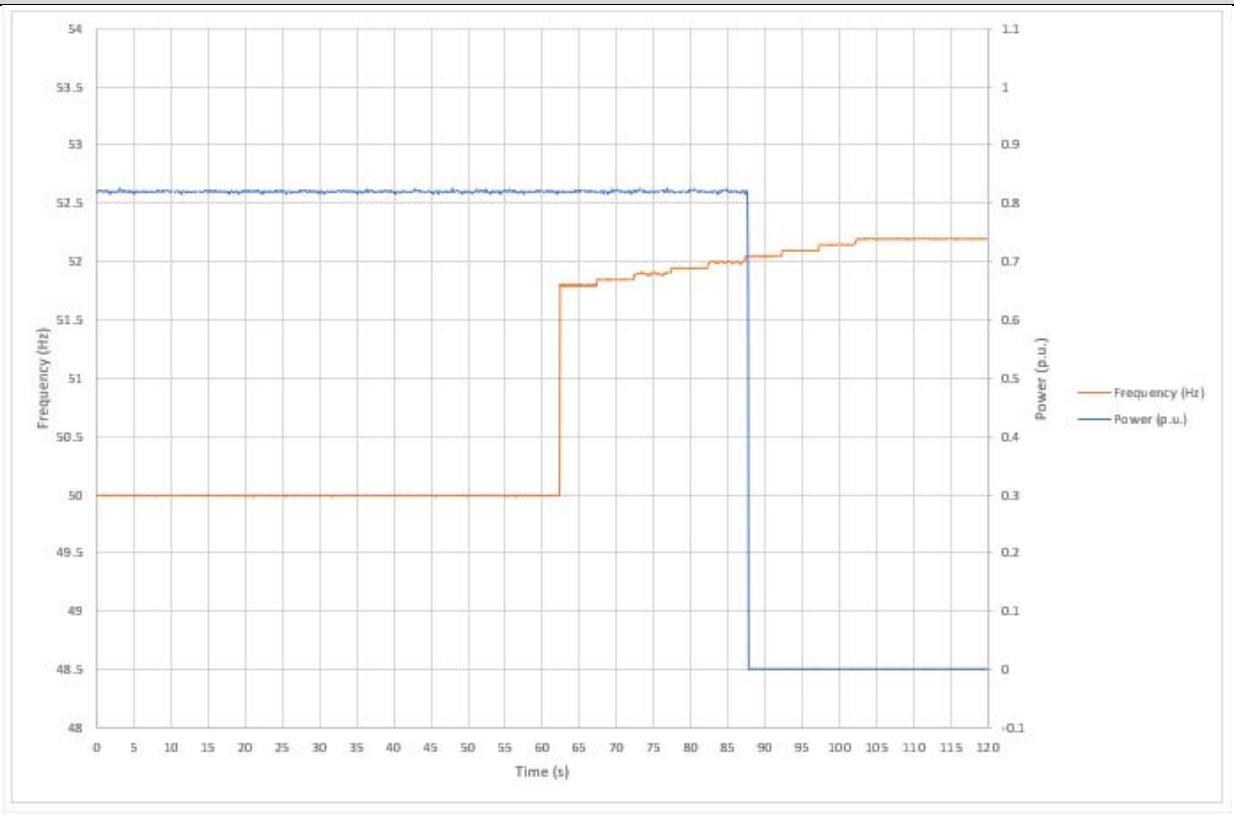

Agilent Technologies
SAT APR 06 14:18:37 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4 200.0ms/ Stop Roll
ΔX = 530.00000000ms
1/ΔX = 1.8868Hz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -5.12000s
X2 -4.59000s
X1 X2

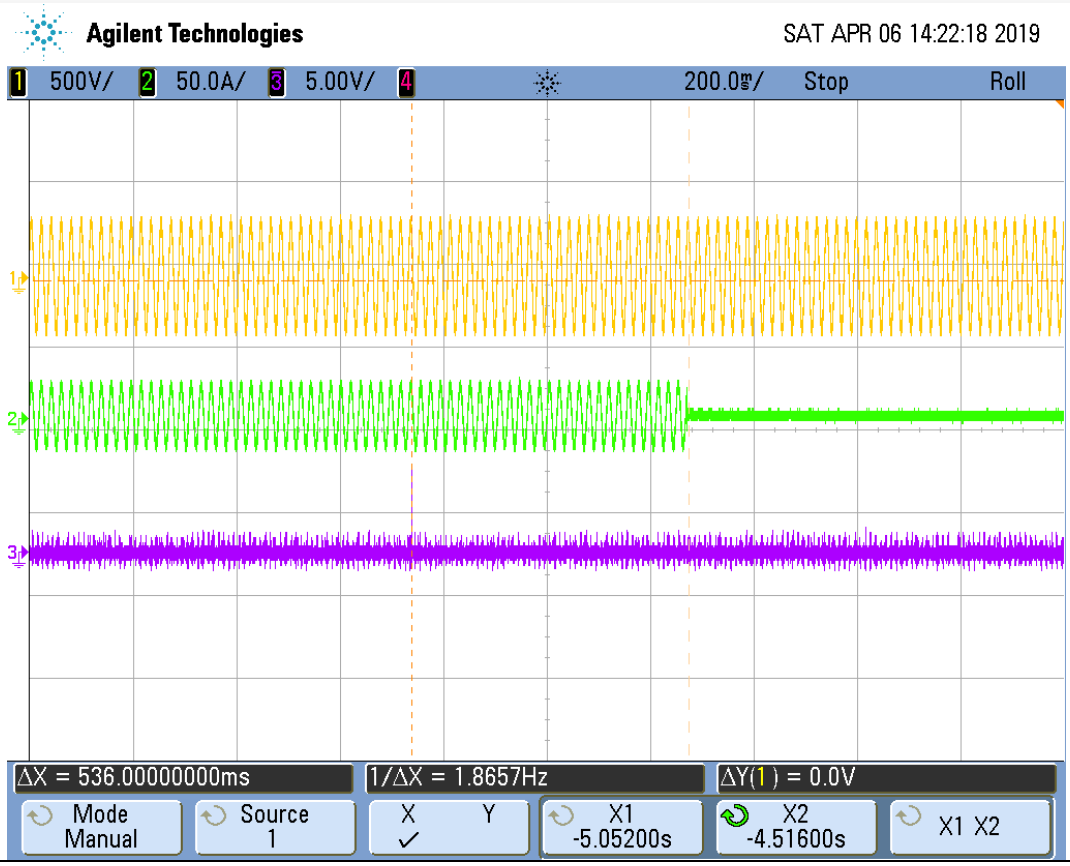
O/F stage 1


Frequency (Hz)
Power (p.u.)
Time (s)
Frequency (Hz)
Power (p.u.)

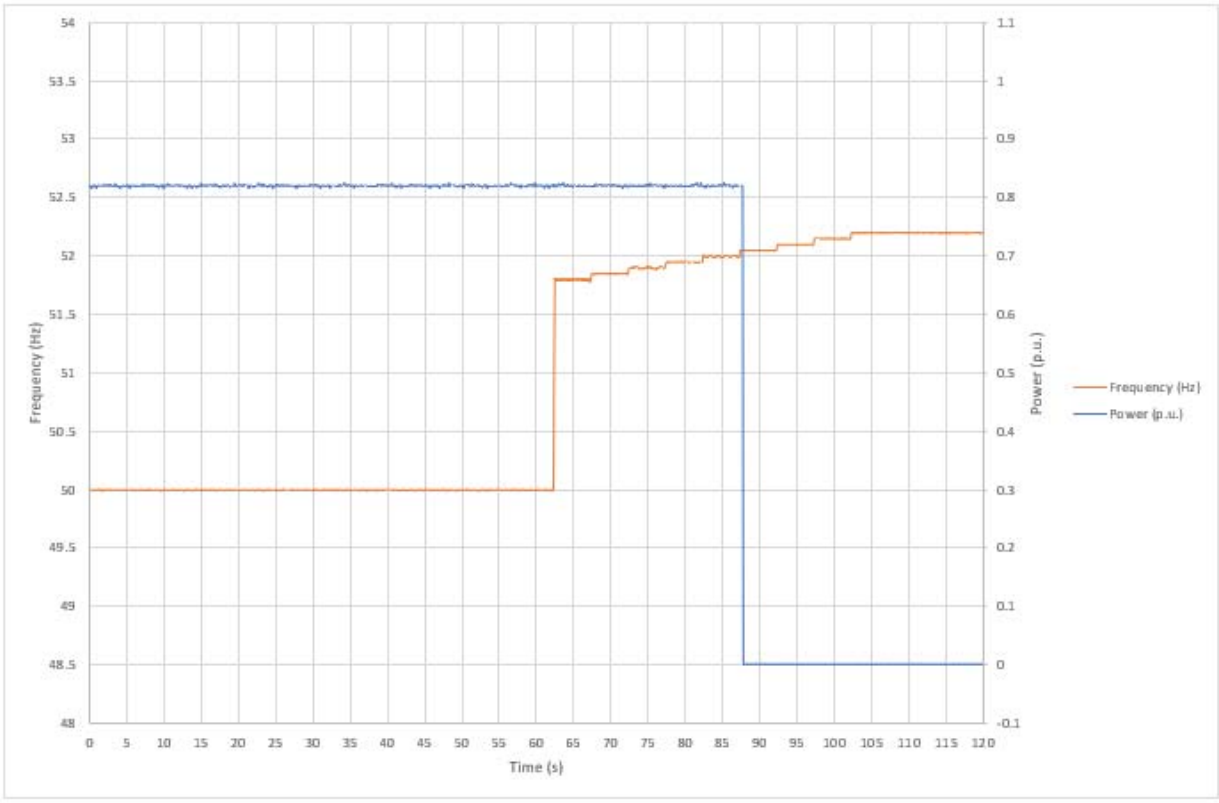

Agilent Technologies
SAT APR 06 14:20:27 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4 200.0ms/ Stop Roll
ΔX = 526.00000000ms
1/ΔX = 1.9011Hz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -5.10400s
X2 -4.57800s
X1 X2

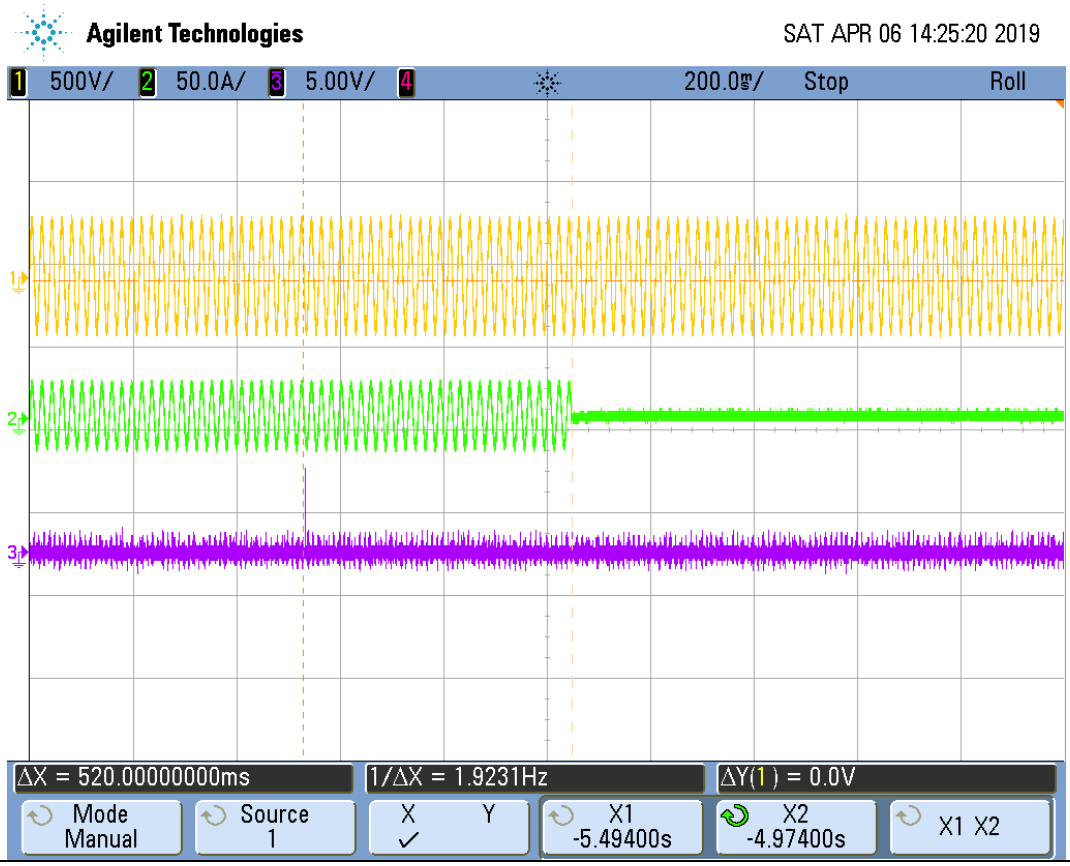
O/F stage 1


Frequency (Hz)
Power (p.u.)
Time (s)
Frequency (Hz)
Power (p.u.)

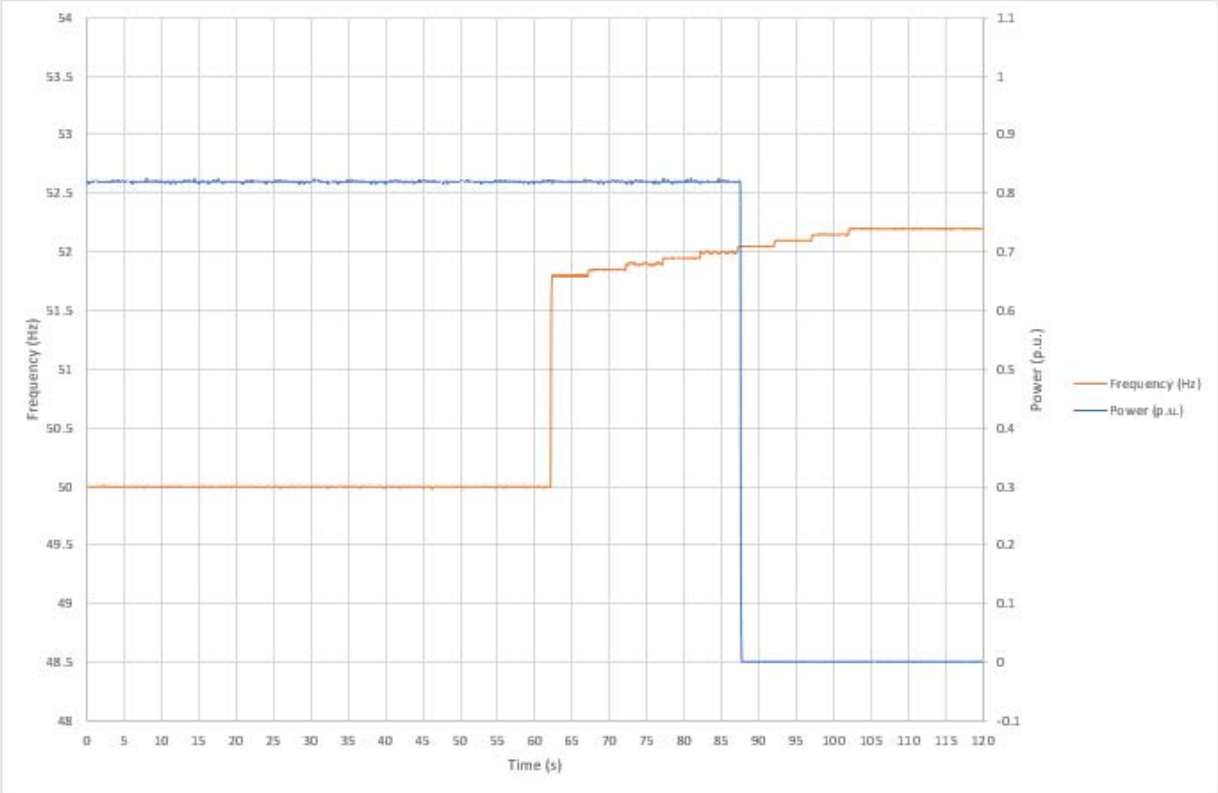

Agilent Technologies
SAT APR 06 14:22:18 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4 200.0ms/ Stop Roll
ΔX = 536.00000000ms
1/ΔX = 1.8657Hz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -5.05200s
X2 -4.51600s
X1 X2

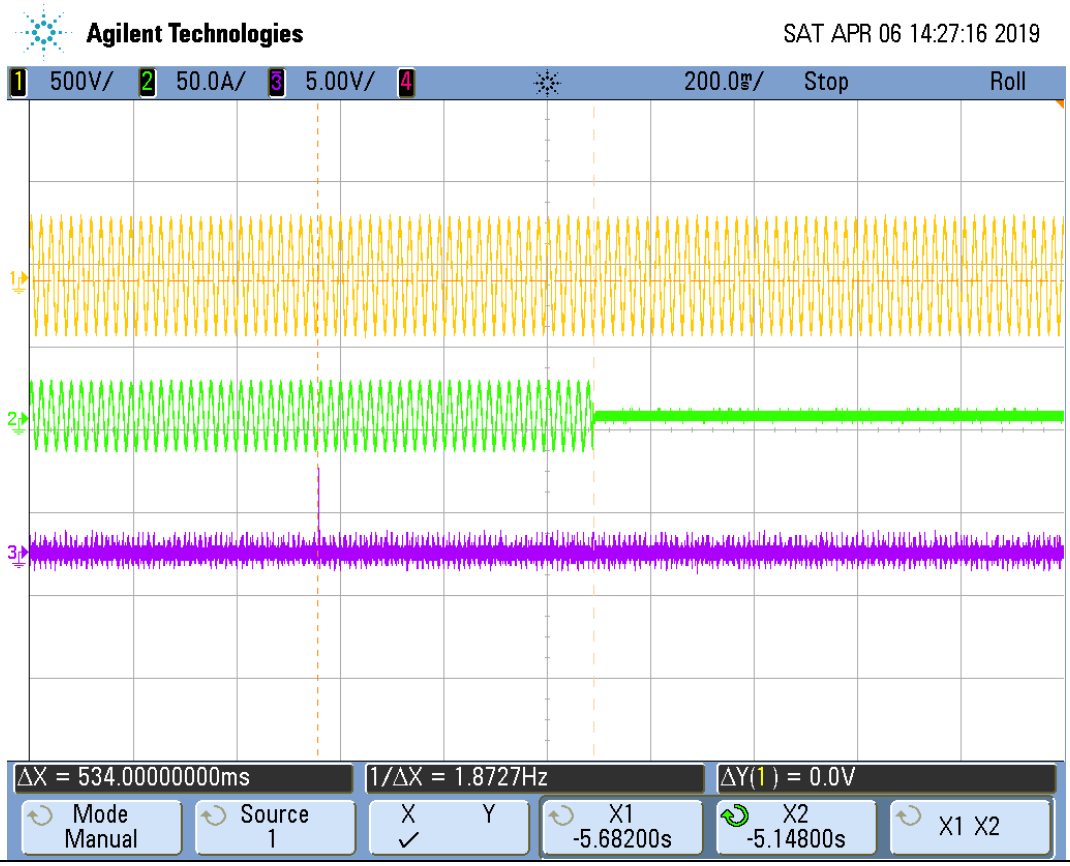
O/F stage 1


Frequency (Hz)
Power (p.u.)
Time (s)
Frequency (Hz)
Power (p.u.)

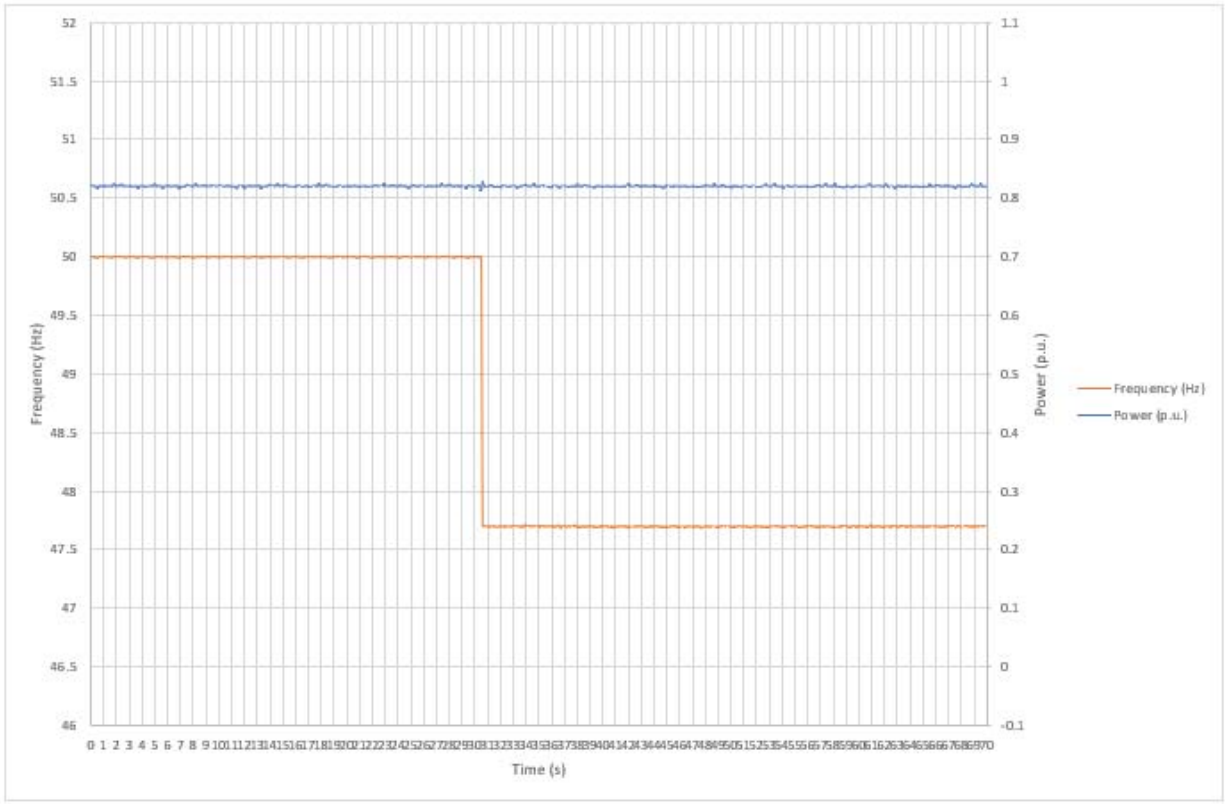

Agilent Technologies
SAT APR 06 14:25:20 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4 200.0ms/ Stop Roll
ΔX = 520.00000000ms
1/ΔX = 1.9231Hz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -5.49400s
X2 -4.97400s
X1 X2

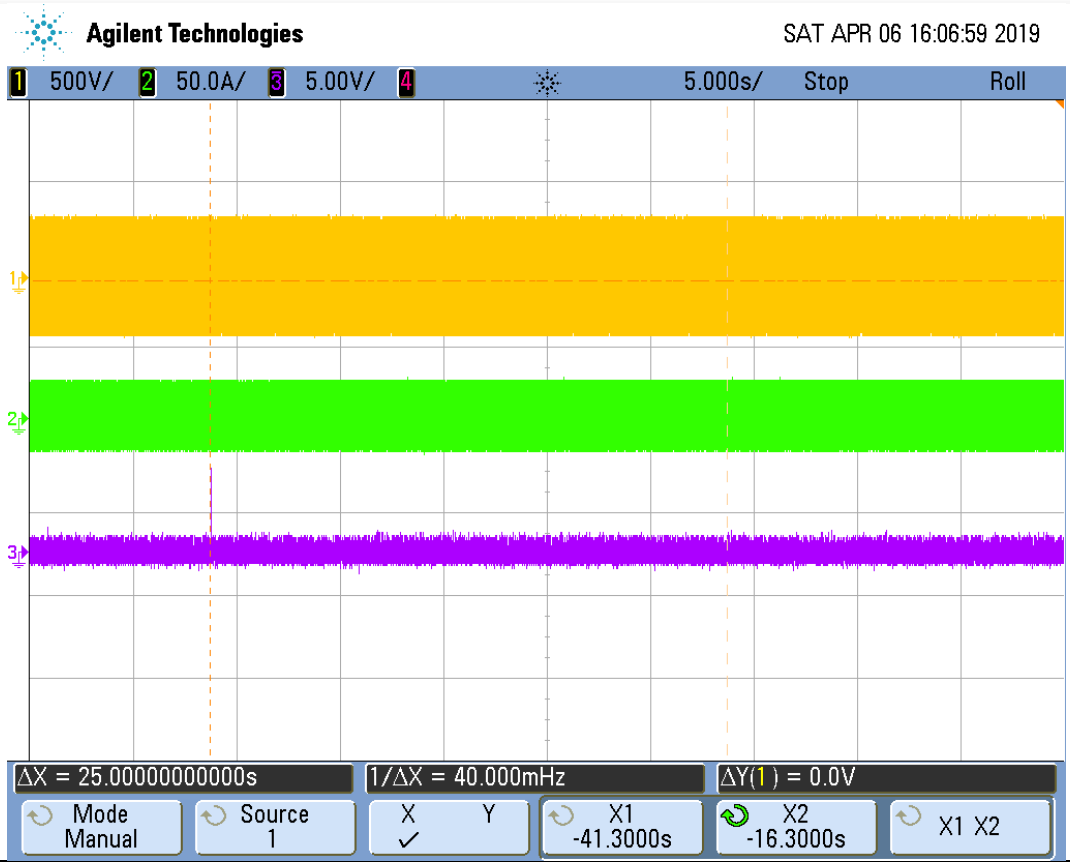
O/F stage 1


Frequency (Hz)
Power (p.u.)
Time (s)
Frequency (Hz)
Power (p.u.)

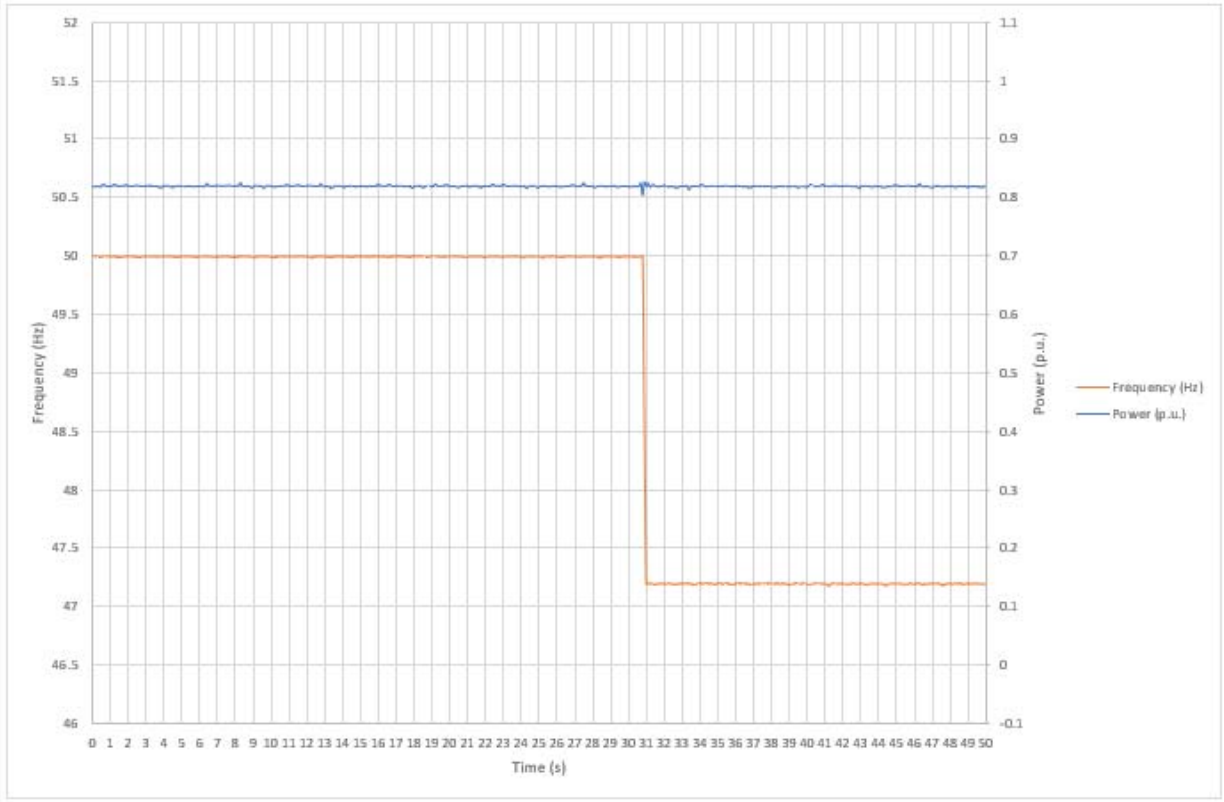

Agilent Technologies
SAT APR 06 14:27:16 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4 200.0ms/ Stop Roll
ΔX = 534.00000000ms
1/ΔX = 1.8727Hz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -5.68200s
X2 -5.14800s
X1 X2

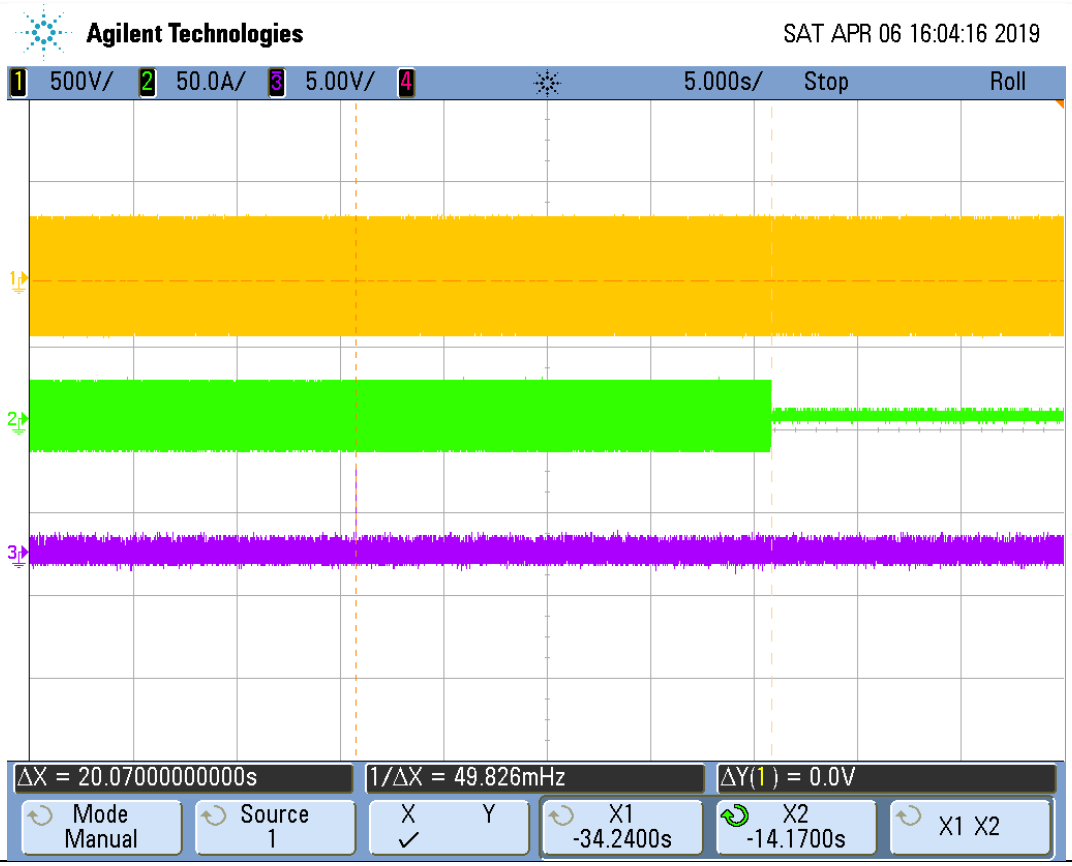
No trip tests - 47.7Hz



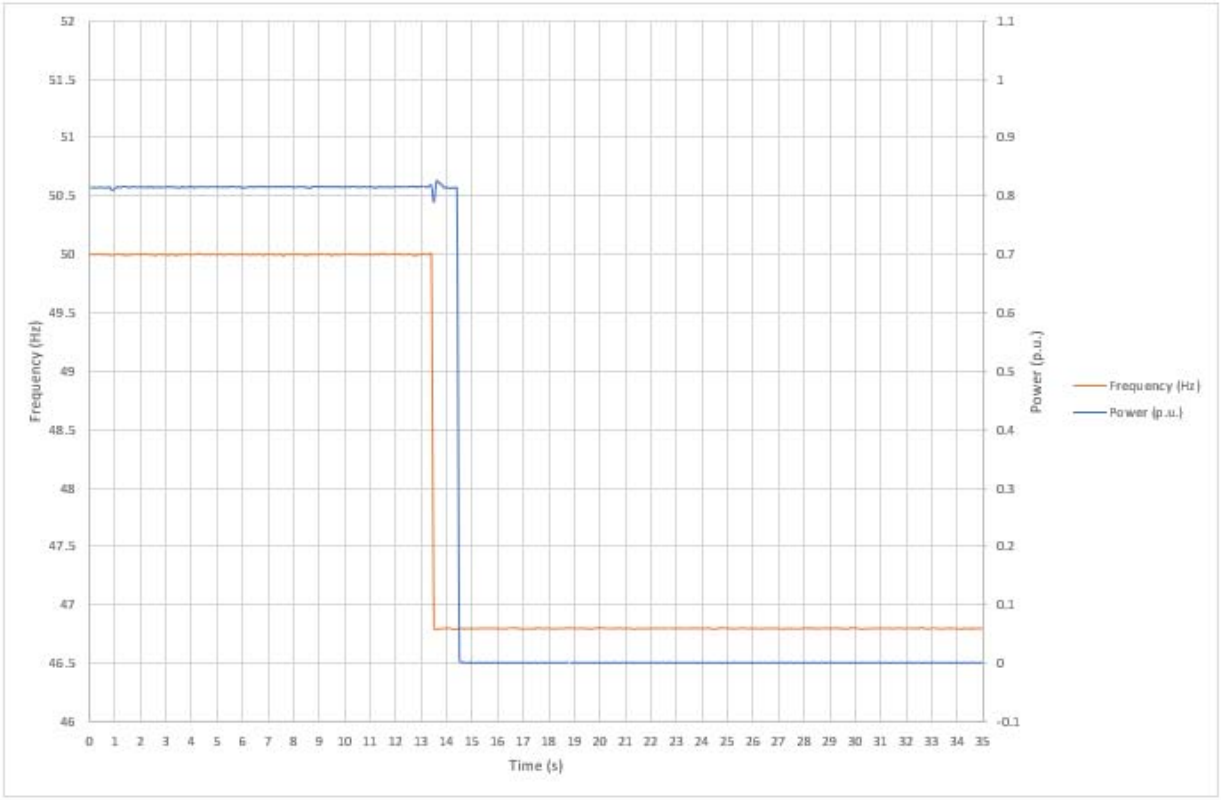


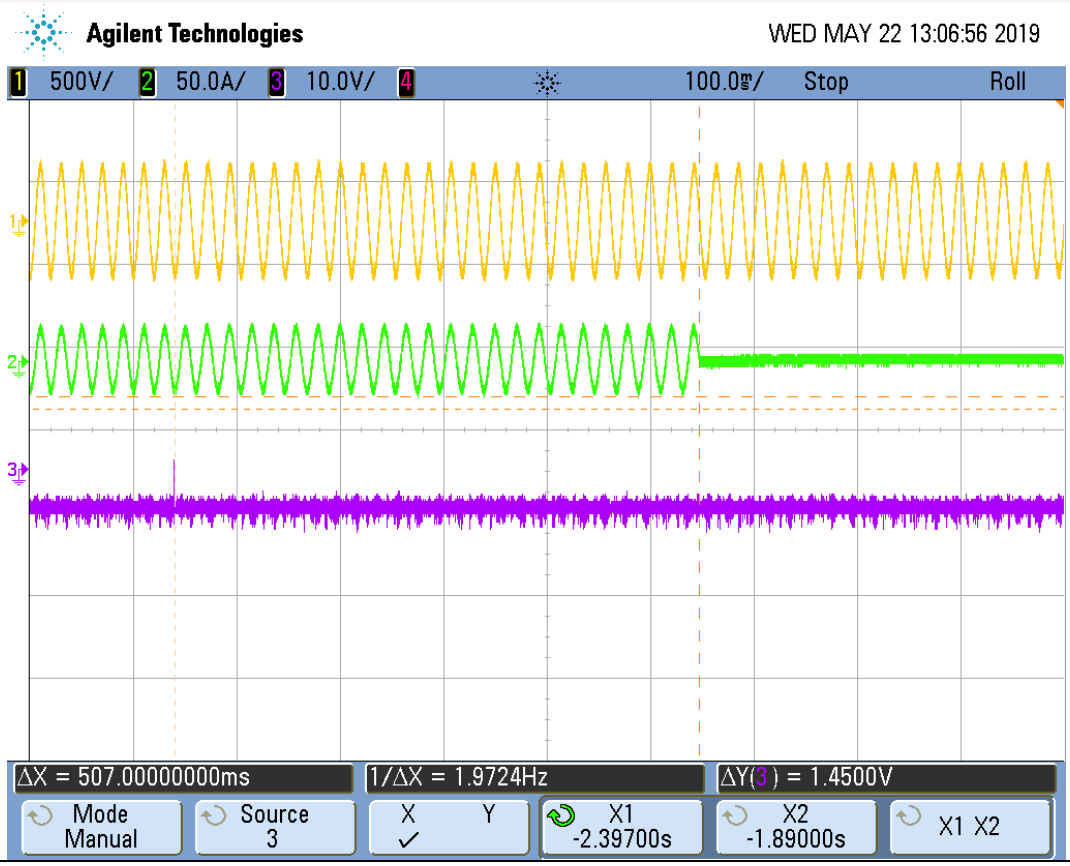
No trip tests – 47.2Hz



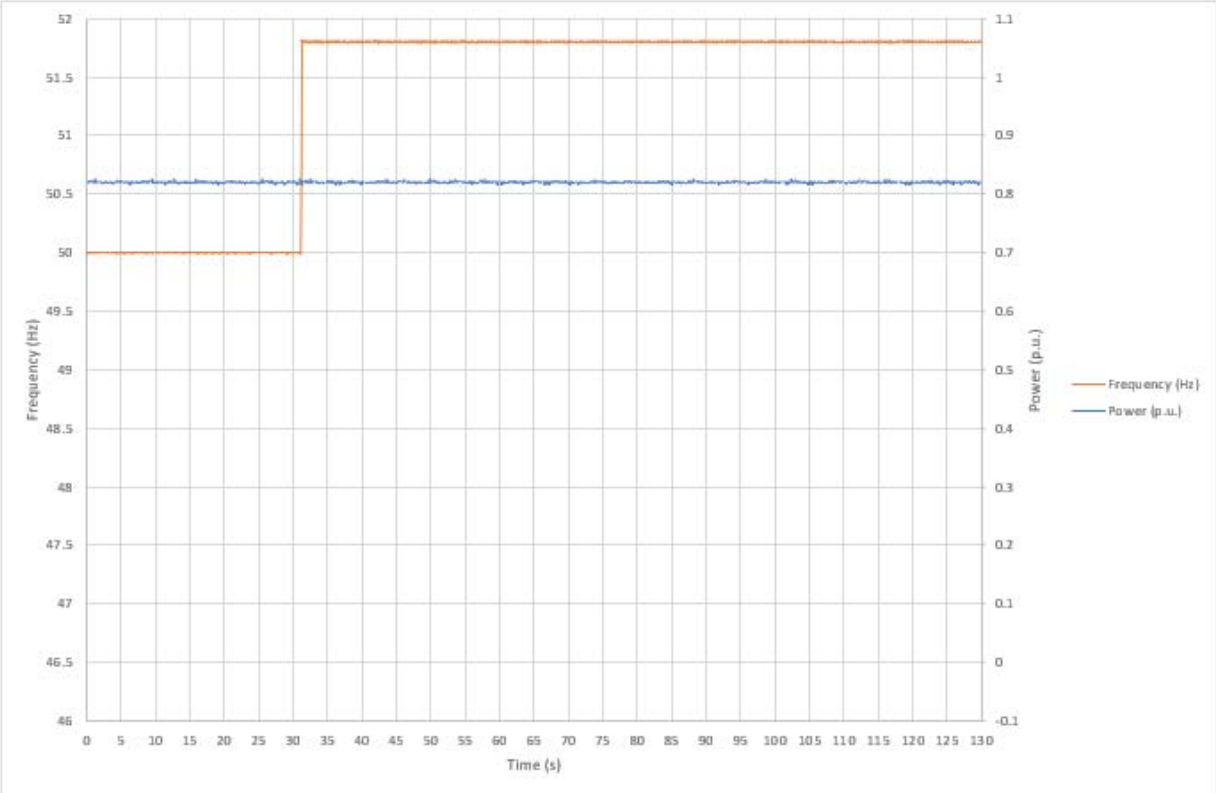


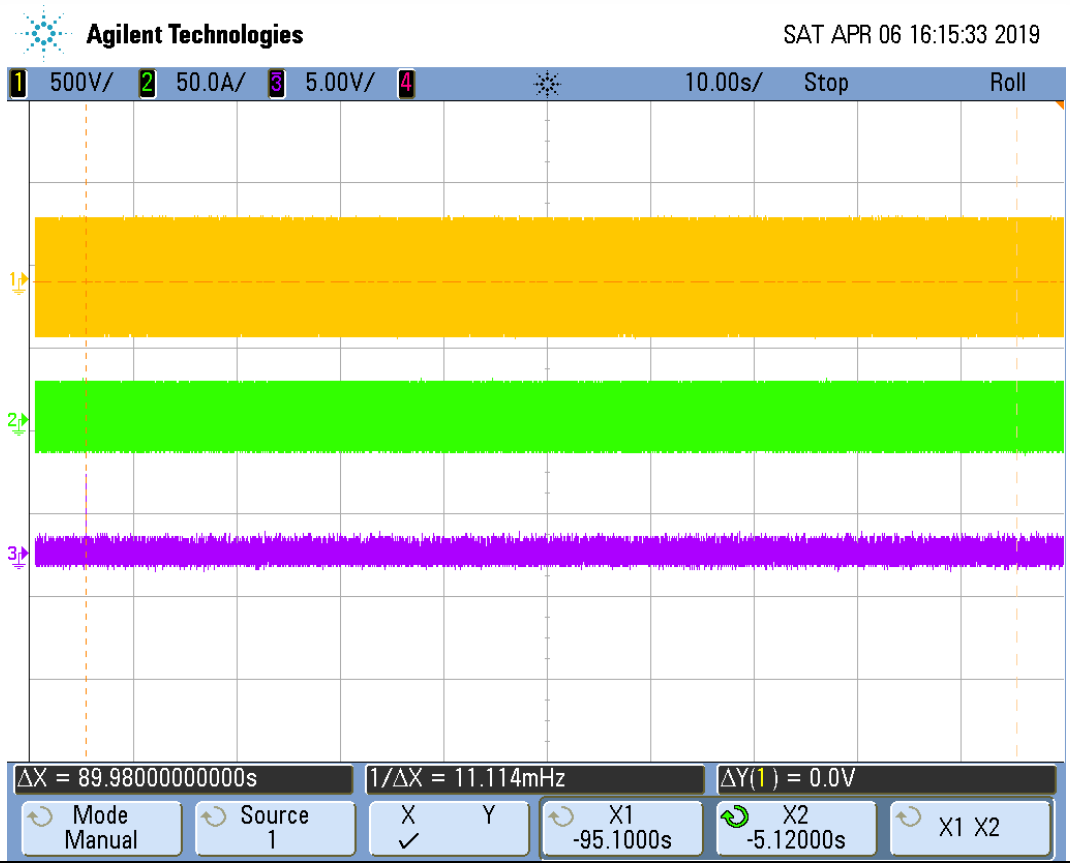
No trip tests – 46.8Hz



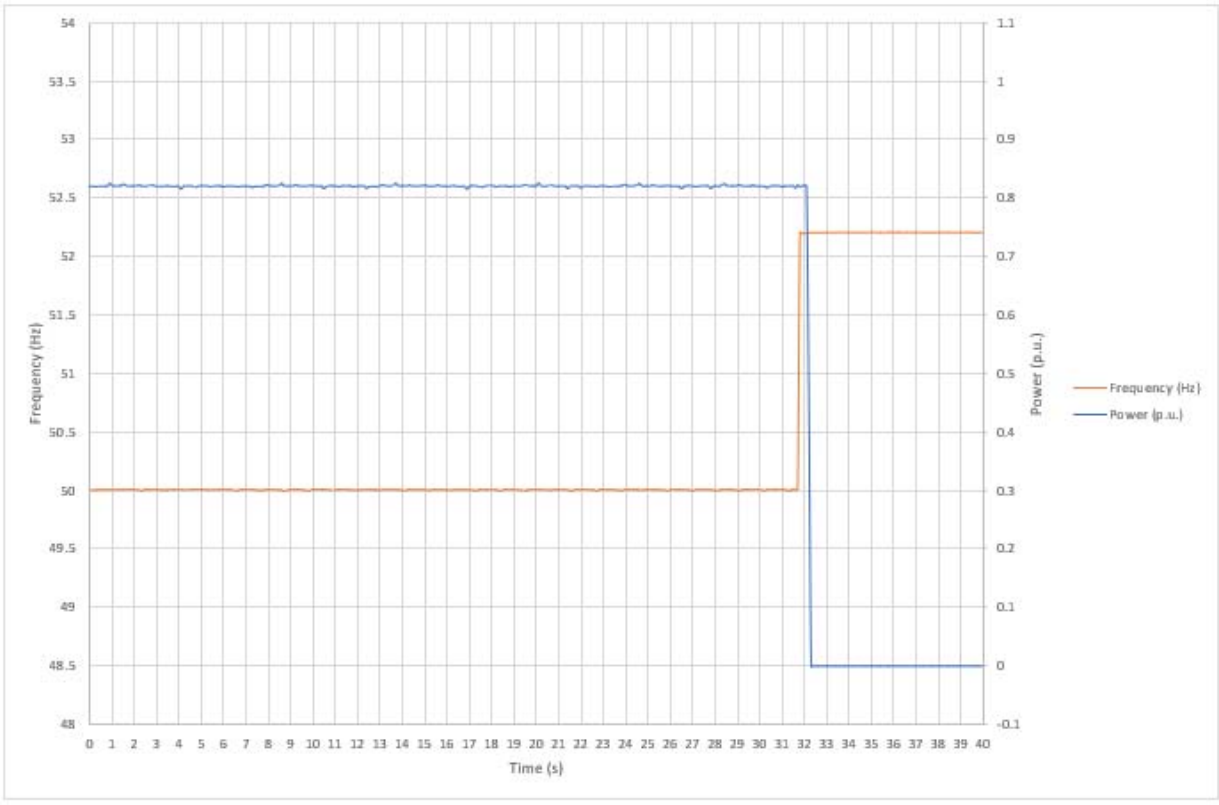


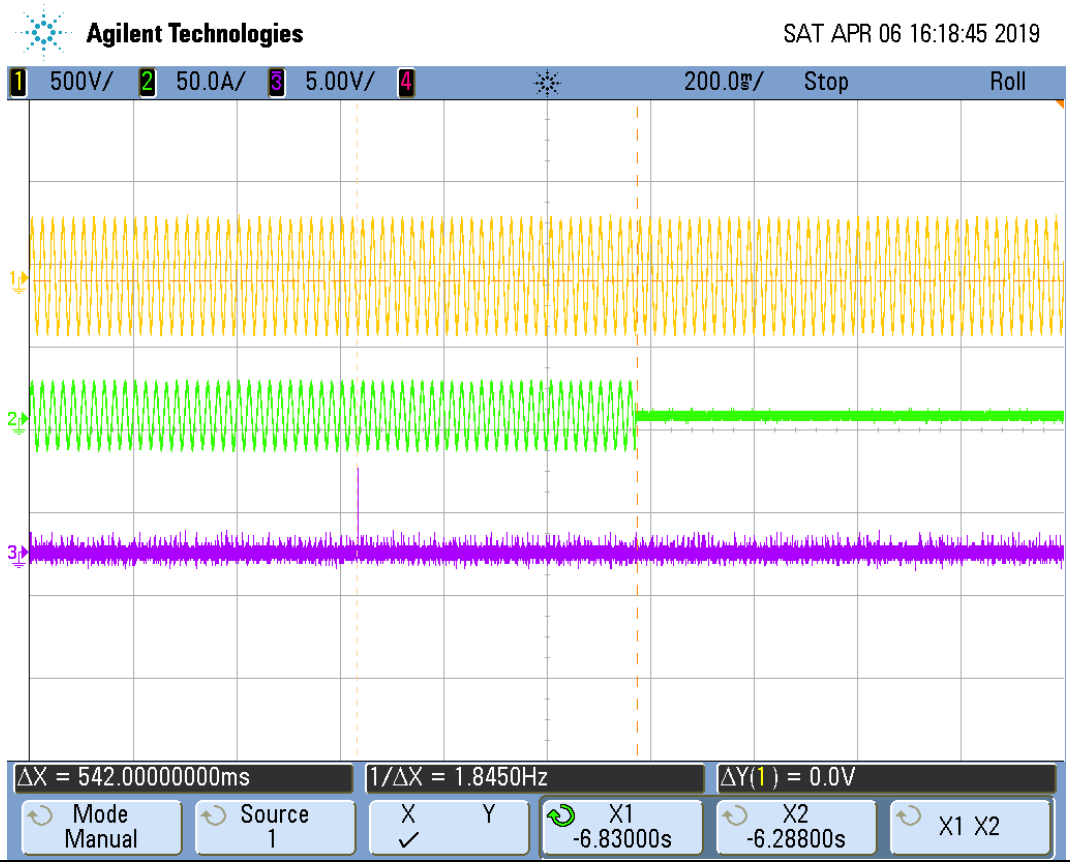
No trip tests - 51.8Hz





No trip tests – 52.2Hz





4.3.2 Voltage tests

To establish the certified trip voltage, the test voltage should be applied in steps of ± 0.5% of setting for a duration that is longer than the trip time delay.

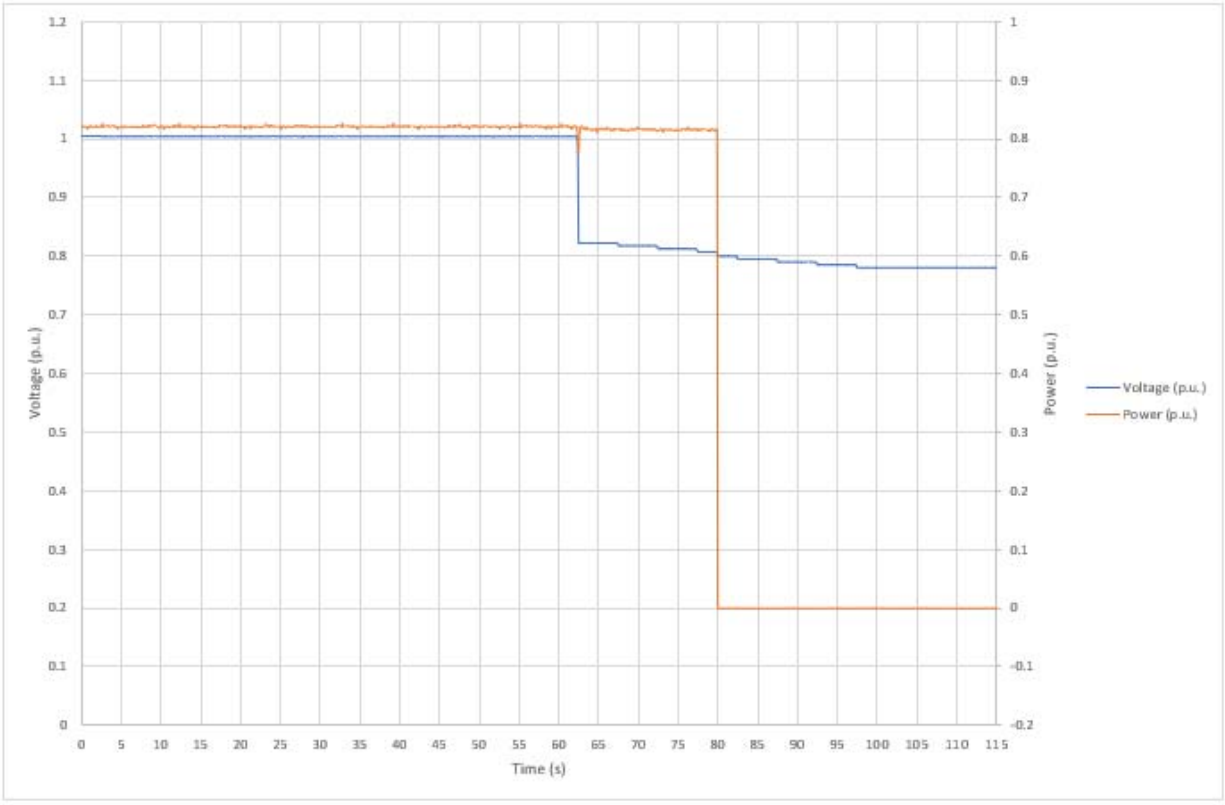
To establish the certified trip time, the test voltage should be applied starting from ± 1.8% below the certified trip voltage in a step of at least ± 0.5% of setting for a duration that is longer than the trip time delay. For each trip setting five tests shall be carried out.

