ENAC ENSAYOS Nº 5/LE011

TESTING FOR THE VERIFICATION OF COMPLIANCE OF PV INVERTER WITH :

ANEXO III DEL PROCEDIMIENTO DE VERIFICACIÓN, VALIDACIÓN Y CERTIFICACIÓN DE LOS REQUISITOS DEL P.O. 12.3 FRENTE A LA RESPUESTA DE LAS INSTALACIONES EÓLICAS Y SOLARES ANTE HUECOS DE TENSIÓN (PVVC VERSIÓN 10).

Procedure: PE.T-LE-61

Test Report Number ..... : 2214 / 0337 / Amp2 / E1 (*)

This report modifies and replaces report Nº 2214 / 0337 / Amp2 (*)

(*) See Test Report Historical Revision table on page 2.

Type ..... : 3Play

Tested Model ..... : INGECON SUN 33TL M

Variants Models ..... : INGECON SUN 28TL M; INGECON SUN 28TL; INGECON SUN 33TL; INGECON SUN 24TL M480 INGECON SUN 40TL M480

APPLICANT

Name ..... : INGETEAM POWER TECHNOLOGY

Address ..... : Av. Ciudad de la Innovación, 13
31621 Sarriguren, Navarra (Spain)

TESTING LABORATORY

Name ..... : SGS Tecnos, S.A.U (Electrical Testing Laboratory)

Address ..... : C/ Trespaderne, 29 - Edificio Barajas 1
28042 MADRID (Spain)

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SGS Tecnos, S.A.
Laboratorio de Ensayos E&E

Date of issue ..... : 21/12/2015

Number of pages ..... : 35

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Test Report Historical Revision:

Test Report Version	Date	Resume
2214 / 0337 / Amp2	10-11-2015	_ _
2214 / 0337 / Amp2 – E1	21-12-2015	Editorial changes. Models added in this version: INGECON SUN 24TL M480; INGECON SUN 40TL M480 See pages 1 and 6.

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1 SCOPE

SGS Electrical Testing Laboratory has been contract by INGETEAM POWER TECHNOLOGY in order to perform the testing according the Anexo III del procedimiento de verificación, validación y certificación de los requisitos del P.O. 12.3 frente a la respuesta de las instalaciones eólicas y solares ante huecos de tensión (PVVC versión 10).

2 GENERAL INFORMATION

2.1 TESTING PERIOD AND CLIMATIC CONDITIONS

The necessary testing has been performed along one working day on 22th of September 2015.

All the tests and checks have been performed in accordance with the reference Standard.

Temperature: Initial 22,5 ºC; Final 22,1 ºC

Pressure: Initial 41,8%HR; Final 41,3% HR

SITES TEST

Name	:	INGETEAM POWER TECHNOLOGY
Address	:	Av. Ciudad de la innovación, 13 Sarriguren, Navarra (Spain)

2.2 EQUIPMENT UNDER TESTING

Apparatus type/ Installation	:	Three Phase Solar Inverter / Fixed installation
Manufacturer/ Supplier/ Installer	:	INGETEAM
Trade mark	:	INGETEAM
Model	:	INGECON SUN 33 TL M
Serial Number	:	360000150830
Software Version	:	ABI 1000
Rated Characteristics	:	Input: 200-820 V_{dc} (1000Vmax); I_{scPV}= 40 A Output: 3x380 V / 3x400 V_{ac}; I_{acMAX}=48A; 3 ~NPE; f=50 / 60 Hz; 33kW

Date of manufacturing: 2014

Test item particulars

Input	DC
Output	3 ~NPE
Class of protection against electric shock	Class I
Degree of protection against moisture	IP 65
Type of connection to the main supply	Three phase – Fixed installation
Cooling group	Heat Sink
Modular	No
Internal Transformer	No

Rating Plate:

Type: 3 Play

Model fully tested: INGECON SUN 33TL M

The variant model is: INGECON SUN 28TL M; INGECON SUN 28TL; INGECON SUN33 TL; INGECON SUN 24TL M480; INGECON SUN 40TL M480.

The variant model has 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
- Output power between ±2,5 of the power tested.
- Output rated current ± 50% of the model tested.

The results obtained apply only to the particular sample tested and the variants model 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 comma is used as the decimal separator.

2.3 SGS TEST EQUIPMENT LIST

EQUIPMENT	MARK/MODEL	SGS CODE (DIE)	CALIBRATION DATE
Oscilloscope	Yokogawa / DL850	630040	19/02/2015 to 19/02/2016
Power analyzer	Yokogawa / WT3000	510014	11/06/2015 to 11/06/2016
4 Voltage Probe	Sapphire / SI-9010	610300-06	7/11/2014 to 7/11/2015
		610300-07 610300-10 610300-11	15/10/2014 to 15/10/2015
Multimeter	Fluke/289	560020	26/08/2015 to 26/08/2016
3 Current clamp	HIOKI / 9669	510010-2 510010-4 510010-6	28/05/2015 to 28/05/2016
Digital Thermohygrometer	Testo / 622	840051	19/02/2015 to 19/02/2016

The test bench used includes:

EQUIPMENT	MARK/MODEL	RATED CHARACTERISTICS
AC Source	AMETEK / MX60-3PI-400-LAN-MB-SNK	Input 72 kVA 400 V 50-60Hz Output 60 kVA 150 / 300 V 16-819 Hz
DC Source	CHROMA / 62150H-1000S	15 kW Output: 200 V / 1000 V 6 A / 15 A

2.4 MEASUREMENT UNCERTAINTY

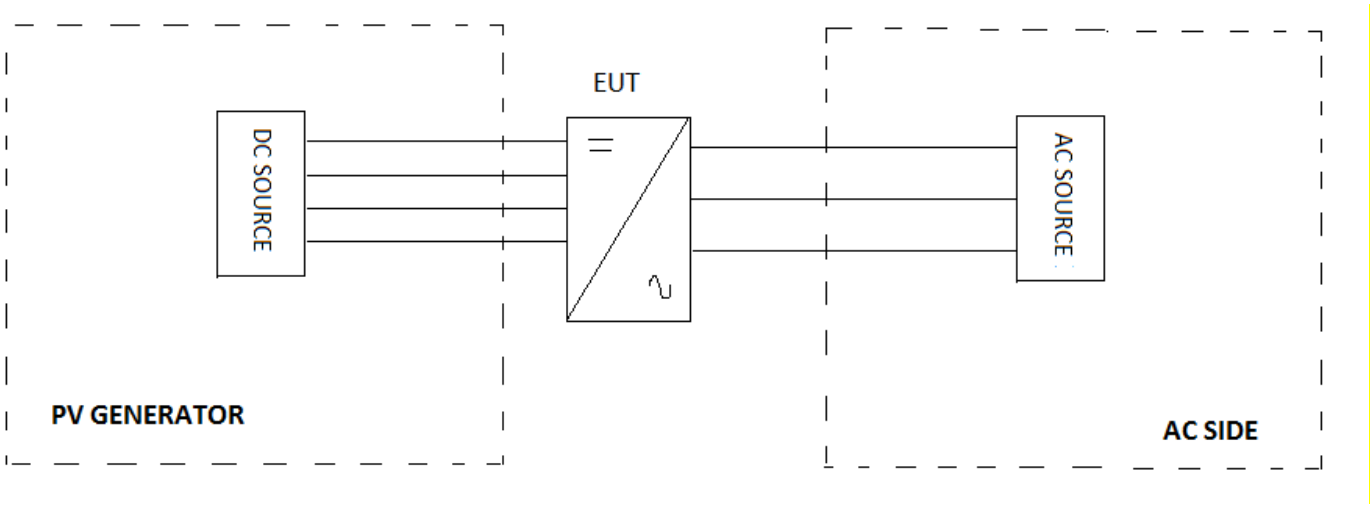
	Voltage measurement uncertainty	±1,5 %
	Current measurement uncertainty	±2,0 %
	Frequency measurement uncertainty	±0,2 %
	Time measurement uncertainty	±0,2 %
	Power measurement uncertainty	±2,5 %
	Phase Angle	±1º
	cosφ	±0,01
Note: The measurement uncertainties associated with other parameters measured during the tests are in the laboratory at disposal of the solicitant.		