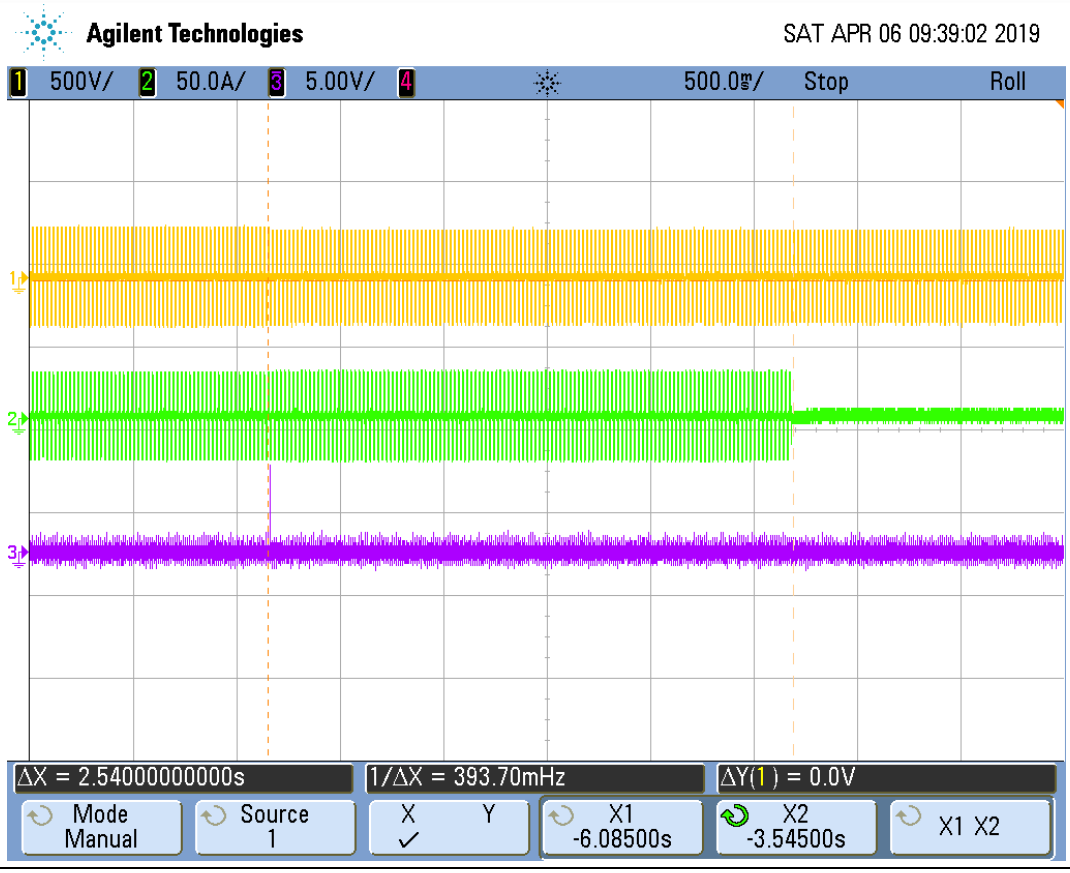
Following tables show the test results:

Function	Setting		Trip test		"No trip tests"	
	Voltage	Time delay	Voltage (V)	Time delay (s)	Voltage /time	Confirm no trip
U/V	184 V	2.5 s	183.85	2.540	188 V / 3.50 s	Pass
			183.91	2.524		
			183.81	2.522		
			183.87	2.510		
			183.88	2.515		
					180 V / 2.48 s	Pass
O/V stage 1	262.2 V	1.0 s	262.01	1.019	258.2 V / 2.0 s	Pass
			261.97	1.010		
			261.98	1.017		
			261.97	1.006		
			262.85	1.015		
O/V stage 2	273.7 V	0.5 s	273.41	0.534	269.7 V / 0.98 s	Pass
			273.46	0.508		
			273.41	0.518		
			273.43	0.510		
			273.67	0.530		
					277.7 V / 0.48 s	Pass
Note for Voltage tests the Voltage required to trip is the setting ±3.45 V. 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 ±4 V and for the relevant times as shown in the table above to ensure that the protection will not trip in error.						

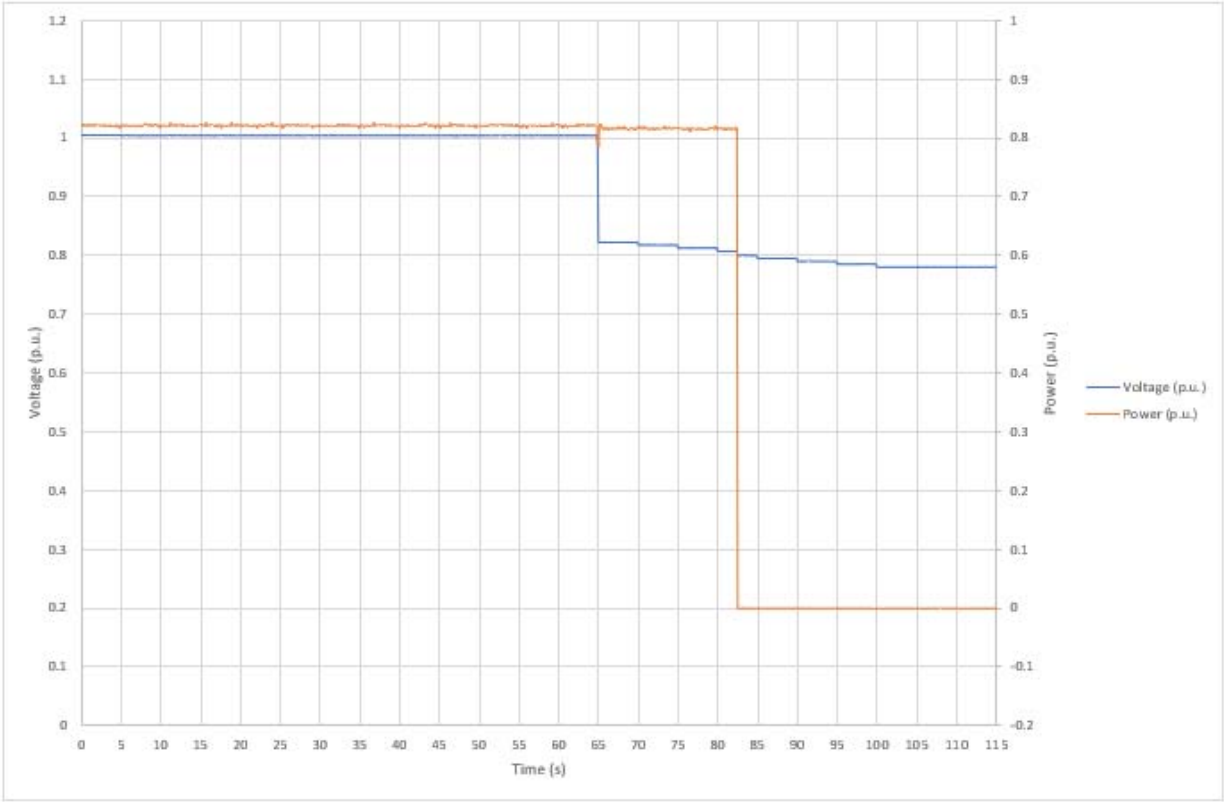
Test results are graphically shown in following pages.

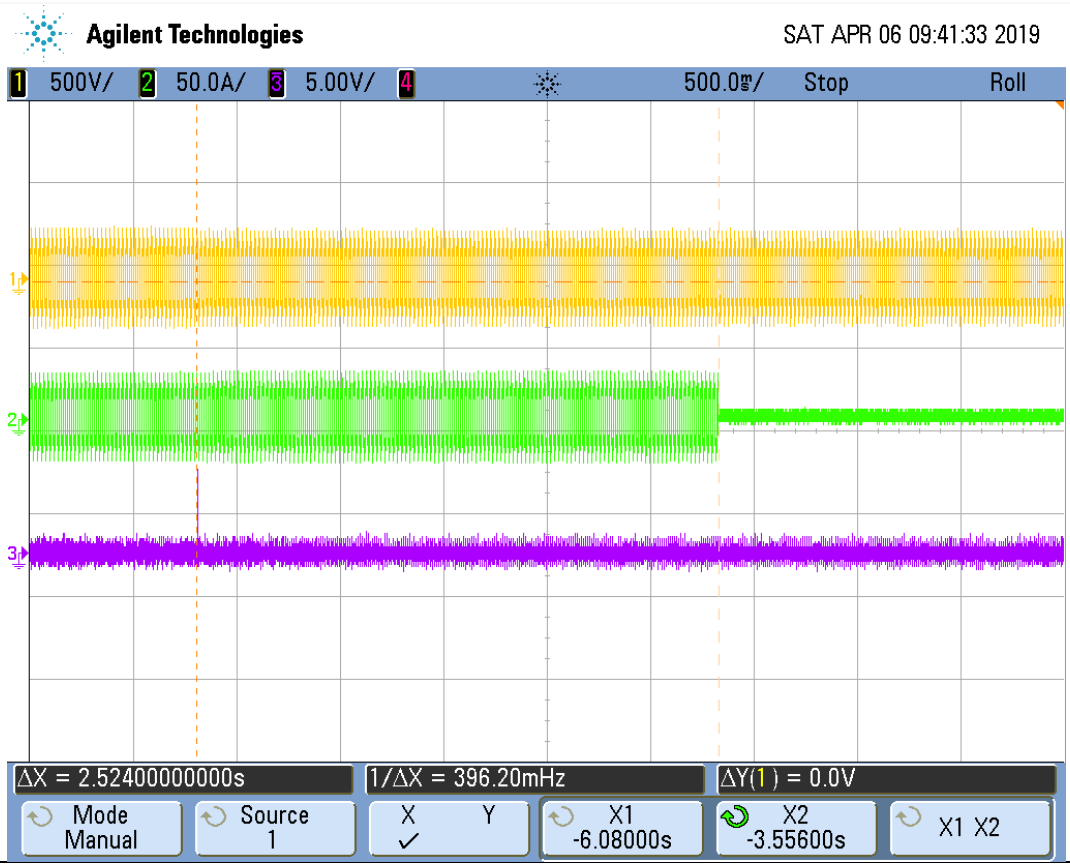
U/V



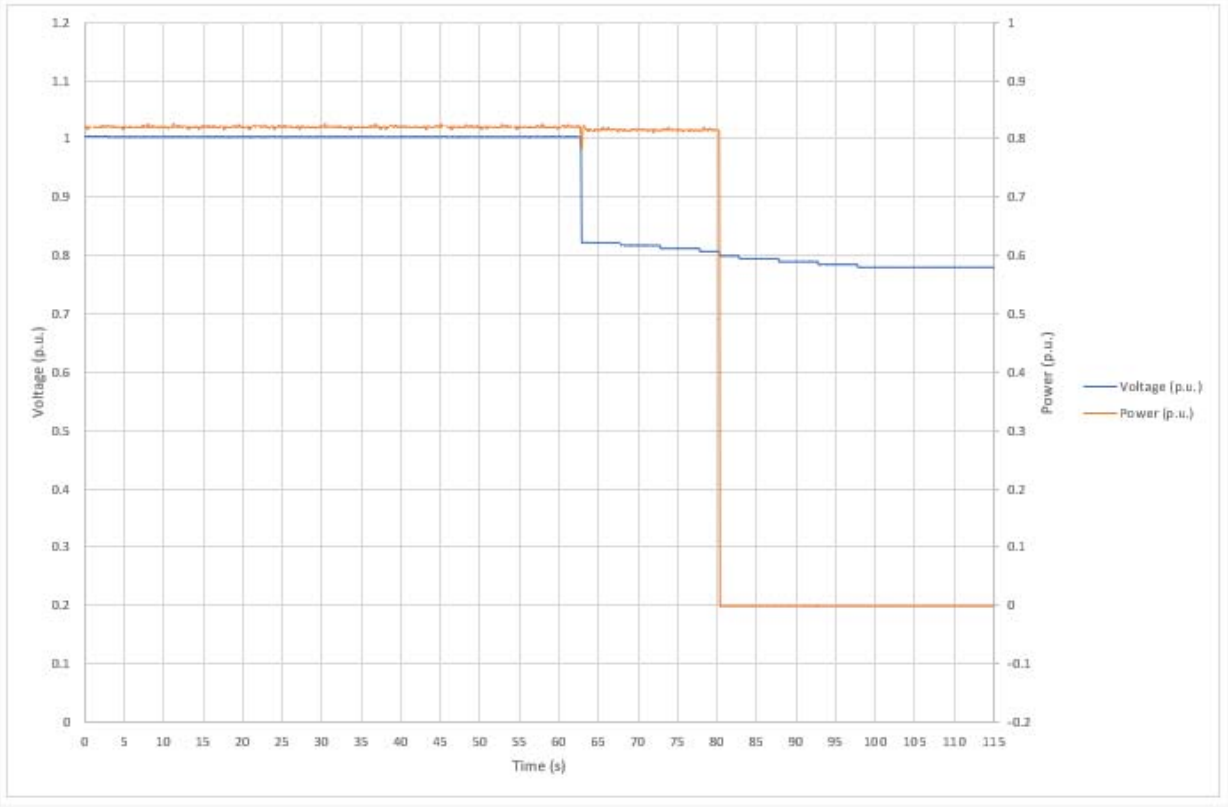


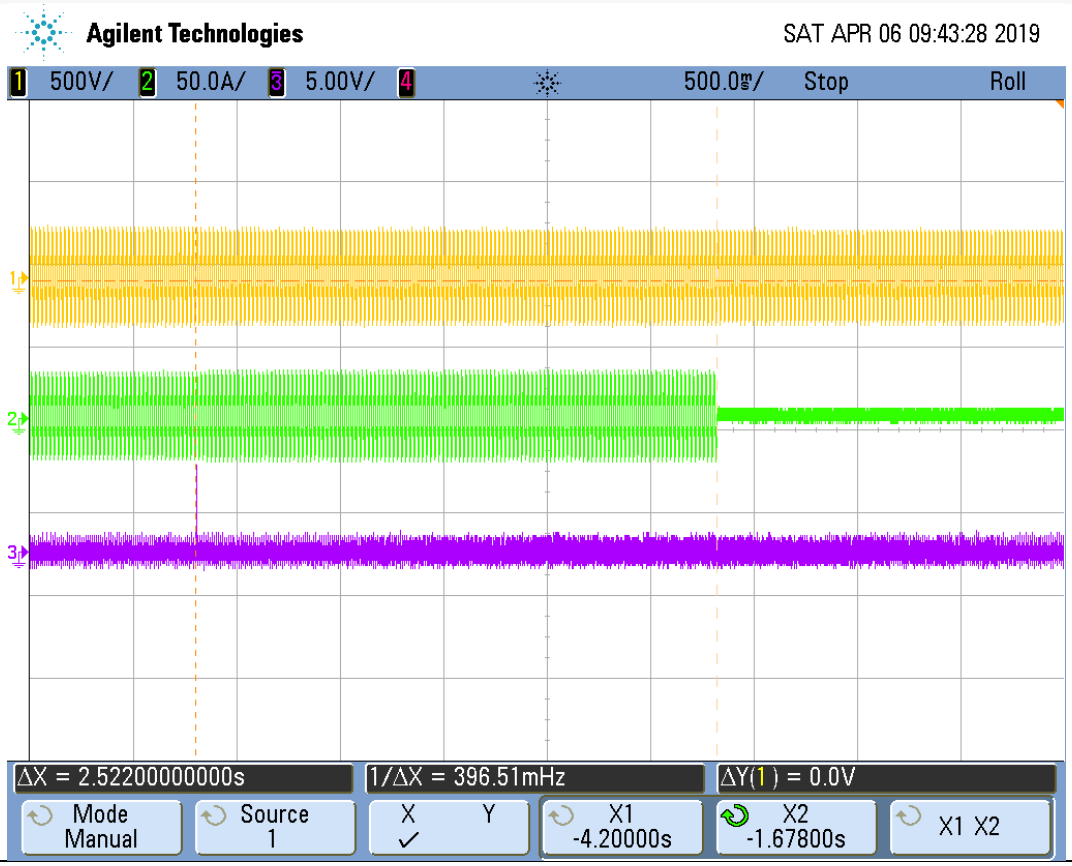
U/V


Voltage (p.u.)
Power (p.u.)
Time (s)
Voltage (p.u.)
Power (p.u.)

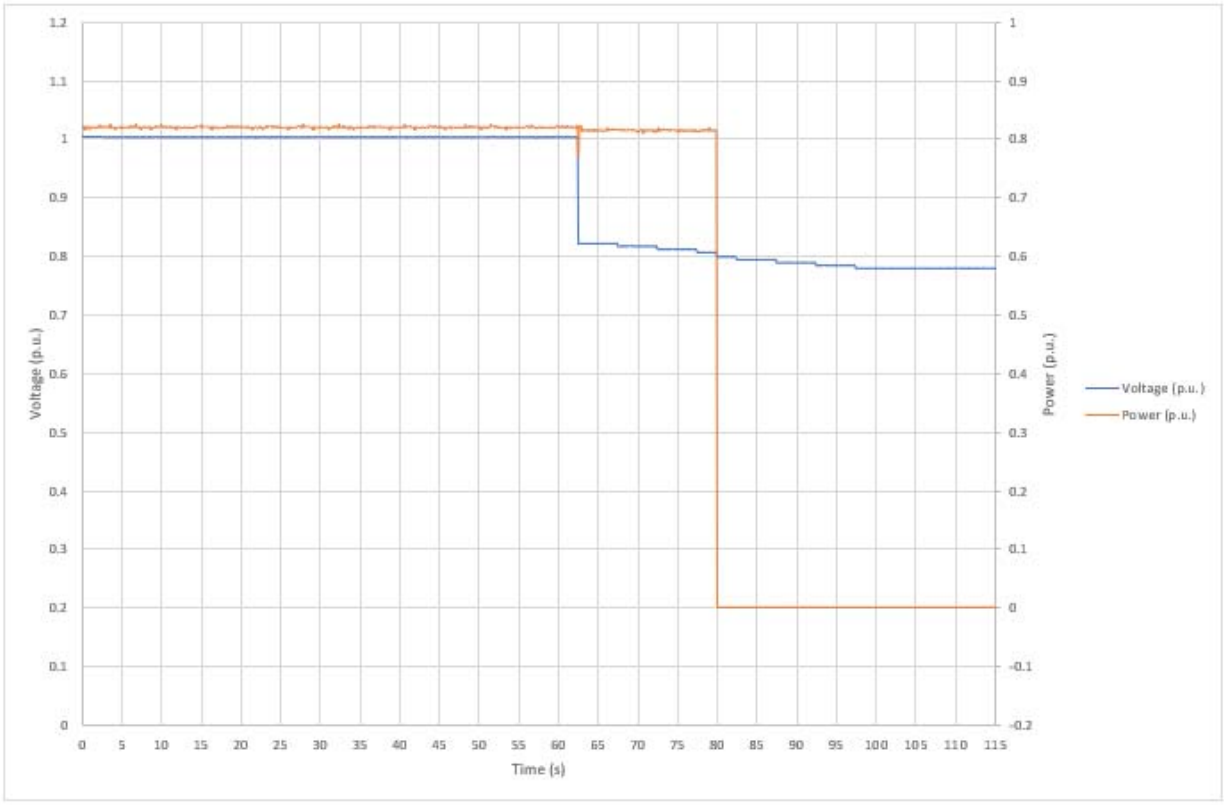

Agilent Technologies
SAT APR 06 09:41:33 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4 500.0ms/ Stop Roll
ΔX = 2.52400000000s
1/ΔX = 396.20mHz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -6.08000s
X2 -3.55600s
X1 X2

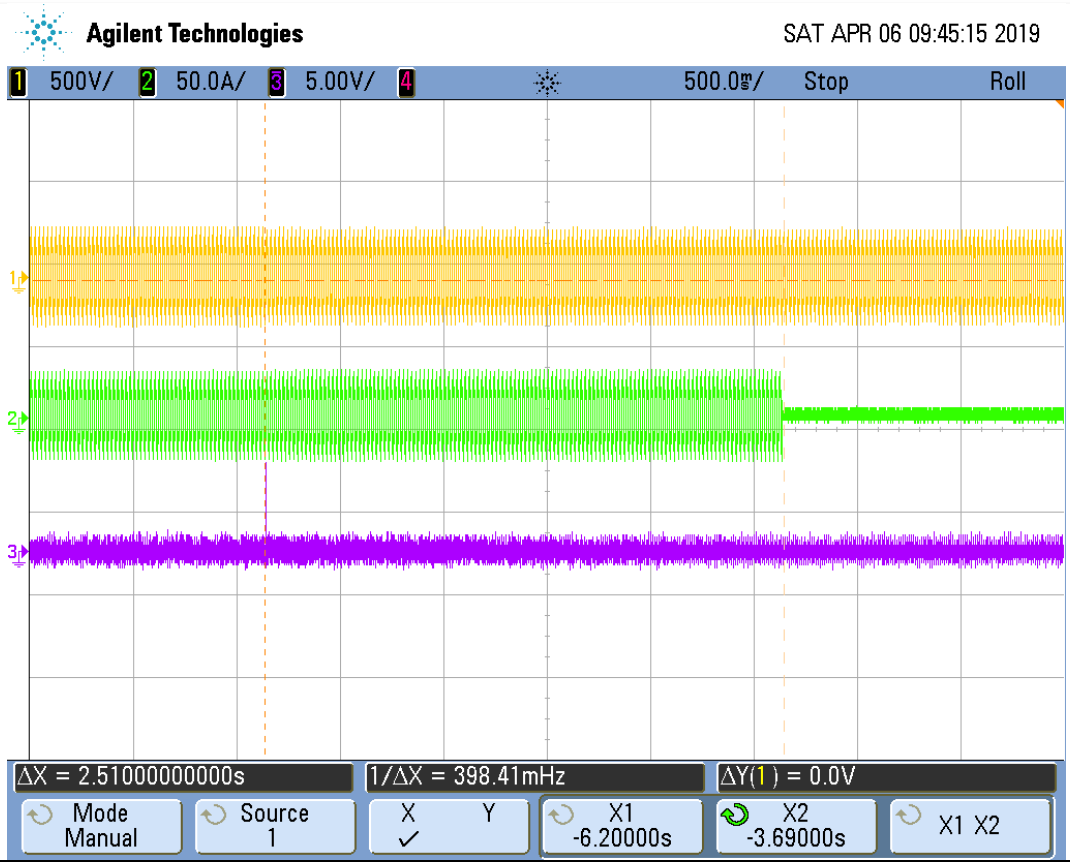
U/V


Voltage (p.u.)
Power (p.u.)
Time (s)
Voltage (p.u.)
Power (p.u.)

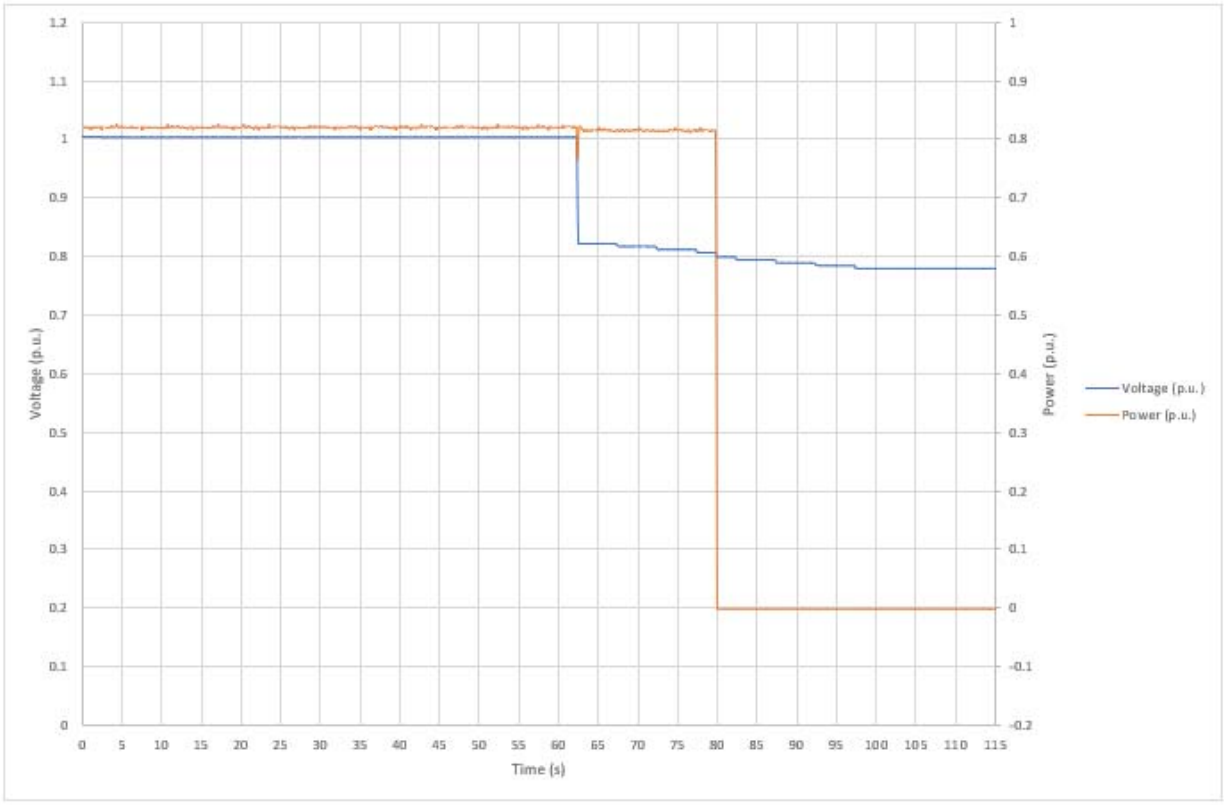

Agilent Technologies
SAT APR 06 09:43:28 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4
500.0ms/ Stop Roll
ΔX = 2.52200000000s
1/ΔX = 396.51mHz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -4.20000s
X2 -1.67800s
X1 X2

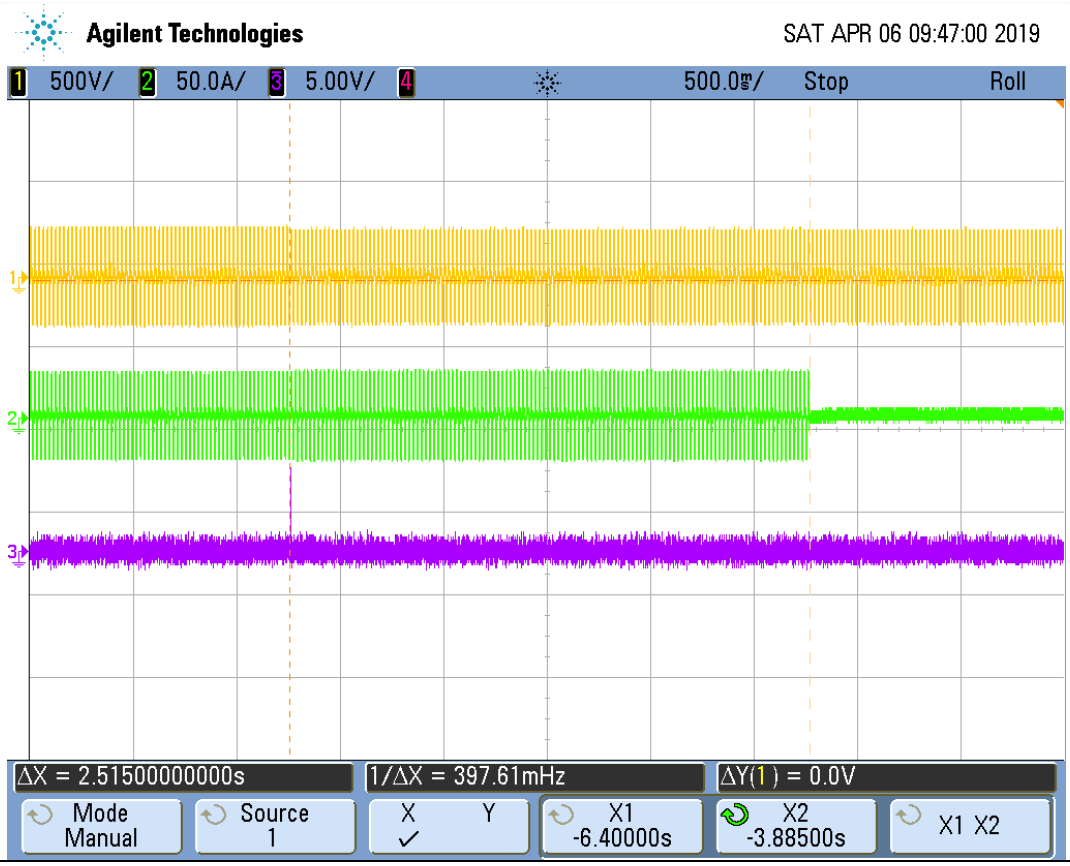
U/V


Voltage (p.u.)
Power (p.u.)
Time (s)
Voltage (p.u.)
Power (p.u.)

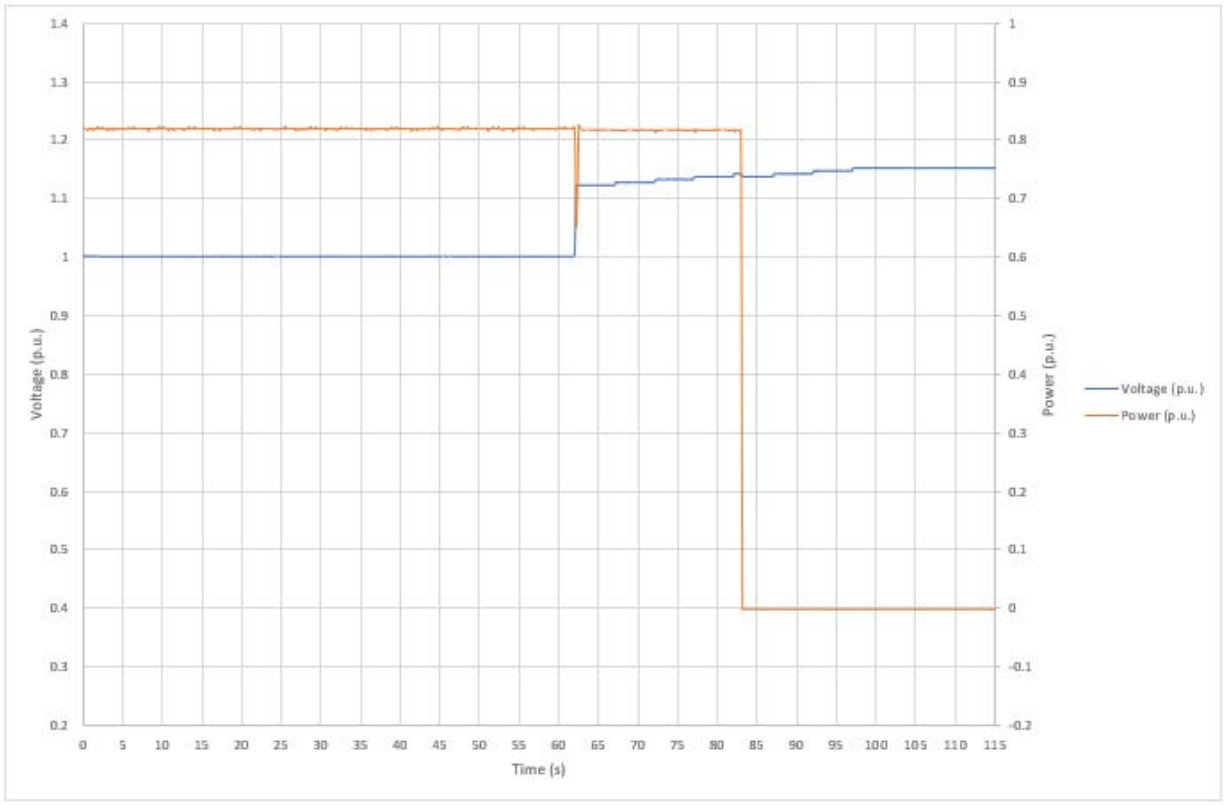

Agilent Technologies
SAT APR 06 09:45:15 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4 500.0ms/ Stop Roll
ΔX = 2.51000000000s
1/ΔX = 398.41mHz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -6.20000s
X2 -3.69000s
X1 X2

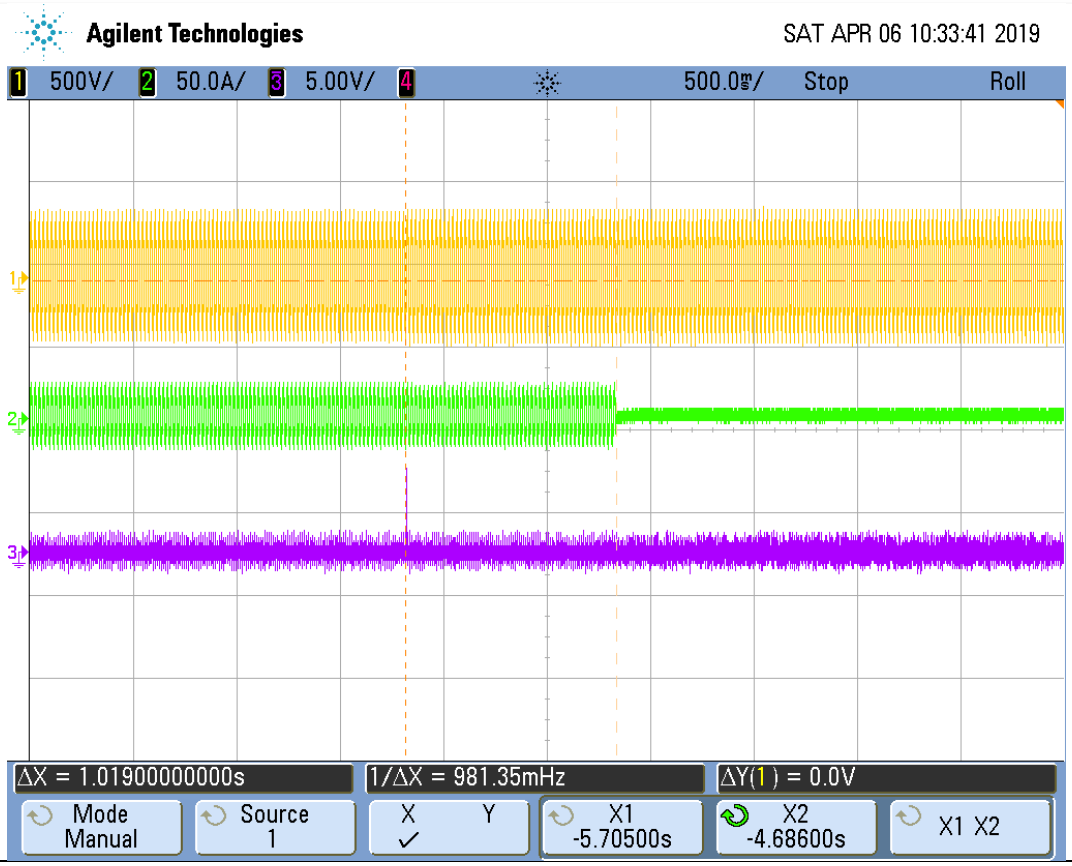
U/V


Voltage (p.u.)
Power (p.u.)
Time (s)
Voltage (p.u.)
Power (p.u.)

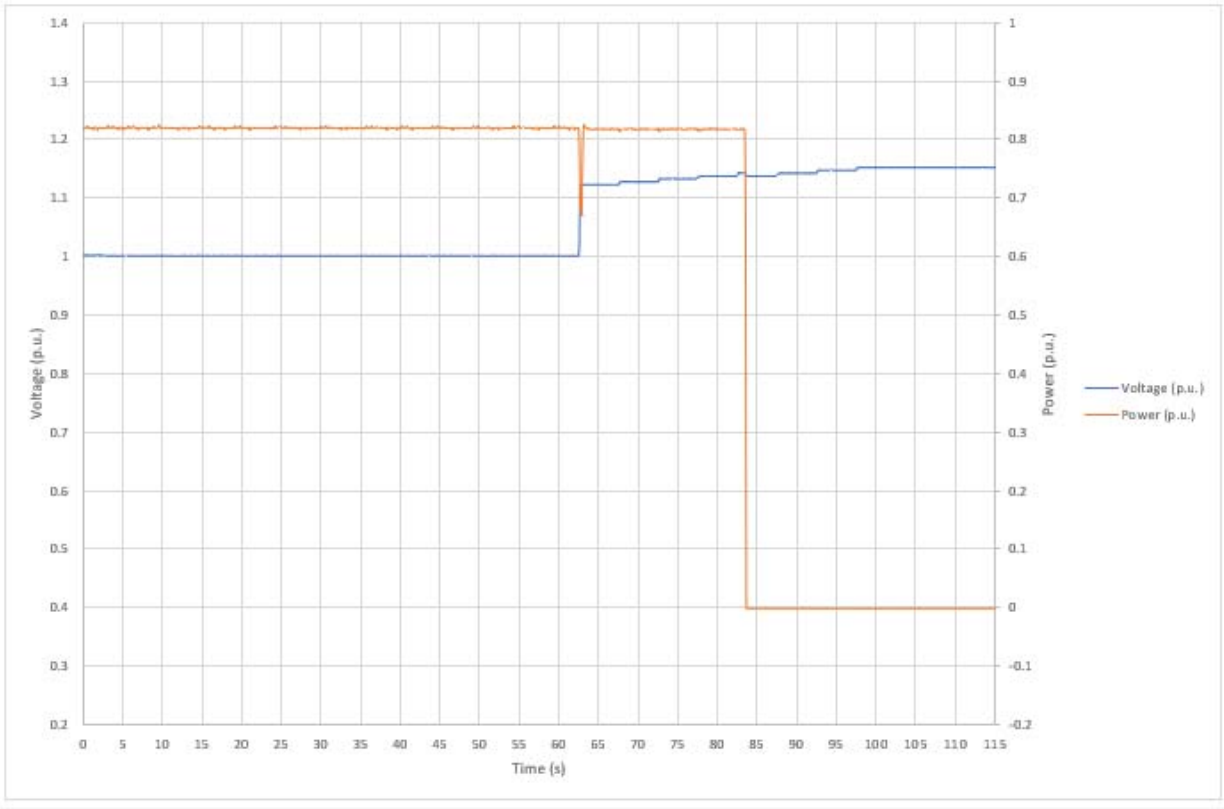

Agilent Technologies
SAT APR 06 09:47:00 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4 500.0ms/ Stop Roll
ΔX = 2.51500000000s
1/ΔX = 397.61mHz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -6.40000s
X2 -3.88500s
X1 X2

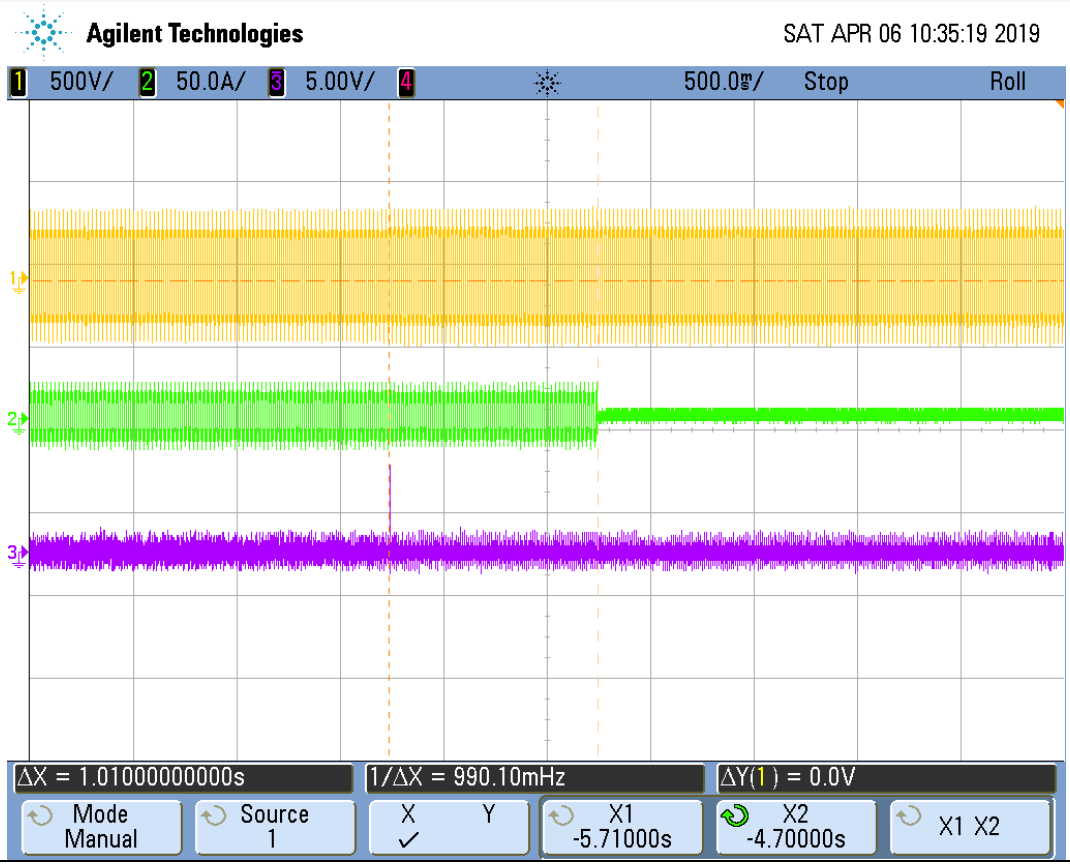
O/V stage 1


Voltage (p.u.)
Power (p.u.)
Time (s)
Voltage (p.u.)
Power (p.u.)

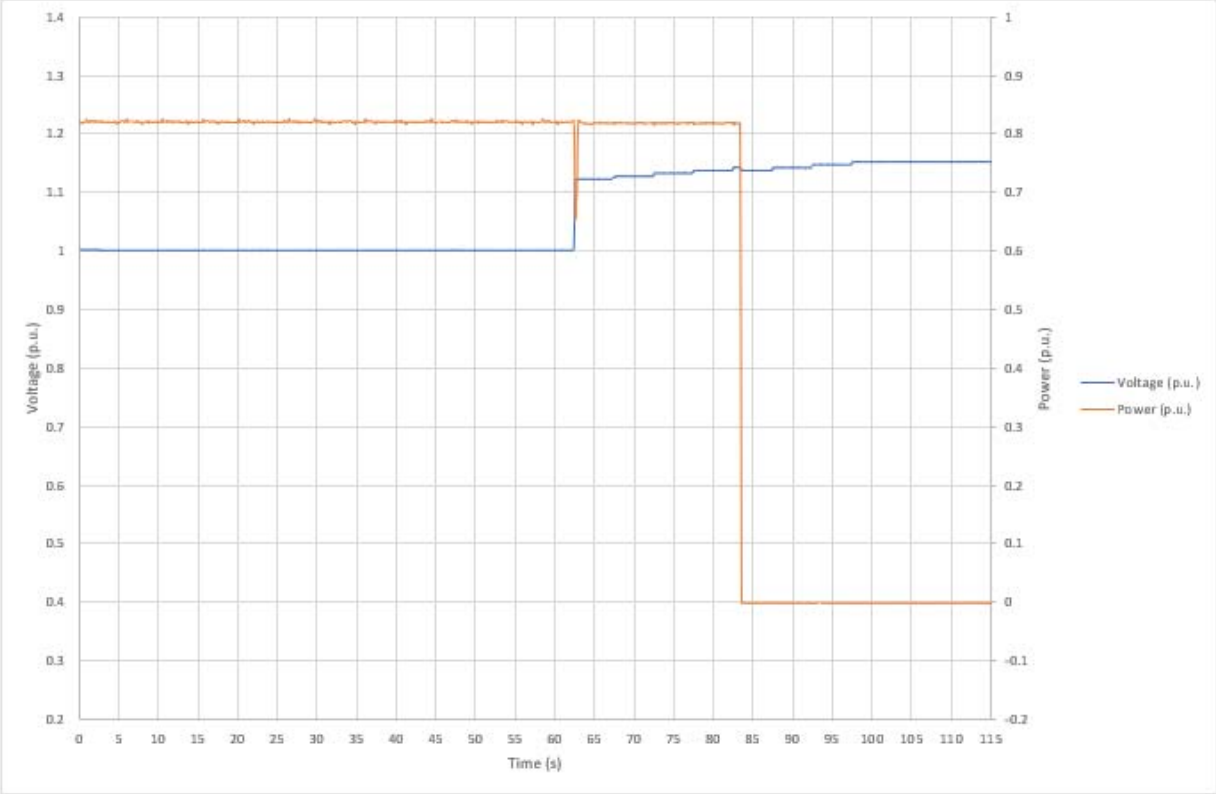

Agilent Technologies
SAT APR 06 10:33:41 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4 500.0ms/ Stop Roll
ΔX = 1.01900000000s
1/ΔX = 981.35mHz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -5.70500s
X2 -4.68600s
X1 X2

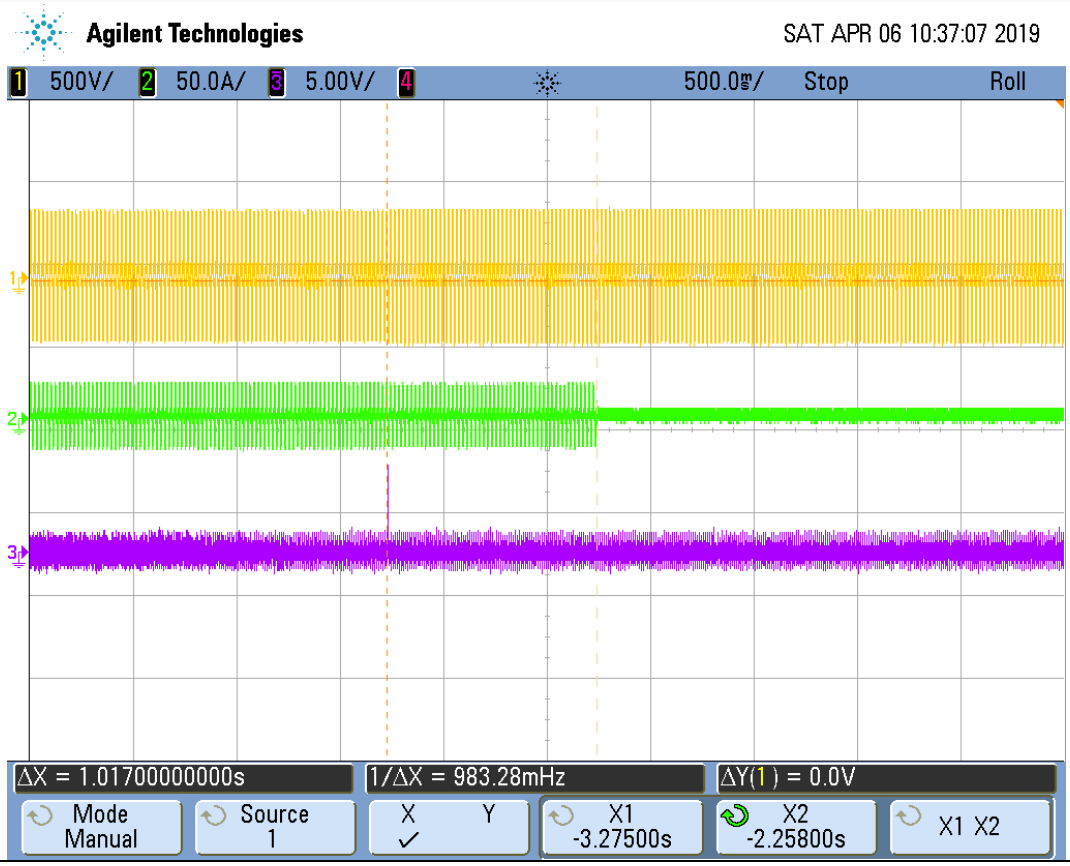
O/V stage 1


Voltage (p.u.)
Power (p.u.)
Time (s)
Voltage (p.u.)
Power (p.u.)

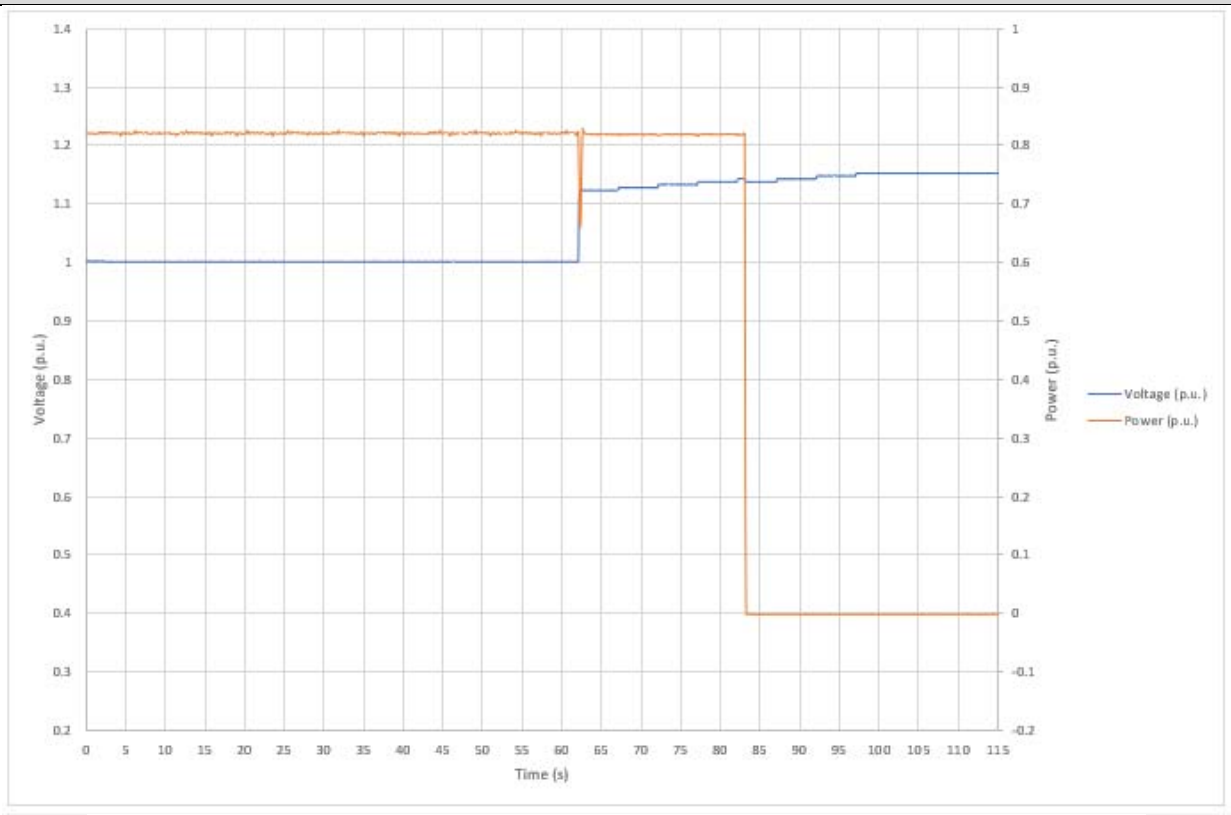

Agilent Technologies
SAT APR 06 10:35:19 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4 500.0ms/ Stop Roll
ΔX = 1.01000000000s
1/ΔX = 990.10mHz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -5.71000s
X2 -4.70000s
X1 X2

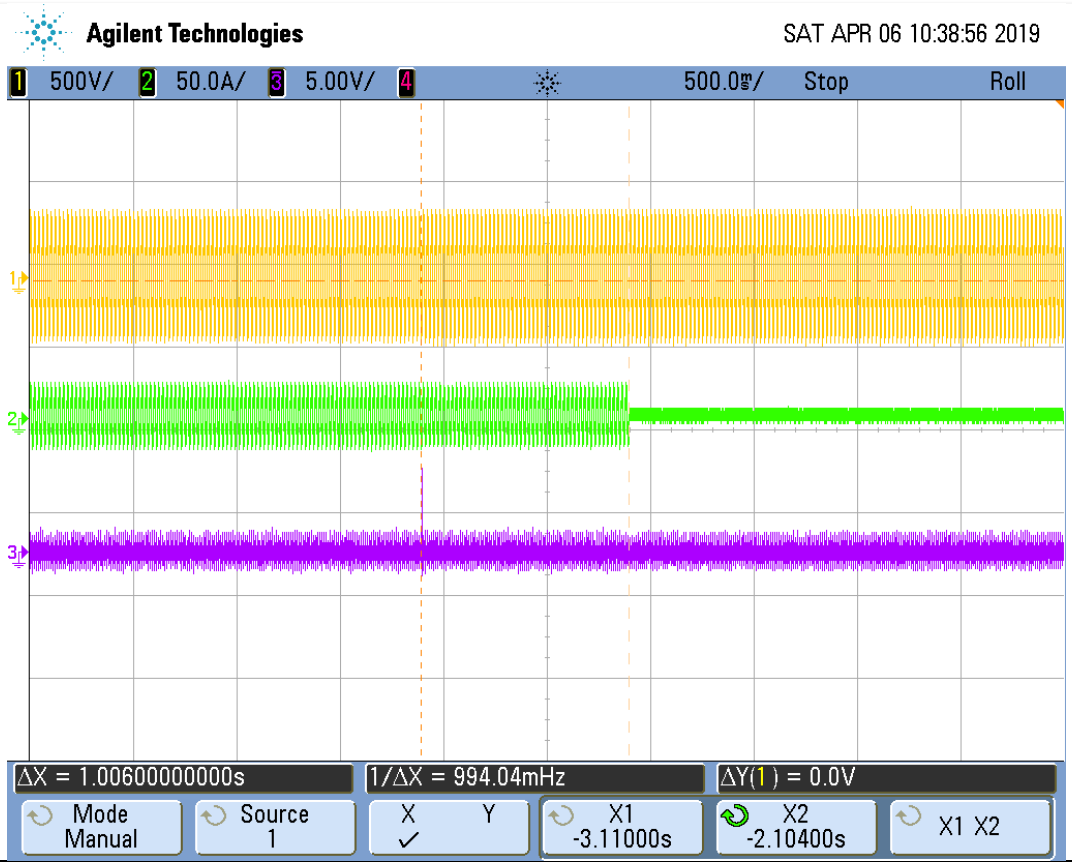
O/V stage 1


Voltage (p.u.)
Power (p.u.)
Time (s)
Voltage (p.u.)
Power (p.u.)