2.5 DEFINITIONS

Ea	Active Energy	P	Active Power
Er	Reactive Energy	p.u	Per unit
In	Nominal Current	Pn	Nominal Power
Ir	Reactive Current	Q	Reactive Power
Itot	Total Current	Sn	Apparent Power
LVRT	Low Voltage Rigth Throught		

2.6 TEST SET UP.

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 output for all the tests.

All the tests described in the following pages have used this specified test setup.

3 RESUME OF TEST RESULTS

INTERPRETATION KEYS

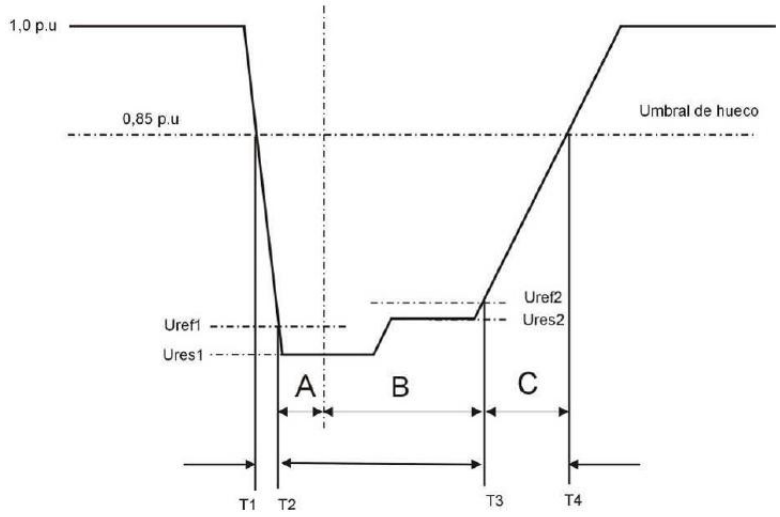
Test object does meet the requirement ..... **P** Pass
Test object does not meet the requirement ..... **F** Fails
Test case does not apply to the test object ..... **N/A** Not applicable
To make a reference to a table or an annex..... See additional sheet
To indicate that the test has not been realized.....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

POWER VERIFICATION	
It has been verified that the solar inverter supplies different power levels.	
P > 80% Pn	P
10 % Pn < P < 30% Pn	P
VERIFICATION OF DIPS WITH NO LOAD	
It has been verified that the dip generator is capable to supply the different levels of voltage drop during the required time.	
Symmetrical fault: T > 500 ms & Ures < 20% Un	P
Asymmetrical fault:T > 500ms & Ures < 60% Un	P
TESTS AND VERIFICATIONS	
Insensitivity to voltage dips	
The equipment remains connected during the test	P
Visual Inspection of the EBE before and after the perturbation	P

4 TEST RESULTS

4.1 LVRT TEST

The LVRT test has been done according with the next figure:



Where:

U_{res1} = Minimum voltage value measured	T_1 = LVRT start instant
U_{ref1} = Minimum voltage value measured plus 3%	T_2= Instant when U is lower than U_{ref1}
U_{res2} = Voltage value measured	T_3 = Instant when U is lower than U_{ref2}
U_{ref2} = Voltage value measured plus 3%	T_4 = LVRT finish instant

U_{res2} is defined in order to considerate a variation in the voltage level inside the LVRT however the LVRT performed only have one voltage minimum level because of this in this case voltage levels U_{res1} and U_{res2} are the same levels. Same argument is applied to U_{ref1} and U_{ref2}.