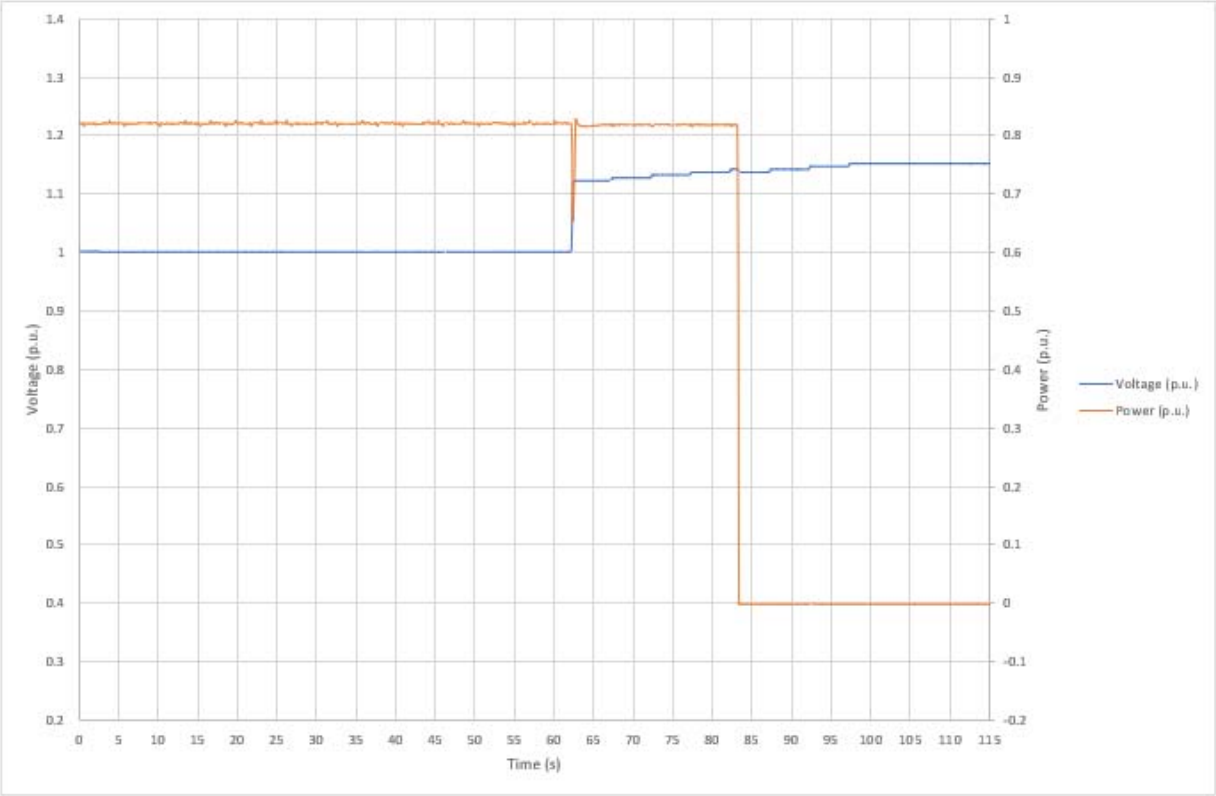

Agilent Technologies
SAT APR 06 10:37:07 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4 500.0ms/ Stop Roll
ΔX = 1.01700000000s
1/ΔX = 983.28mHz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -3.27500s
X2 -2.25800s
X1 X2

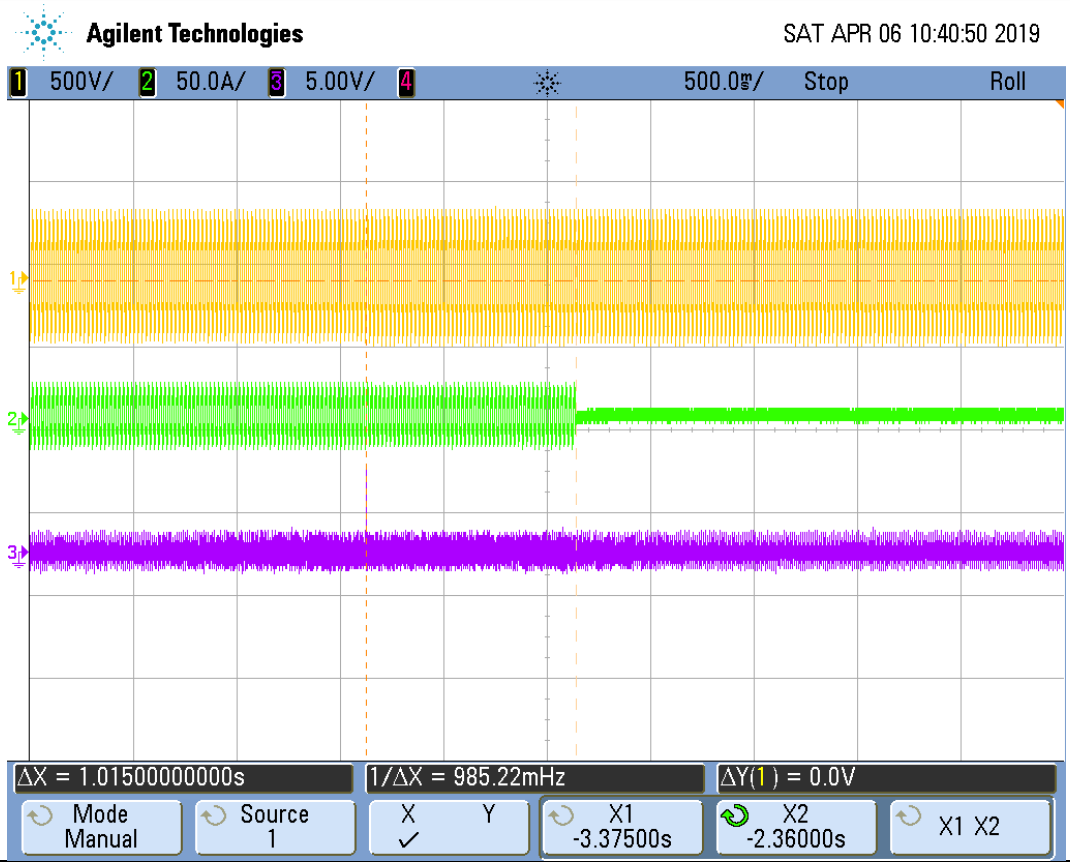
O/V stage 1


Voltage (p.u.)
Power (p.u.)
Time (s)
Voltage (p.u.)
Power (p.u.)

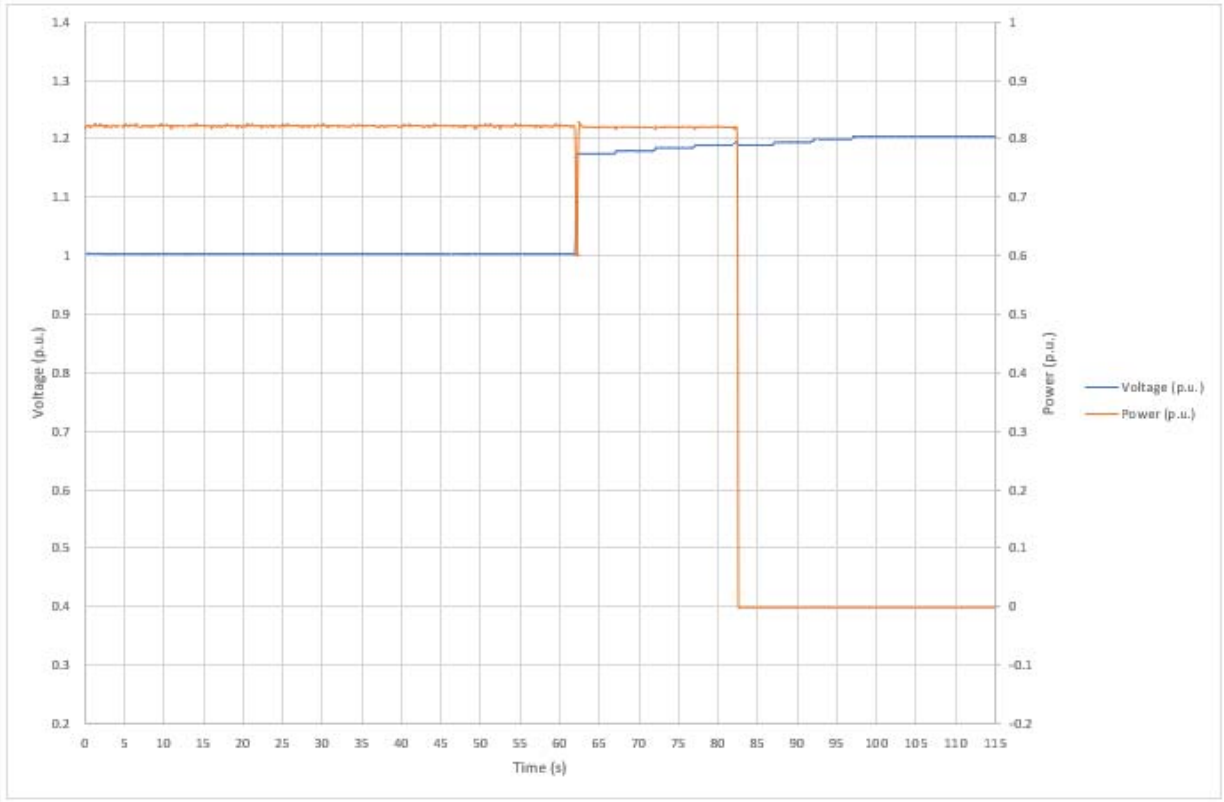

Agilent Technologies
SAT APR 06 10:38:56 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4 500.0ms/ Stop Roll
ΔX = 1.00600000000s
1/ΔX = 994.04mHz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -3.11000s
X2 -2.10400s
X1 X2

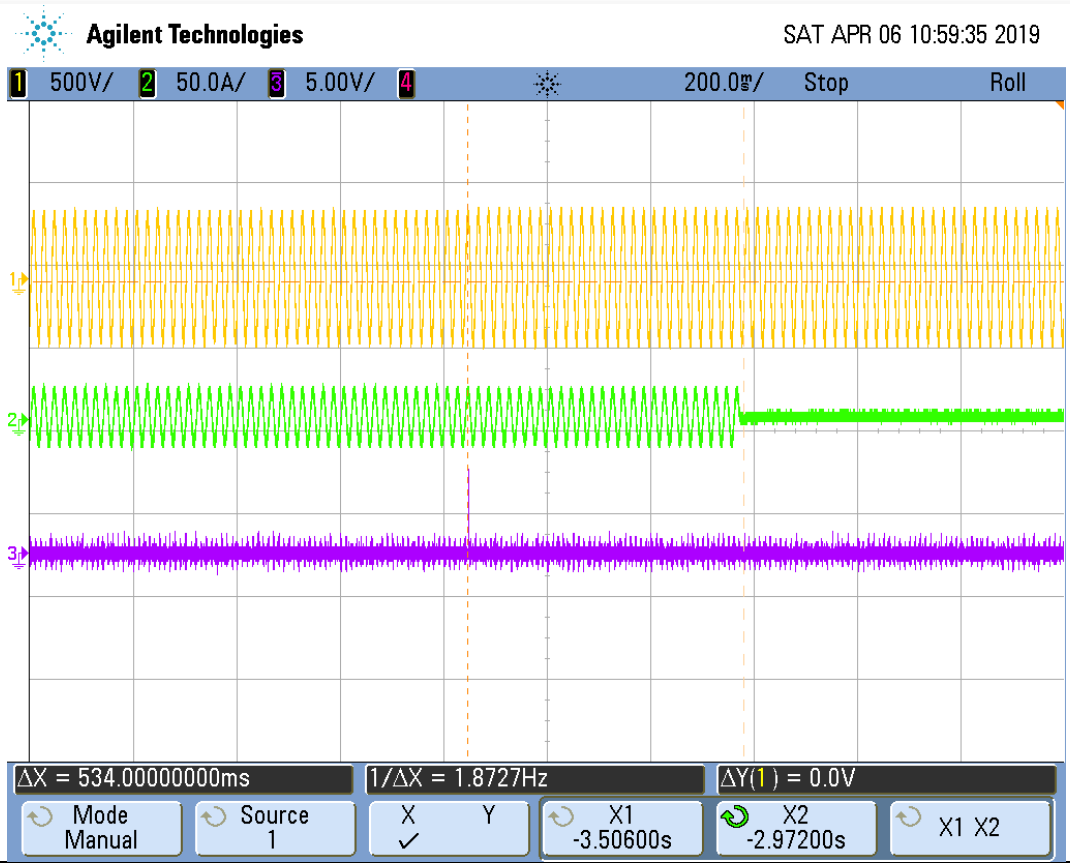
O/V stage 1


Voltage (p.u.)
Power (p.u.)
Time (s)
Voltage (p.u.)
Power (p.u.)

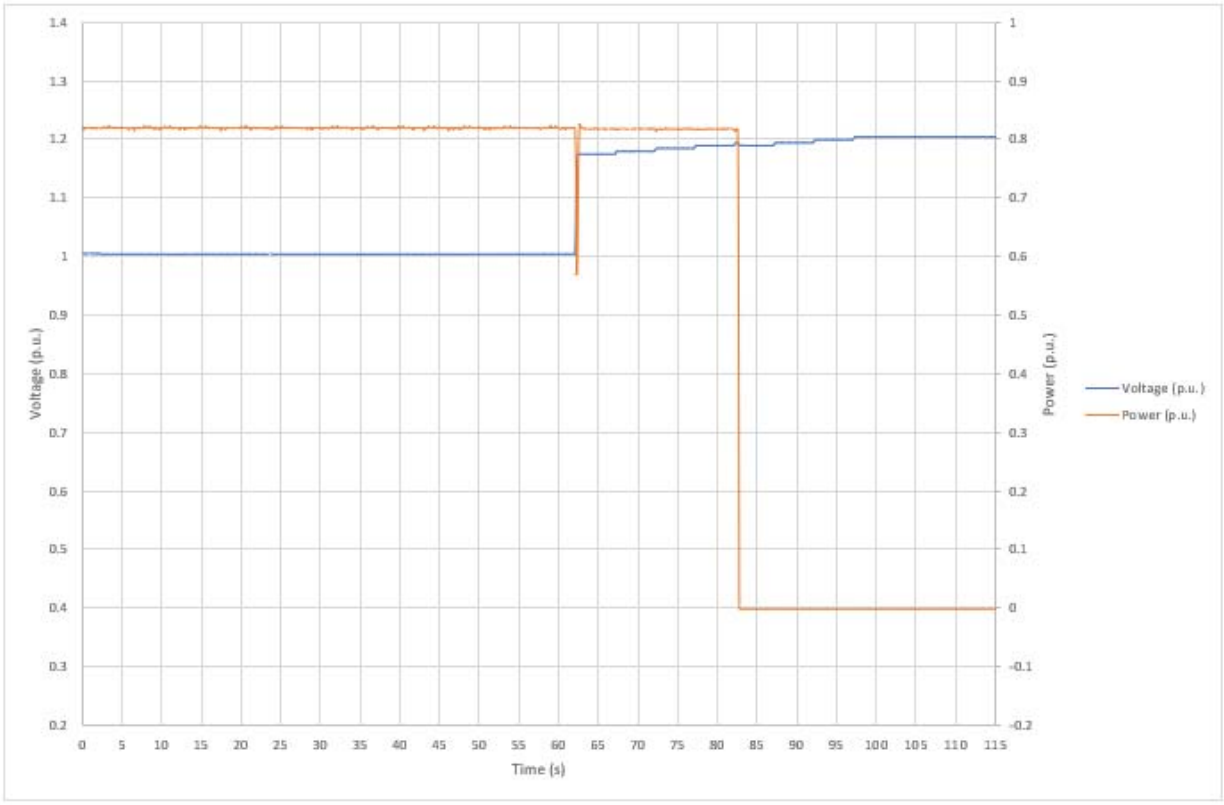

Agilent Technologies
SAT APR 06 10:40:50 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4
500.0ms/ Stop Roll
ΔX = 1.01500000000s
1/ΔX = 985.22mHz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -3.37500s
X2 -2.36000s
X1 X2

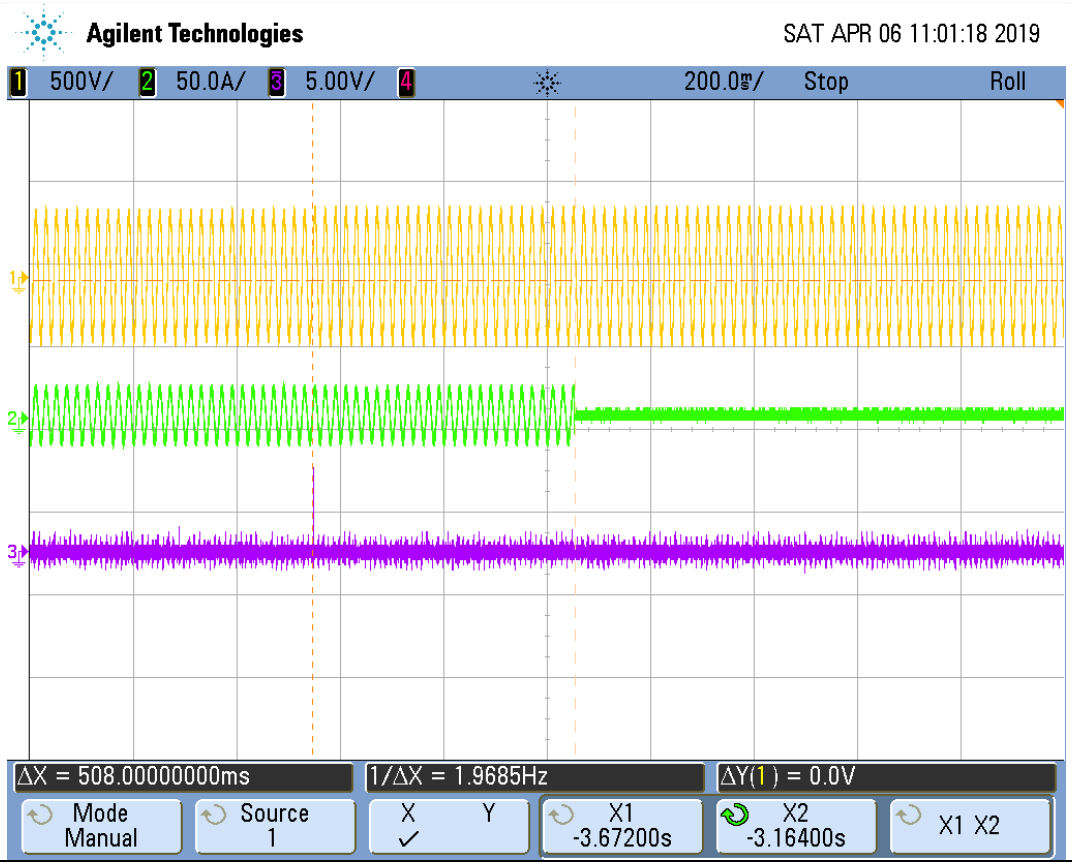
O/V stage 2


Voltage (p.u.)
Power (p.u.)
Time (s)
Voltage (p.u.)
Power (p.u.)

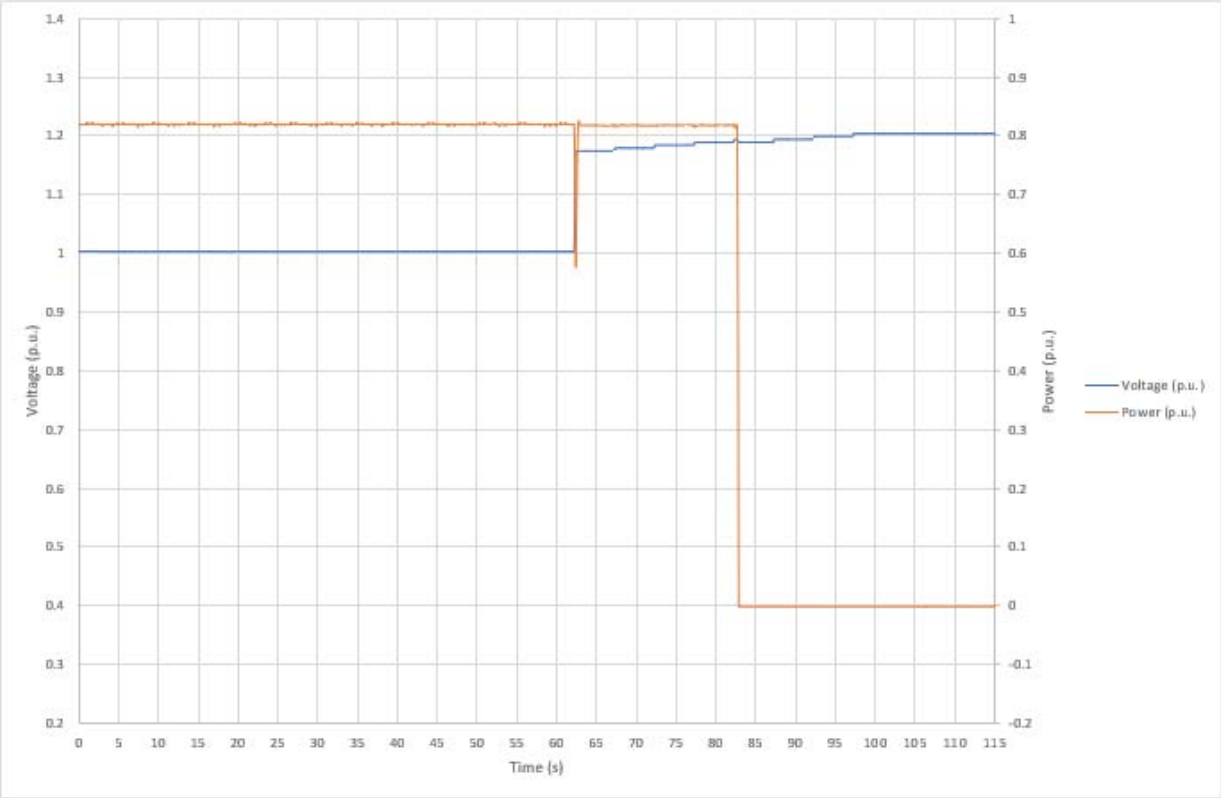

Agilent Technologies
SAT APR 06 10:59:35 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4 200.0ms/ Stop Roll
ΔX = 534.00000000ms
1/ΔX = 1.8727Hz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -3.50600s
X2 -2.97200s
X1 X2

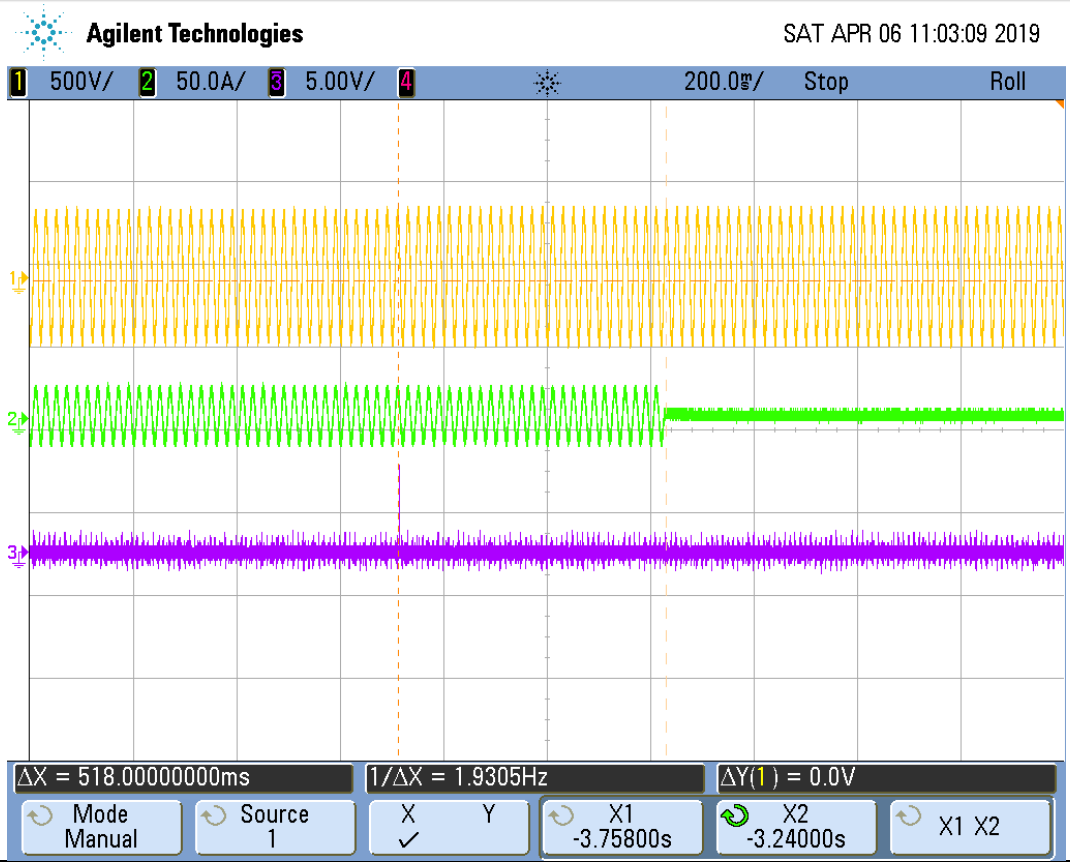
O/V stage 2


Voltage (p.u.)
Power (p.u.)
Time (s)
Voltage (p.u.)
Power (p.u.)

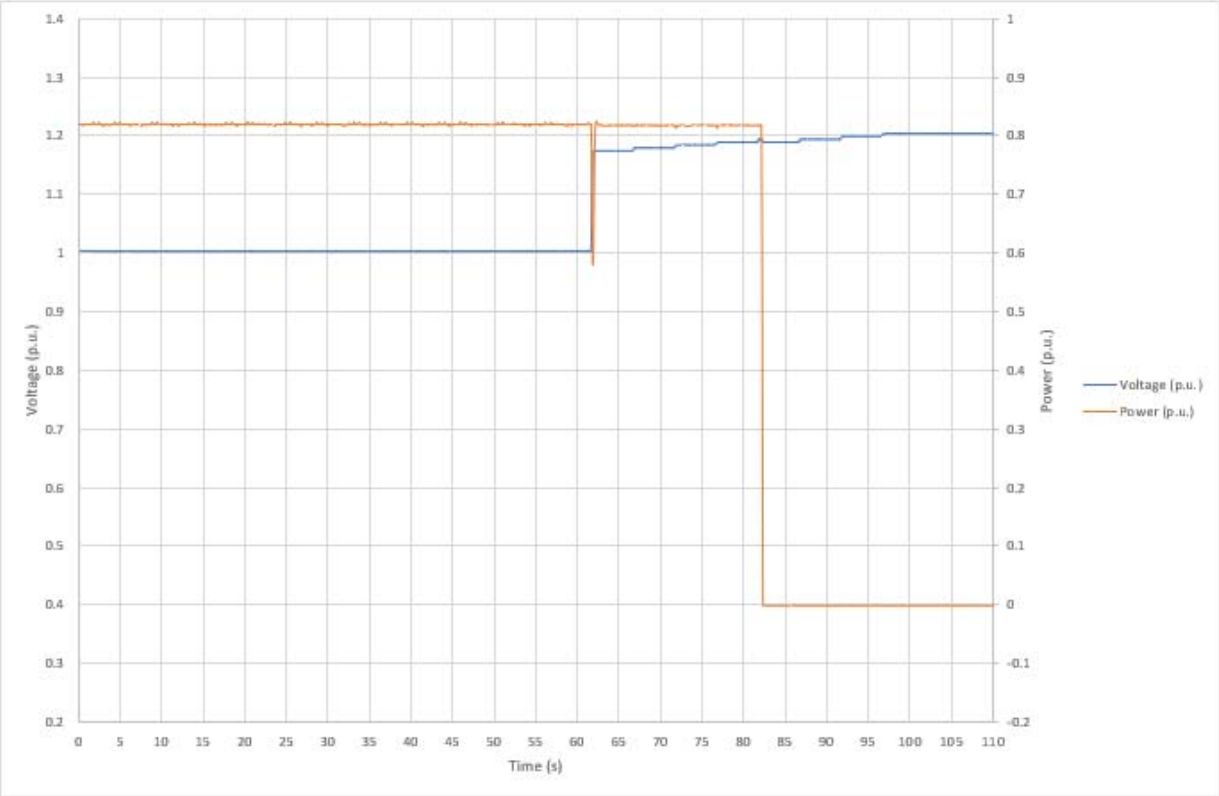

Agilent Technologies
SAT APR 06 11:01:18 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4 200.0ms/ Stop Roll
ΔX = 508.00000000ms
1/ΔX = 1.9685Hz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -3.67200s
X2 -3.16400s
X1 X2

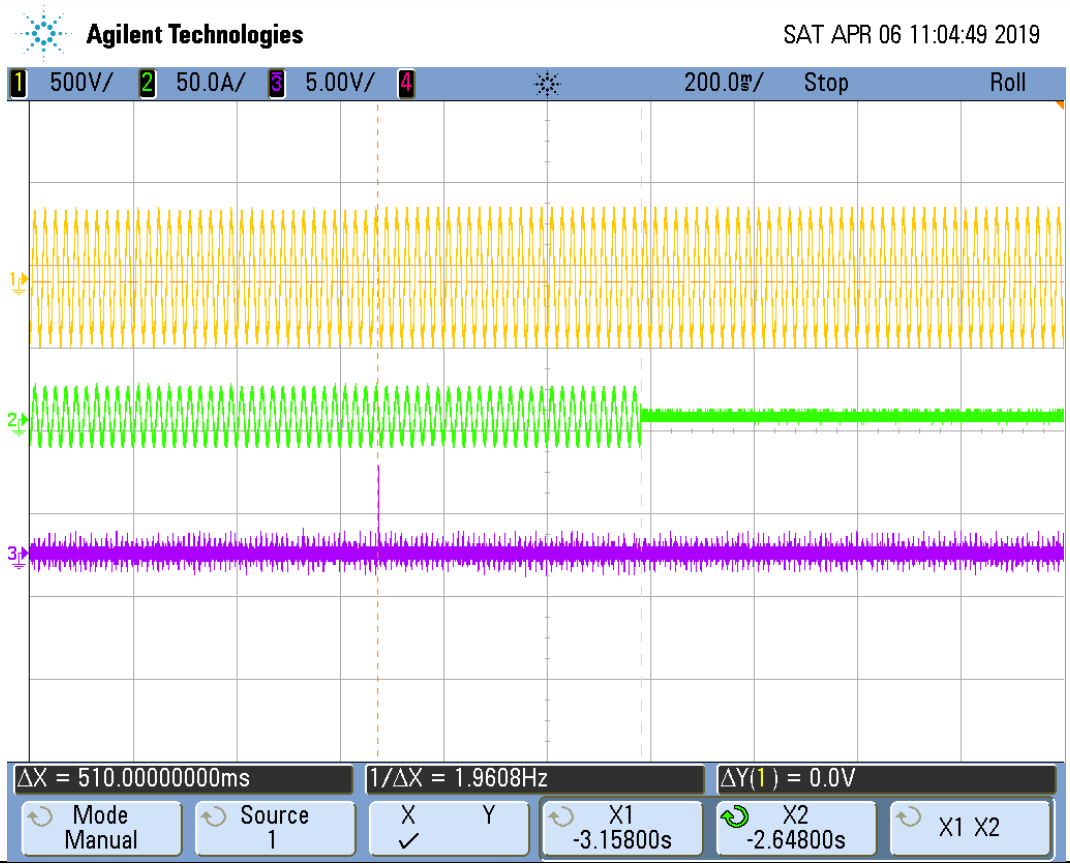
O/V stage 2


Voltage (p.u.)
Power (p.u.)
Time (s)
Voltage (p.u.)
Power (p.u.)

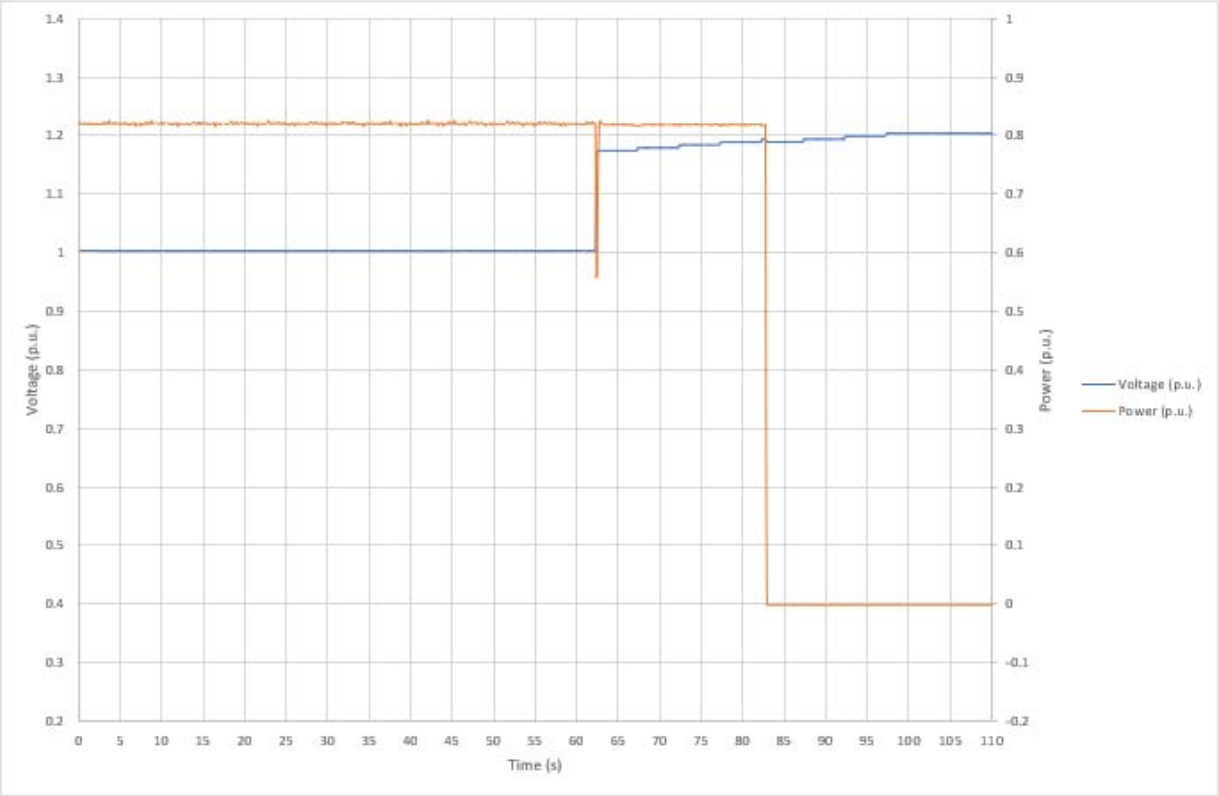

Agilent Technologies
SAT APR 06 11:03:09 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4 200.0s/ Stop Roll
ΔX = 518.00000000ms
1/ΔX = 1.9305Hz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -3.75800s
X2 -3.24000s
X1 X2

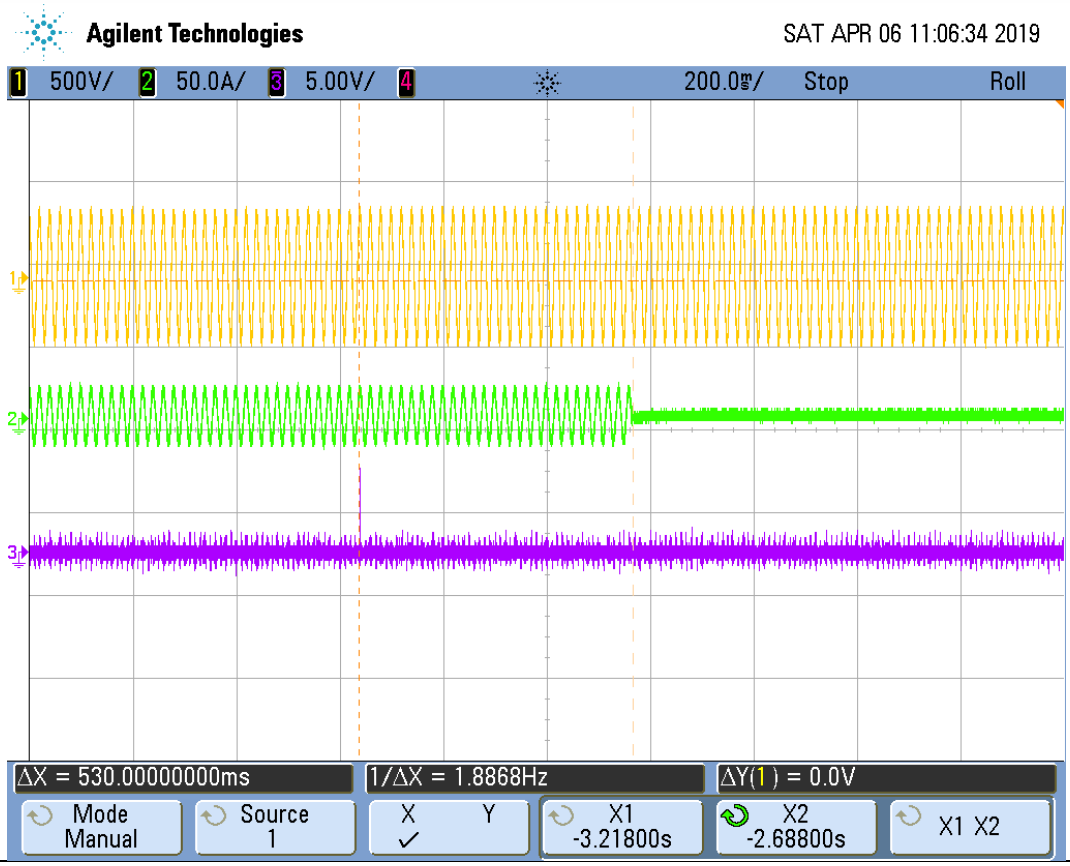
O/V stage 2


Voltage (p.u.)
Power (p.u.)
Time (s)
Voltage (p.u.)
Power (p.u.)

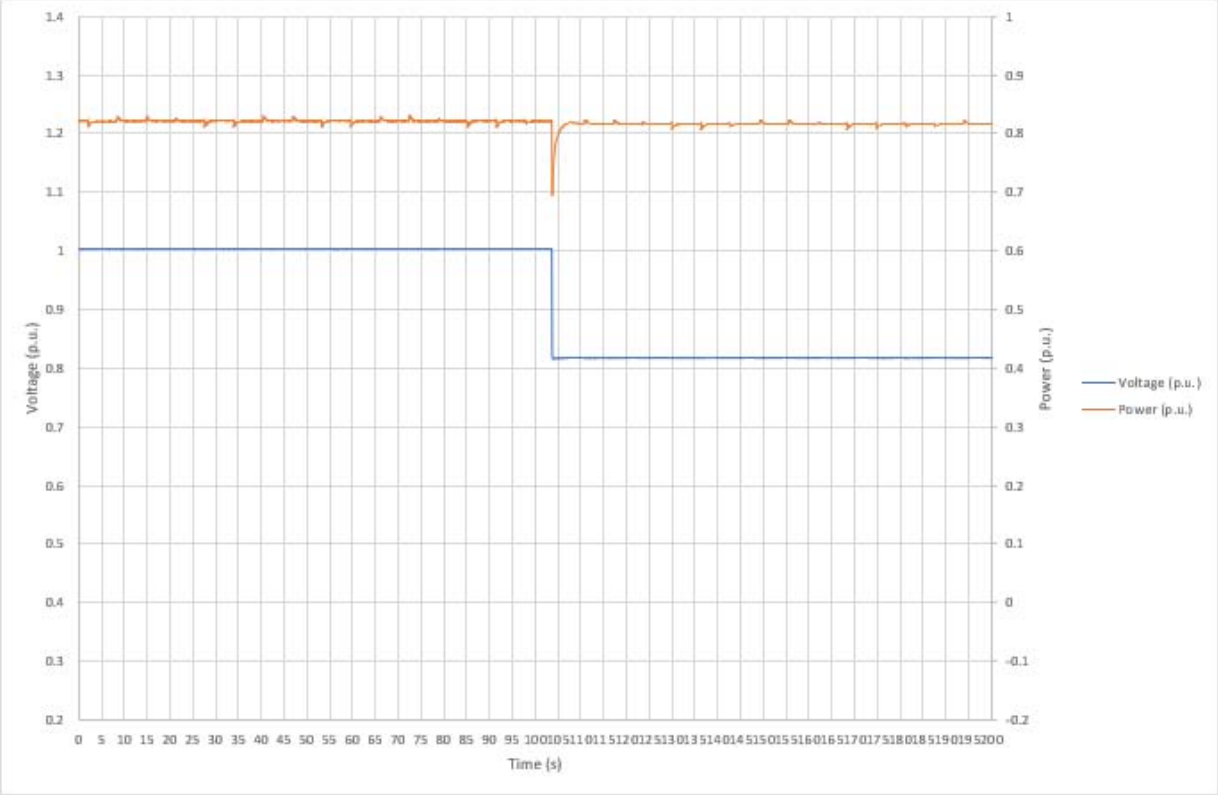

Agilent Technologies
SAT APR 06 11:04:49 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4
200.0ms/ Stop Roll
ΔX = 510.00000000ms
1/ΔX = 1.9608Hz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -3.15800s
X2 -2.64800s
X1 X2

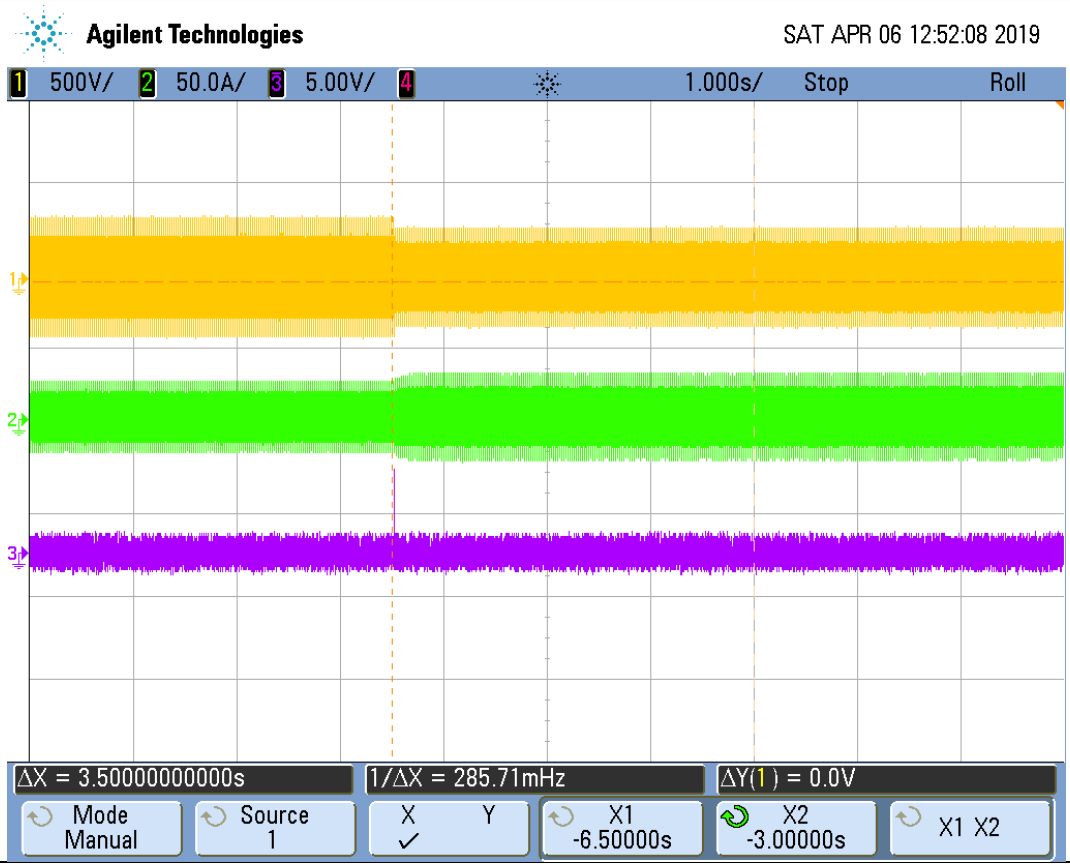
O/V stage 2


Voltage (p.u.)
Power (p.u.)
Time (s)
Voltage (p.u.)
Power (p.u.)