- A zone: All the voltage values between T_2 and T_2 +150 ms
- B zone: All the voltages values between T_2+150 ms and T_3.
- C zone: All the voltage values between and T_4 or T_3+150 ms whichever is lower

4.1.1 Symmetrical faults.

The test has been performed at two power levels. Each power level is repeated three times ensuring a voltage level lower than 20% of Un and a fault duration higher than 500 ms.

- Requirements for A zone:

  Q consumption has to be lower than 60% of Pn measured during 20 ms.

- Requirements for B zone:

  P consumption has to be lower than 10% of Pn measured during 20 ms.
  Ir/Itot media has to be higher than 90%.

- Requirements for C zone:

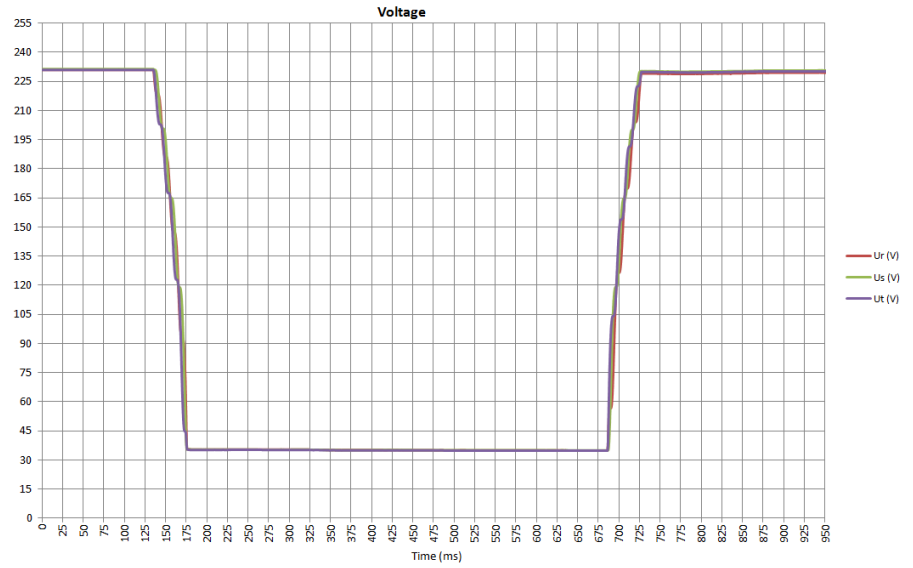
  Er consumption has to be lower than 60% of Pn measured during 150 ms.
  Ir has to be lower than 1,5 per unit measured during 20 ms.

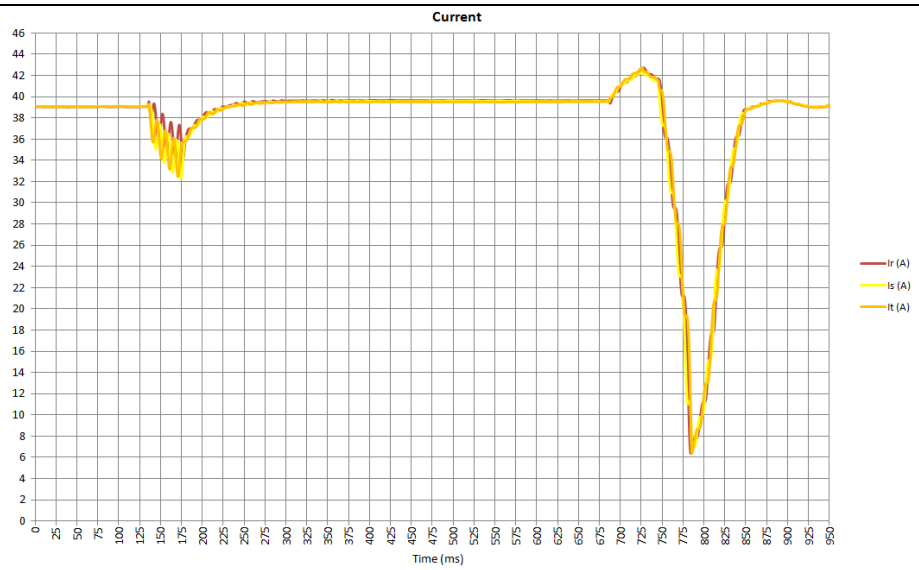
First Test at P > 80% Pn					
Power Desired / Measured		Voltage Level Desired / Measured		Time Desired / Measured	
> 80% Pn	81,99 %	< 20% Un	15,09 %	> 500	568,7 ms
P.O. 12.3 Requirements				**Results**	
ZONE A					
Q < 60 % Pn (20 ms)		-0,6 p.u.		0,116 p.u	
ZONE B					
P < 10 % Pn (20 ms)		-0,1 p.u.		0,002 p.u	
Ir/Itot average		0,9 p.u.		0,999 p.u	
ZONE C					
Er < 60 % Pn * 150 ms		-90 ms.pu		14,185 ms p.u	
Ir < 1,5 In (20 ms)		-1,5 p.u.		0,848 p.u	

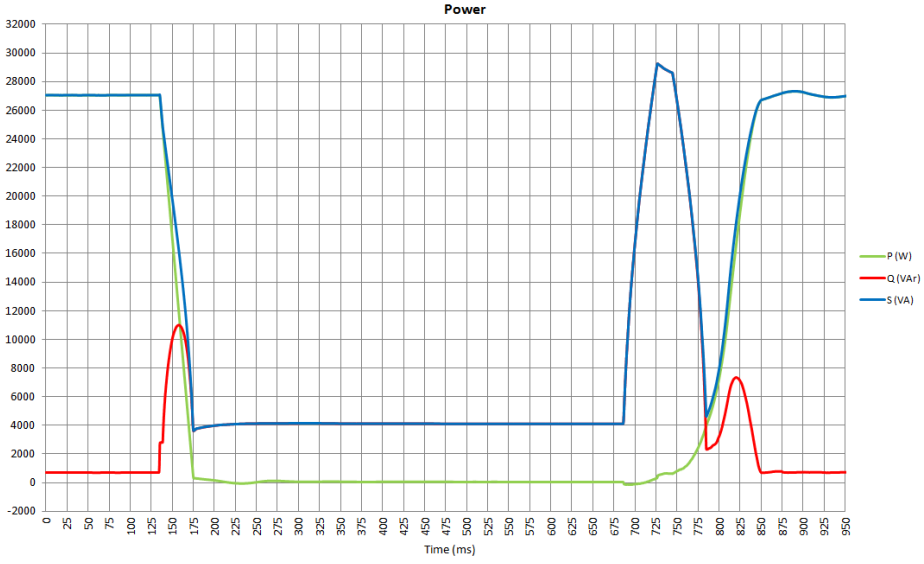
Second Test at P > 80% Pn					
Power Desired / Measured		Voltage Level Desired / Measured		Time Desired / Measured	
> 80% Pn	81,93 %	< 20% Un	15,11 %	> 500	568,8 ms
P.O. 12.3 Requirements				**Results**	
ZONE A					
Q < 60 % Pn (20 ms)		-0,6 p.u.		0,117 p.u	
ZONE B					
P < 10 % Pn (20 ms)		-0,1 p.u.		0,002 p.u	
Ir/Itot average		0,9 p.u.		0,999 p.u	
ZONE C					
Er < 60 % Pn * 150 ms		-90 ms.pu		14,192 ms p.u	
Ir < 1,5 In (20 ms)		-1,5 p.u.		0,847 p.u	