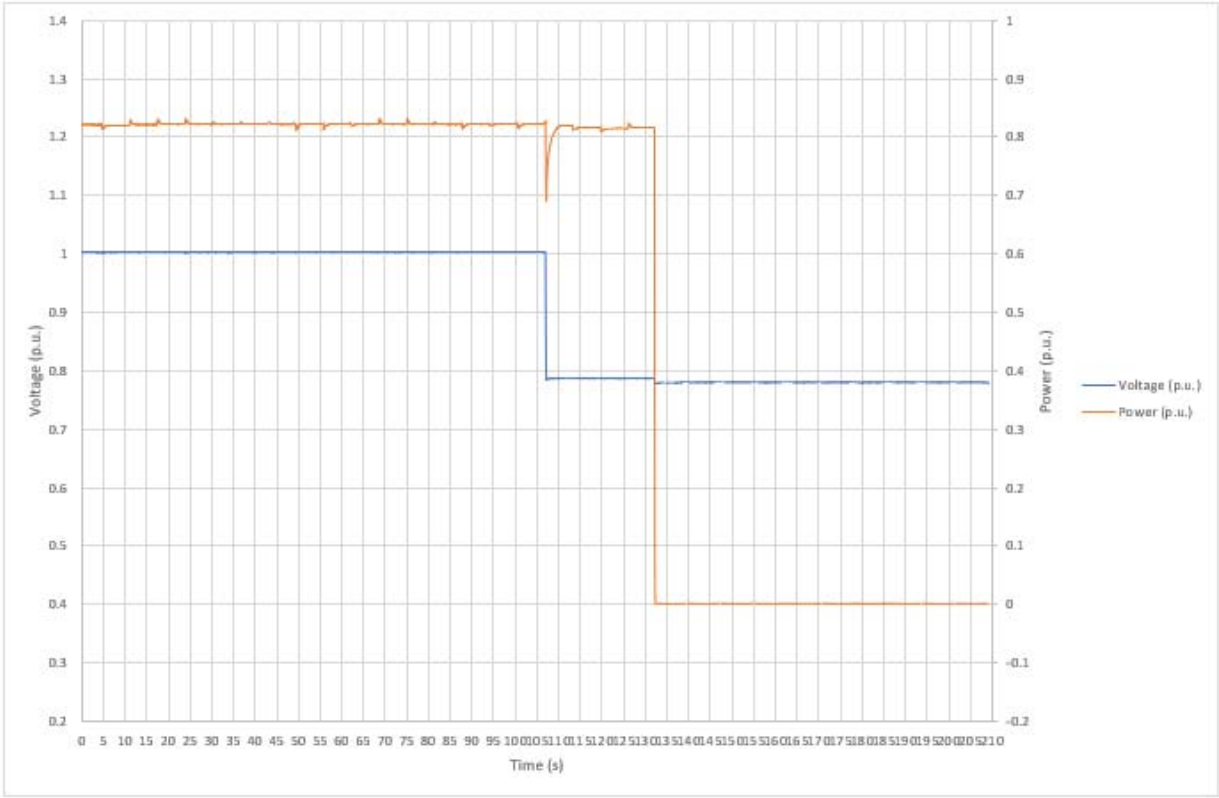

Agilent Technologies
SAT APR 06 11:06:34 2019
1 500V/ 2 50.0A/ 3 5.00V/ 4 200.0ms/ Stop Roll
ΔX = 530.00000000ms
1/ΔX = 1.8868Hz
ΔY(1) = 0.0V
Mode Manual
Source 1
X Y
X1 -3.21800s
X2 -2.68800s
X1 X2

No trip tests – 188V

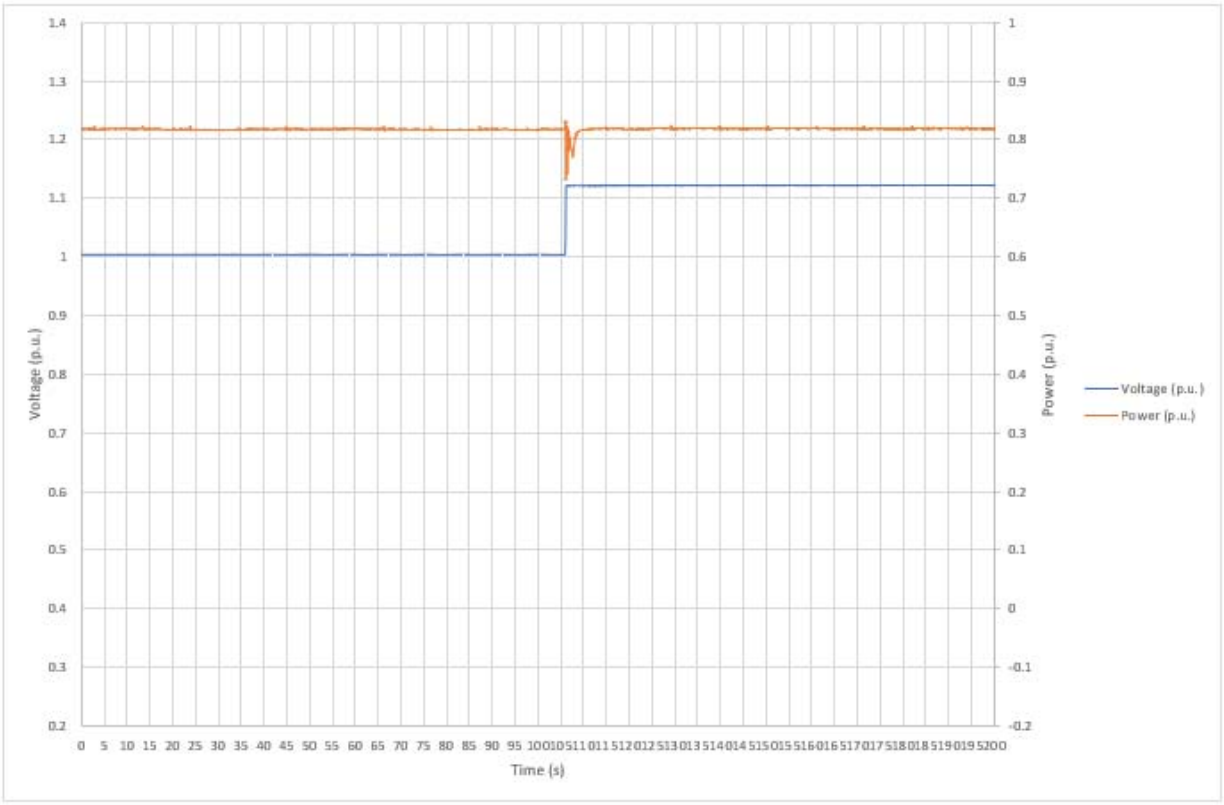


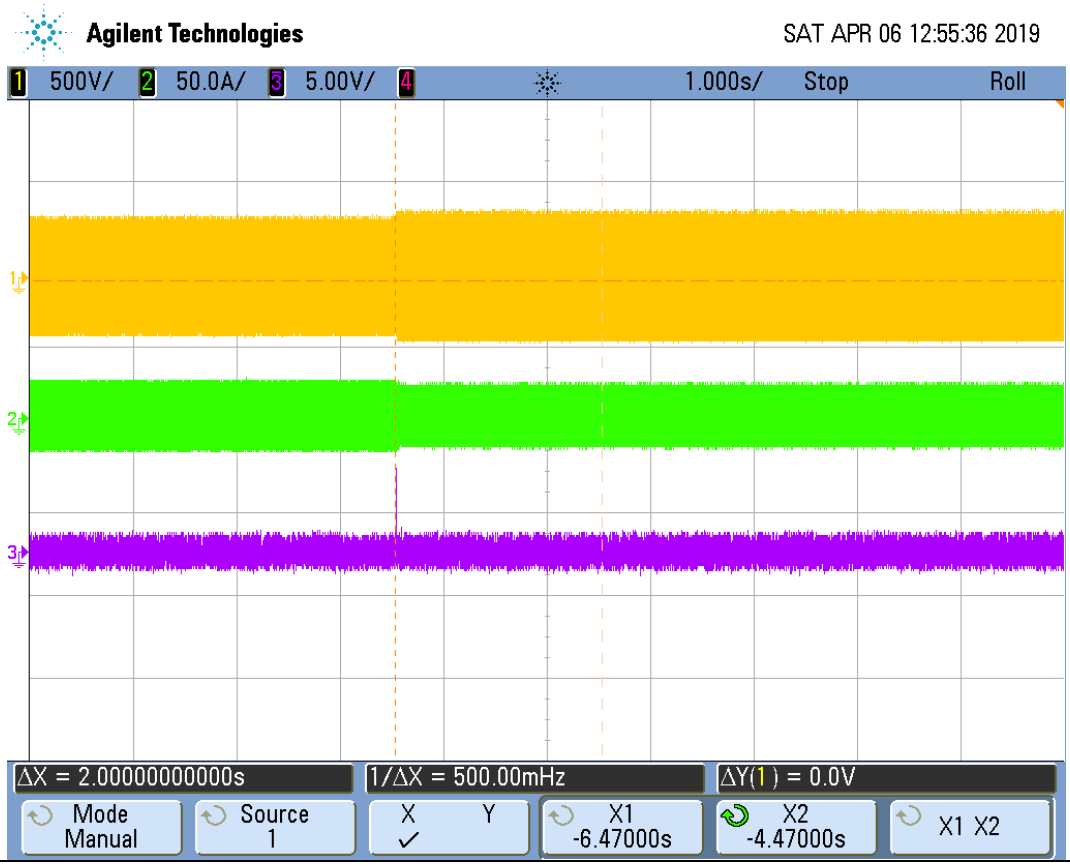


No trip tests – 180V

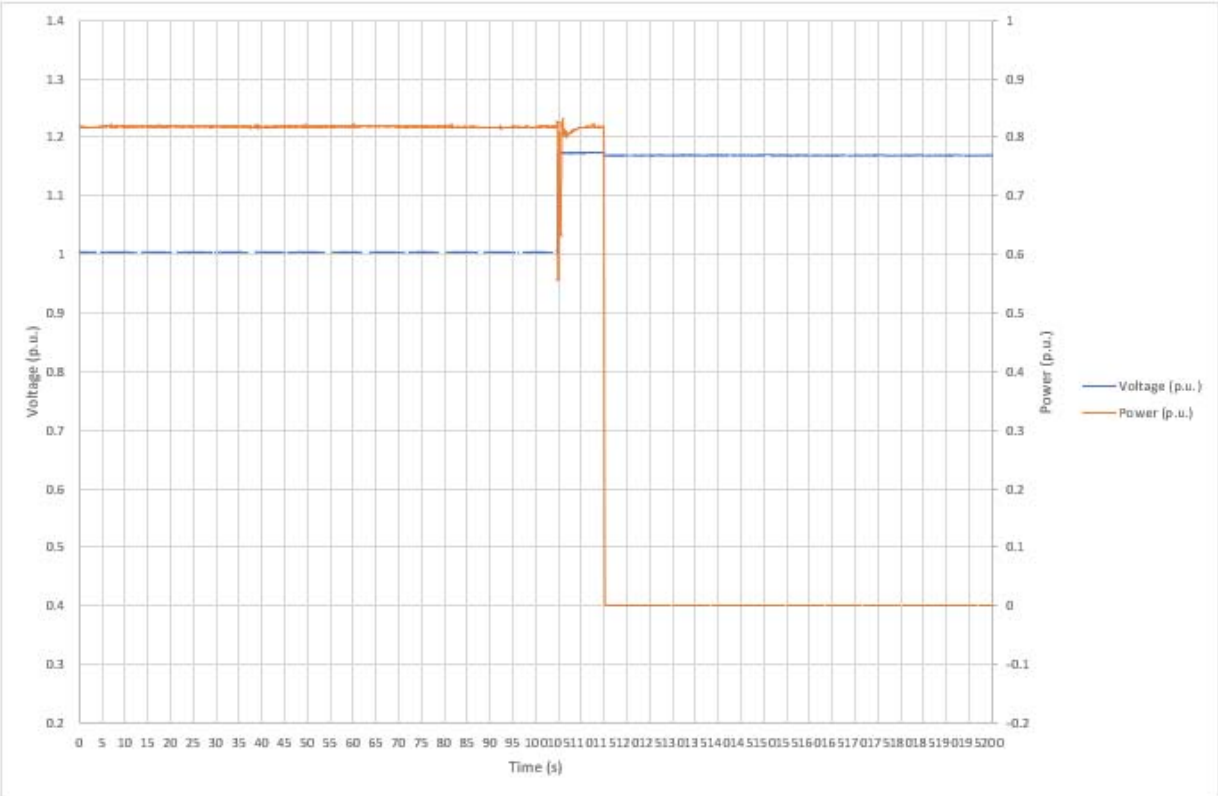


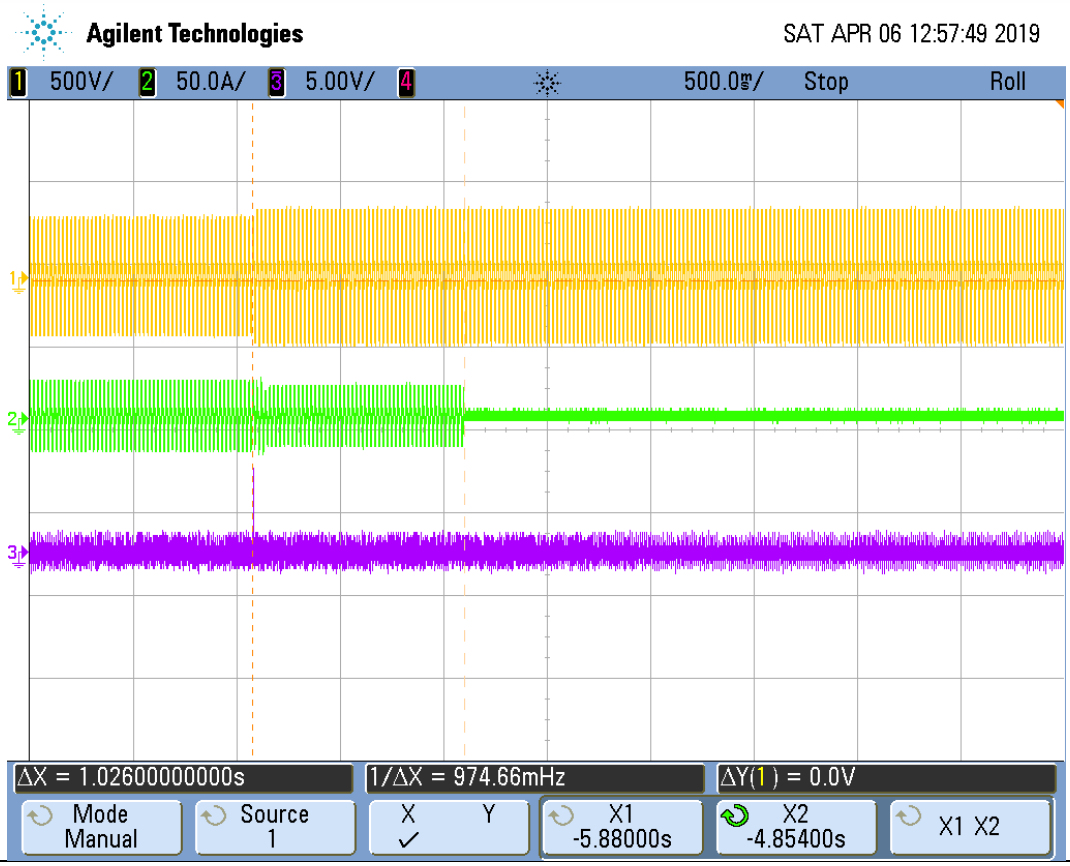
No trip tests – 258.2V



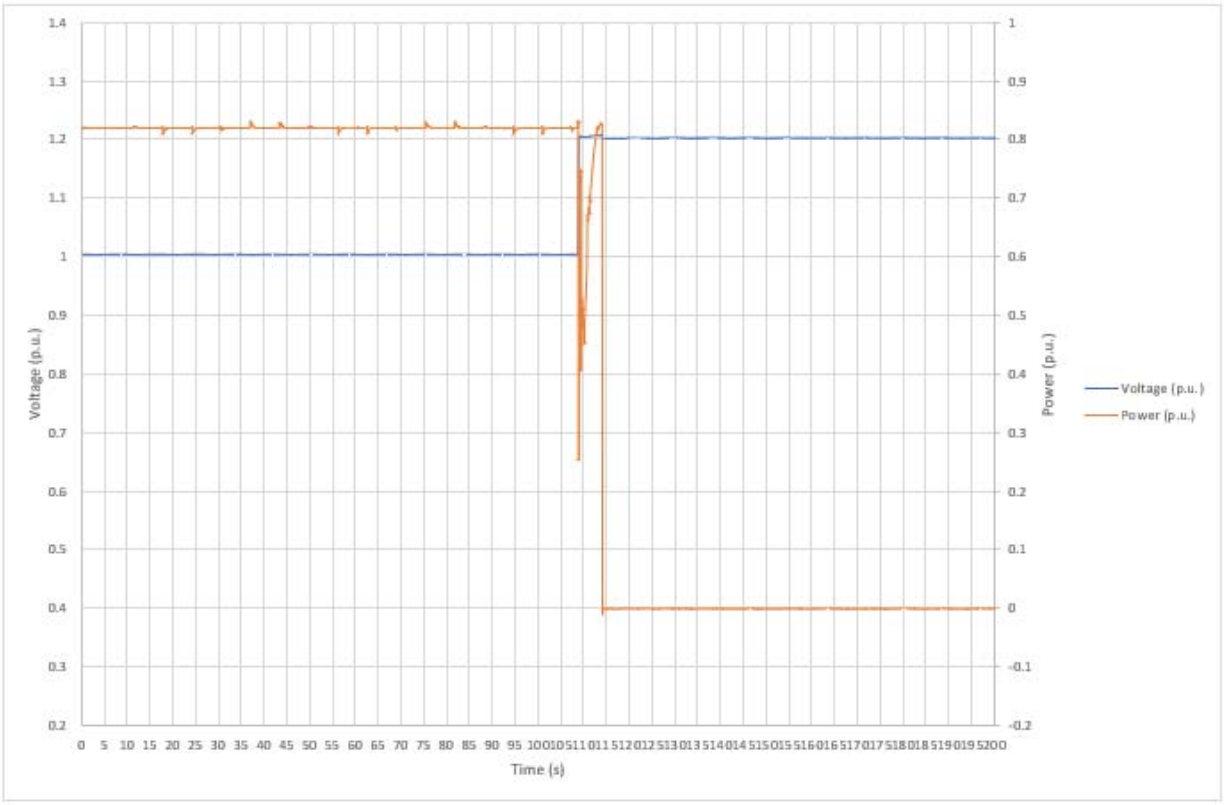


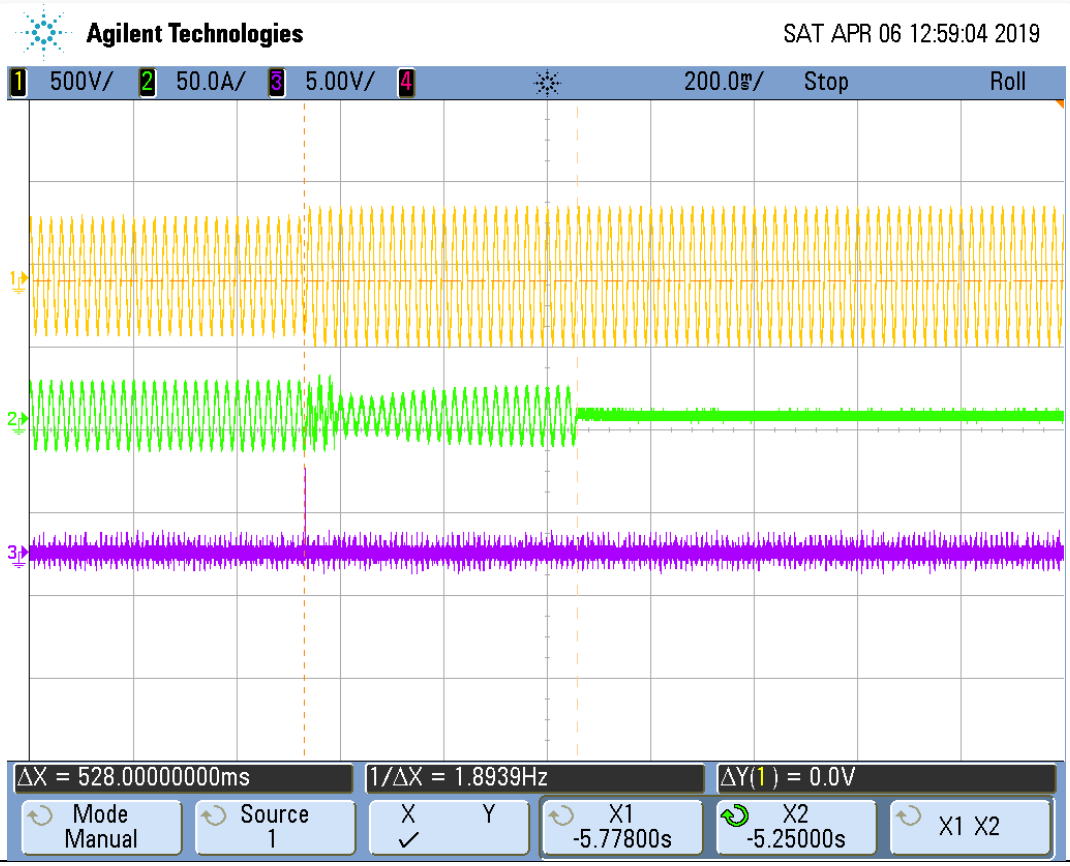
No trip tests – 269.7V





No trip tests – 277.7V





4.3.3 Loss of Mains test

For PV Inverters shall be tested in accordance with BS EN 62116.

The maximum trip time is 0.5 s.

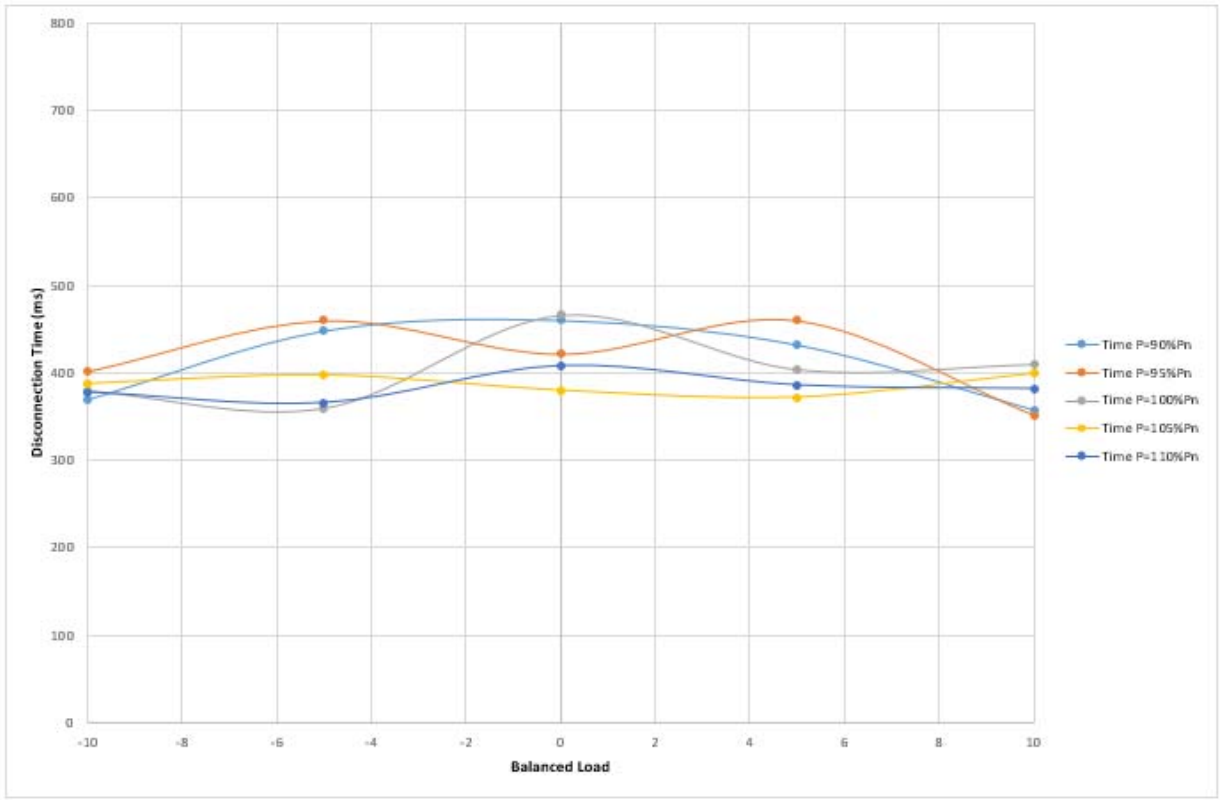
Note for technologies which have a substantial shut down time this can be added to the 0.5 s in establishing that the trip occurred in less than 0.5 s. Maximum shut down time could therefore be up to 1.0 s for these technologies.

Following tables show the test results:

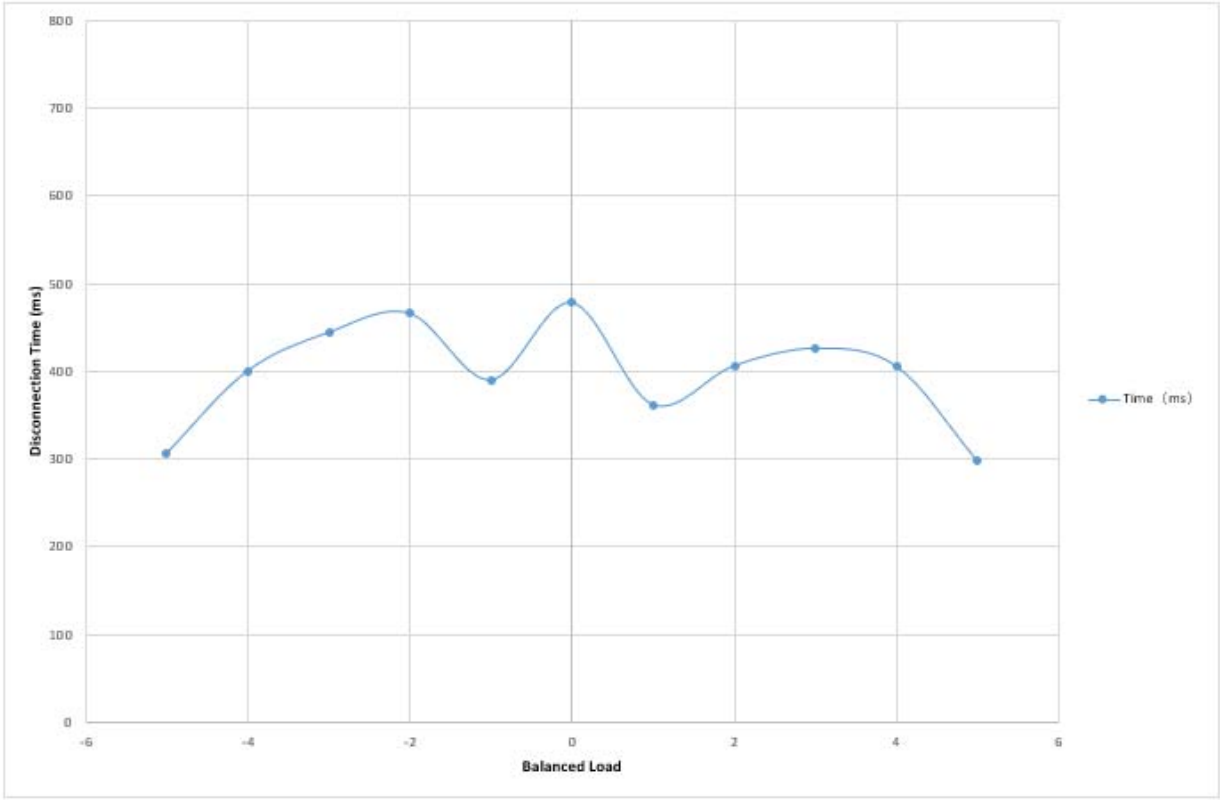
	Table: tested condition and trip time					P
No.	P_{EUT} (% of EUT rating)	Reactive load (% of normial)	P_{AC}	Q_{AC}	Trip time(s)	Which load is selected to be adjusted (R or L)
Test condition A						
1	100	100	0	0	466	--
2	100	100	-5	-5	460	R/L
3	100	100	-5	0	422	R
4	100	100	-5	+5	354	R/L
5	100	100	0	-5	360	L
6	100	100	0	+5	404	L
7	100	100	+5	-5	398	R/L
8	100	100	+5	0	380	R
9	100	100	+5	+5	372	R/L
10	100	100	-10	+10	358	R/L
11	100	100	-5	+10	352	R/L
12	100	100	0	+10	410	L
13	100	100	+10	+10	382	R/L
14	100	100	+10	+5	386	R/L
15	100	100	+10	0	408	R
16	100	100	+10	-5	366	R/L
17	100	100	+10	-10	378	R/L
18	100	100	+5	-10	388	R/L
19	100	100	+5	+10	400	R/L
20	100	100	0	-10	380	L
21	100	100	-5	-10	402	R/L
22	100	100	-10	-10	370	R/L
23	100	100	-10	-5	448	R/L
24	100	100	-10	0	460	R
25	100	100	-10	+5	432	R/L
Test condition B						
1	66	66	0	0	478	--
2	66	66	0	-5	306	L
3	66	66	0	-4	400	L
4	66	66	0	-3	444	L
5	66	66	0	-2	466	L
6	66	66	0	-1	390	L
7	66	66	0	1	362	L
8	66	66	0	2	406	L
9	66	66	0	3	426	L
10	66	66	0	4	406	L
11	66	66	0	5	298	L
Test condition C						
1	33	33	0	0	458	--
2	33	33	0	-5	356	L
3	33	33	0	-4	430	L
4	33	33	0	-3	442	L
5	33	33	0	-2	428	L
6	33	33	0	-1	424	L
7	33	33	0	1	356	L
8	33	33	0	2	364	L
9	33	33	0	3	444	L
10	33	33	0	4	370	L
11	33	33	0	5	302	L

Test results are graphically shown in following pages.

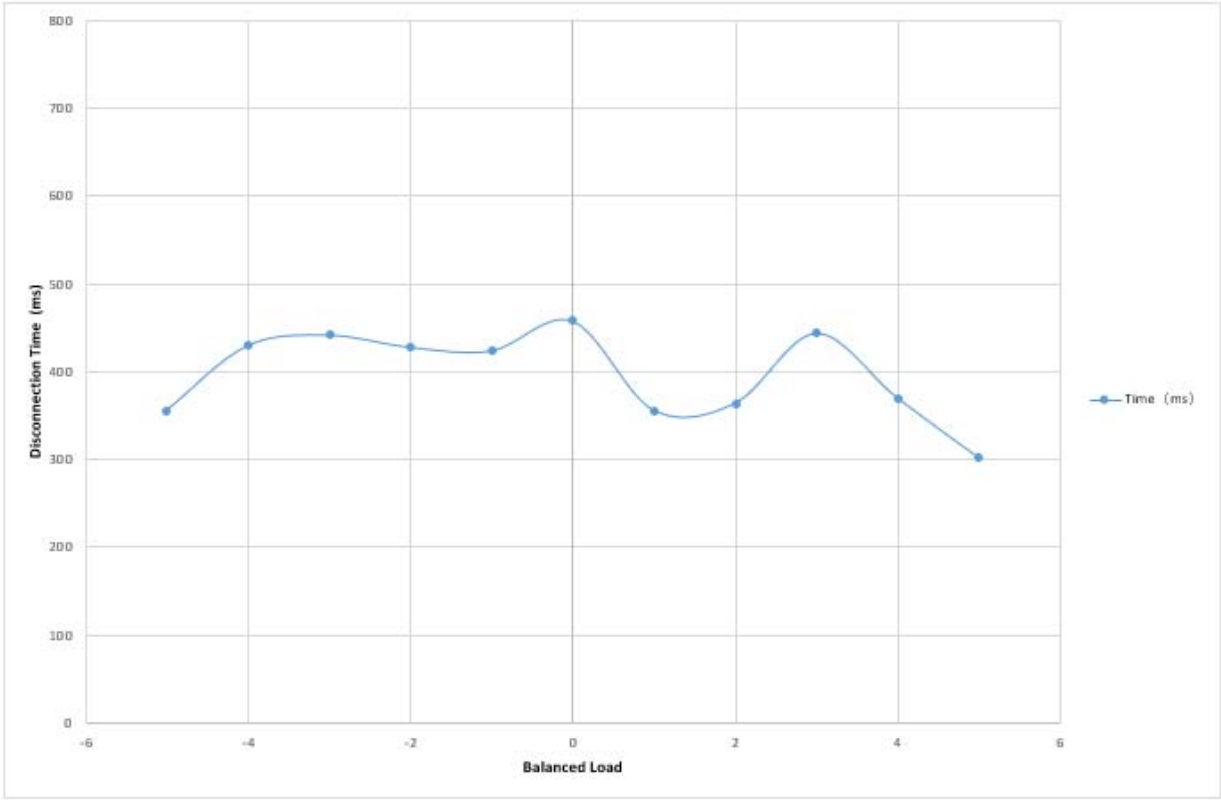
Test Condition A



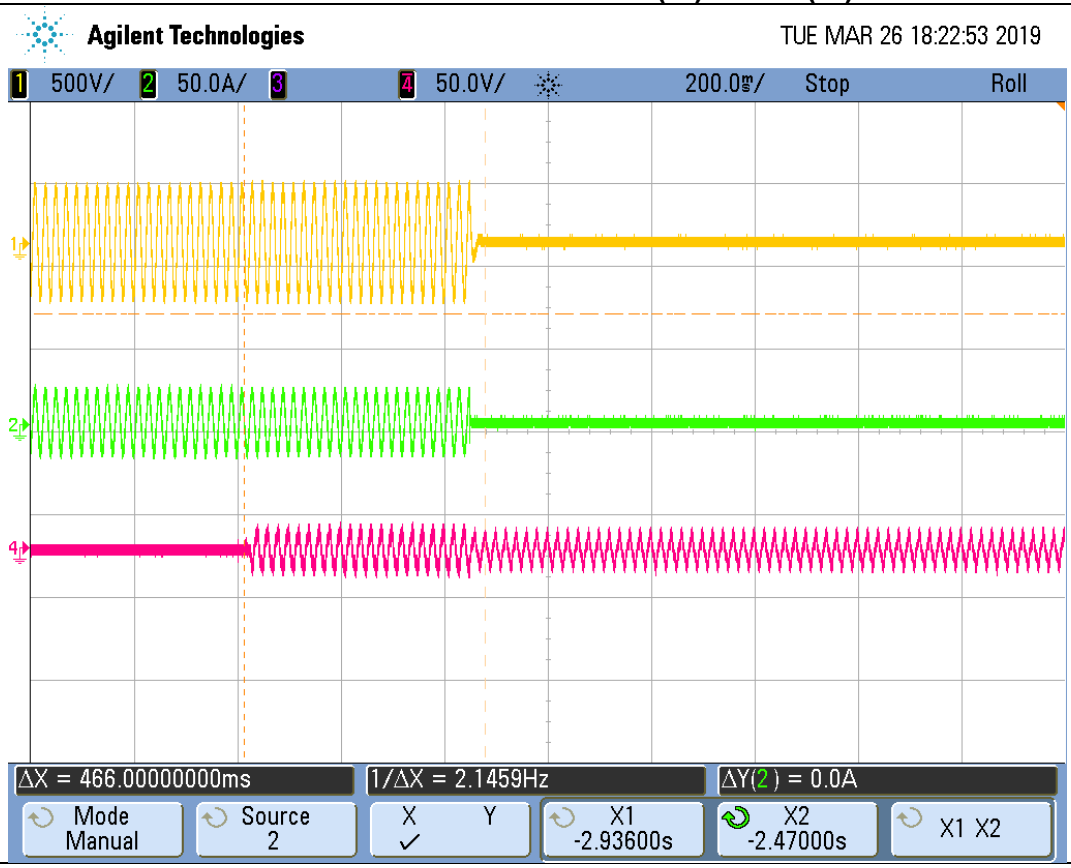
Test Condition B



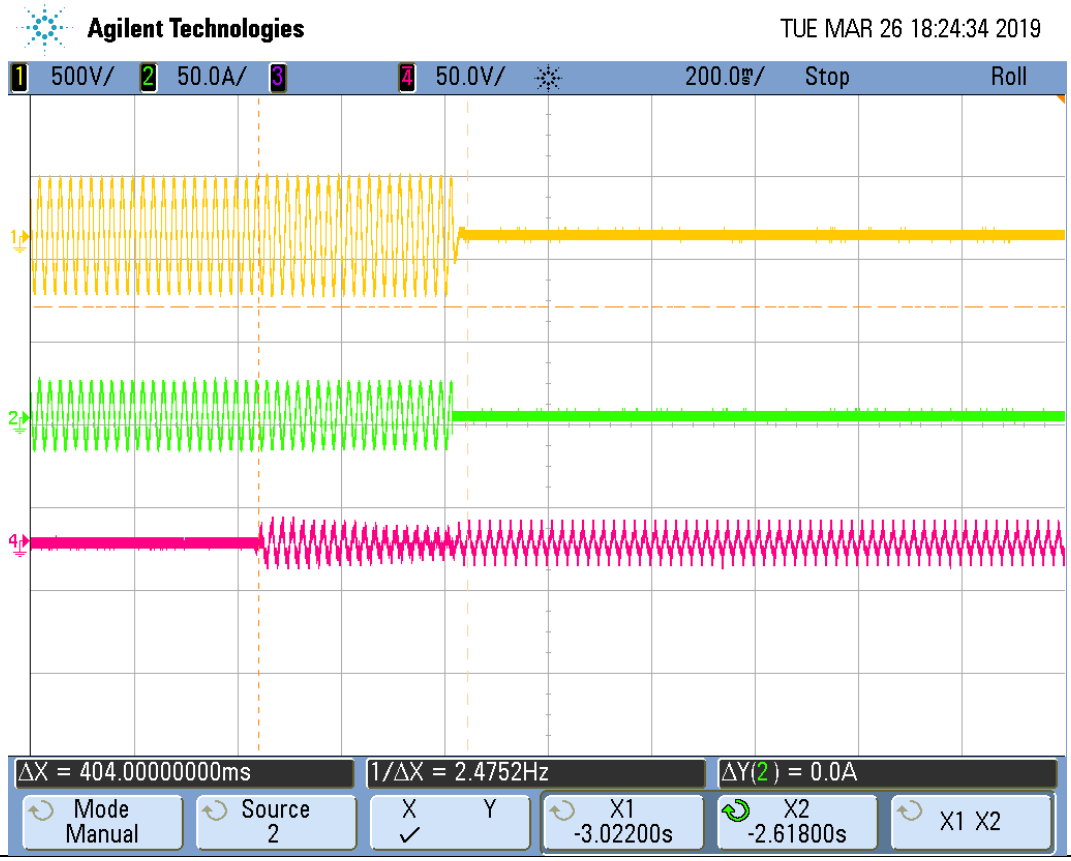
Test Condition C



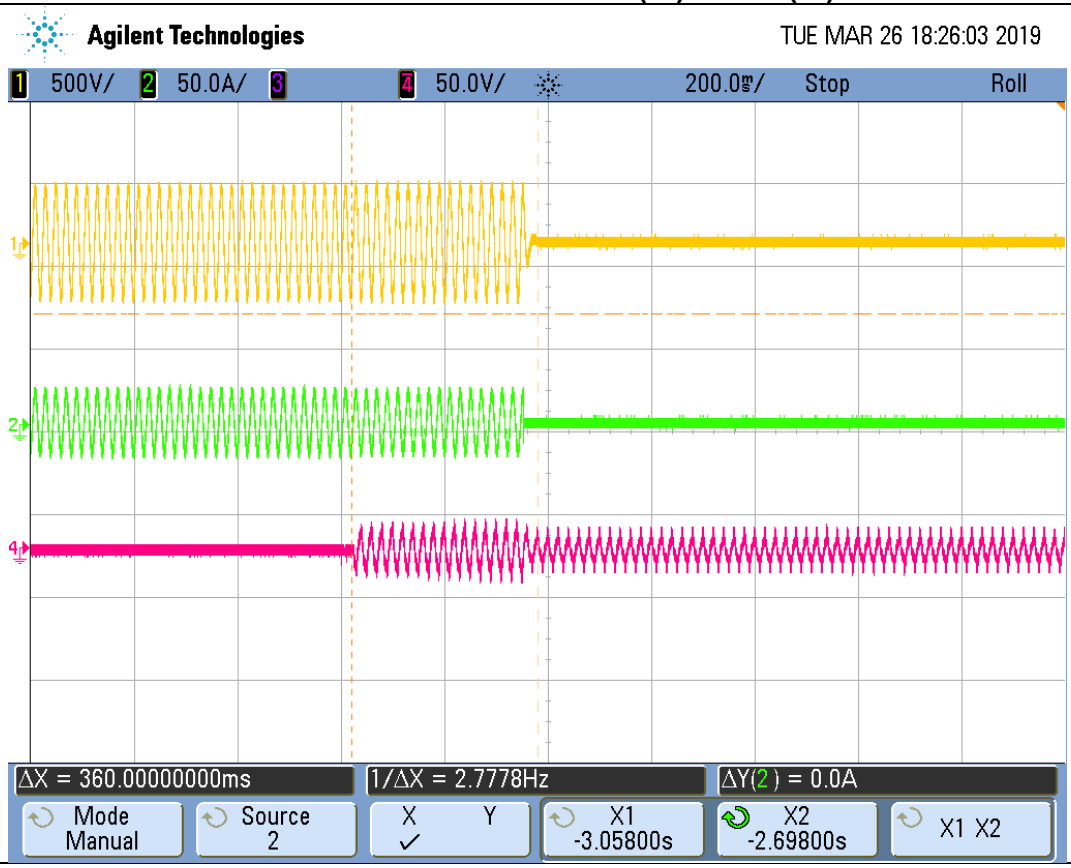
Test A	M(%)=0 & N(%)=0



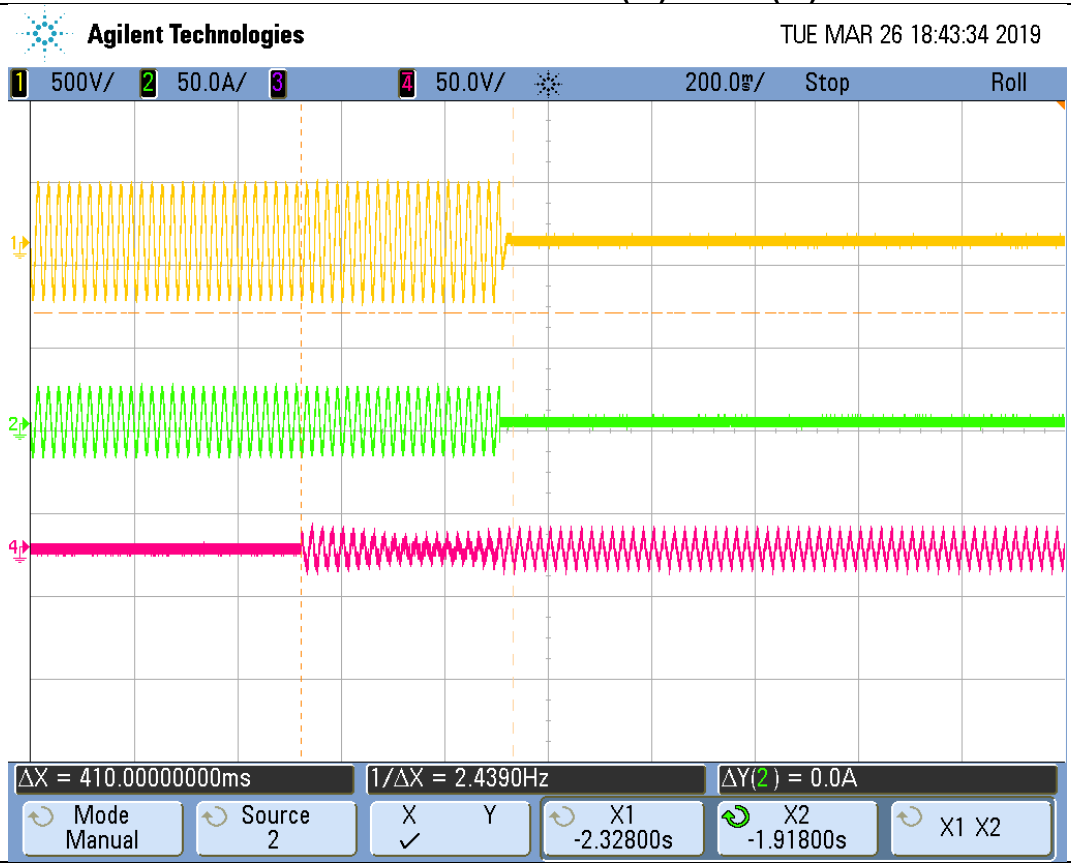
Test A	M(%)=0 & N(%)=+5



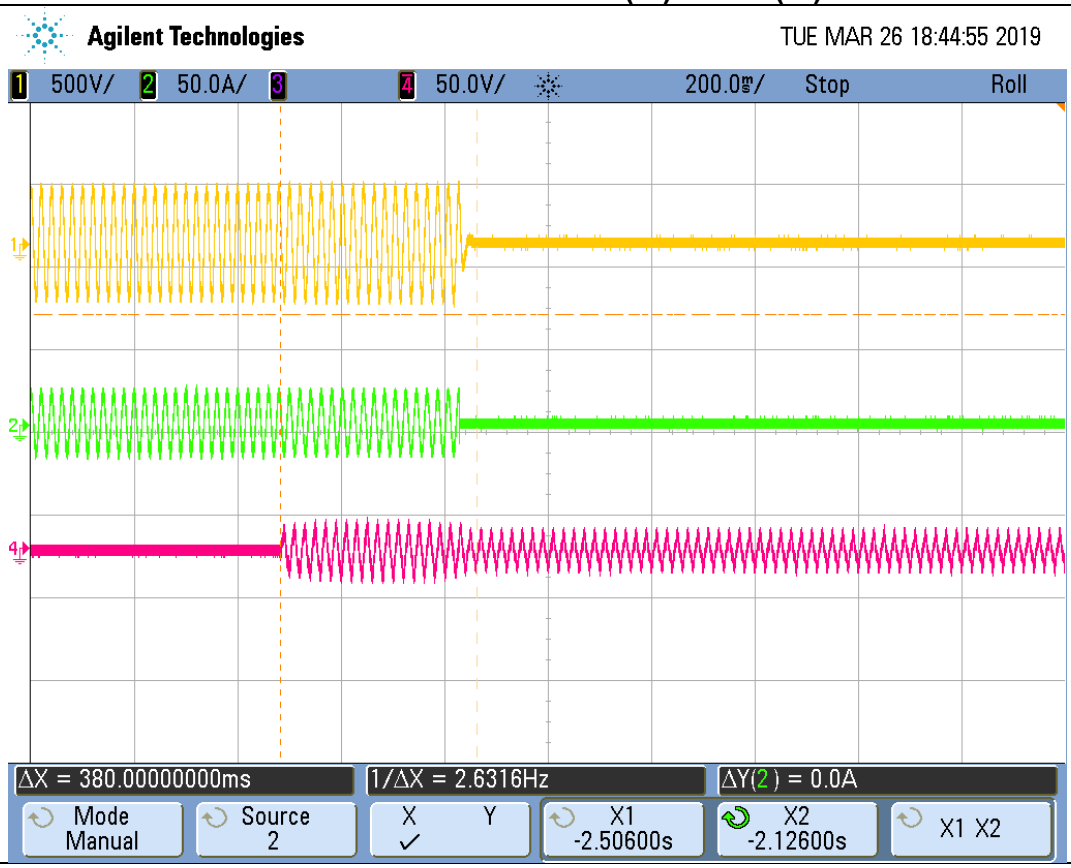
Test A **M(%)=0 & N(%)=-5**



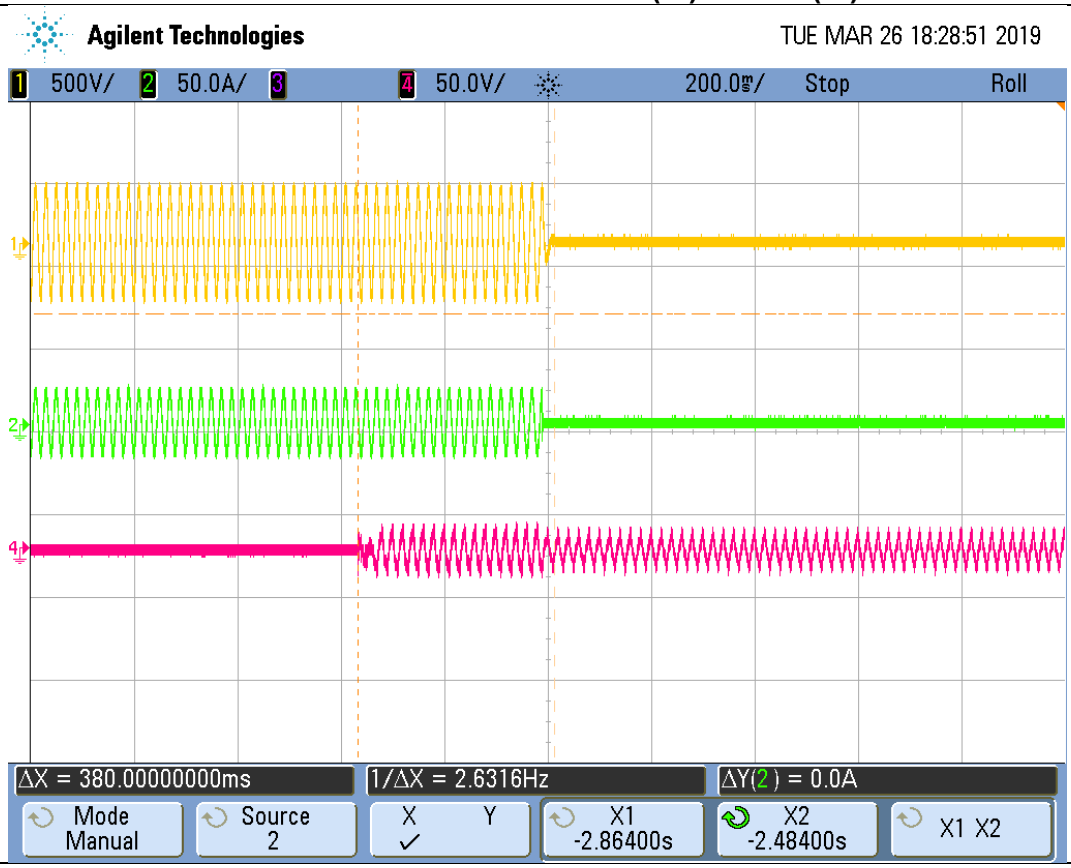
Test A **M(%)=0 & N(%)=+10**



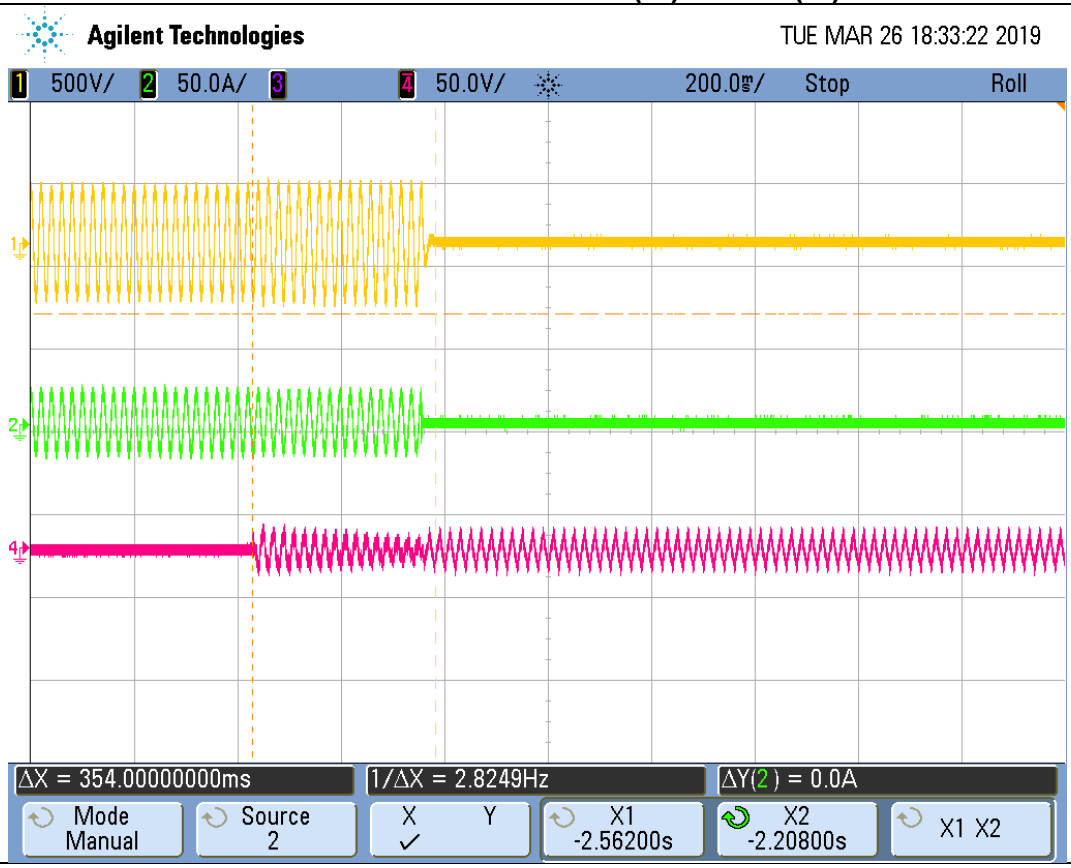
Test A **M(%)=0 & N(%)=-10**



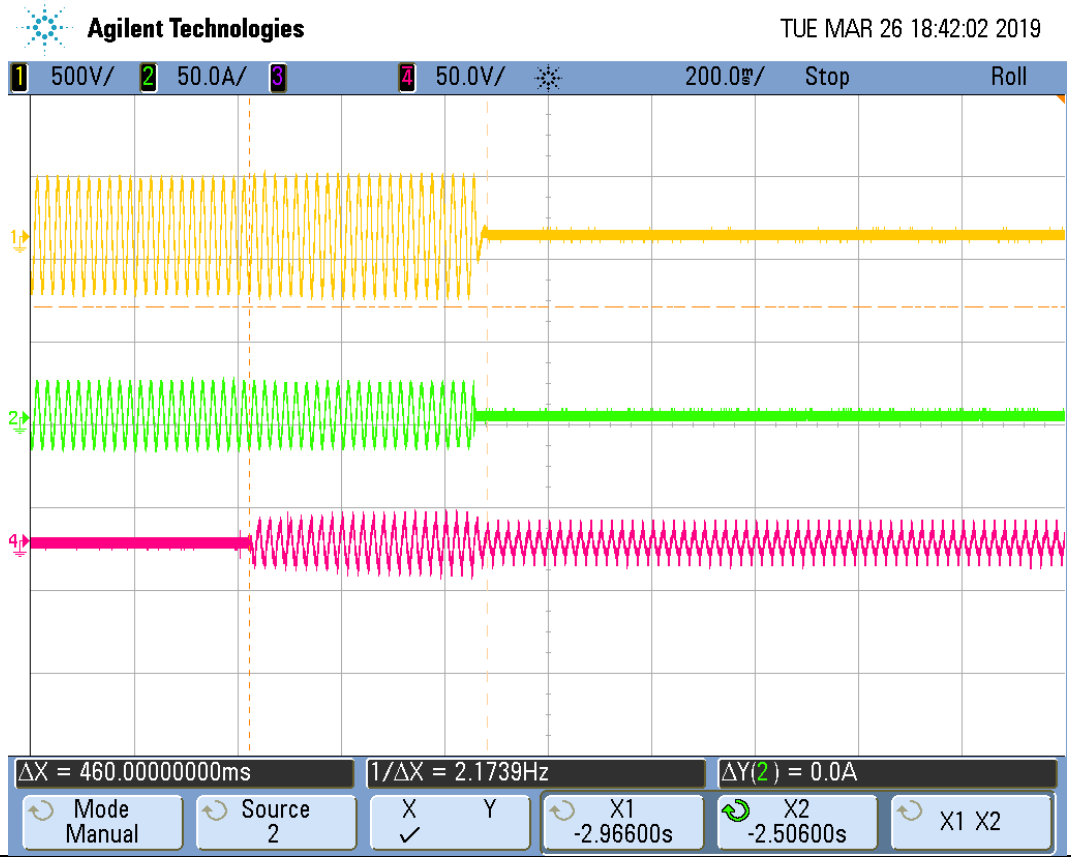
Test A **M(%)=-5 & N(%)=0**



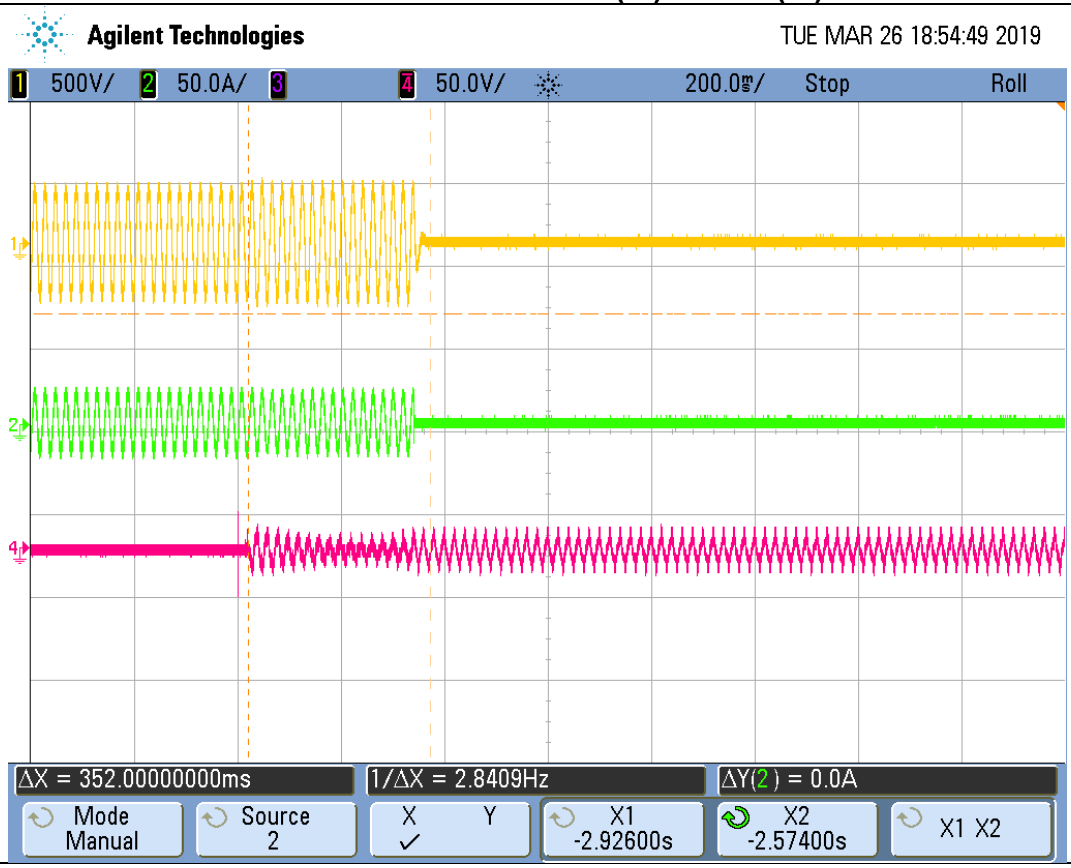
Test A **M(%)=-5 & N(%)=+5**



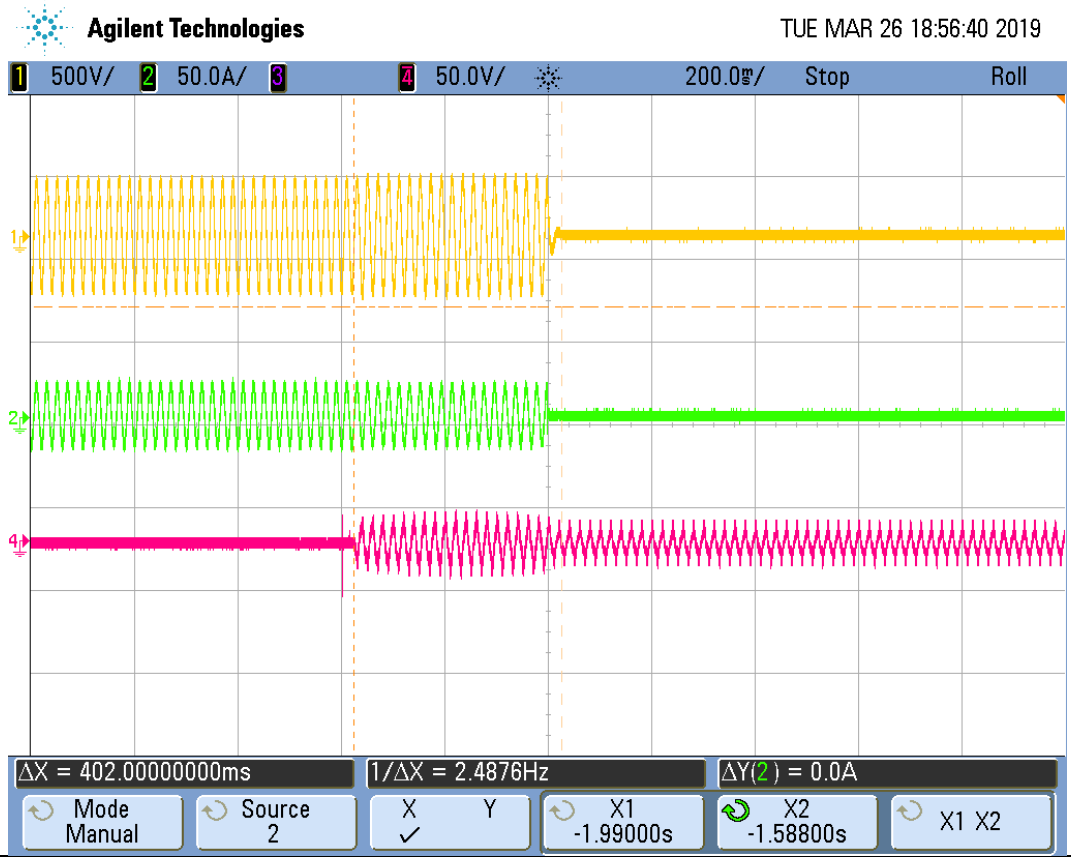
Test A **M(%)=-5 & N(%)=-5**



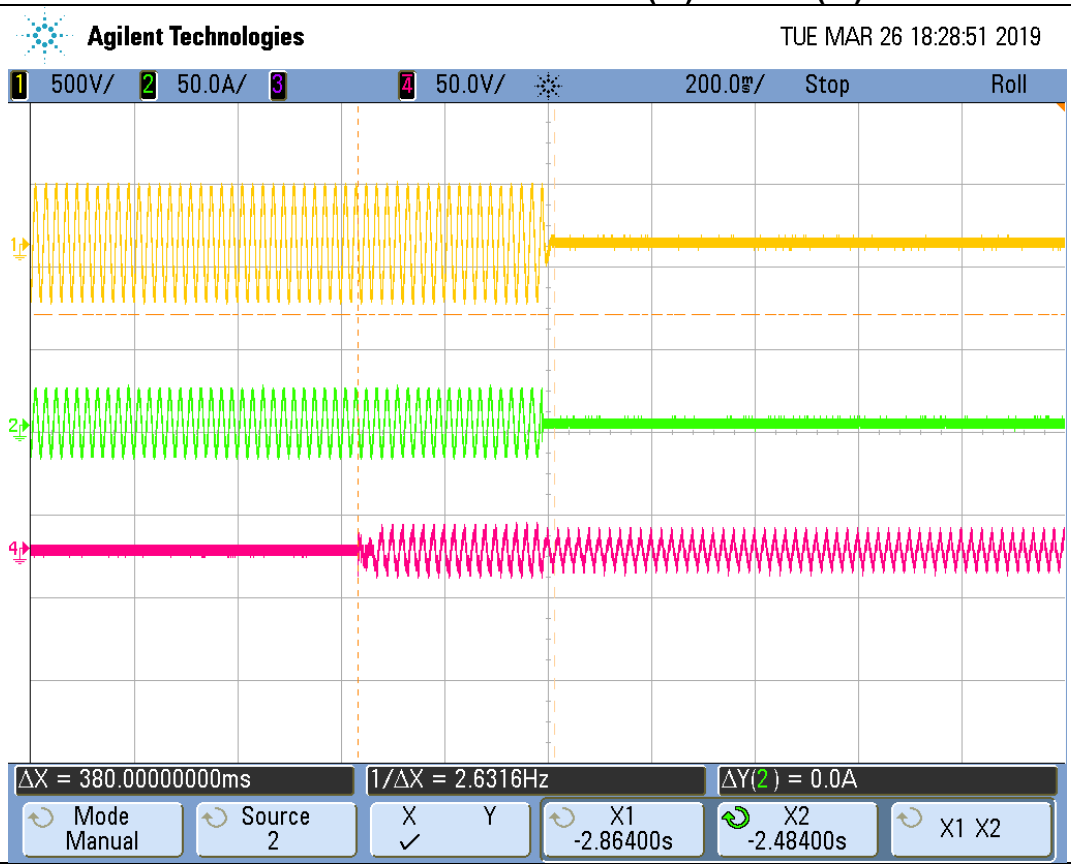
Test A	M(%)=-5 & N(%)=+10



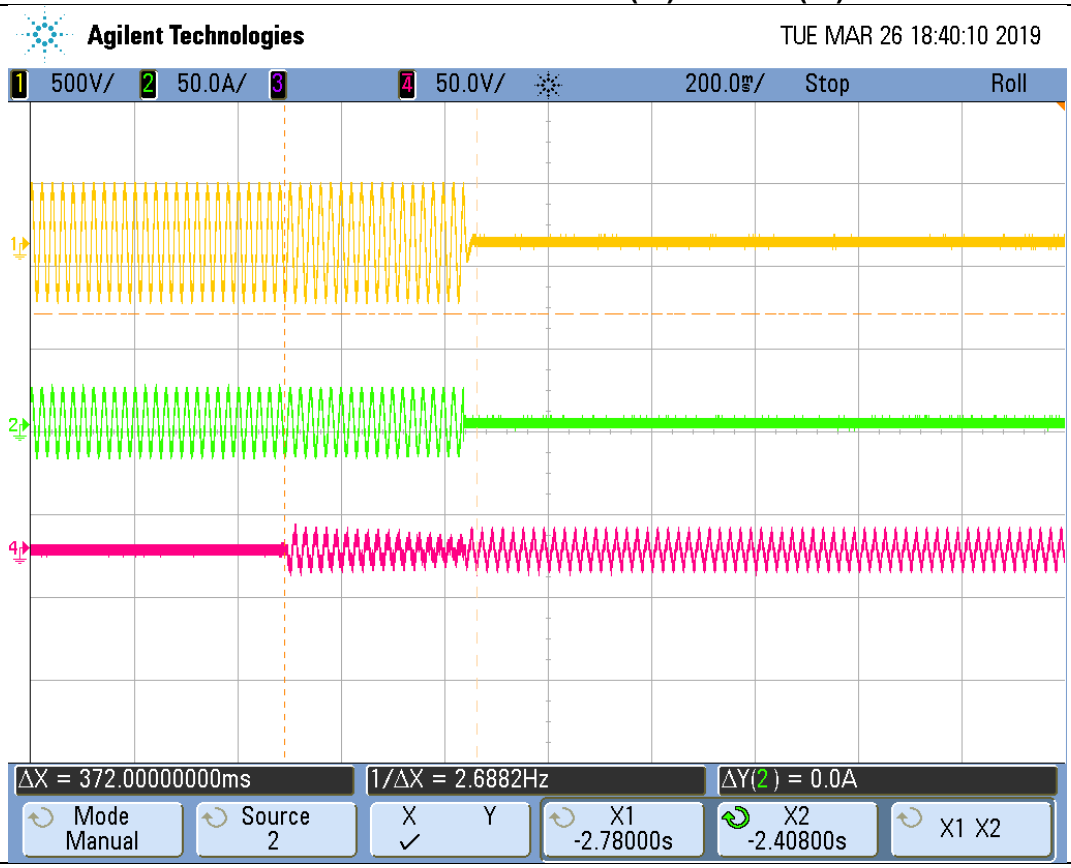
Test A	M(%)=-5 & N(%)=-10



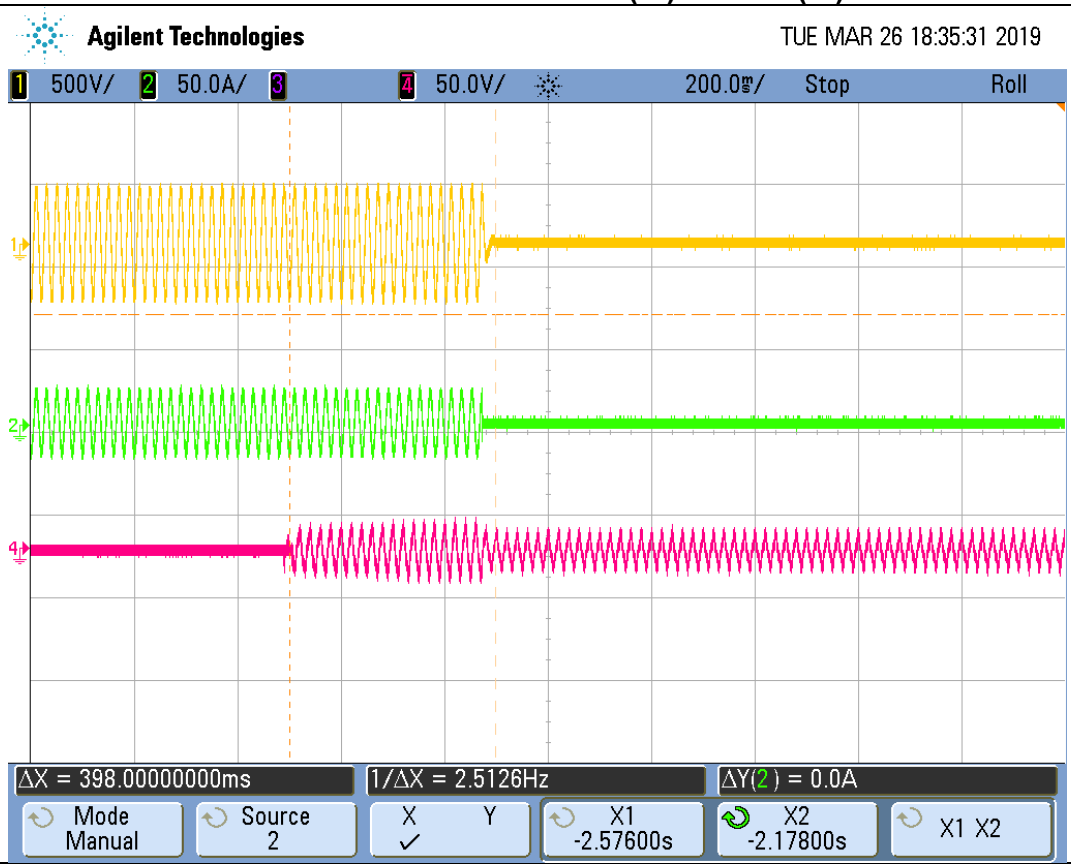
Test A **M(%)=+5 & N(%)=0**



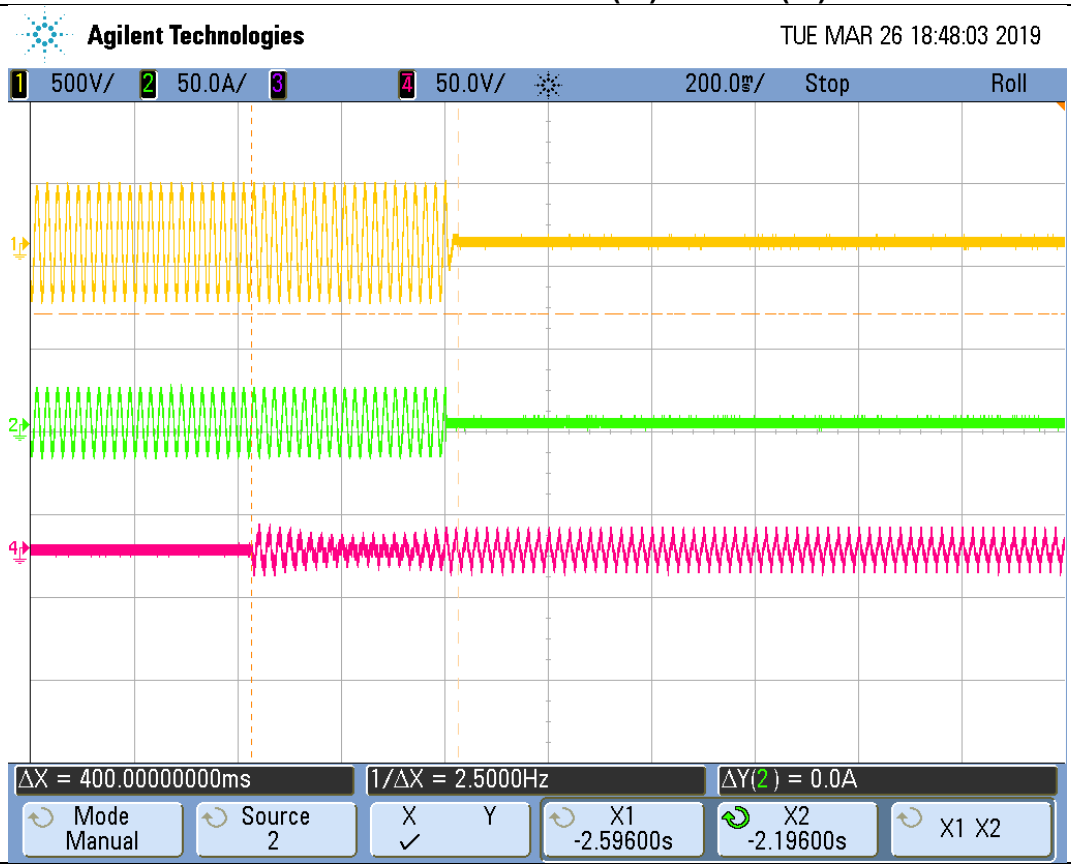
Test A **M(%)=+5 & N(%)=+5**



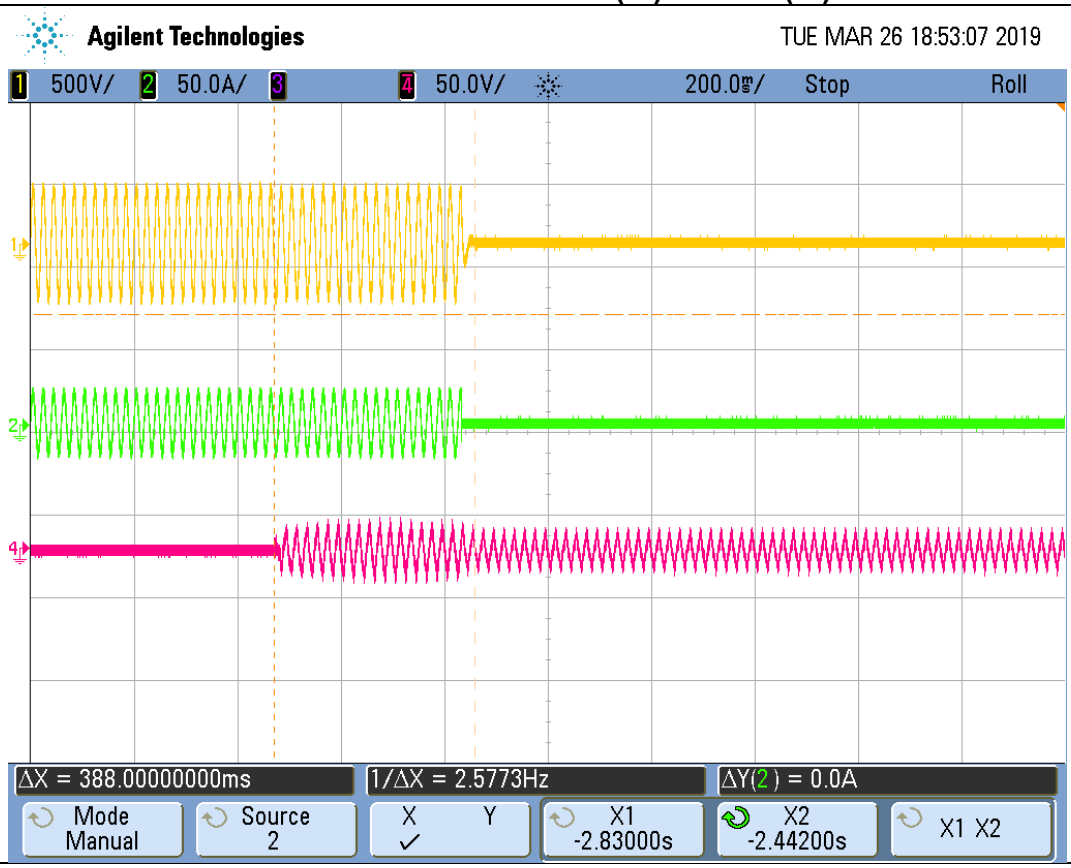
Test A **M(%)=+5 & N(%)=-5**



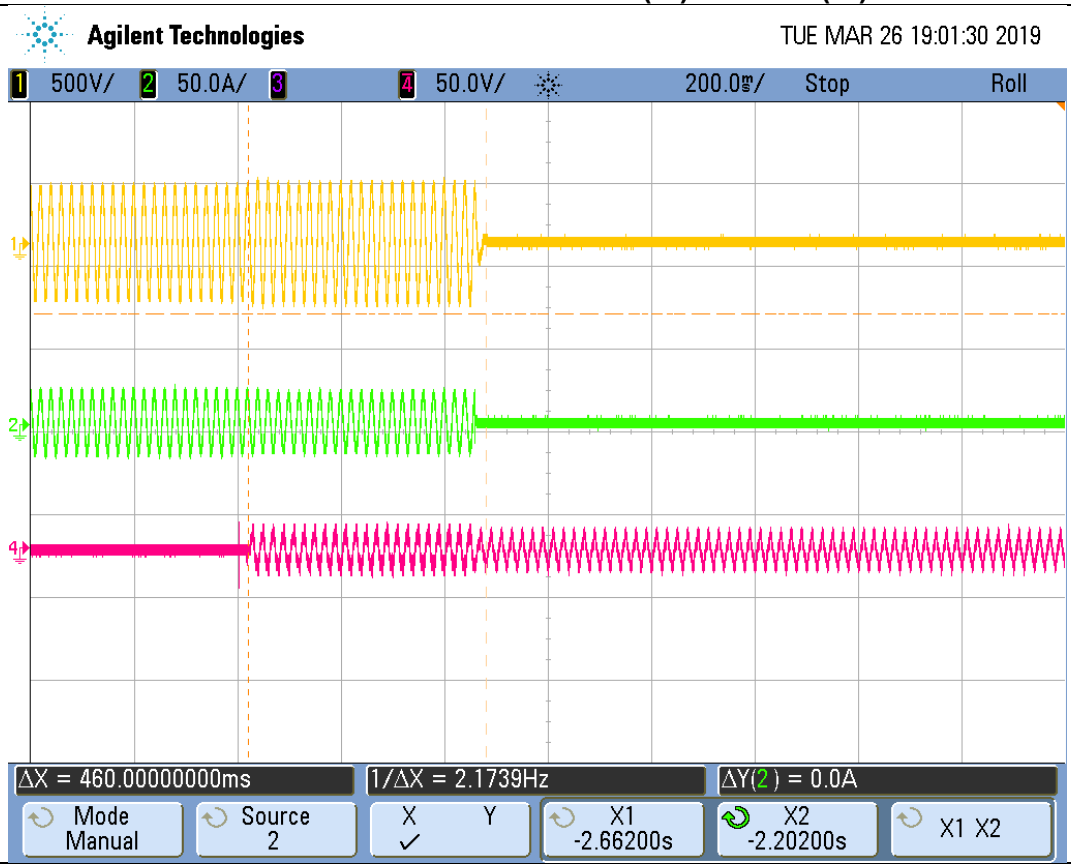
Test A **M(%)=+5 & N(%)=+10**



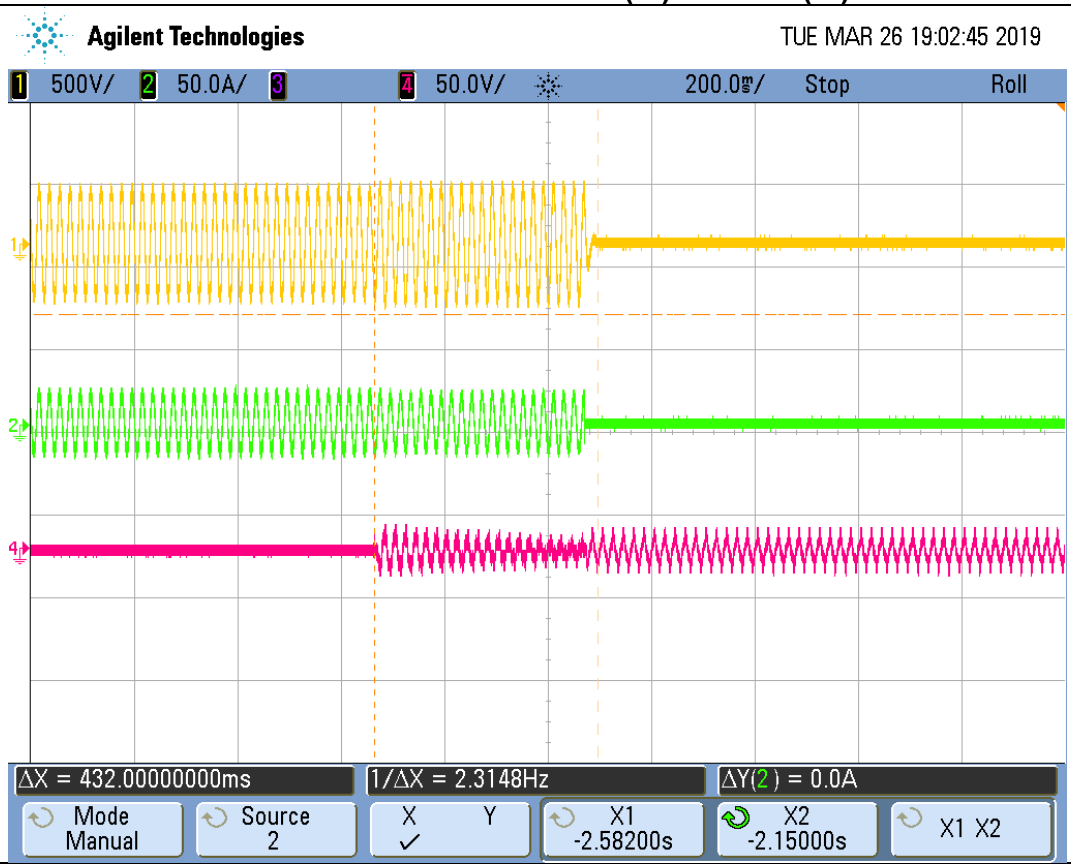
Test A **M(%)=+5 & N(%)=-10**



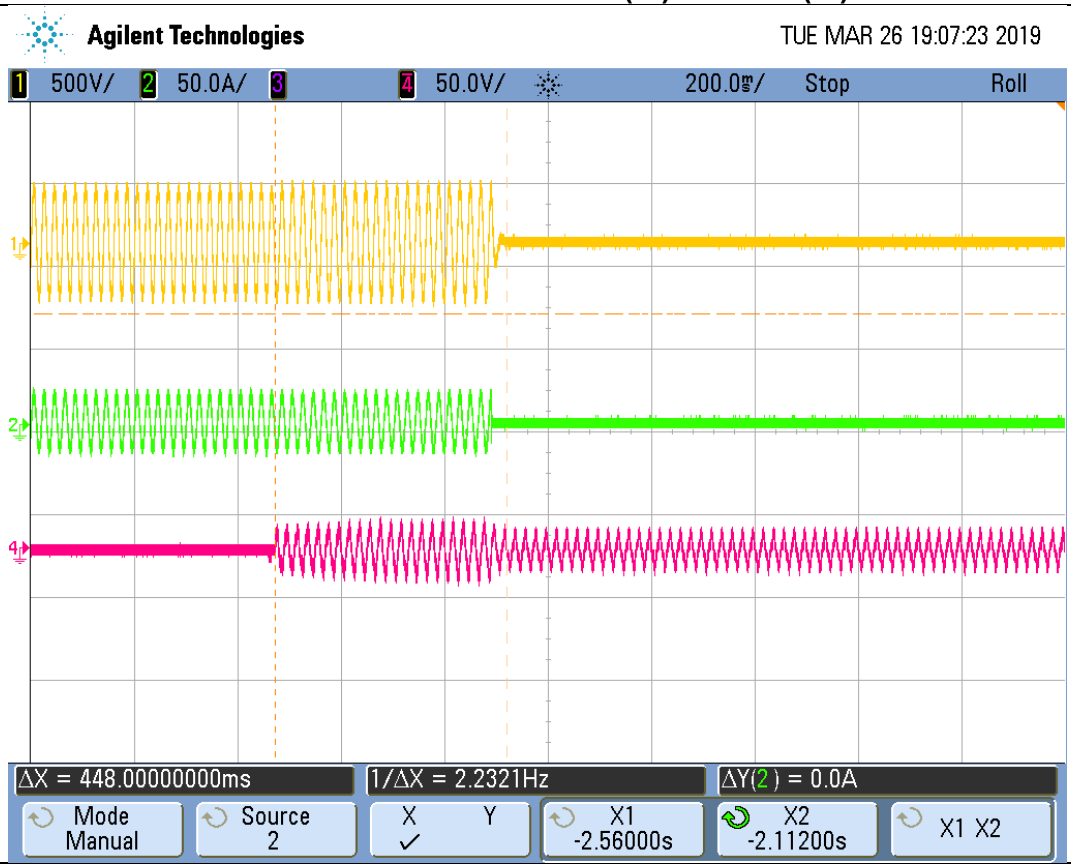
Test A **M(%)=-10 & N(%)=0**



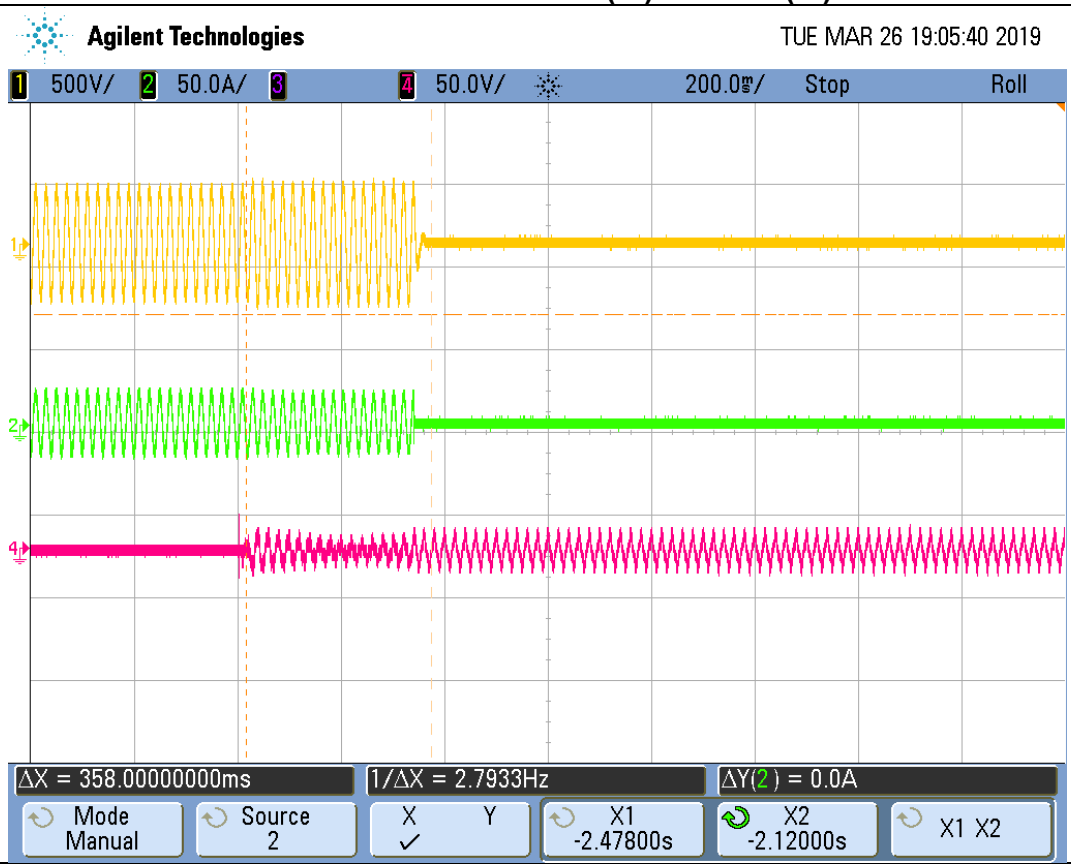
Test A **M(%)=-10 & N(%)=+5**



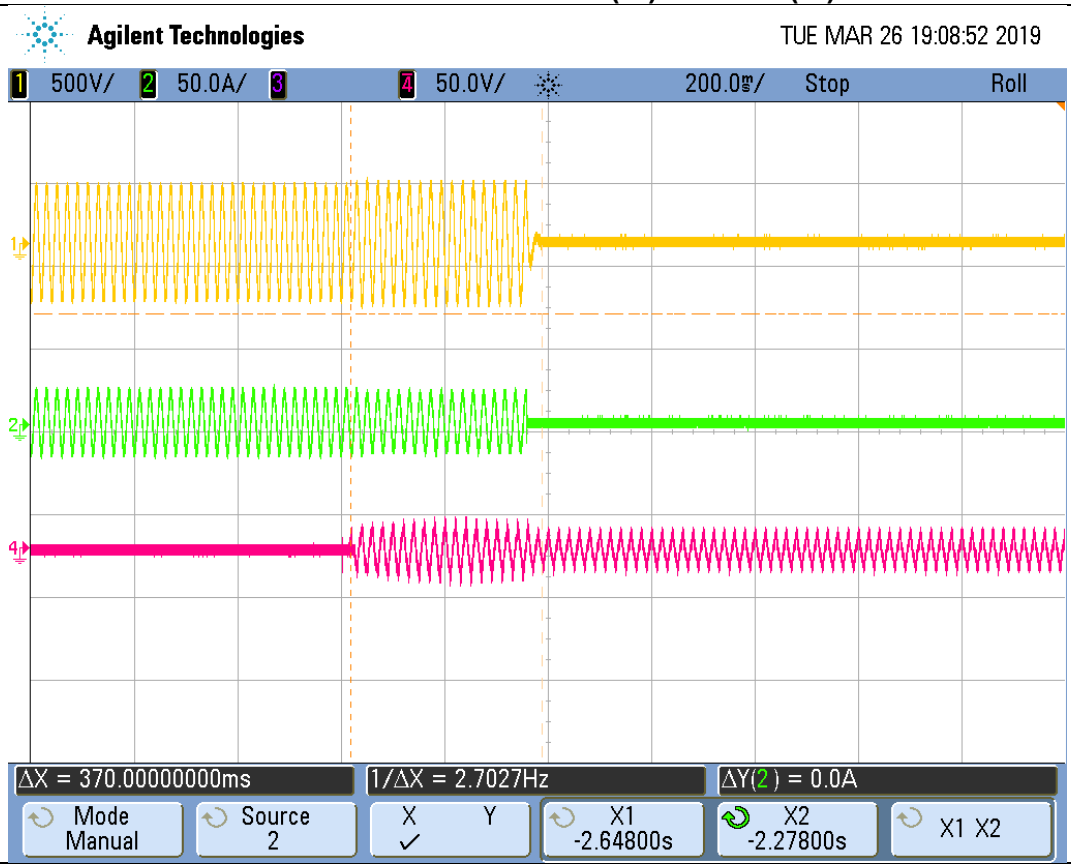
Test A **M(%)=-10 & N(%)=-5**



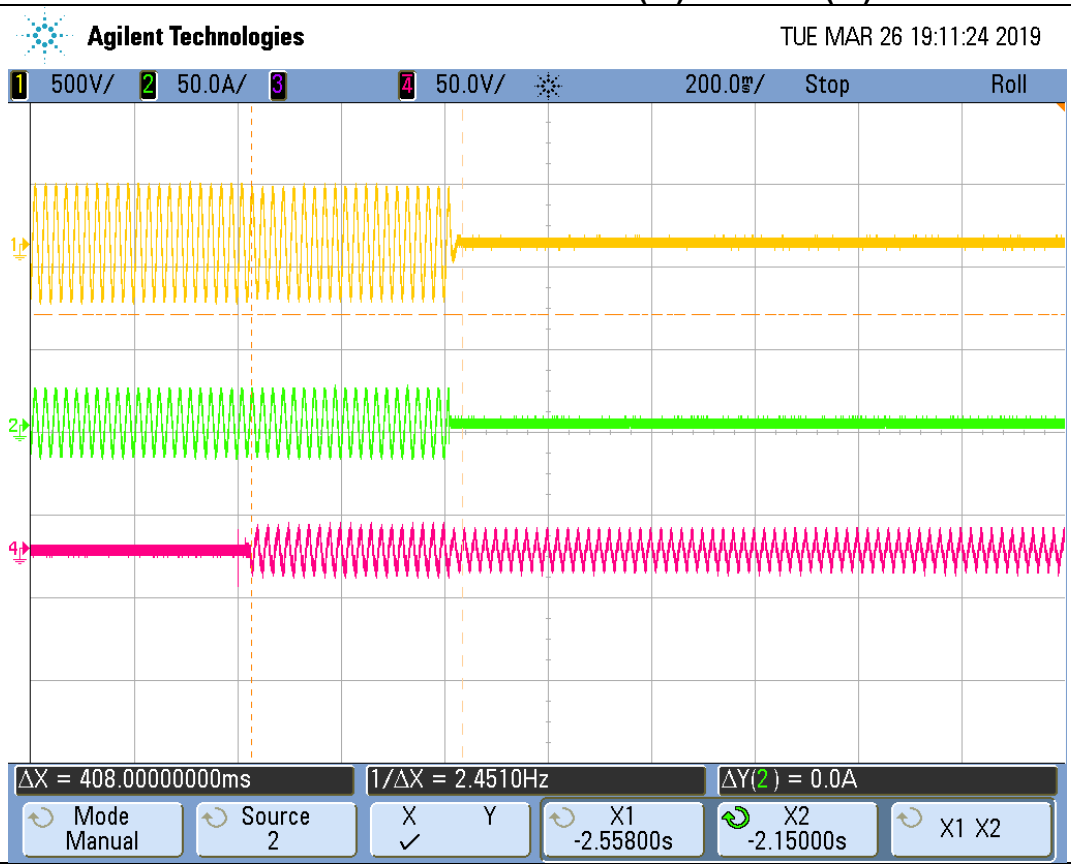
Test A **M(%)=-10 & N(%)=+10**



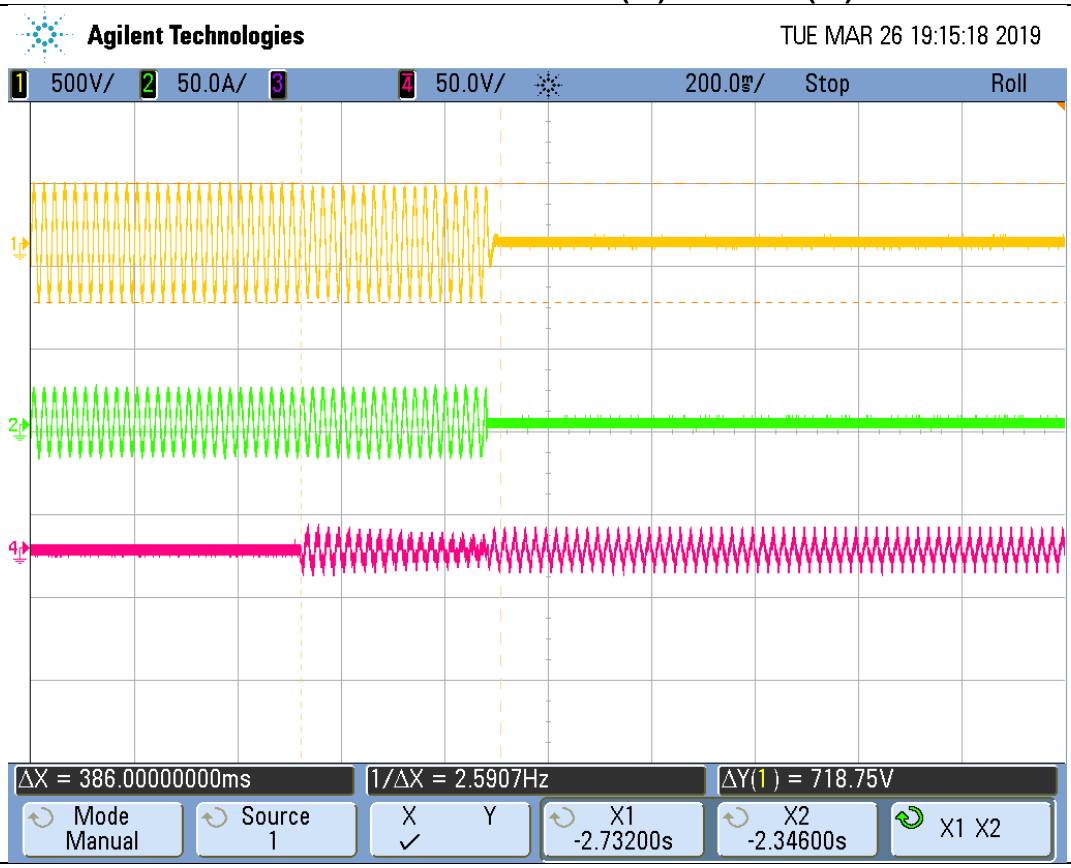
Test A **M(%)=-10 & N(%)=-10**



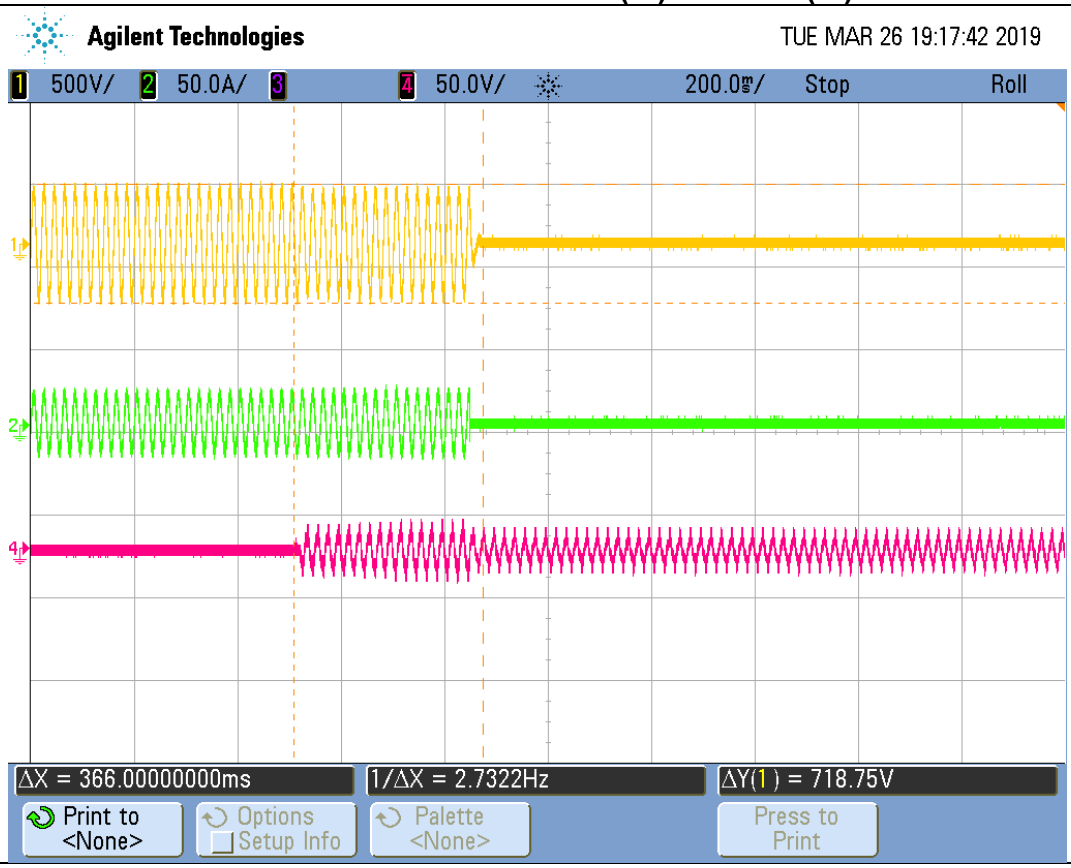
Test A **M(%)=+10 & N(%)=0**



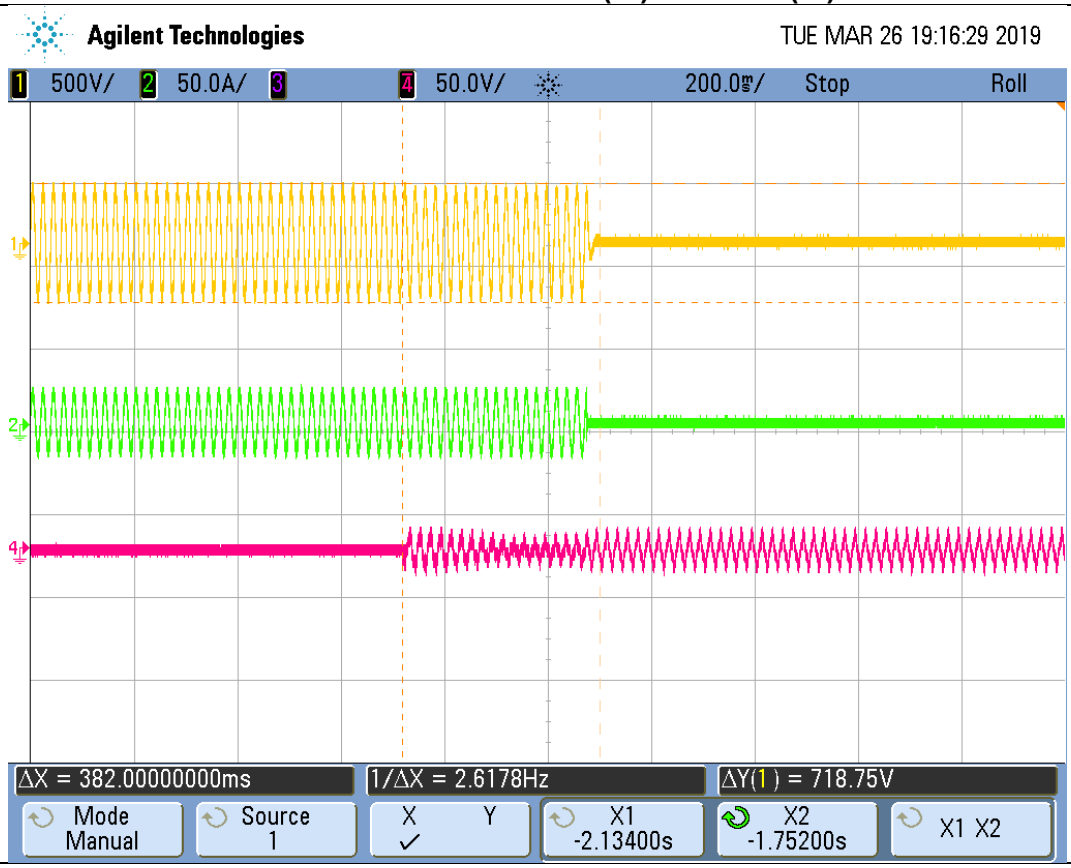
Test A **M(%)=+10 & N(%)=+5**



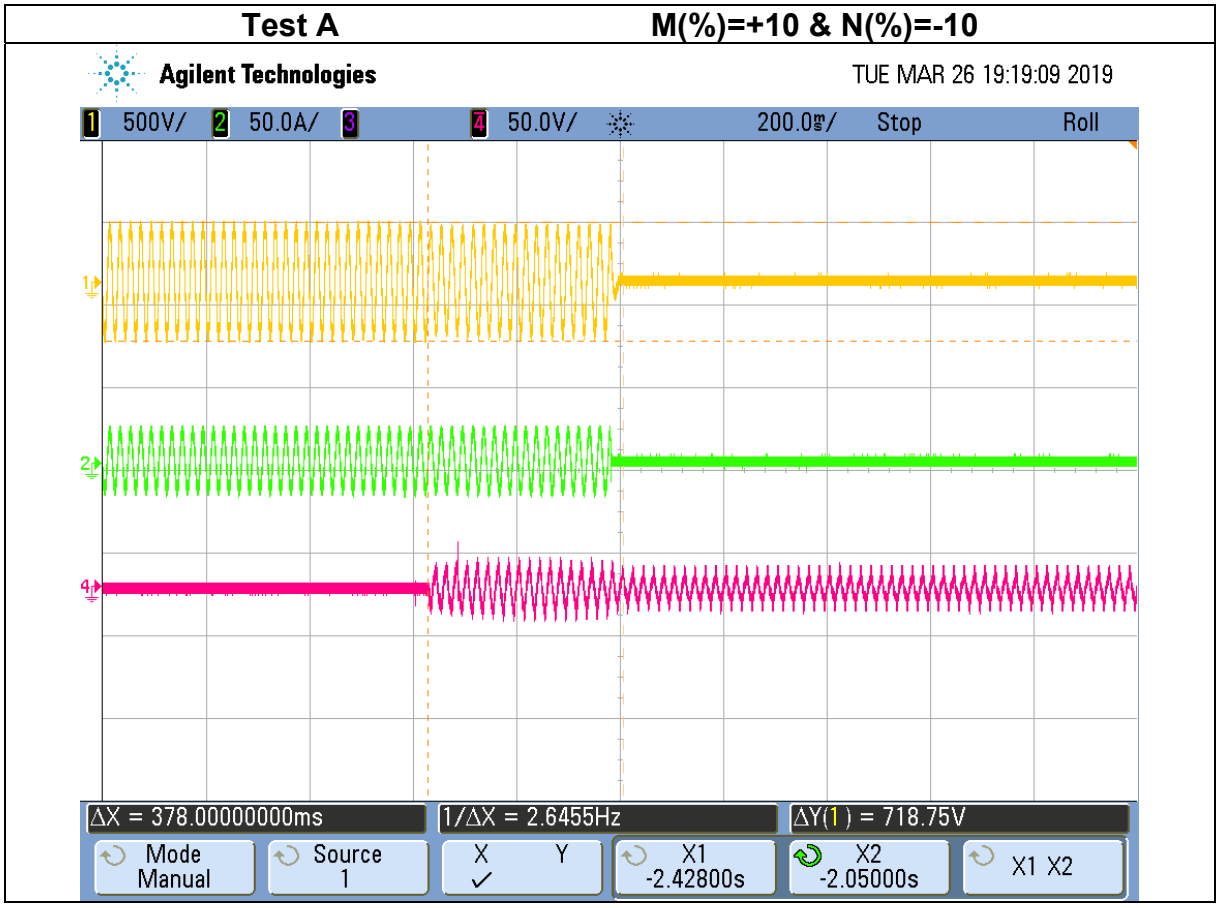
Test A **M(%)=+10 & N(%)=-5**



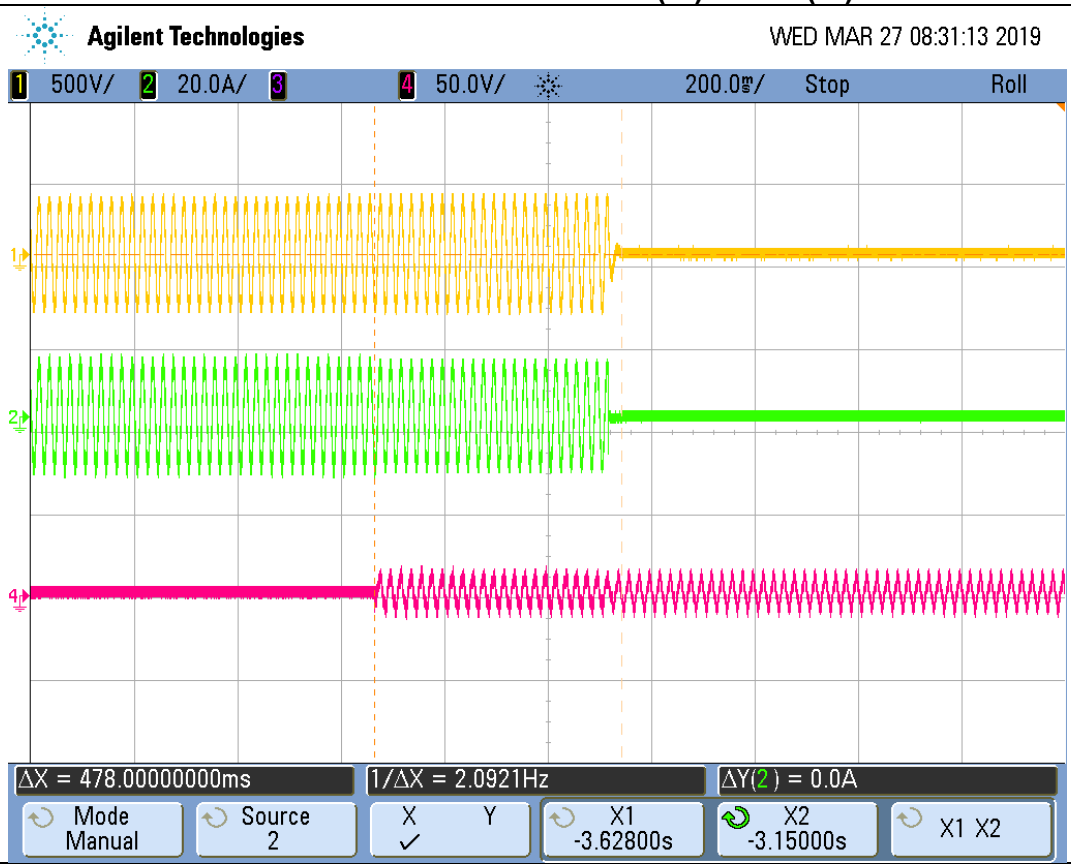
Test A **M(%)=+10 & N(%)=+10**



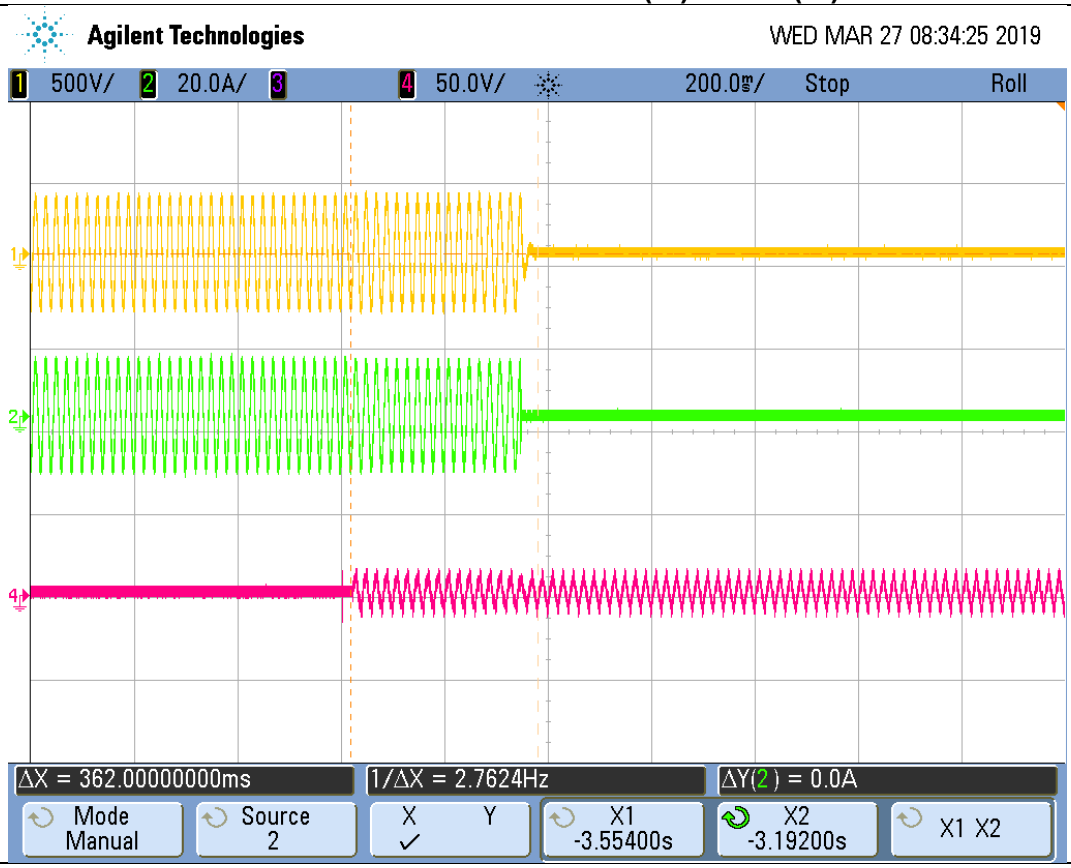
Test A **M(%)=+10 & N(%)=-10**



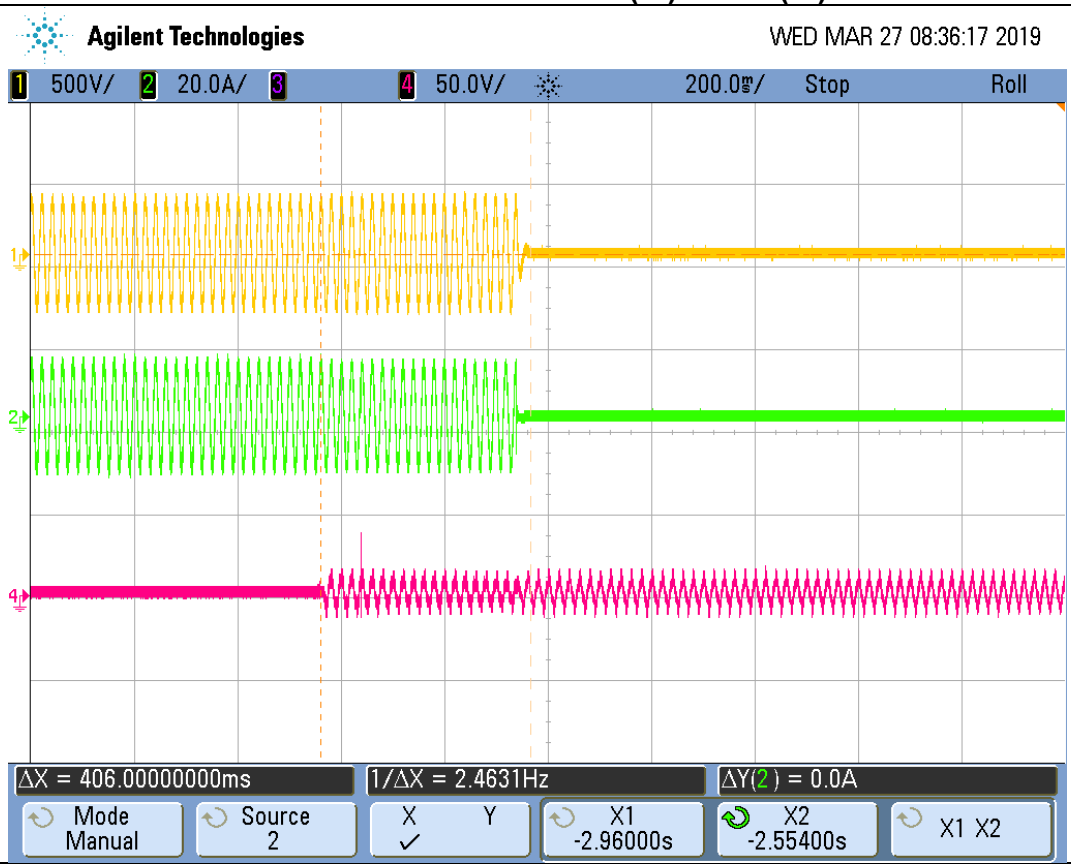
Test B **M(%)=0 & N(%)=0**



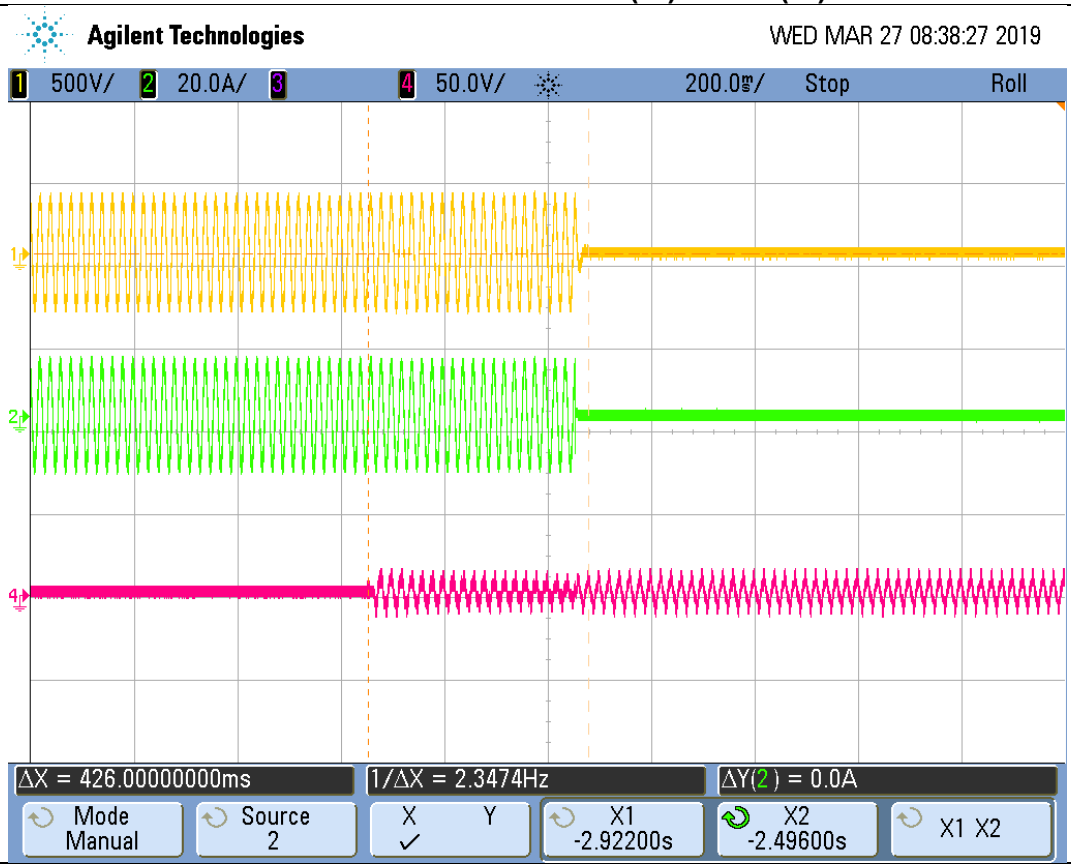
Test B **M(%)=0 & N(%)=+1**



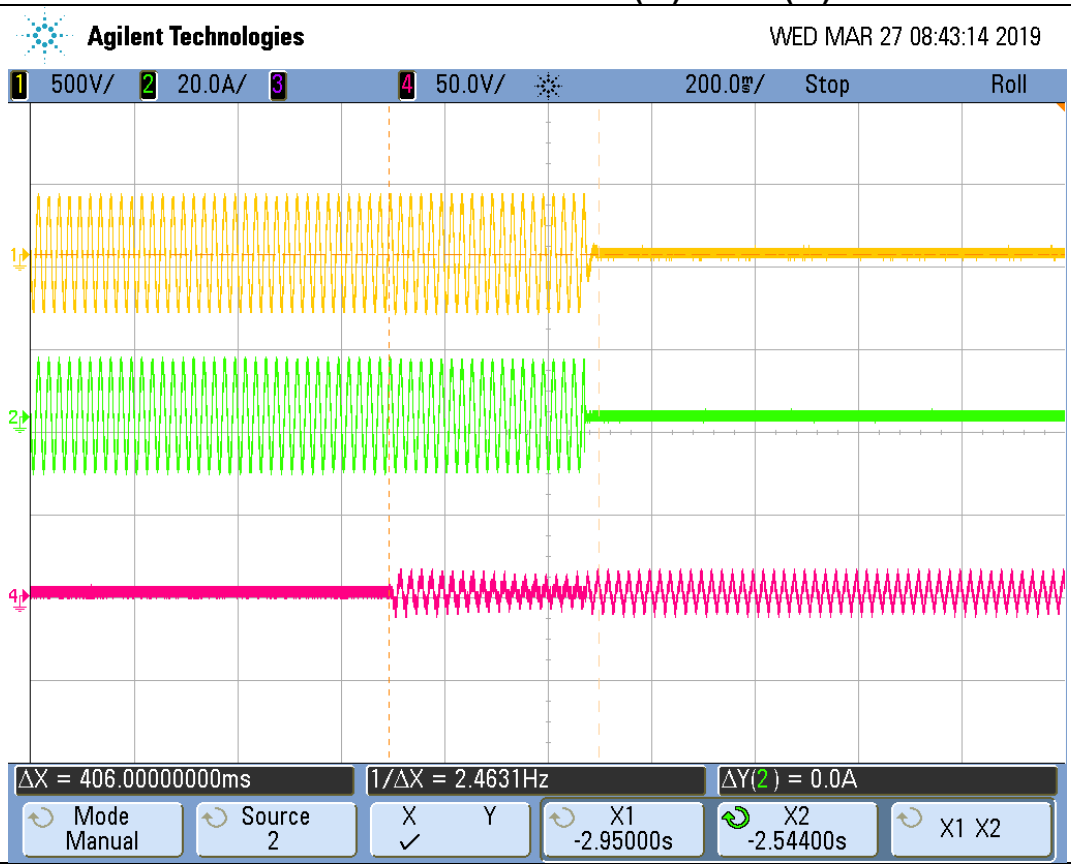
Test B	M(%)=0 & N(%)=+2



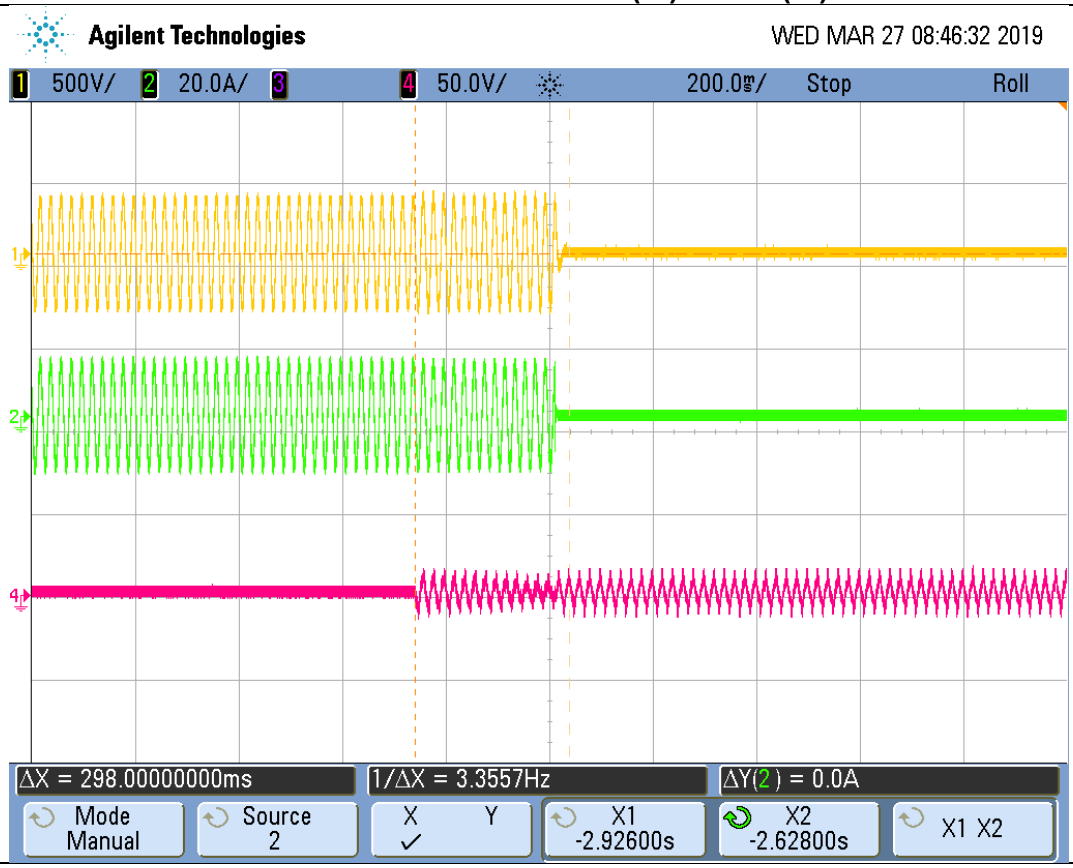
Test B	M(%)=0 & N(%)=+3



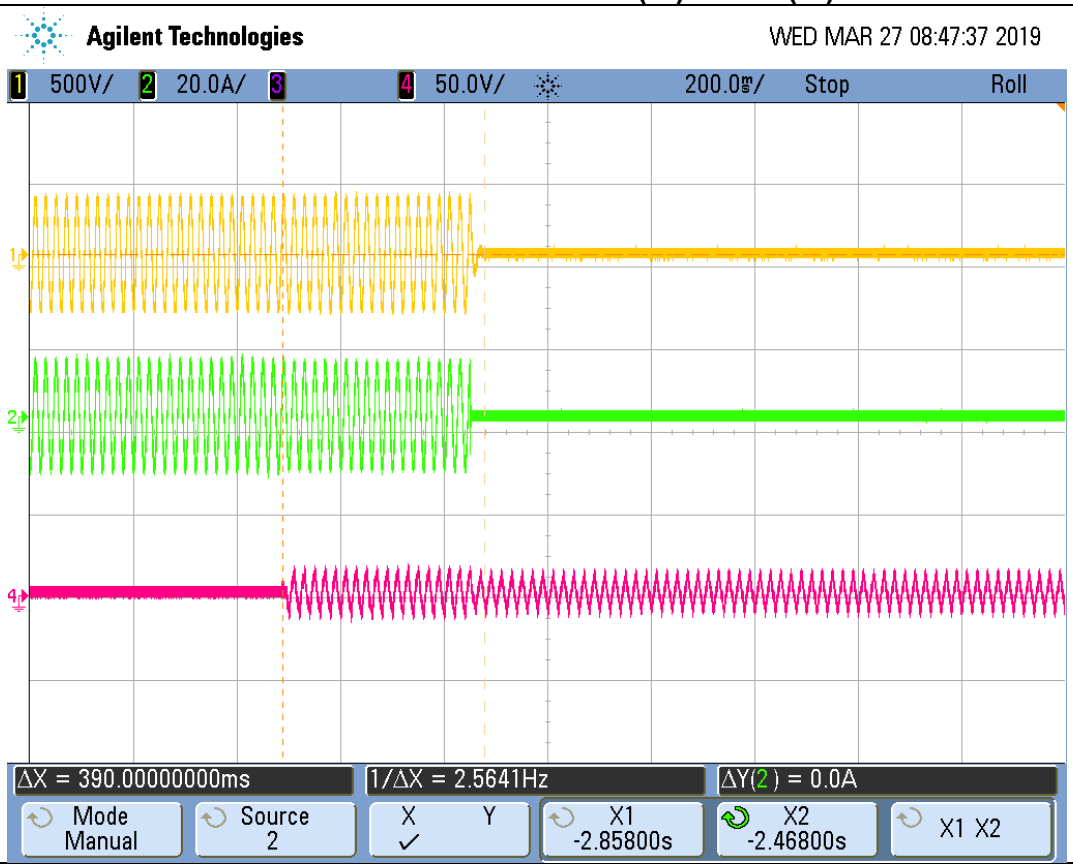
Test B **M(%)=0 & N(%)=+4**



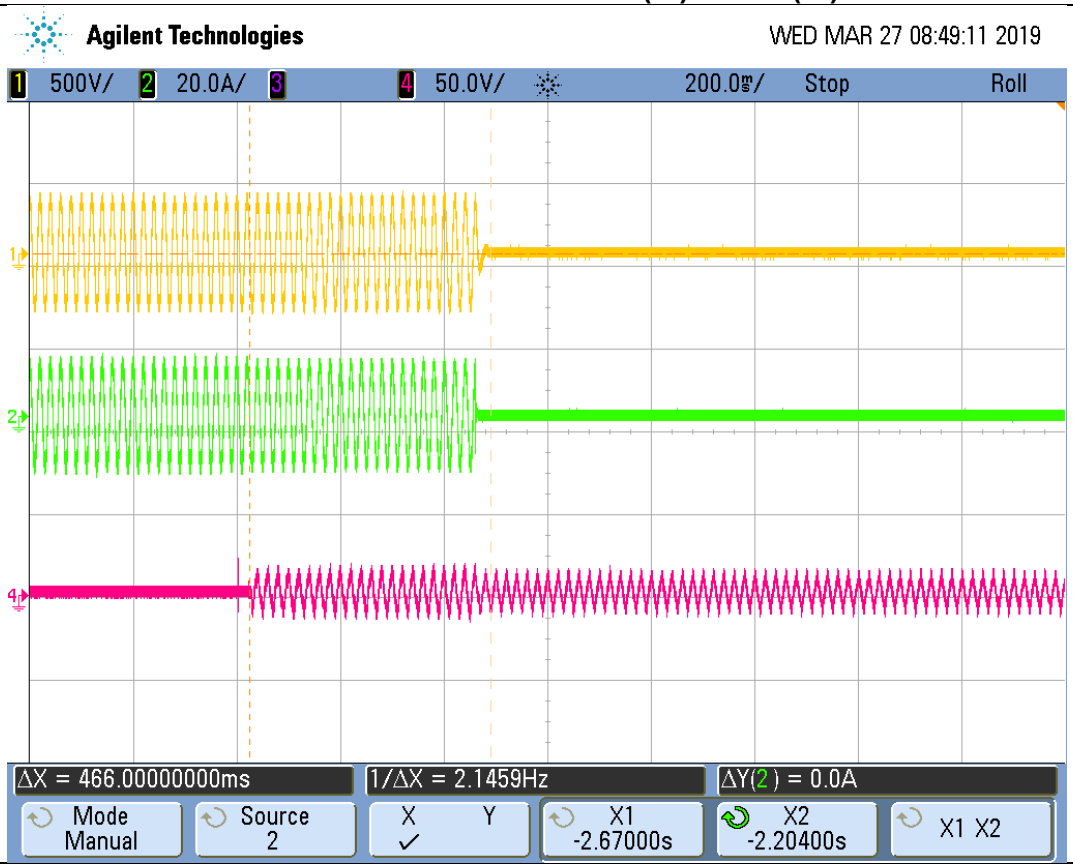
Test B **M(%)=0 & N(%)=+5**



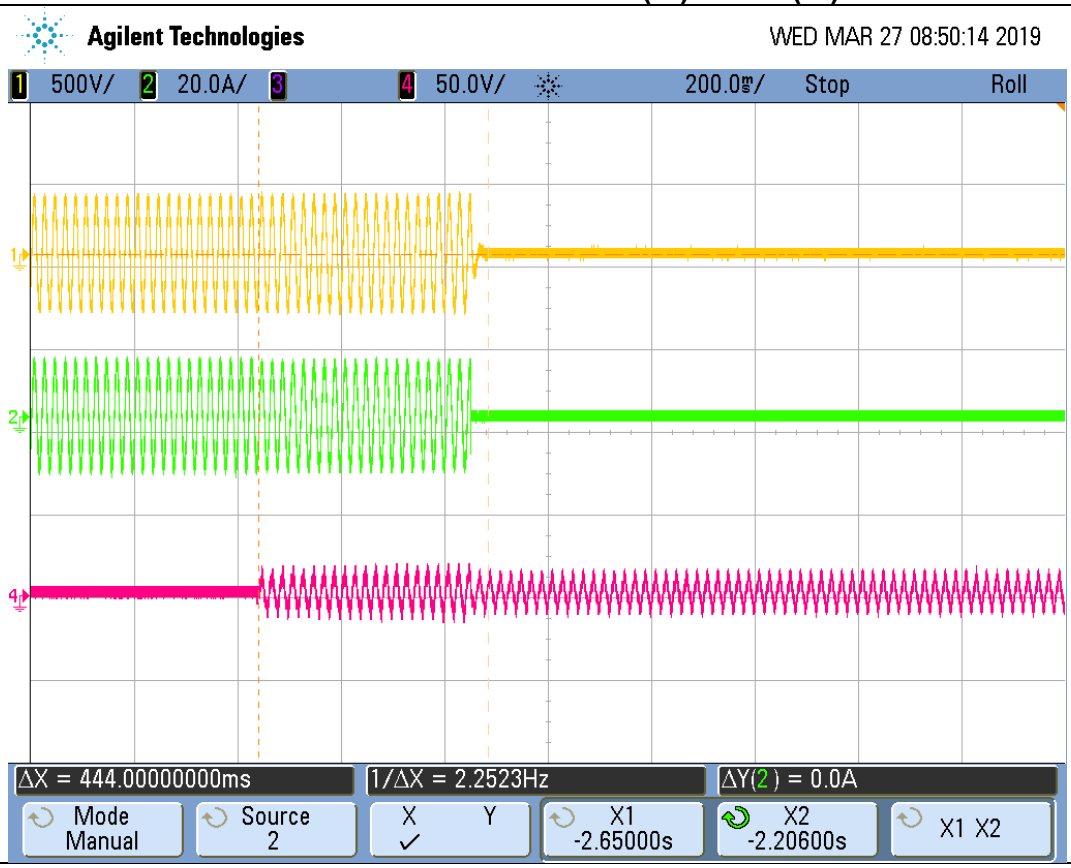
Test B **M(%)=0 & N(%)=-1**



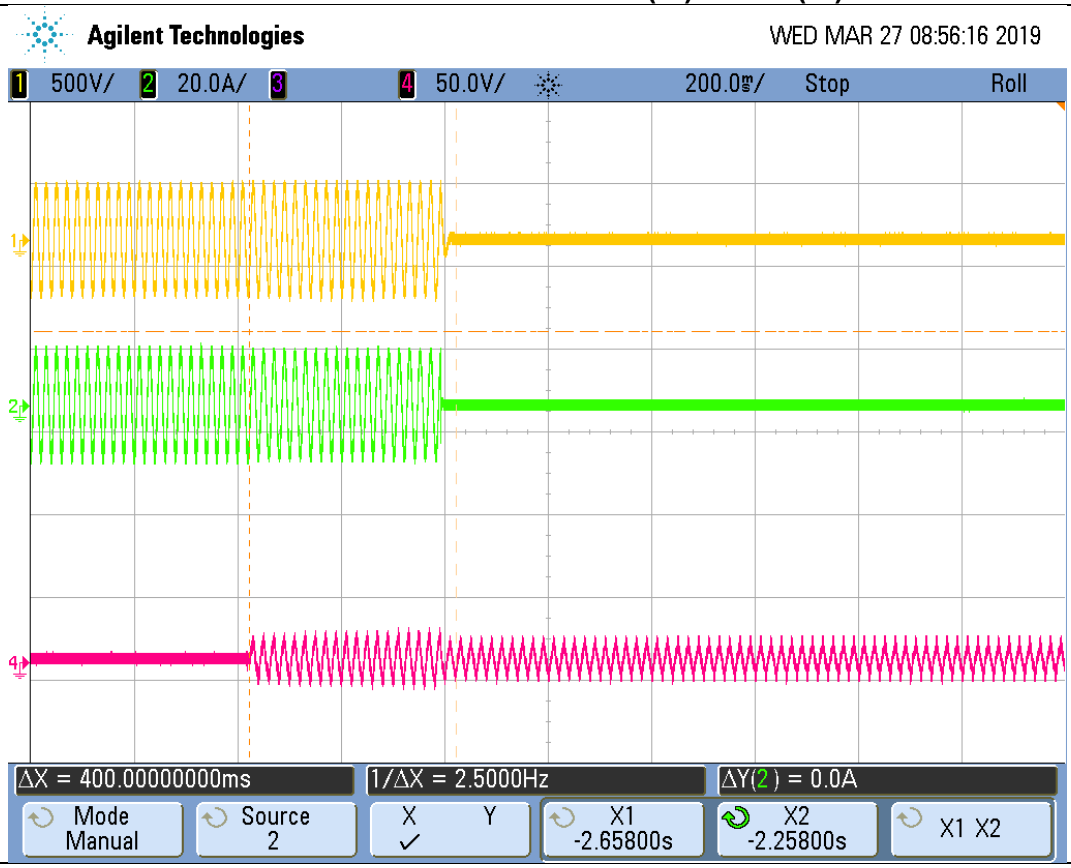
Test B **M(%)=0 & N(%)=-2**



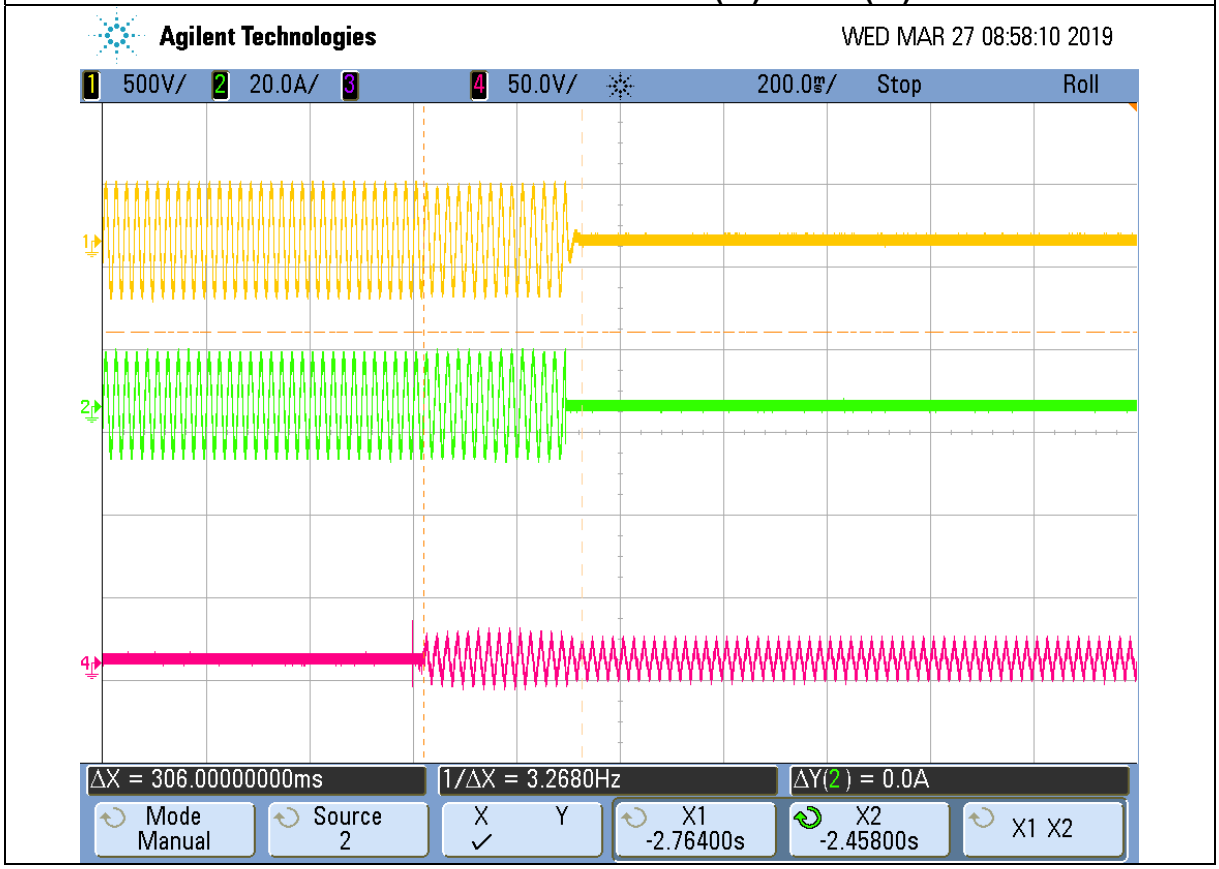
Test B	M(%)=0 & N(%)=-3



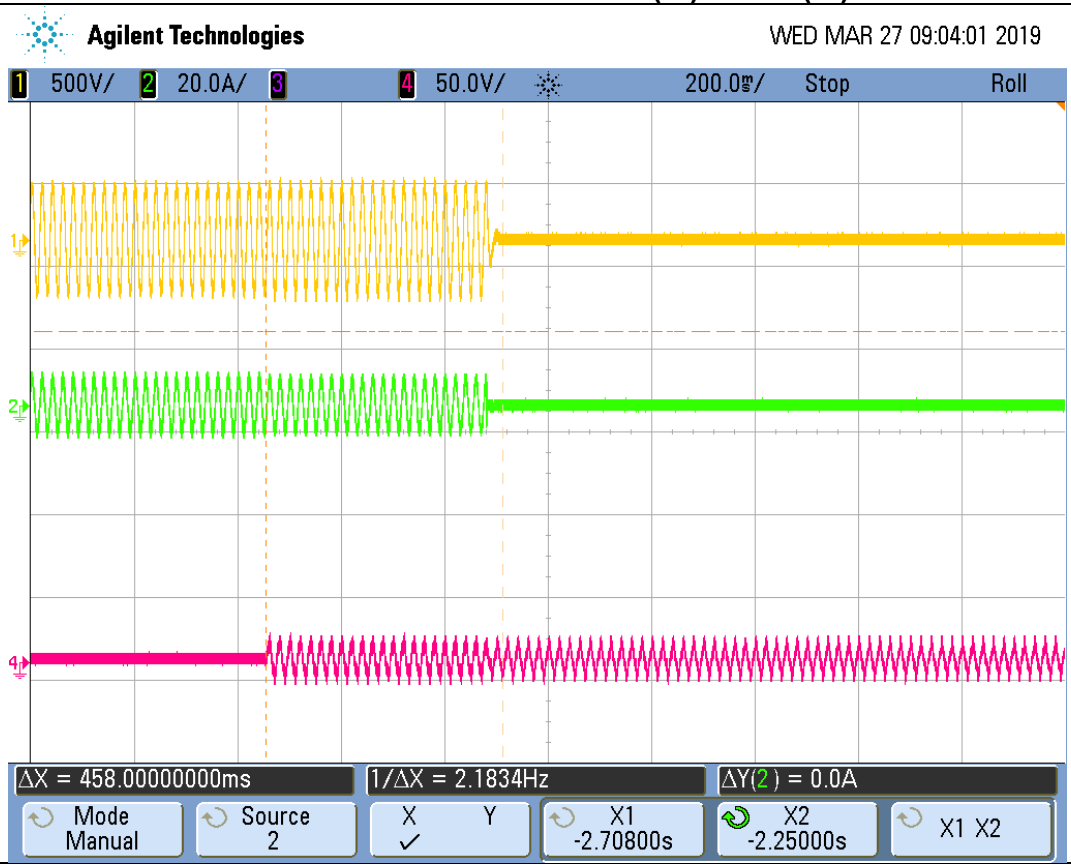
Test B	M(%)=0 & N(%)=-4



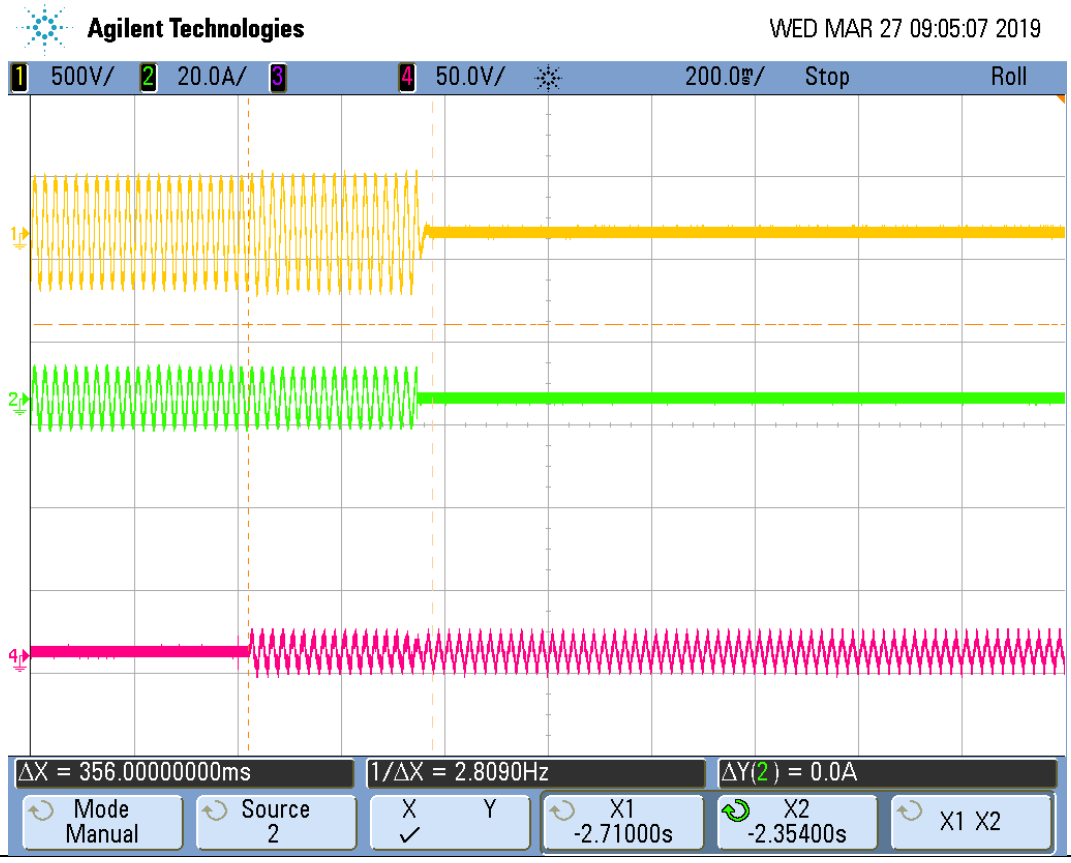
Test B	M(%)=0 & N(%)=-5


Agilent Technologies
WED MAR 27 08:58:10 2019
1 500V/ 2 20.0A/ 3 4 50.0V/ 200.0ns/ Stop Roll
ΔX = 306.00000000ms
1/ΔX = 3.2680Hz
ΔY(2) = 0.0A
Mode Manual
Source 2
X Y
X1 -2.76400s
X2 -2.45800s
X1 X2

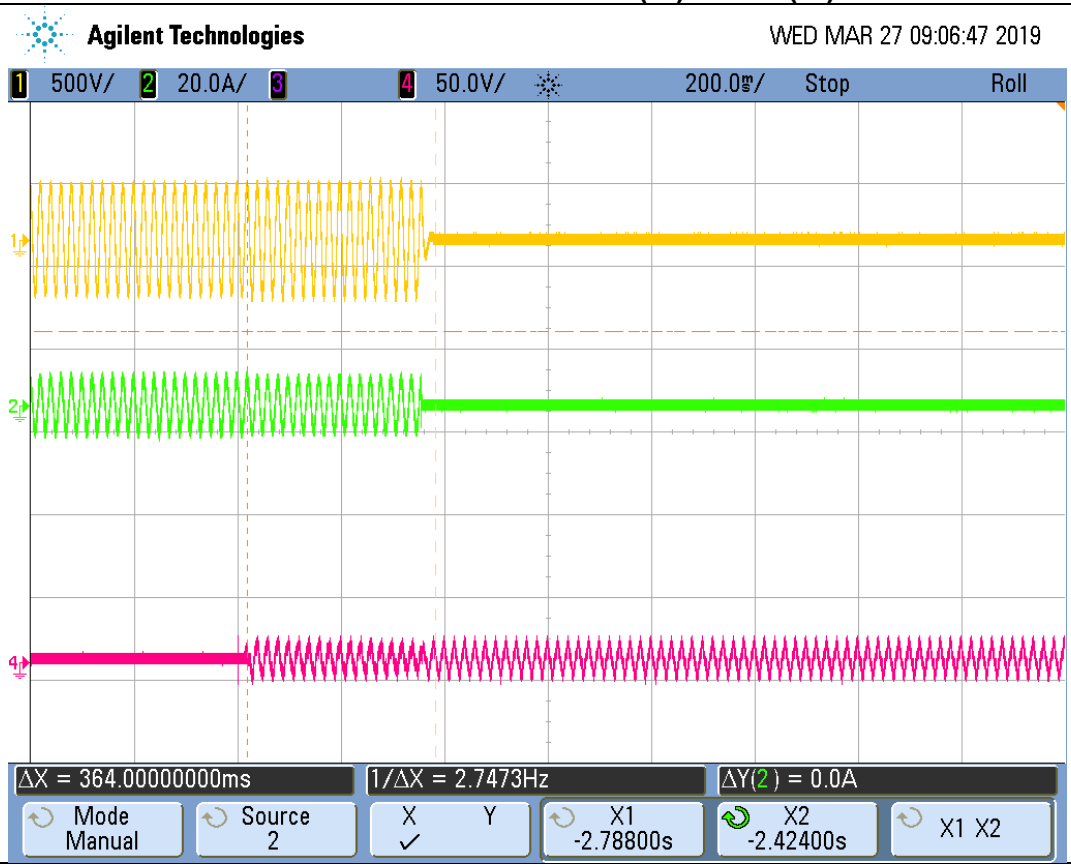
Test C	M(%)=0 & N(%)=0



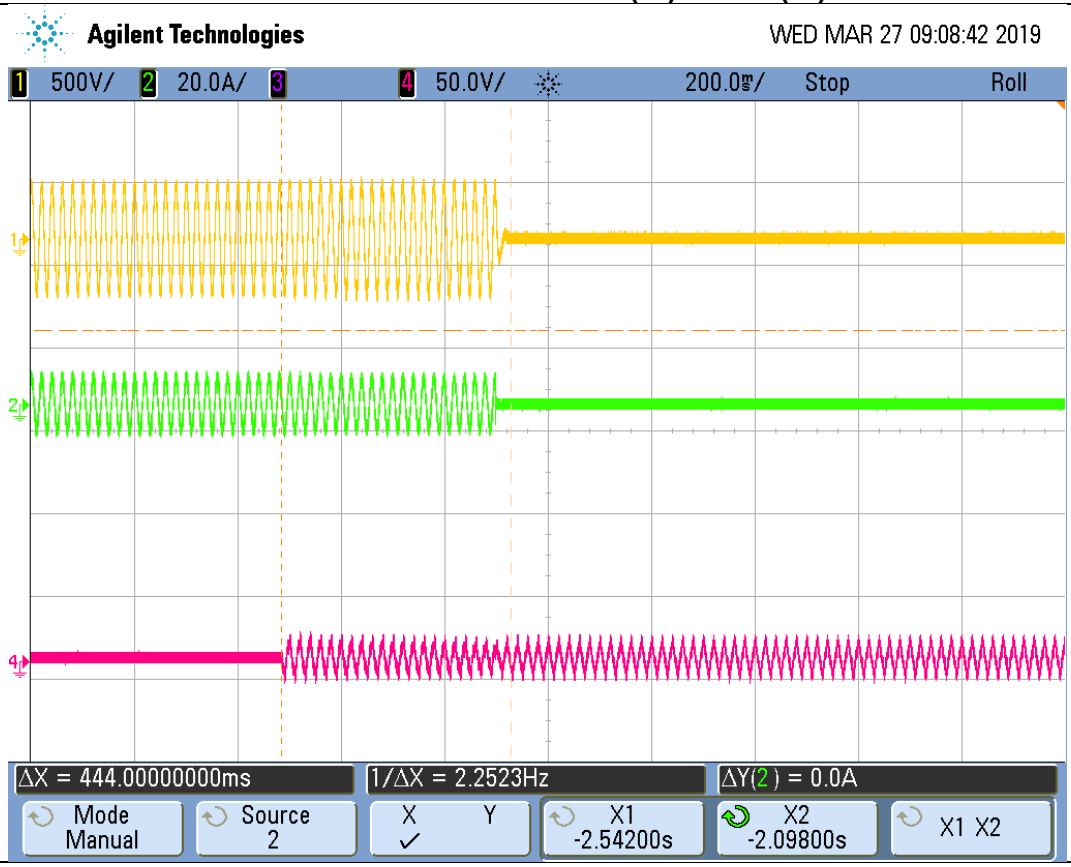
Test C	M(%)=0 & N(%)=+1



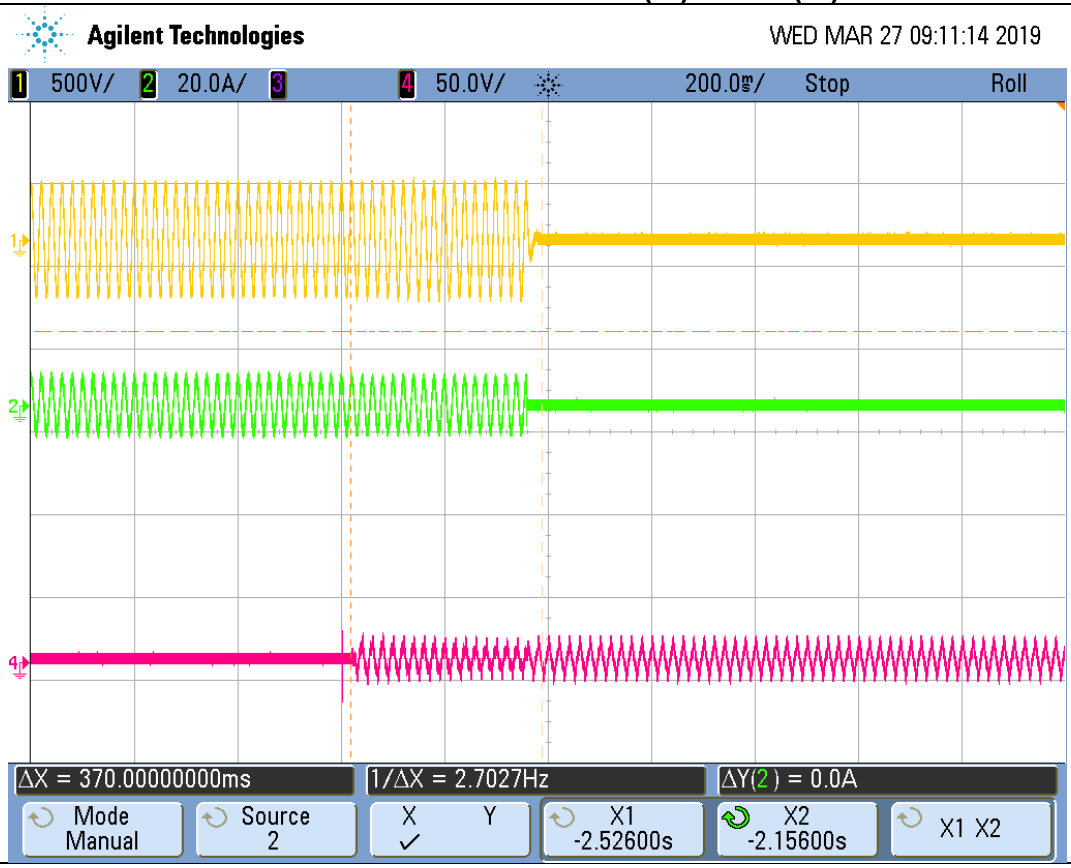
Test C	M(%)=0 & N(%)=+2



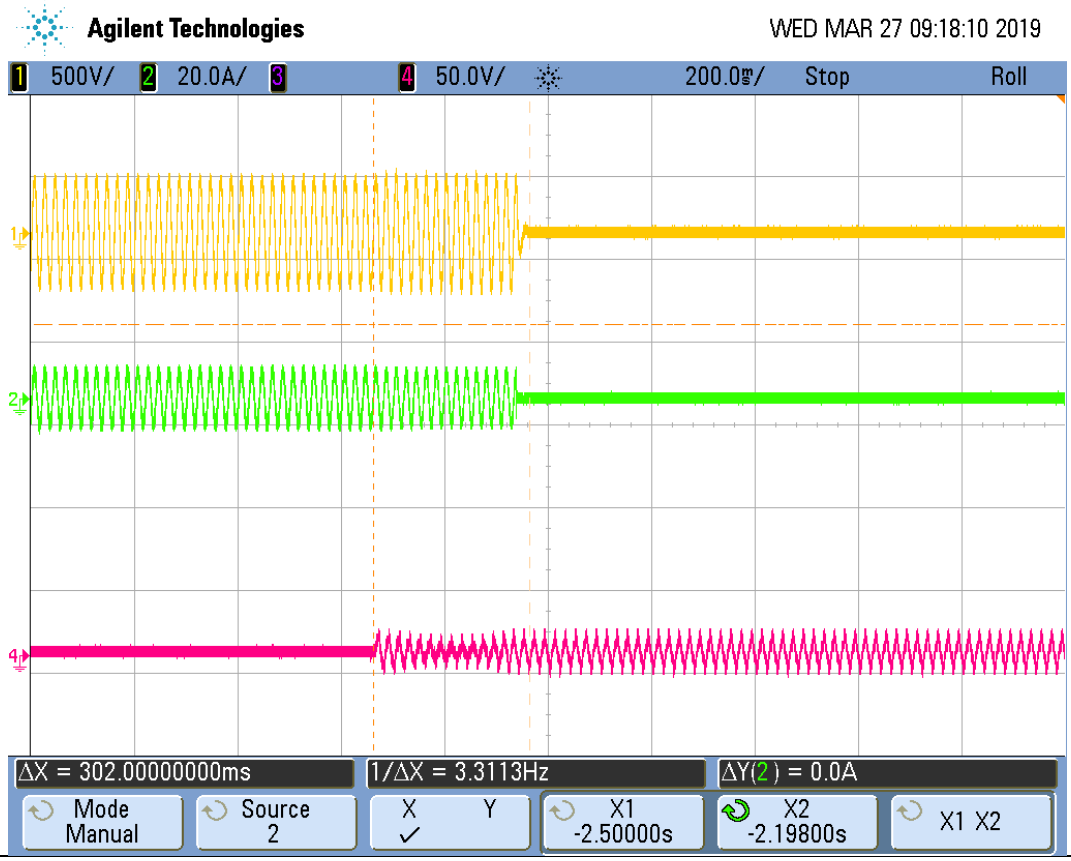
Test C	M(%)=0 & N(%)=+3



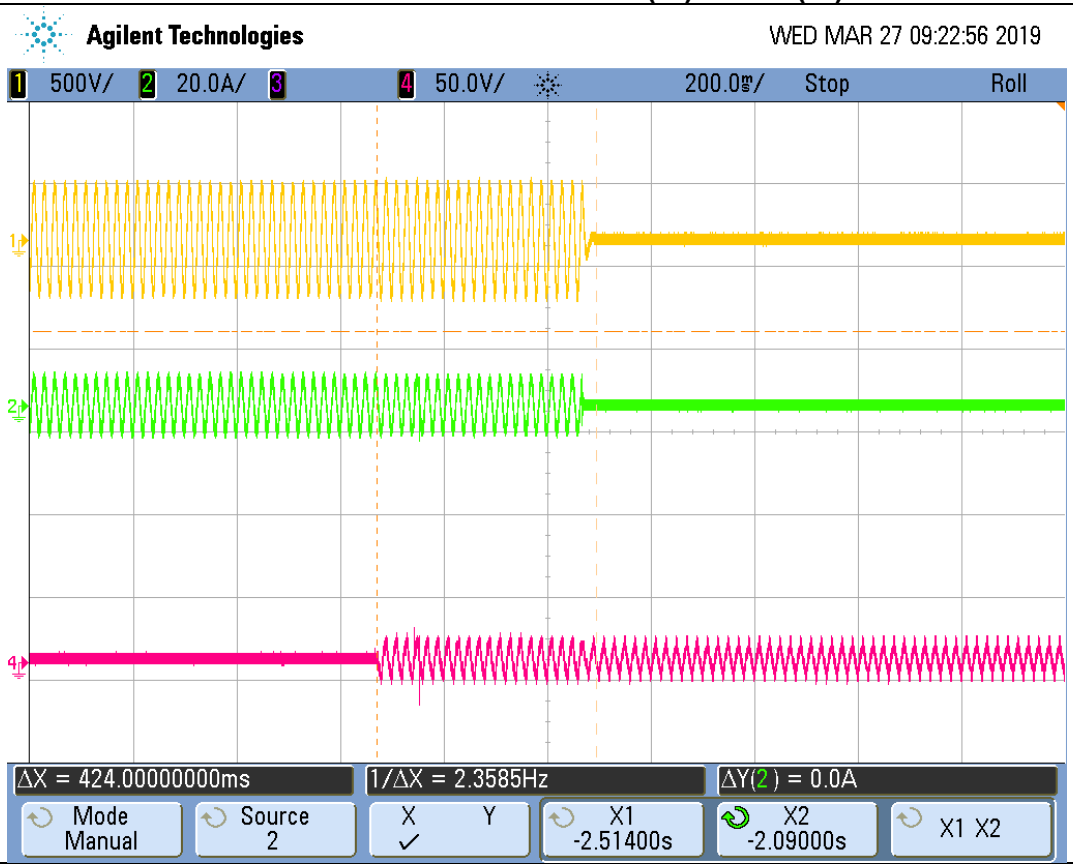
Test C **M(%)=0 & N(%)=+4**



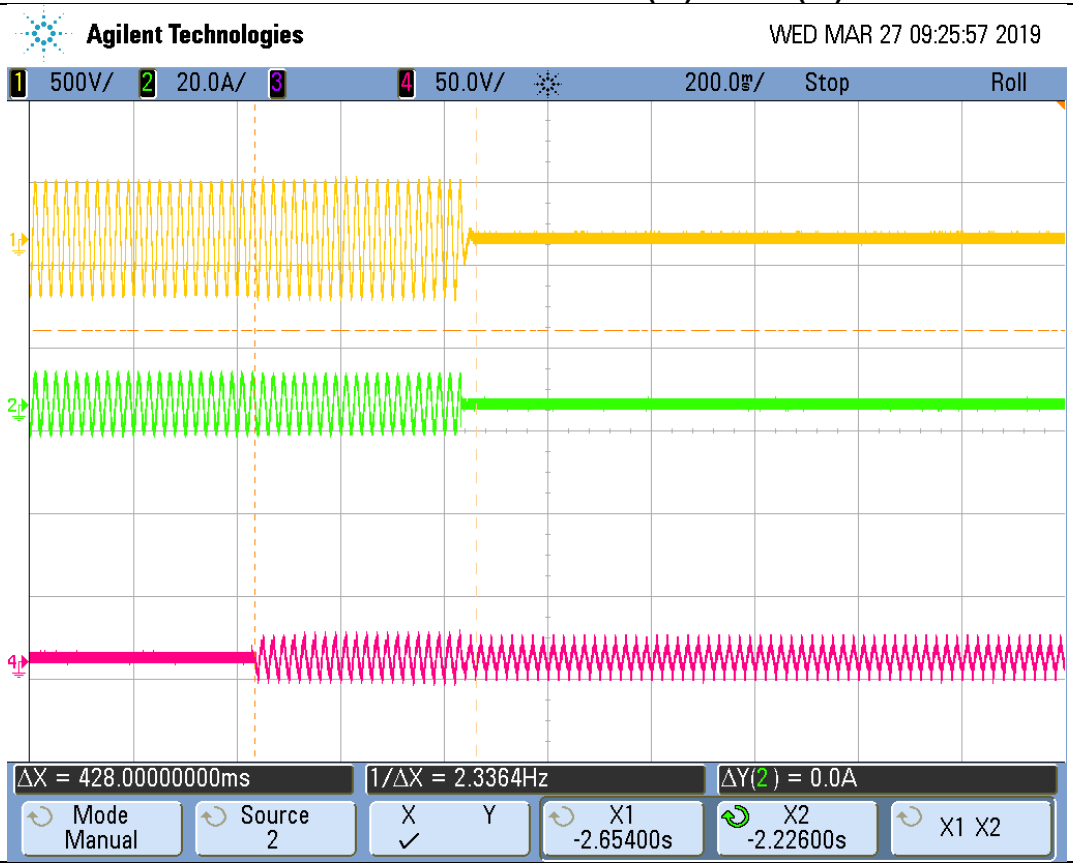
Test C **M(%)=0 & N(%)=+5**



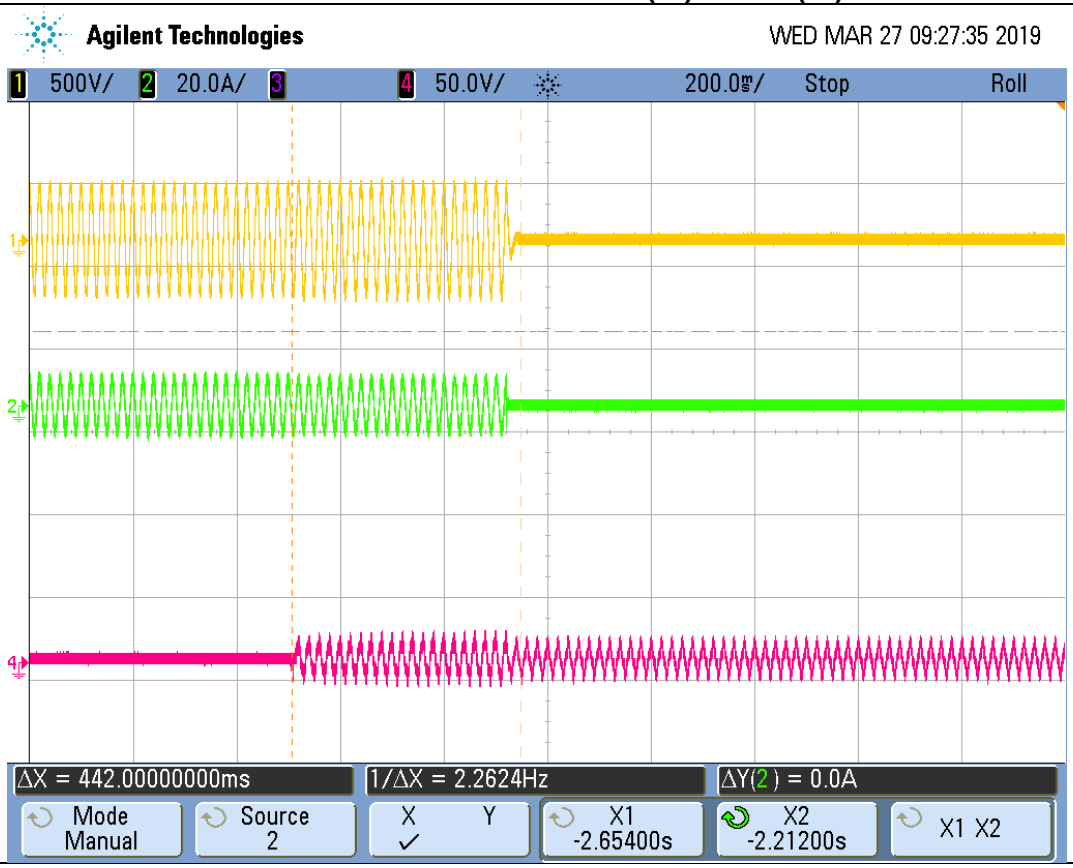
Test C **M(%)=0 & N(%)=-1**



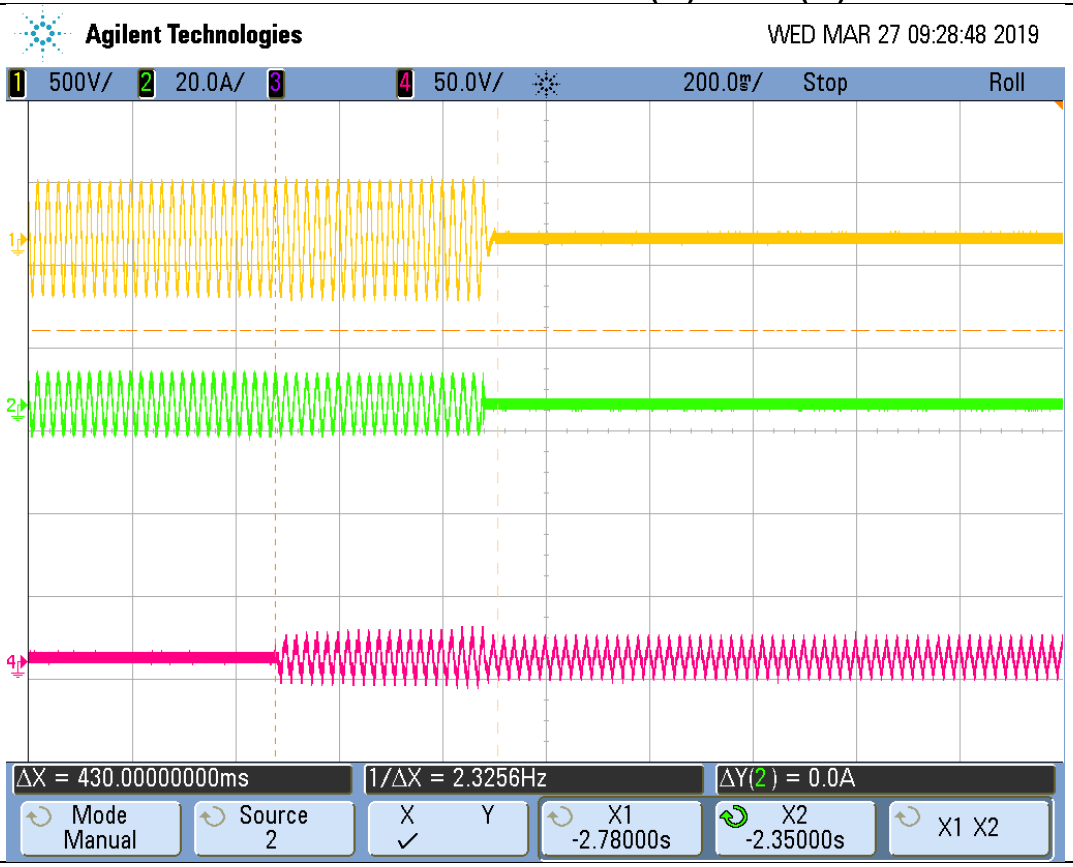
Test C **M(%)=0 & N(%)=-2**



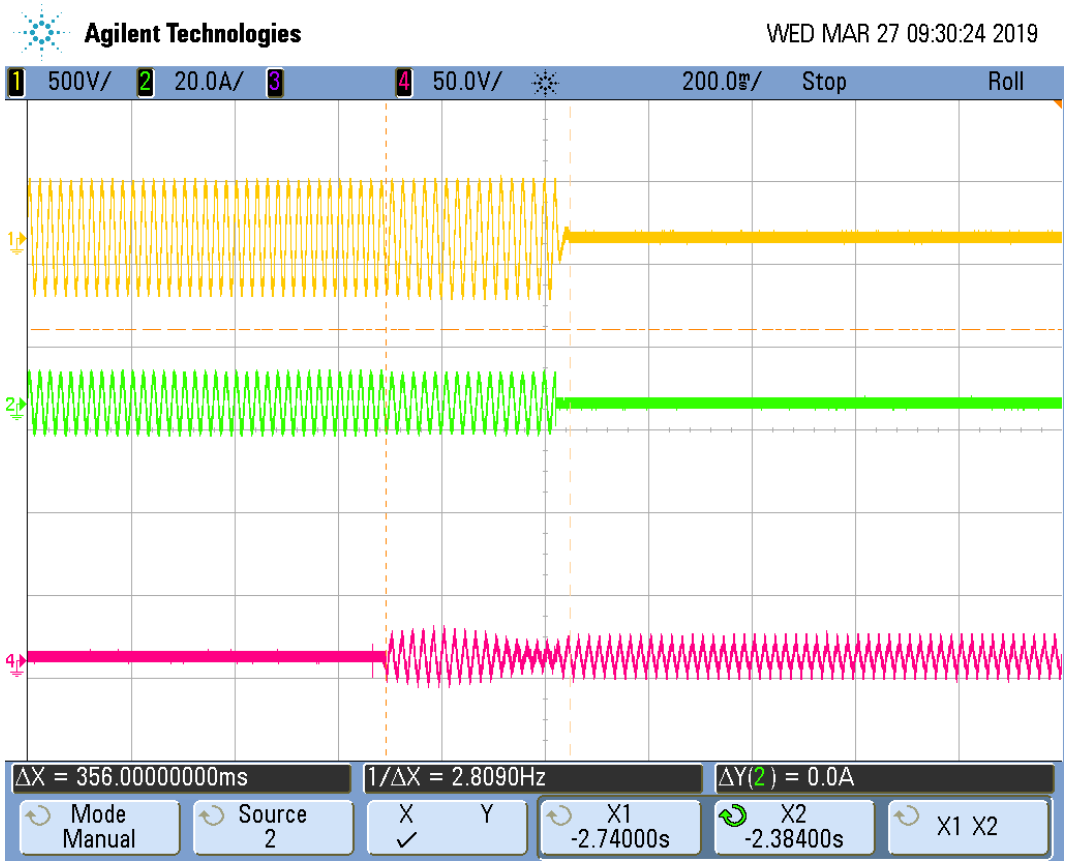
Test C **M(%)=0 & N(%)=-3**



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



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


Agilent Technologies
WED MAR 27 09:30:24 2019
1 500V/ 2 20.0A/ 3 4 50.0V/ 200.0ms/ Stop Roll
ΔX = 356.00000000ms
1/ΔX = 2.8090Hz
ΔY(2) = 0.0A
Mode Manual
Source 2
X Y
X1 -2.74000s
X2 -2.38400s
X1 X2

4.3.4 Frequency change, Vector Shift Stability test and RoCoF Stability test

Four tests are required to be carried out with all protection functions enabled including loss of mains. For each stability test the Micro-generator should not trip during the test.

For the step change test the Micro-generator should be operated with a measurable output at the start frequency and then a vector shift should be applied by extending or reducing the time of a single cycle with subsequent cycles returning to the start frequency. The start frequency should then be maintained for a period of at least 10 s to complete the test. The Micro-generator should not trip during this test.

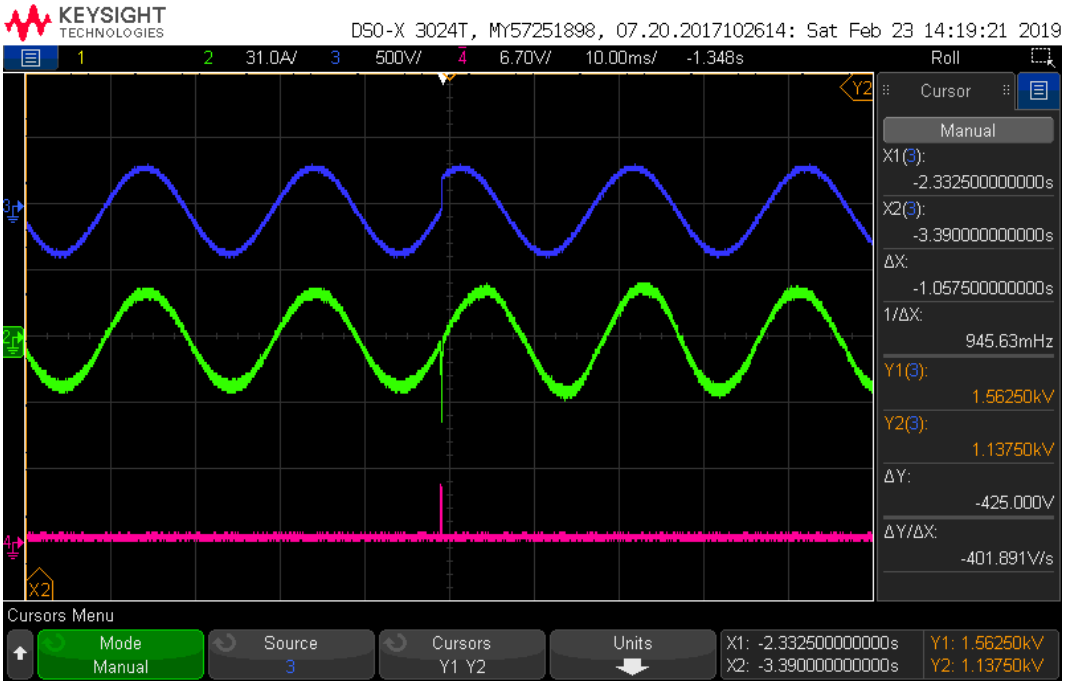
For frequency drift tests the Micro-generator should be operated with a measurable output at the start frequency and then the frequency changed in a ramp function at 0.95 Hzs-1 to the end frequency. On reaching the end frequency it should be maintained for a period of at least 10 s. The Micro-generator should not trip during this test.

Test results are graphically shown in following pages.

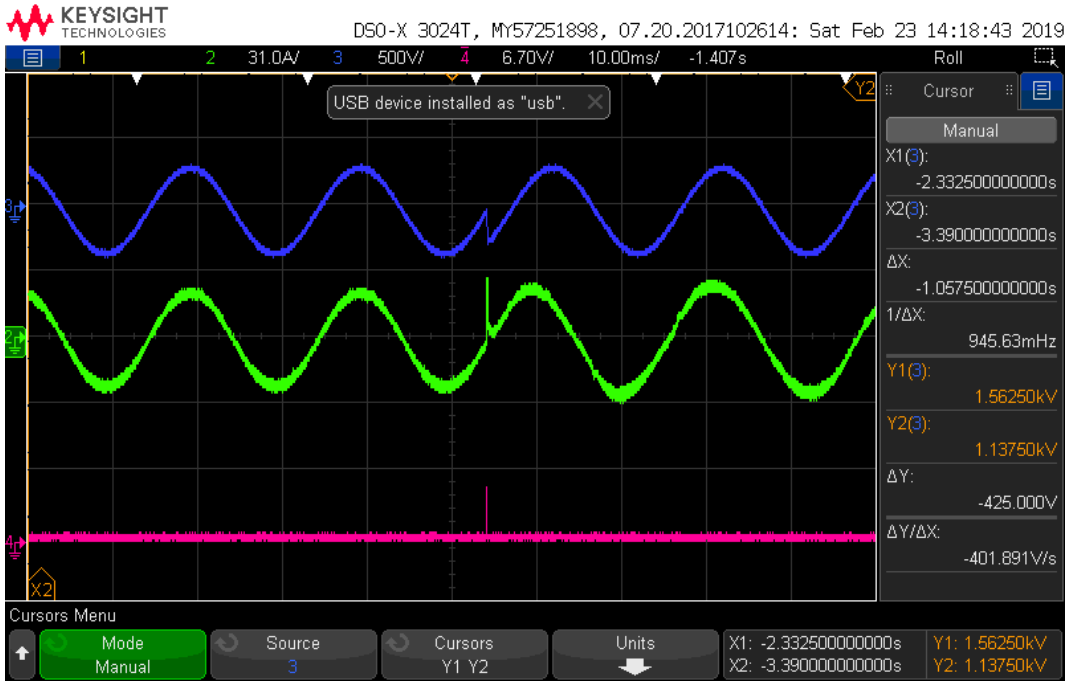
Protection – Frequency change, Vector Shift Stability test: This test should be carried out in accordance with EREC G98 Annex A1 A.1.2.6 (**Inverter** connected) or Annex A2 A.2.2.6 (Synchronous).

	Start Frequency	Change	Confirm no trip
Positive Vector Shift	49.0 Hz	+50 degrees	Pass
Negative Vector Shift	50.0 Hz	- 50 degrees	Pass

Positive Vector Shift:



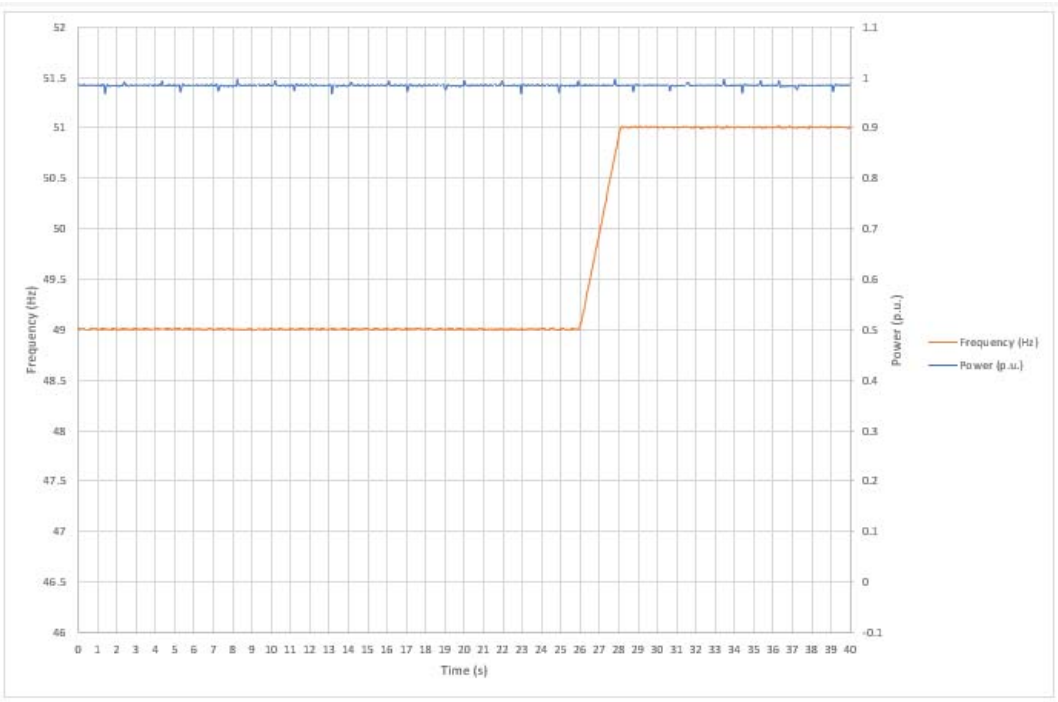
Negative Vector Shift:



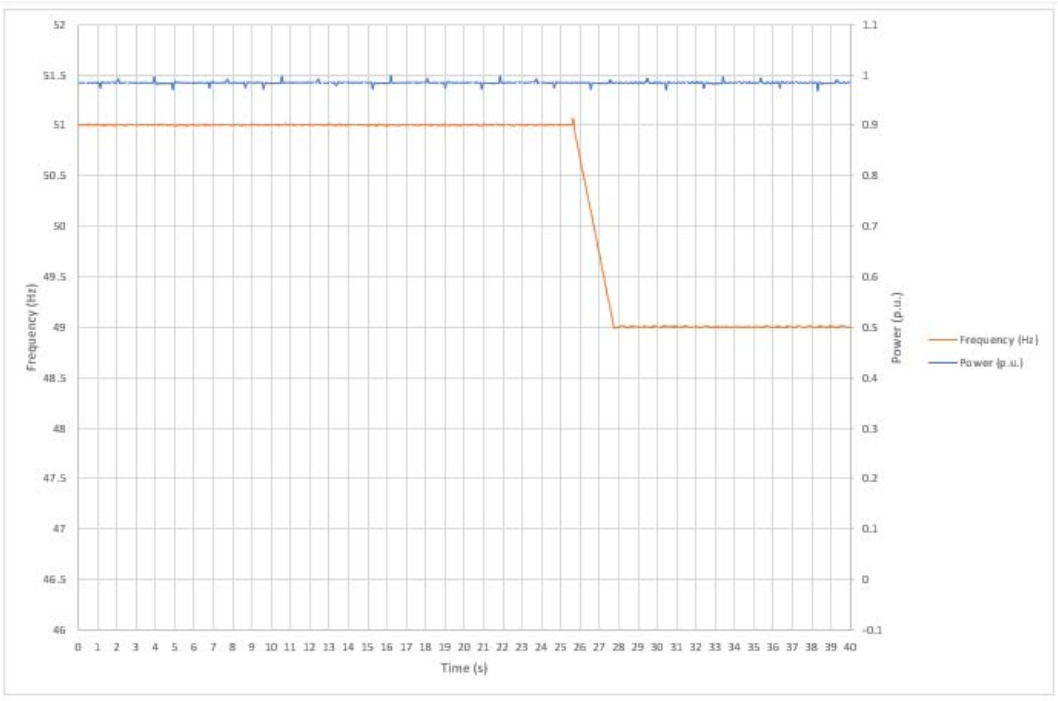
Protection – Frequency change, RoCoF Stability test: The requirement is specified in section 11.3, test procedure in Annex A.1.2.6 (**Inverter** connected) or Annex A2 A.2.2.6 (Synchronous).

Ramp range	Test frequency ramp:	Test Duration	Confirm no trip
49.0 Hz to 51.0 Hz	+0.95 Hzs^{-1}	2.1 s	Pass
51.0 Hz to 49.0 Hz	-0.95 Hzs^{-1}	2.1 s	Pass

+0.95 Hz/s:



-0.95 Hz/s:



4.4 Limited Frequency Sensitive Mode - Overfrequency test

The test serves to verify the active power reduction of the micro-generator at over-frequency. We perform the test according to EN 50438 Annex D.3.3 Power response to over-frequency.

The tests for providing evidence of the frequency dependent active power feed-in of the micro-generator shall be carried out on a network simulator.

The test should be carried out using the specific threshold frequency of 50.4 Hz and Droop of 10%.

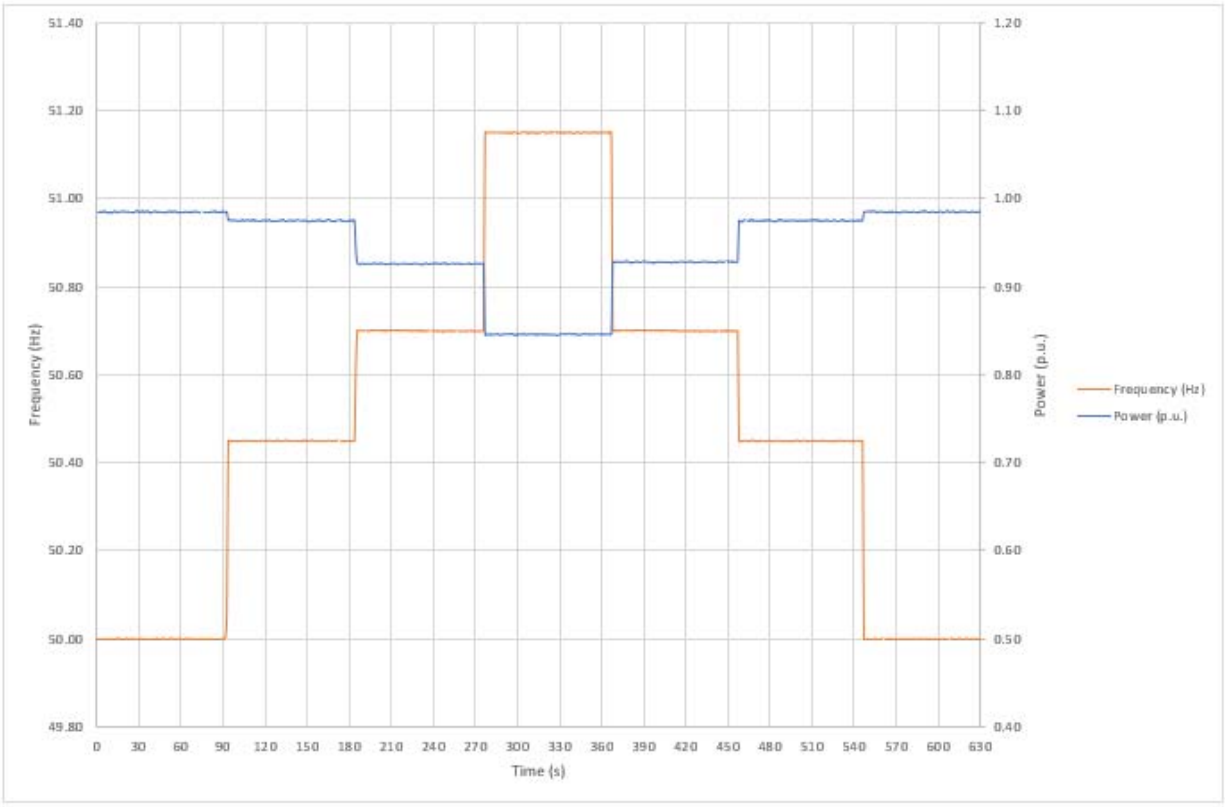
Following tables show the test results:

Test sequence at Registered Capacity >80%	Measured Active Power Output (W)	Frequency (Hz)	Primary Power Source	Active Power Gradient
Step a) 50.00 Hz ±0.01 Hz	3625.78	50.00	DC Souce	N/A
Step b) 50.45 Hz ±0.05 Hz	3589.27	50.45		9.93%
Step c) 50.70 Hz ±0.10 Hz	3409.01	50.70		10.04%
Step d) 51.15 Hz ±0.05 Hz	3113.45	51.15		10.62%
Step e) 50.70 Hz ±0.10 Hz	3416.37	50.70		10.39%
Step f) 50.45 Hz ±0.05 Hz	3589.21	50.45		9.91%
Step g) 50.00 Hz ±0.01 Hz	3625.86	50.00		N/A

Test sequence at Registered Capacity 40% - 60%	Measured Active Power Output (W)	Frequency (Hz)	Primary Power Source	Active Power Gradient
Step a) 50.00 Hz ±0.01 Hz	1816.61	50.00	DC Souce	N/A
Step b) 50.45 Hz ±0.05 Hz	1798.45	50.45		10.00%
Step c) 50.70 Hz ±0.10 Hz	1707.72	50.70		10.00%
Step d) 51.15 Hz ±0.05 Hz	1553.54	51.15		10.36%
Step e) 50.70 Hz ±0.10 Hz	1711.17	50.70		10.34%
Step f) 50.45 Hz ±0.05 Hz	1798.39	50.45		9.97%
Step g) 50.00 Hz ±0.01 Hz	1816.94	50.00		N/A

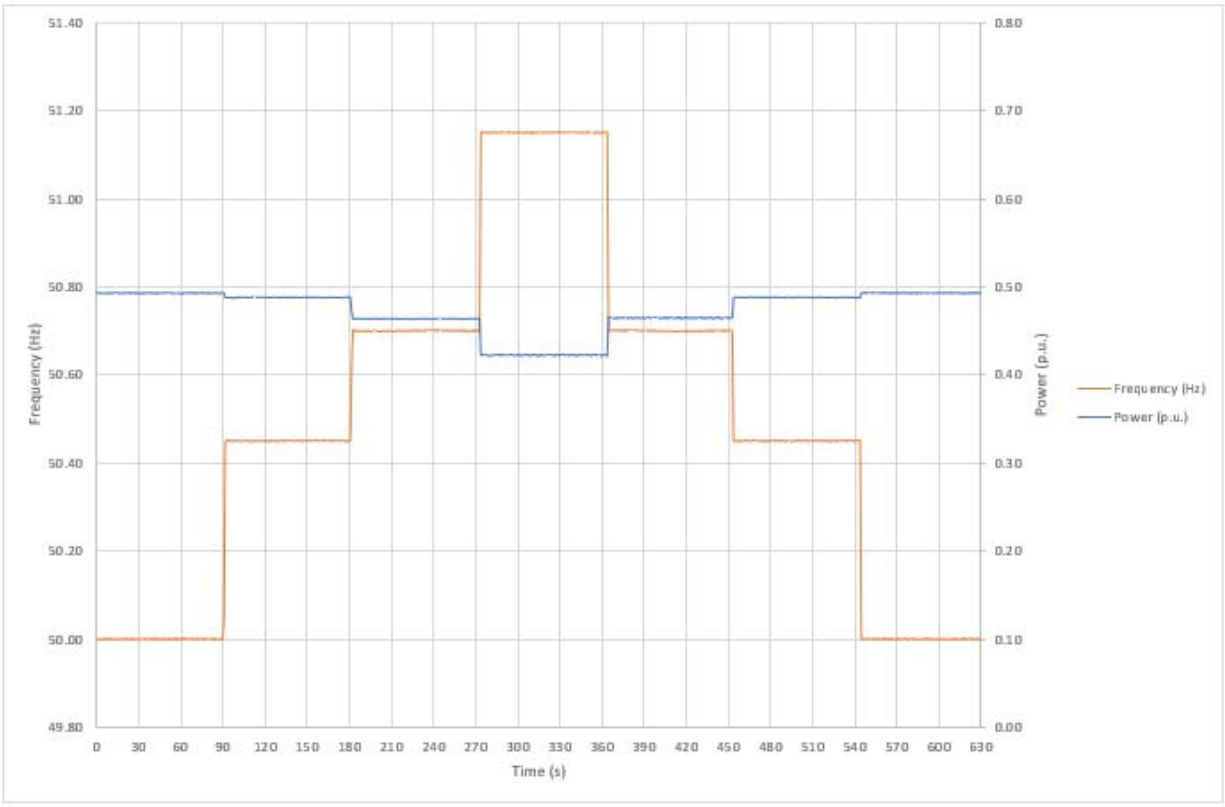
Test results are graphically shown in following pages.

Over-frequency curve (droop of 10 % at 100% Pn)



Remark:Test for frequency threshold 50.4Hz with droop 10%, intentional delay is setting to 0s.

Over-frequency curve (droop of 10 % at 50% Pn)



Remark:Test for frequency threshold 50.4Hz with droop 10%, intentional delay is setting to 0s.

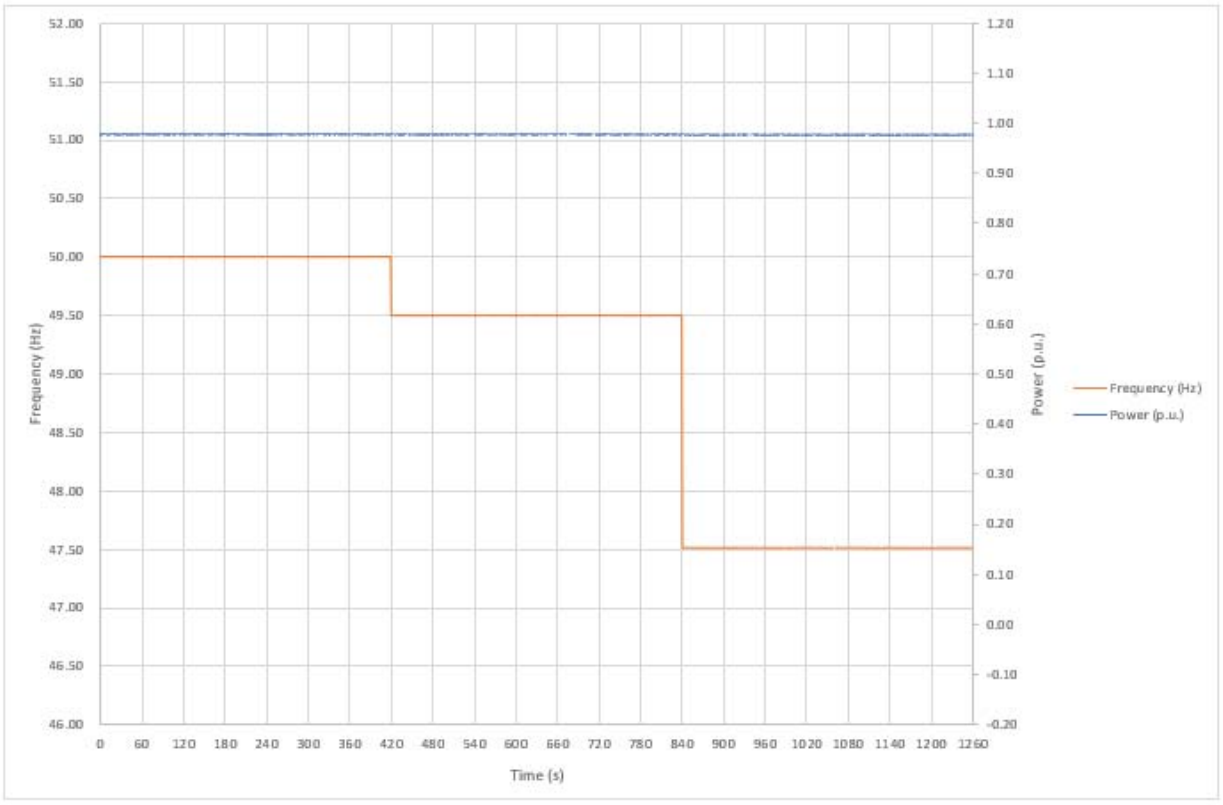
4.5 Power output with falling frequency test

This test should be carried out in accordance with EN 50438 Annex D.3.2 active power feed-in at under-frequency.

Test sequence	Measured Active Power Output (W)	Frequency (Hz)	Primary power source
Test a) 50 Hz ± 0.01 Hz	3596	50.00	-
Test b) Point between 49.5 Hz and 49.6 Hz	3589	49.50	-
Test c) Point between 47.5 Hz and 47.6 Hz	3594	47.52	-
NOTE: The operating point in Test (b) and (c) shall be maintained for at least 5 minutes			

Test results are graphically shown in following pages.

POWER OUTPUT WITH FALLING FREQUENCY TEST



4.6 Re-connection timer

Test should prove that the reconnection sequence starts after a minimum delay of 20 s for restoration of voltage and frequency to within the stage 1 settings of Table 2. These tests should be undertaken in accordance with Annex A.2.2.5.

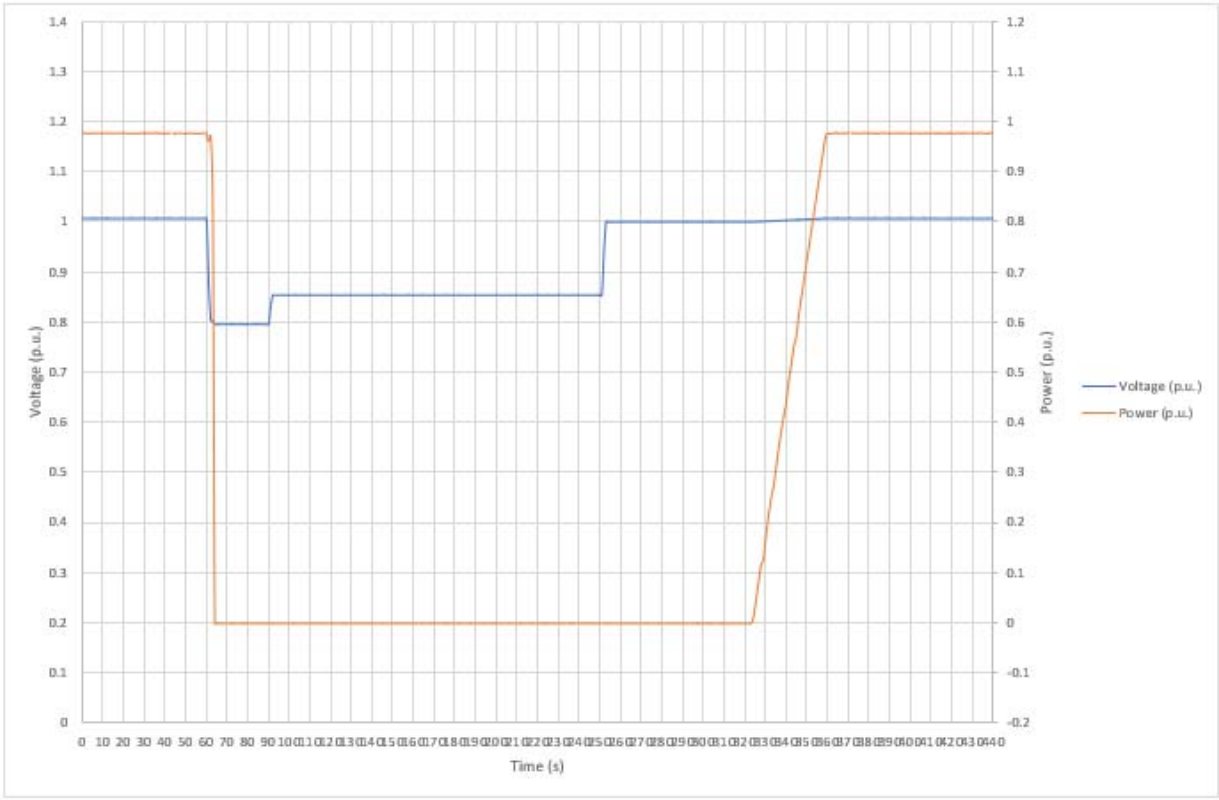
4.6.1 Voltage Reconnection Conditions

The following table detail tests performed.

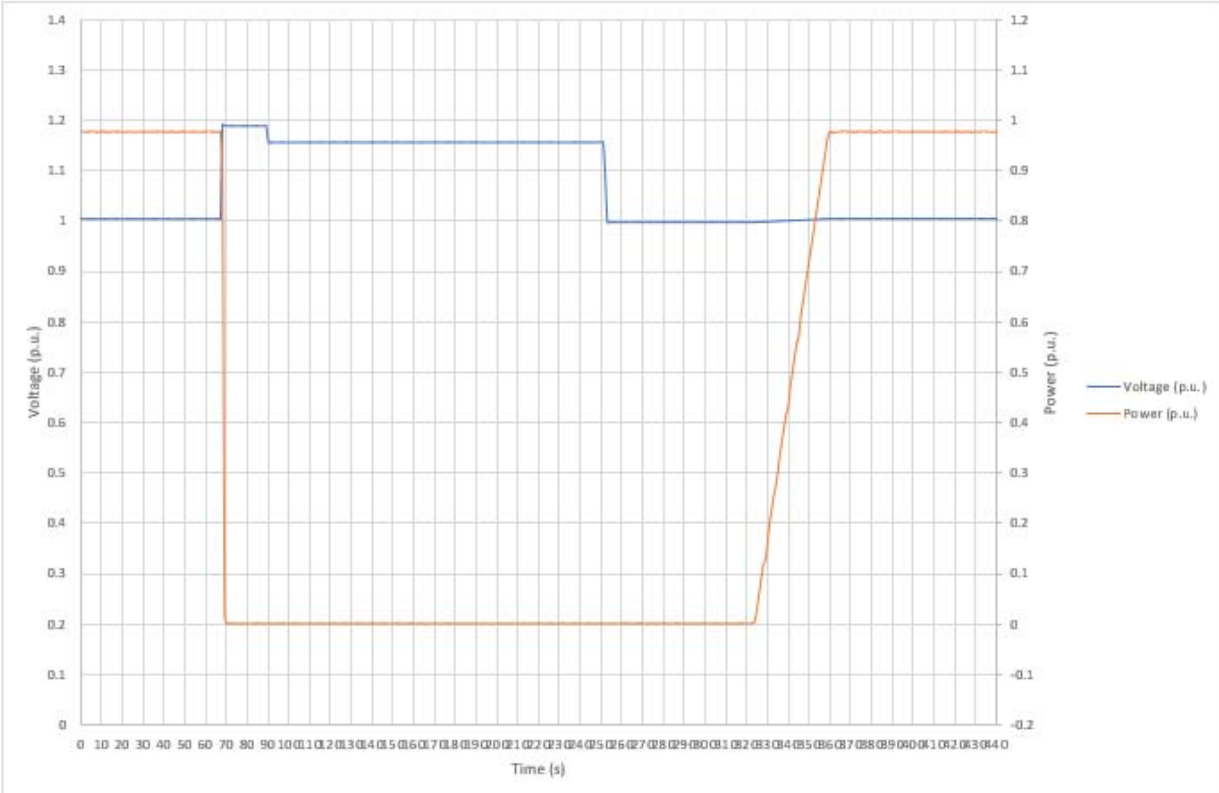
Test at	Time delay setting(s)	Measured delay(s)	Checks on no reconnection when voltage is brought to just outside stage 1 limits of table 1.	
UV	65	71	At 266.2V	At 196.1V
OV	65	71		
Confirmation that the Micro-generator does not re-connect.			Not reconnection	Not reconnection

Test results are graphically shown below.

Under voltage reconnection



Over voltage reconnection



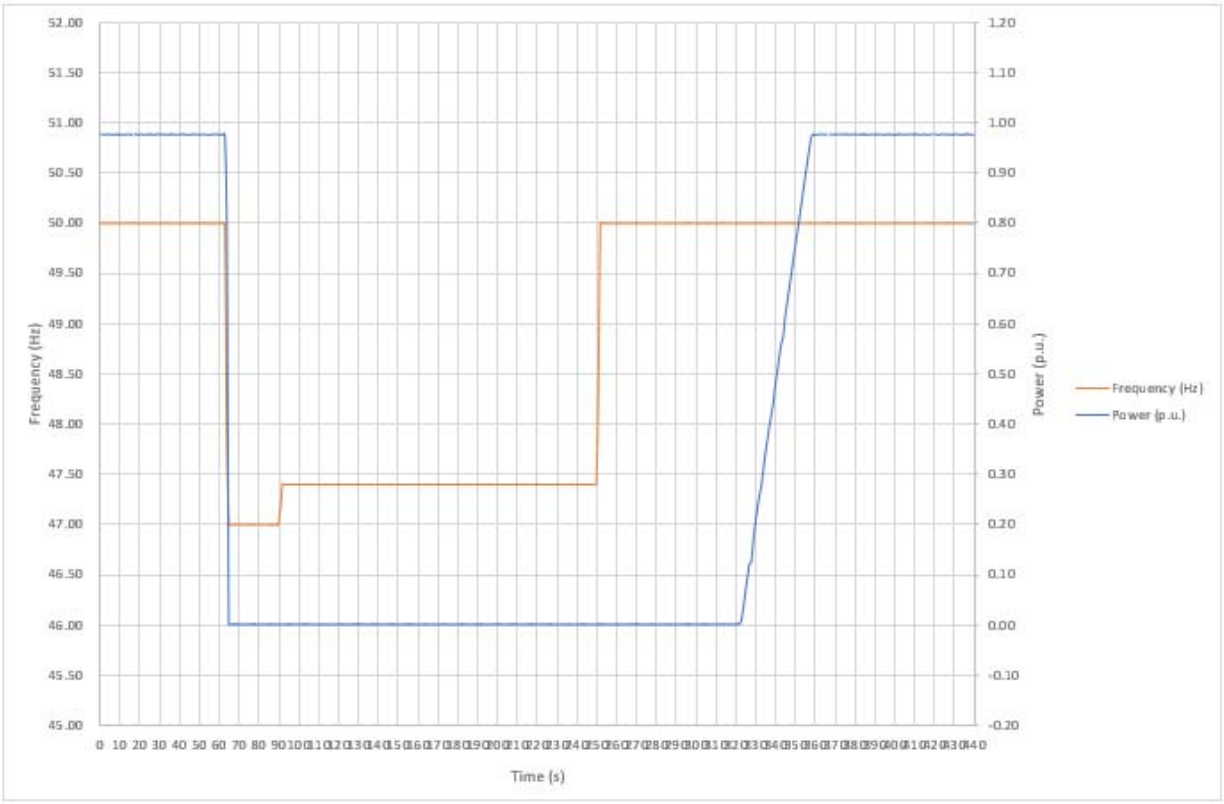
4.6.2 Frequency Reconnection Conditions

The following table detail tests performed.

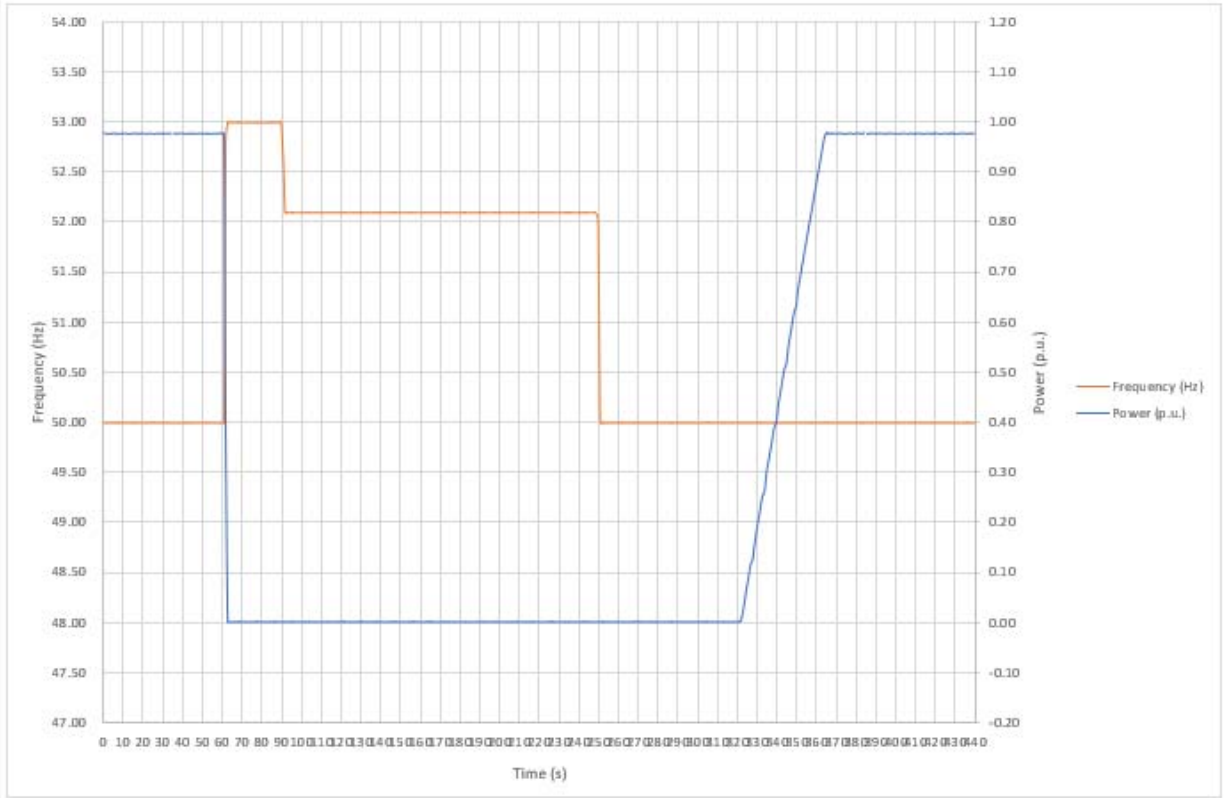
Test at	Time delay setting(s)	Measured delay(s)	Checks on no reconnection when frequency is brought to just outside stage 1 limits of table 1.	
UF	65	72	At 47.4Hz	At 52.1Hz
OF	65	71		
Confirmation that the Micro-generator does not re-connect.			Not reconnection	Not reconnection

Test results are graphically shown below.

Under frequency reconnection



Over frequency reconnection



4.7 Fault level contribution

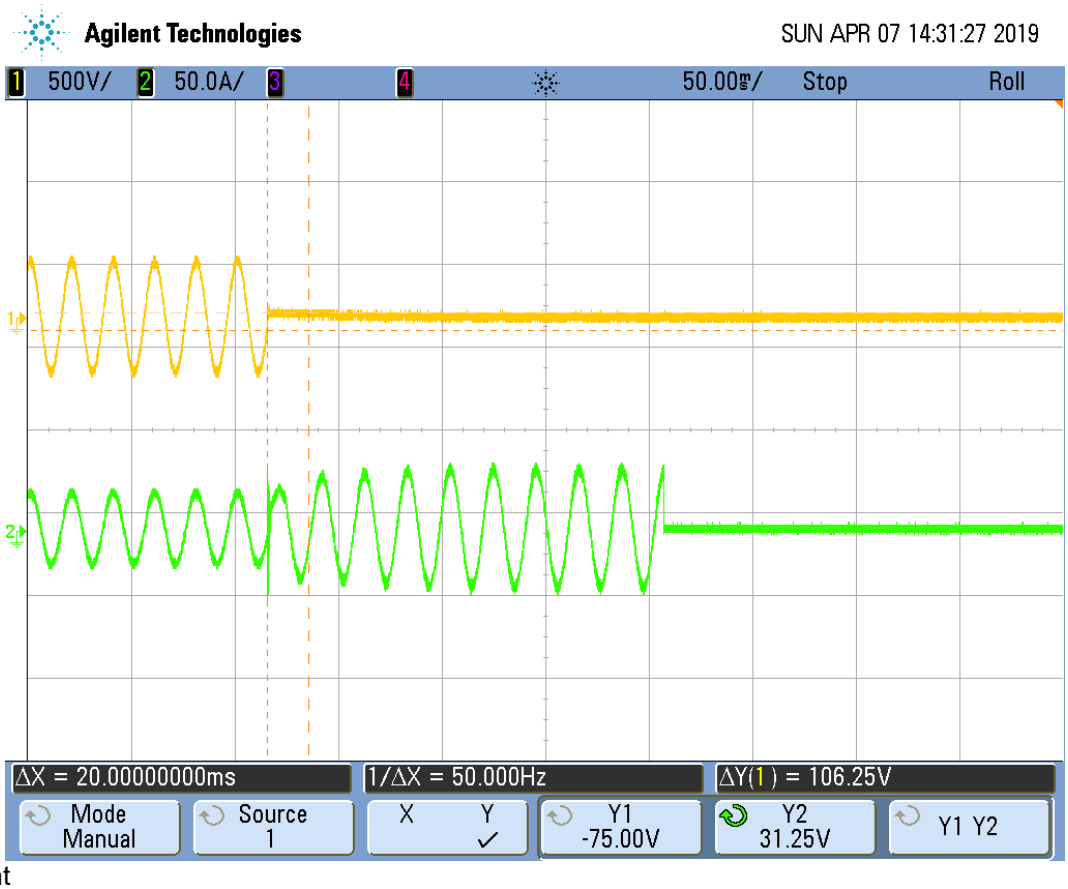
These tests shall be carried out in accordance with EREC G98 Annex A1 A.1.3.5 (Inverter connected) and Annex A2 A.2.3.4 (Synchronous).

They have been performed different short circuit tests that are detailed in the table and pictures below.

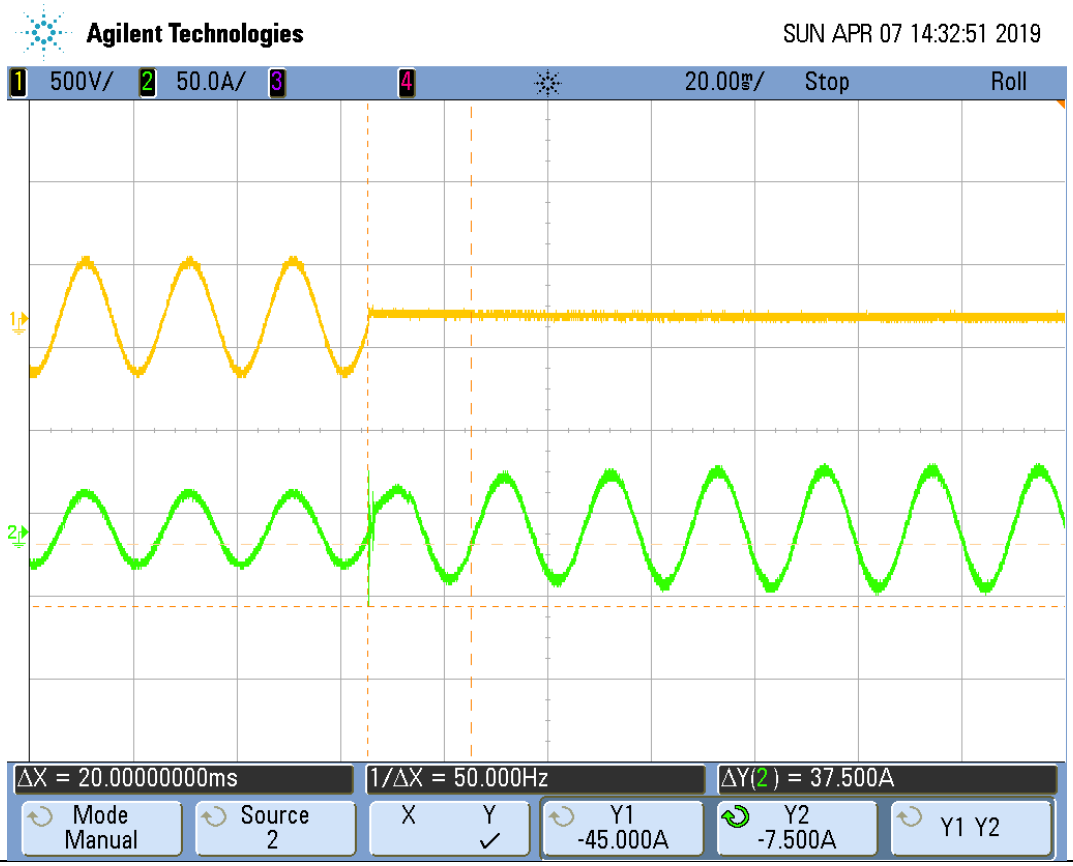
Short circuit current		
Time after fault	**Volts(V)**	**Amps(A)**
20ms	31.25	-7.5
100ms	0	-28.8
250ms	0	0
500ms	0	0
Time to trip	0	In seconds

Time after 20ms fault

Voltage:

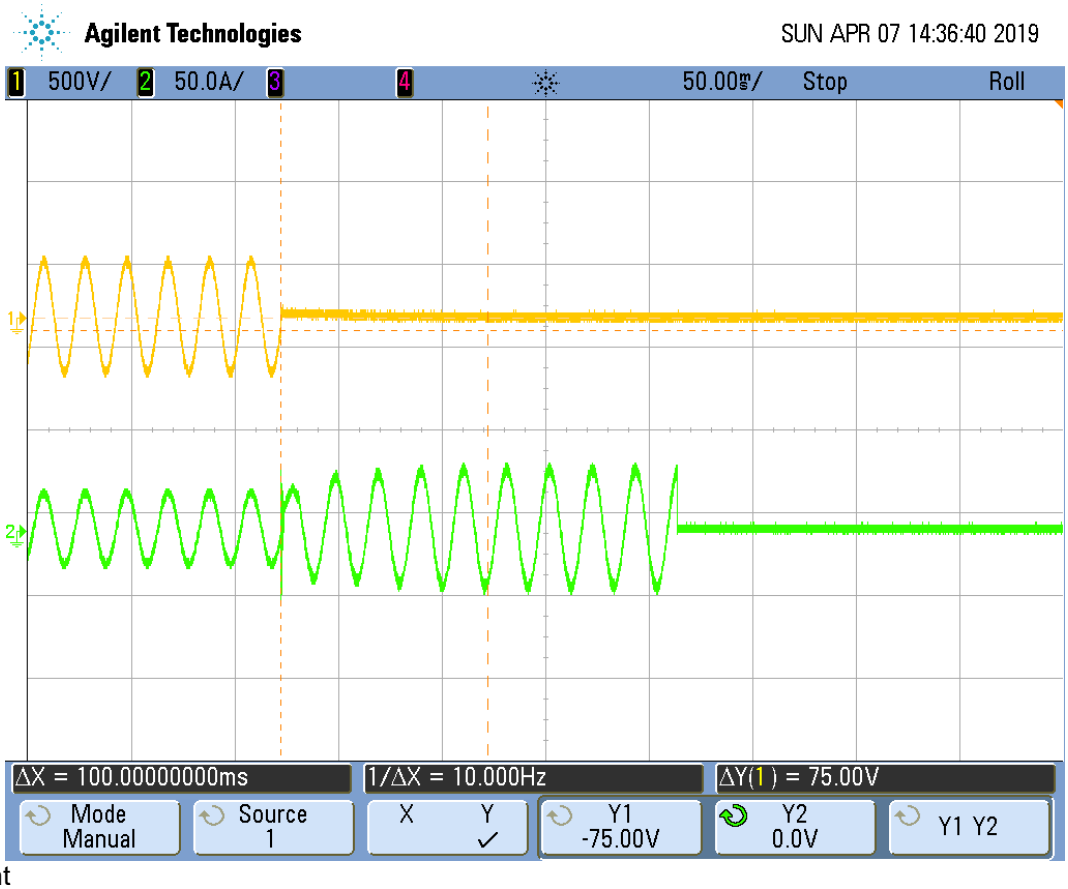


Current

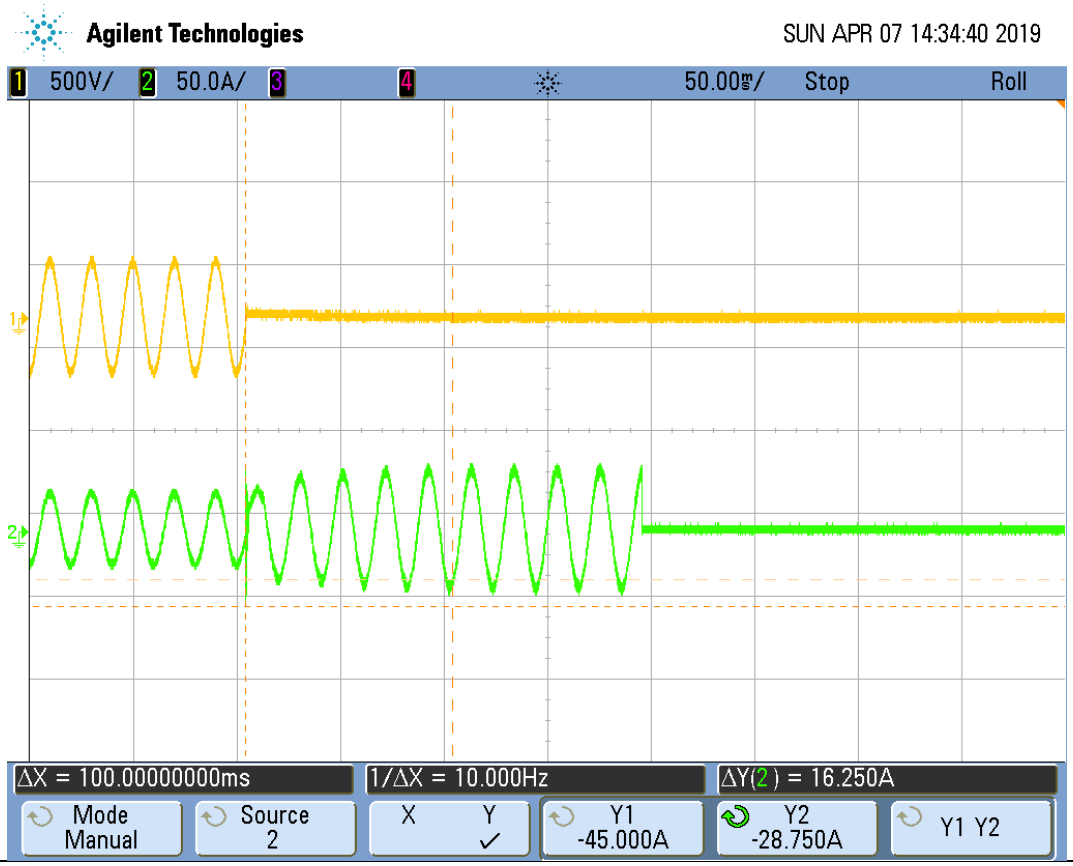


Time after 100ms fault

Voltage:

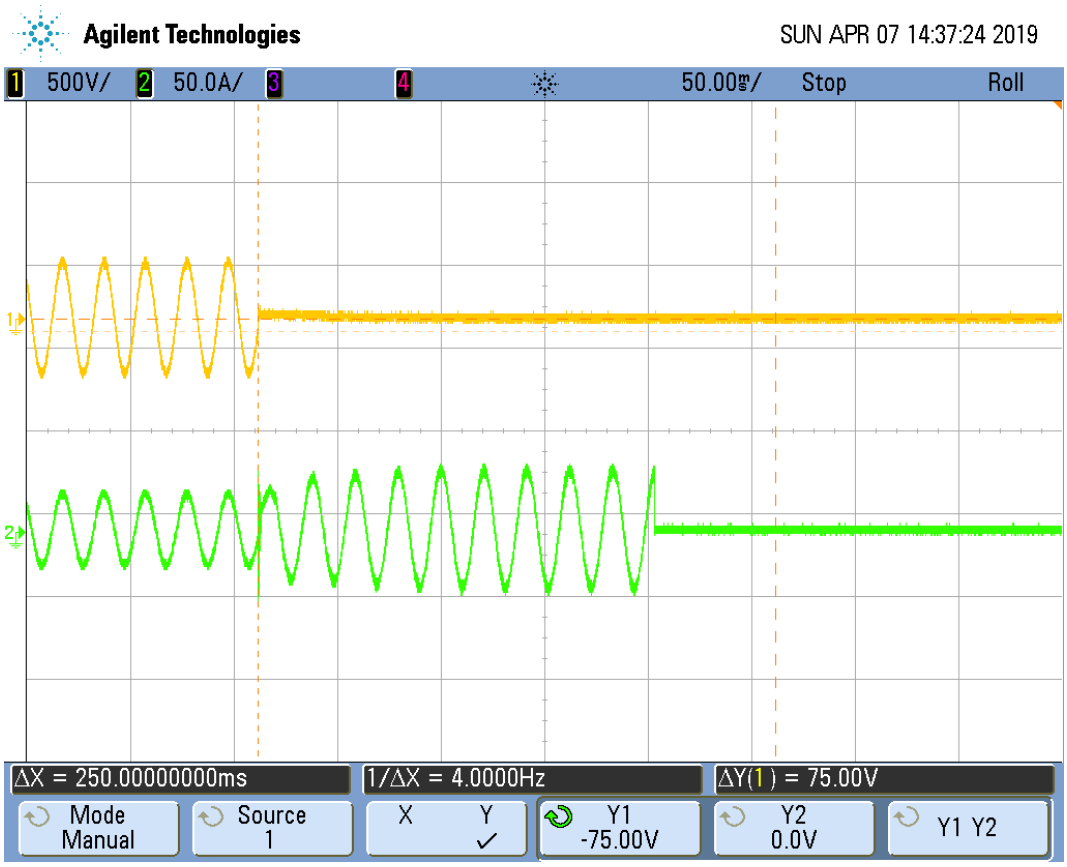


Current

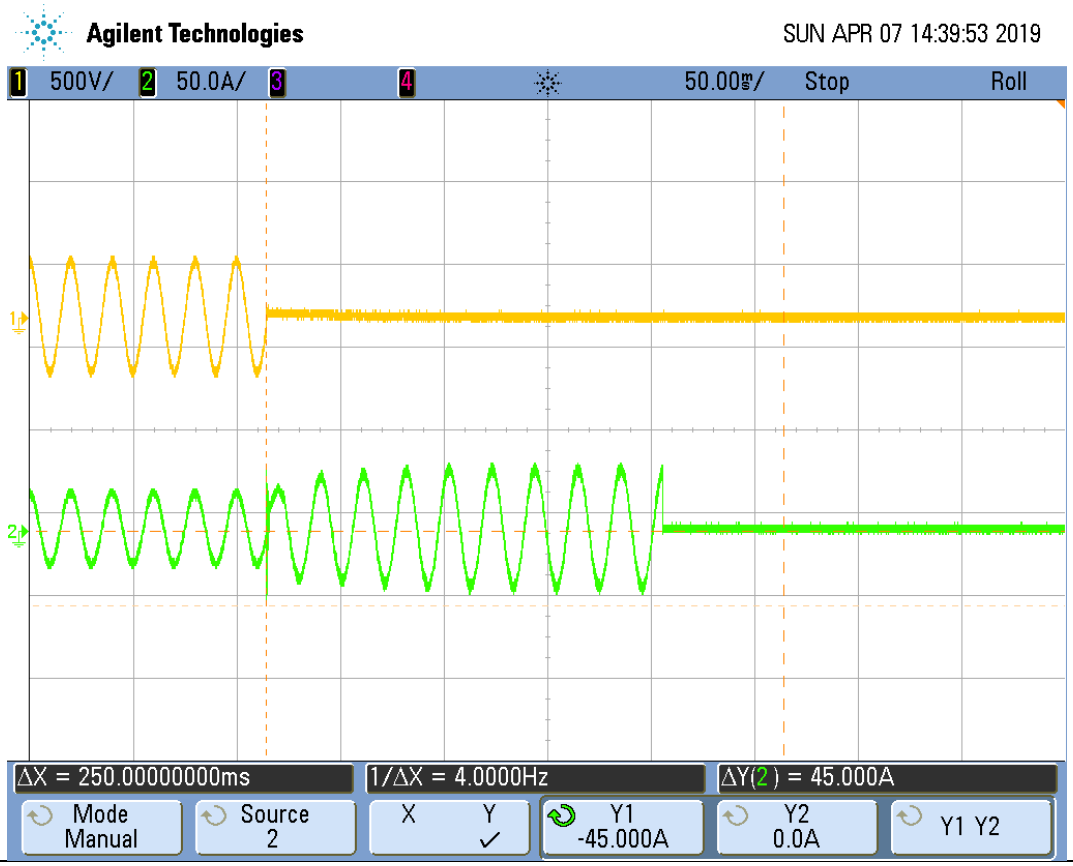


Time after 250ms fault

Voltage:



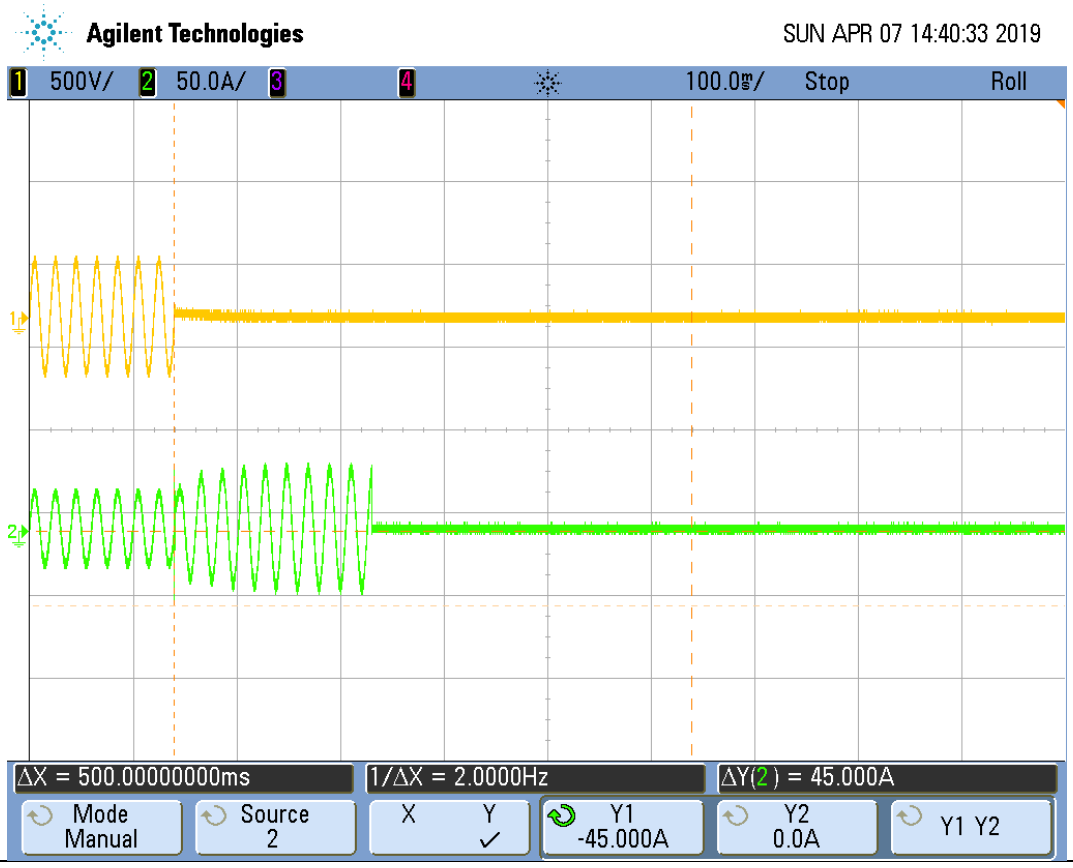
Current



Time after 500ms fault

Voltage:

Current



Time to trip

4.8 SELF-MONITORING SOLID STATE SWITCHING

The evaluation of this point has been made according to EREC G98 Annex A1 A.1.3.6.

This test does not apply because in the inverter there are not solid-state switching devices.

4.9 ELECTROMAGNETIC COMPATIBILITY (EMC)

All equipment shall conform to the generic EMC standards: BS EN61000-6-3: Electromagnetic Compatibility, Generic Emission Standard; and BS EN61000-6-1: Electromagnetic Compatibility, Generic Immunity Standard.

The compliances with these requirements are stated in the following test report:
-EN 61000-6-3:2007 + A1:2011, EN 61000-3-2:2014, EN 61000-3-3:2013, EN 61000-3-11:2011, EN 61000-3-12:2011, EN61000-6-2:2005: Test Report no. CE170829N003 on 2017/12/08 which issued by Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch.

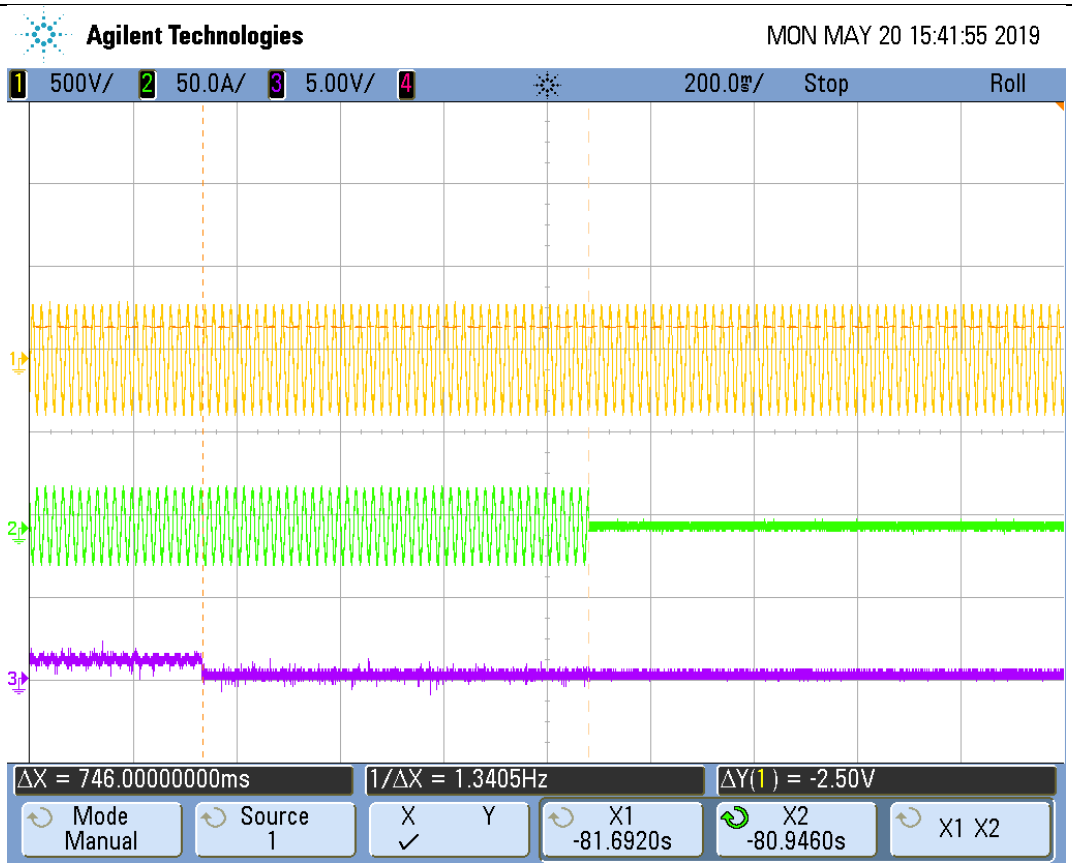
4.10 LOGIC INTERFACE.

Confirm that an input port is provided and can be used to shut down the module.

The evaluation of this point has been made according to Clause 9.4.3 of the standard.

Power Generating Modules connected to the DNO's Distribution Network shall be equipped with a logic interface (input port) in order to cease Active Power output within 5 s following an instruction being received at the input port.

Test results are graphically shown as below.



Ch1: AC Voltage

Ch2: Output Current

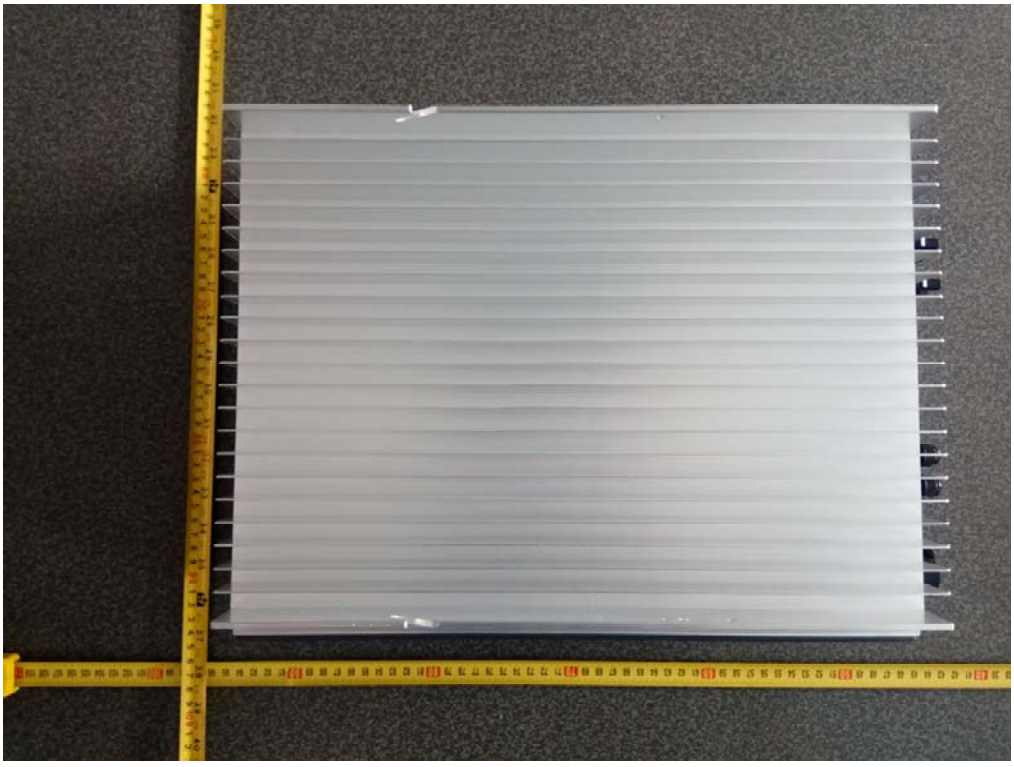
Ch3: Signal of logic interface.

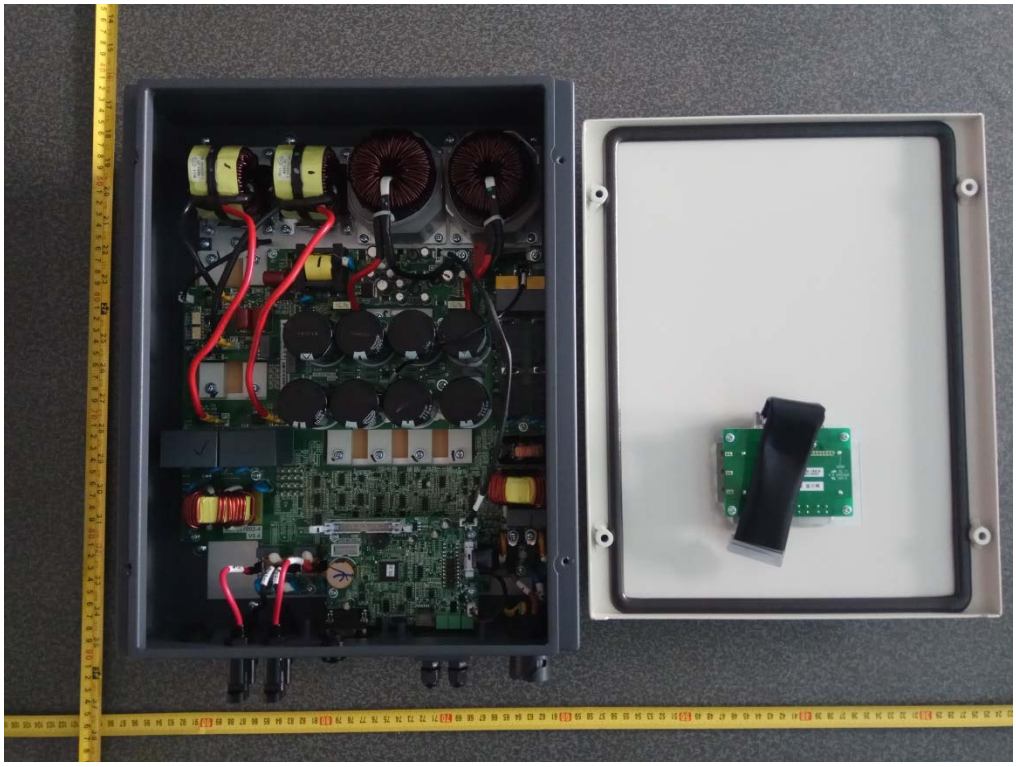
5 PICTURES

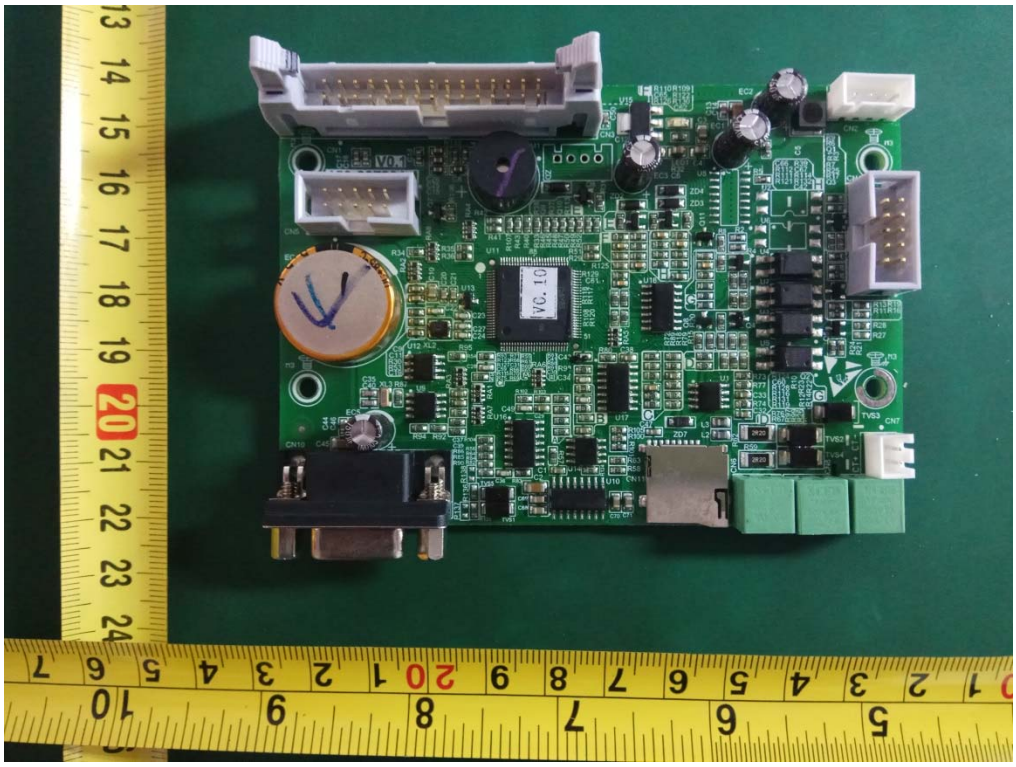
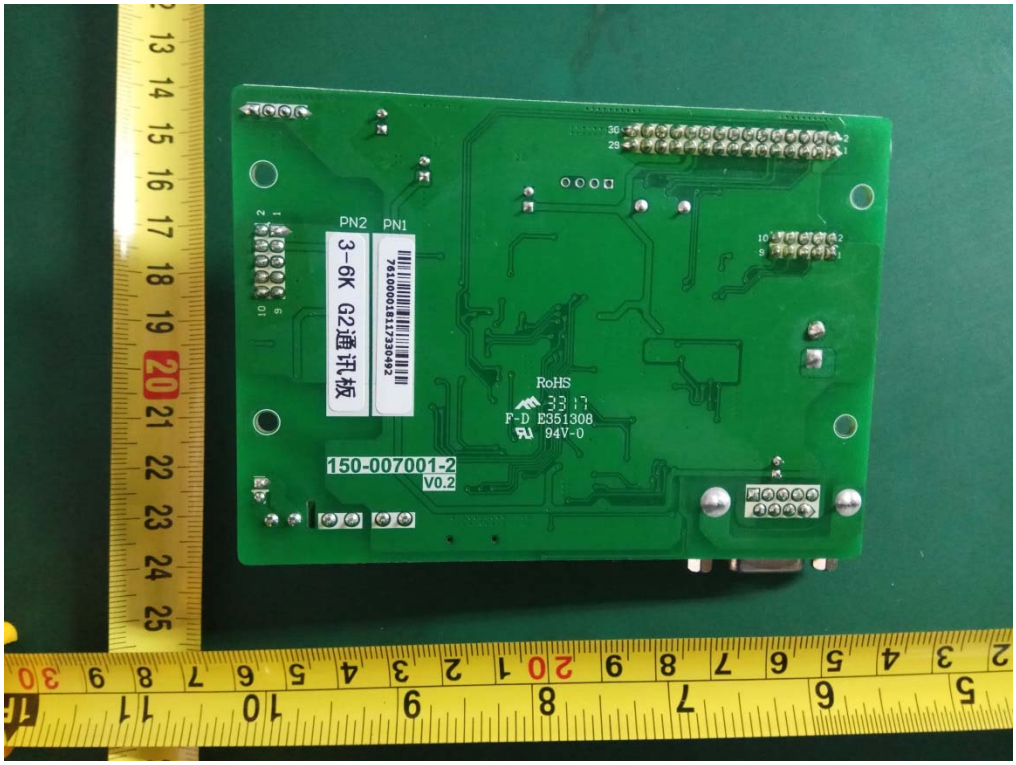
Front

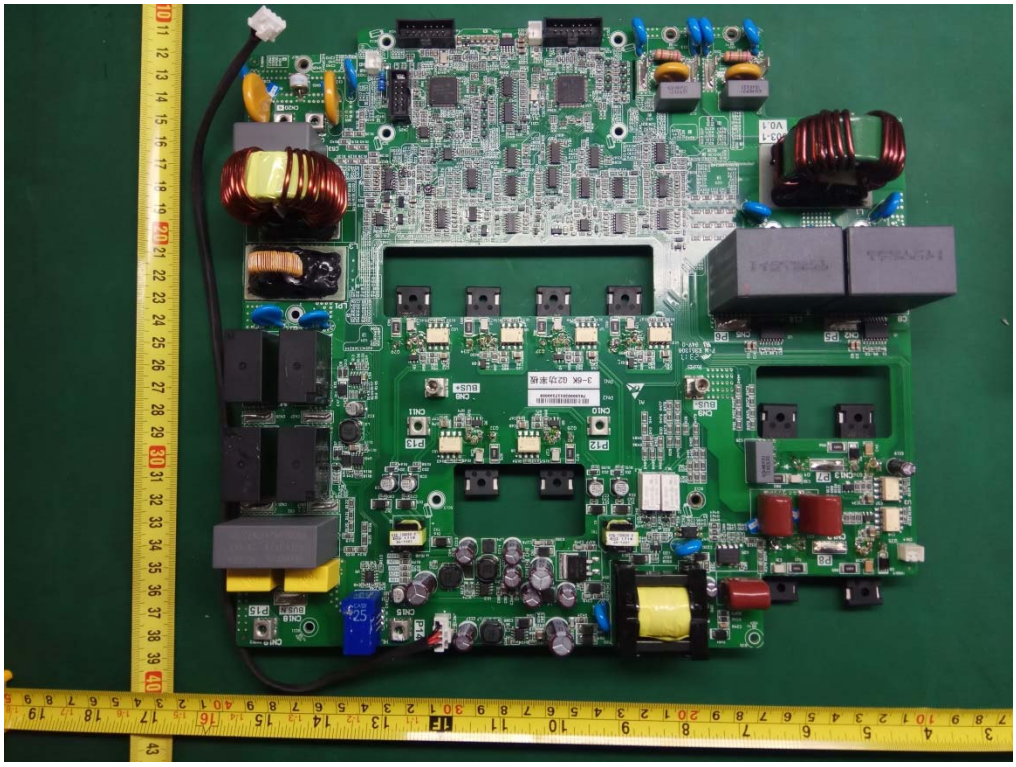
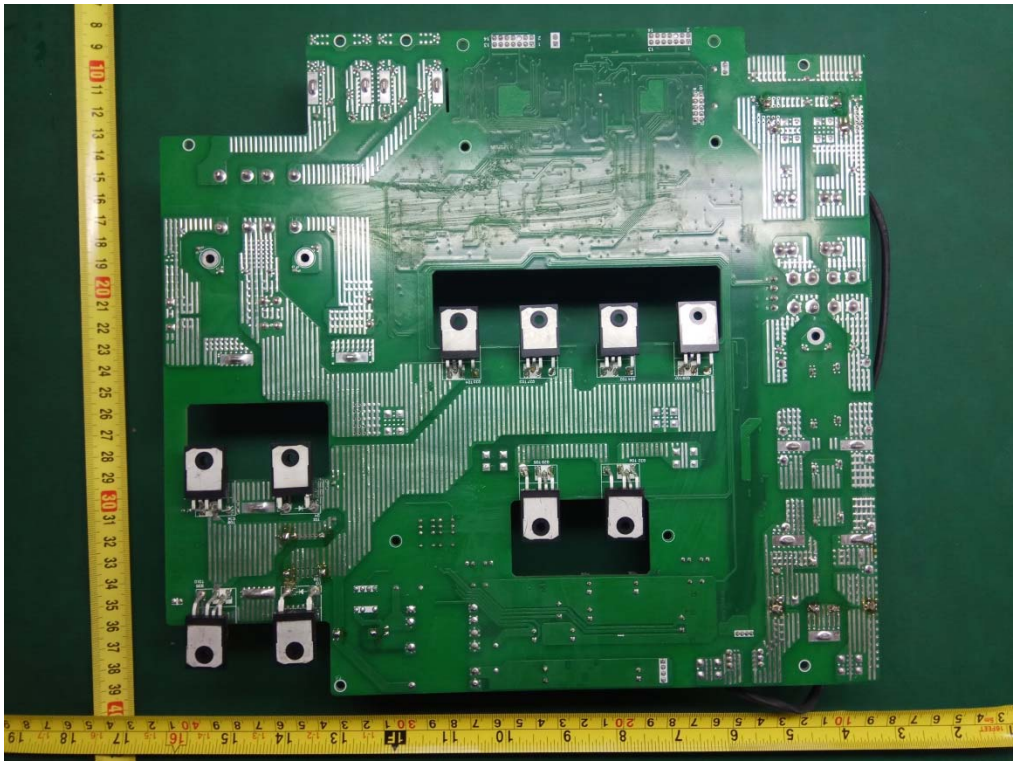
Side

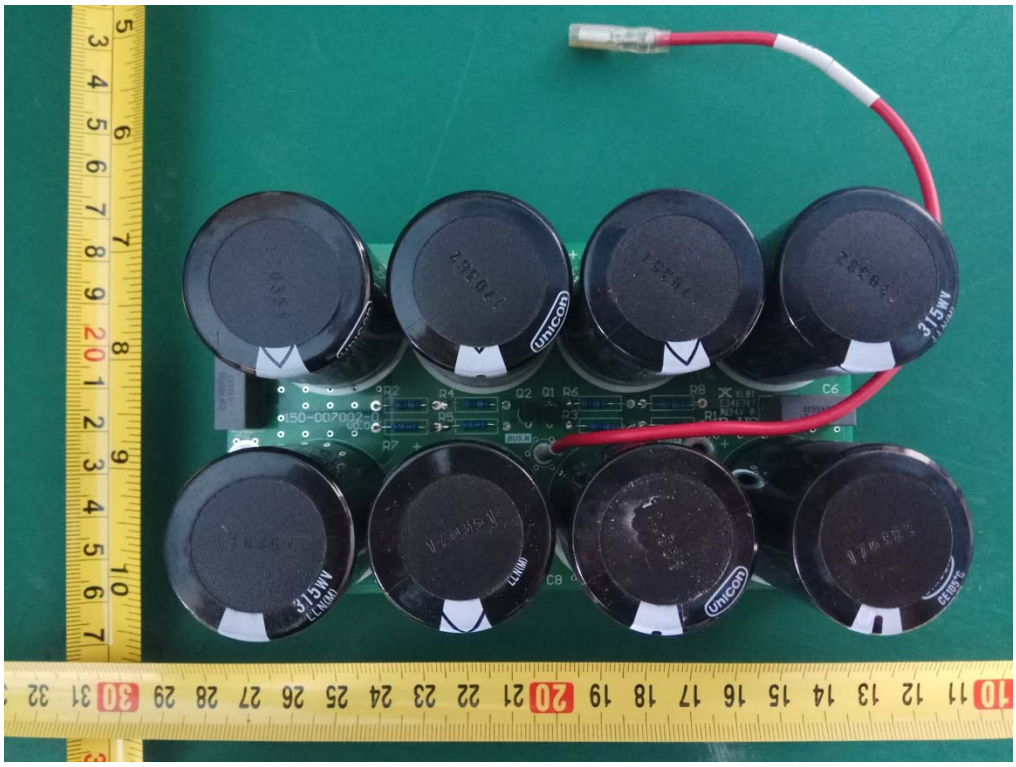
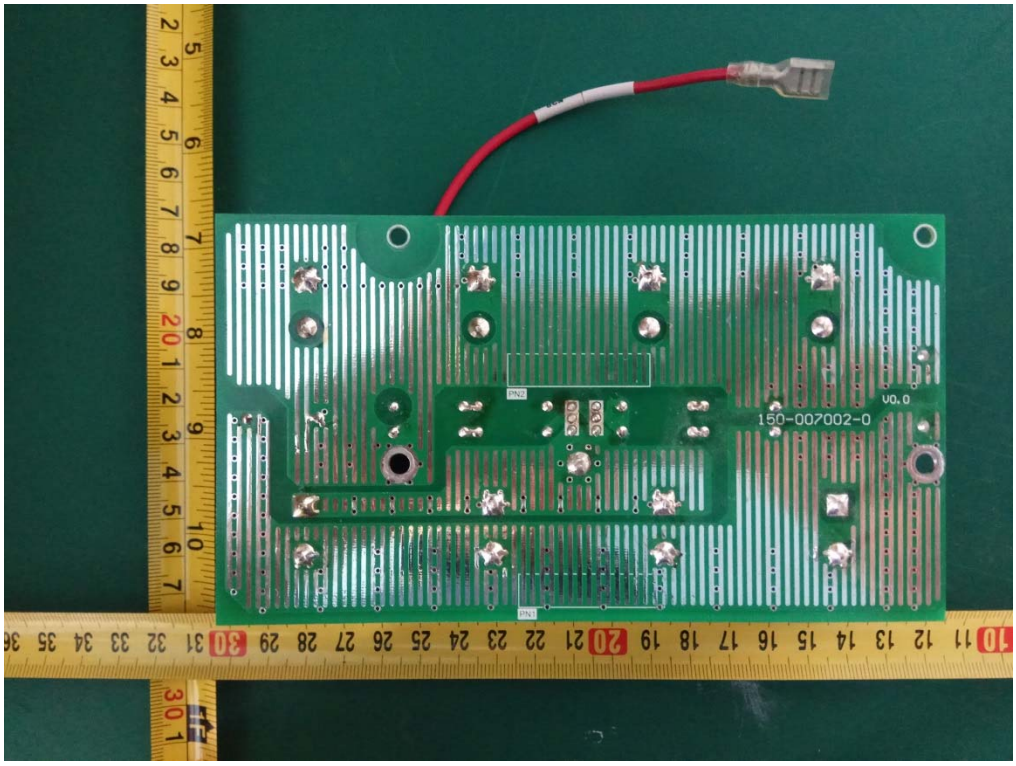

Connection interface

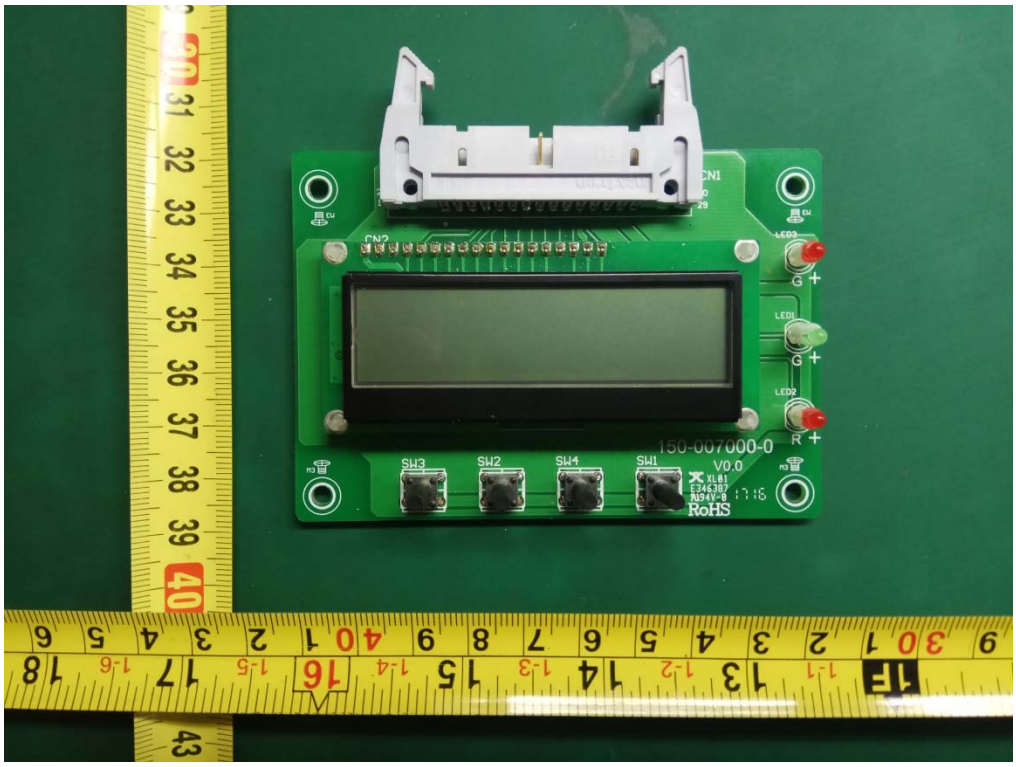
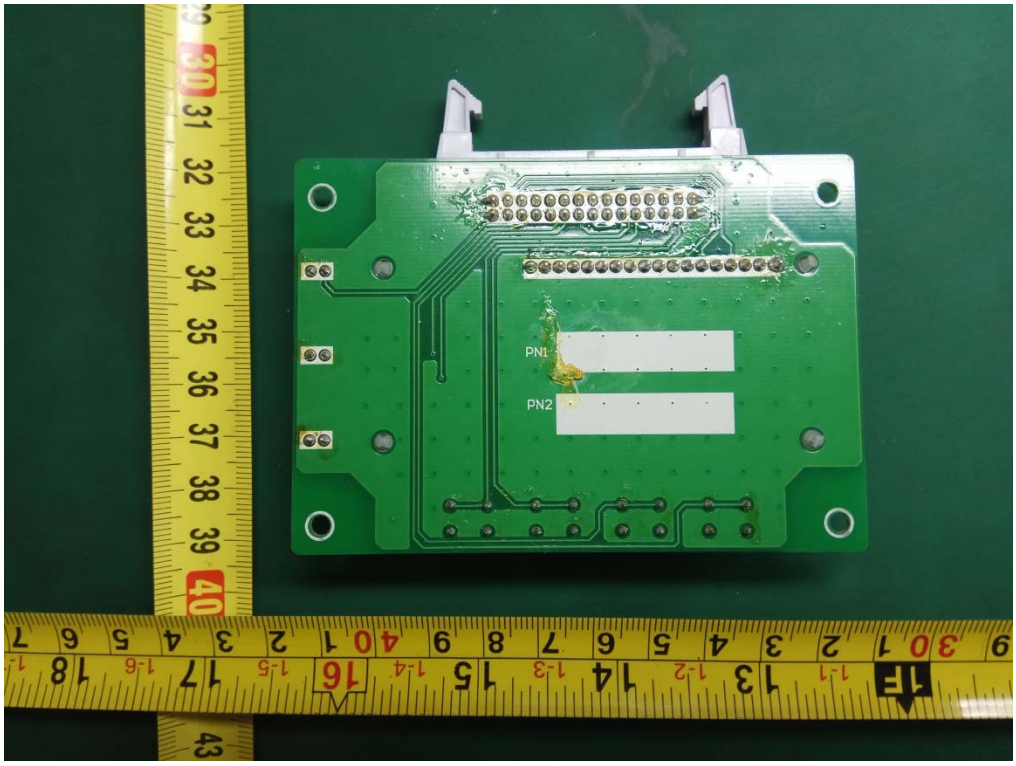
Back Side


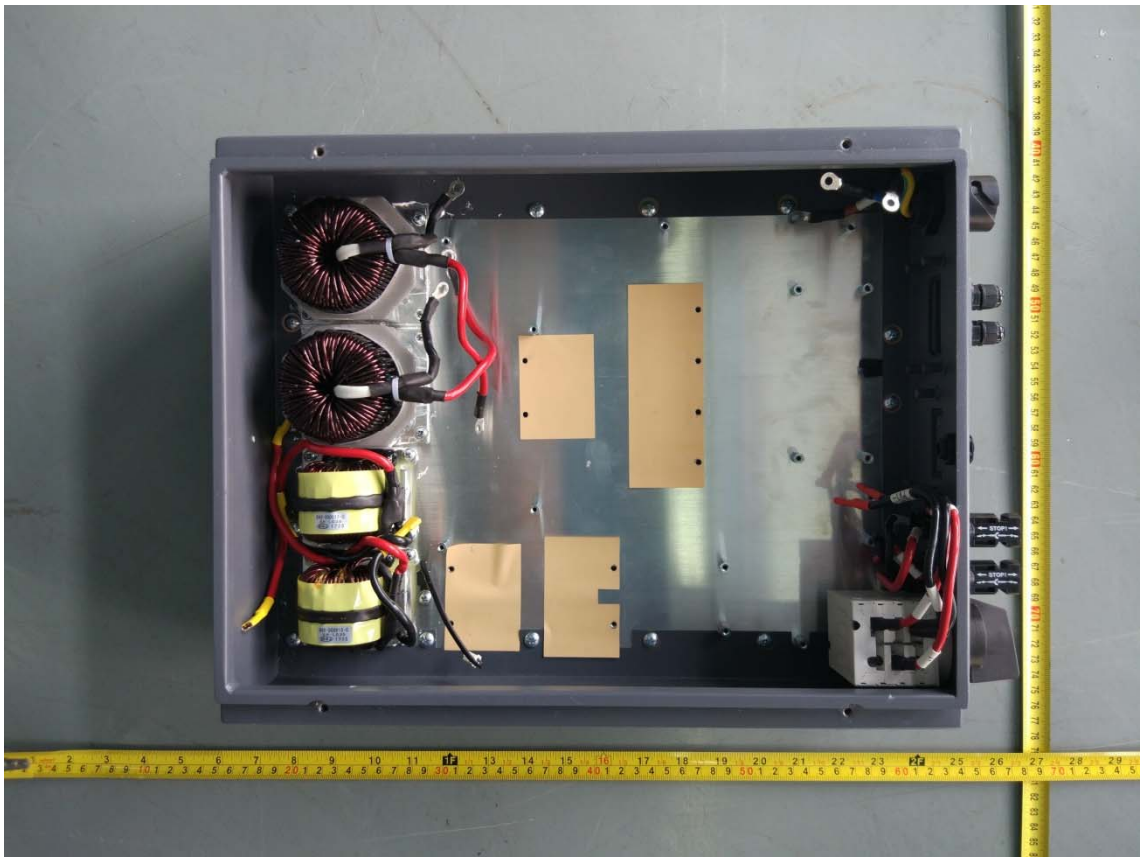
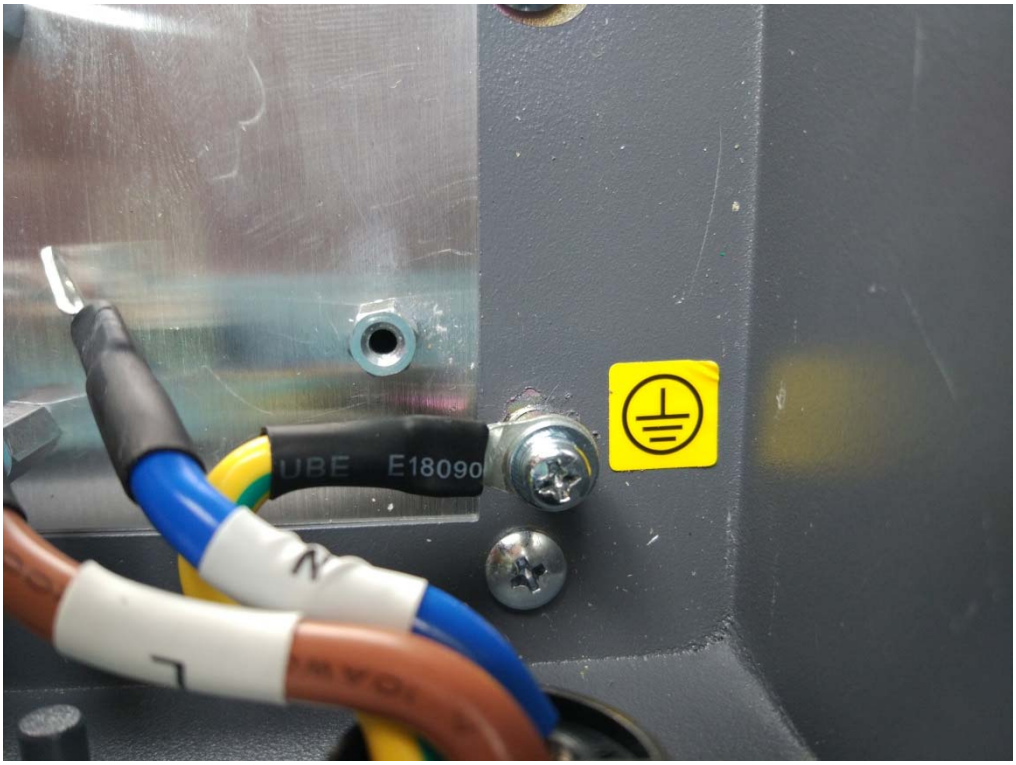
Internal

Internal

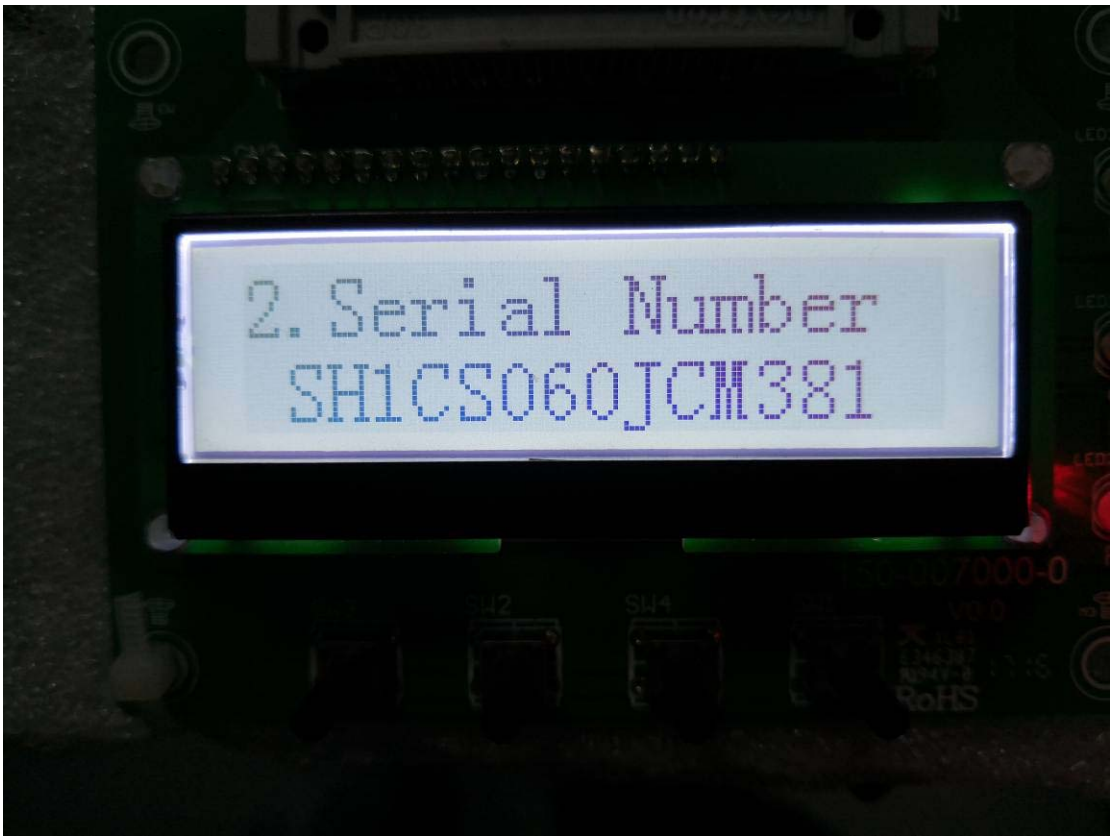

Front side of communication baord

Back side of communication baord


Front side of Main board

Front side of Main board


Front side of Bus capacitors board

Back side of Bus capacitors board


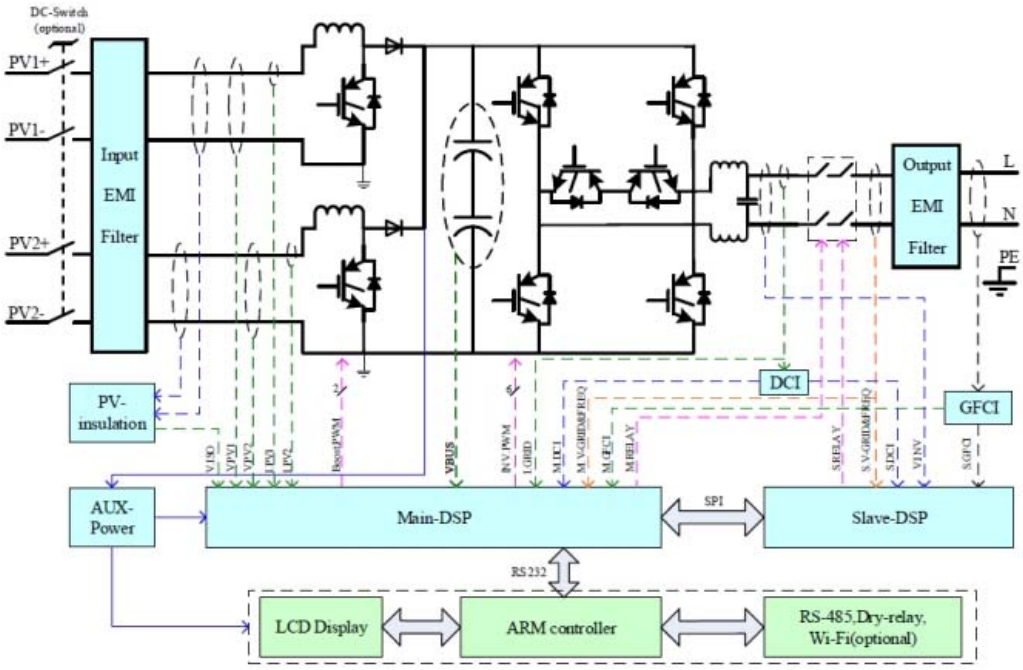
Front side of display board

Back side of display board


Removed all PCBAs

Cover


Serial Number

Software version


6 ELECTRICAL SCHEMES

Equipment under testing



----------END OF REPORT----------