Third Test at P > 80% Pn					
Power Desired / Measured		Voltage Level Desired / Measured		Time Desired / Measured	
> 80% Pn	81,95 %	< 20% Un	15,06 %	> 500	568,9 ms
P.O. 12.3 Requirements				**Results**	
ZONE A					
Q < 60 % Pn (20 ms)		-0,6 p.u.		0,116 p.u	
ZONE B					
P < 10 % Pn (20 ms)		-0,1 p.u.		0,002 p.u	
Ir/Itot average		0,9 p.u.		0,999 p.u	
ZONE C					
Er < 60 % Pn * 150 ms		-90 ms.pu		14,17 ms p.u	
Ir < 1,5 In (20 ms)		-1,5 p.u.		0,846 p.u	

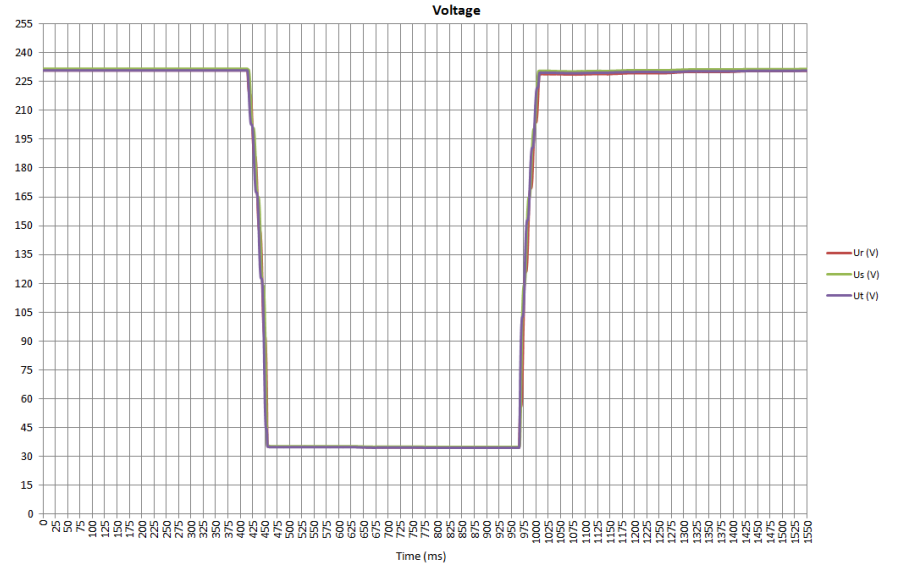
First Test at P > 80% Pn

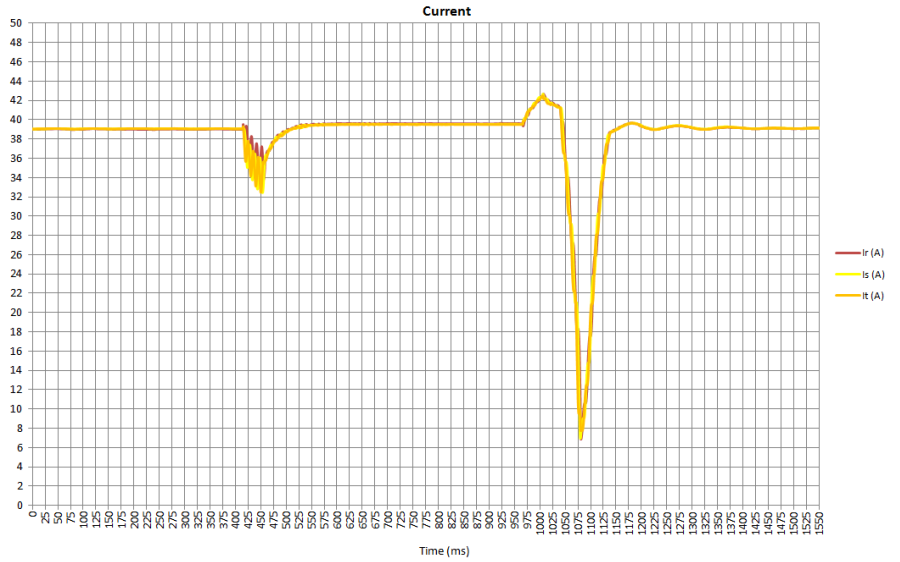


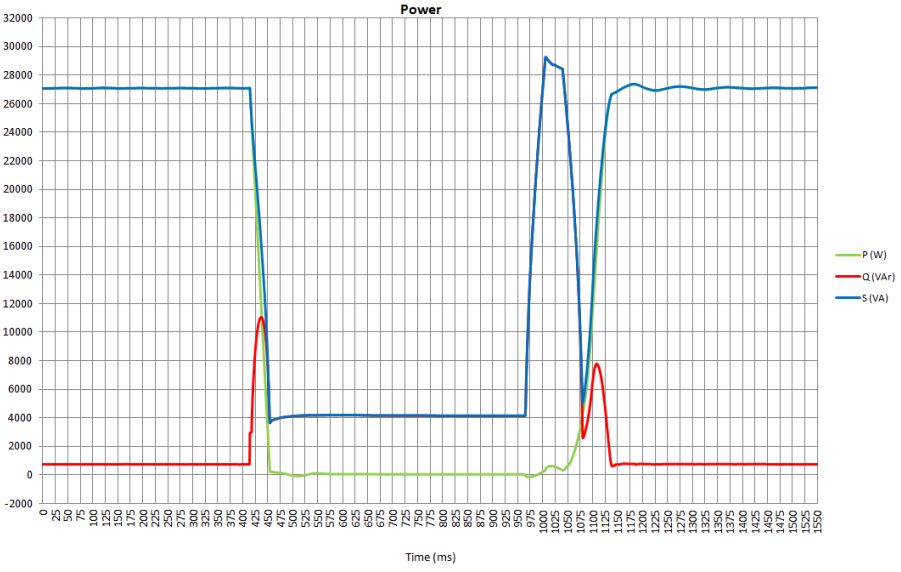




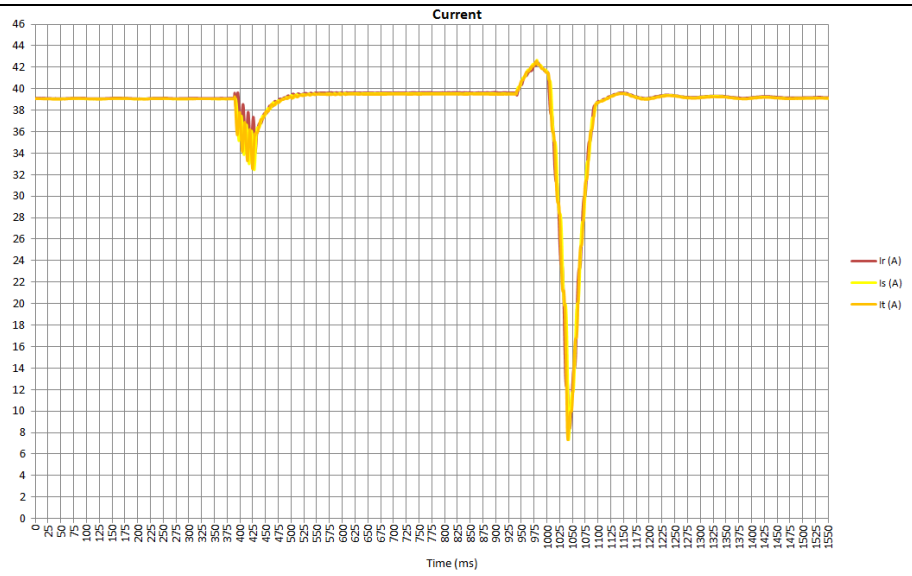
Second Test at P > 80% Pn

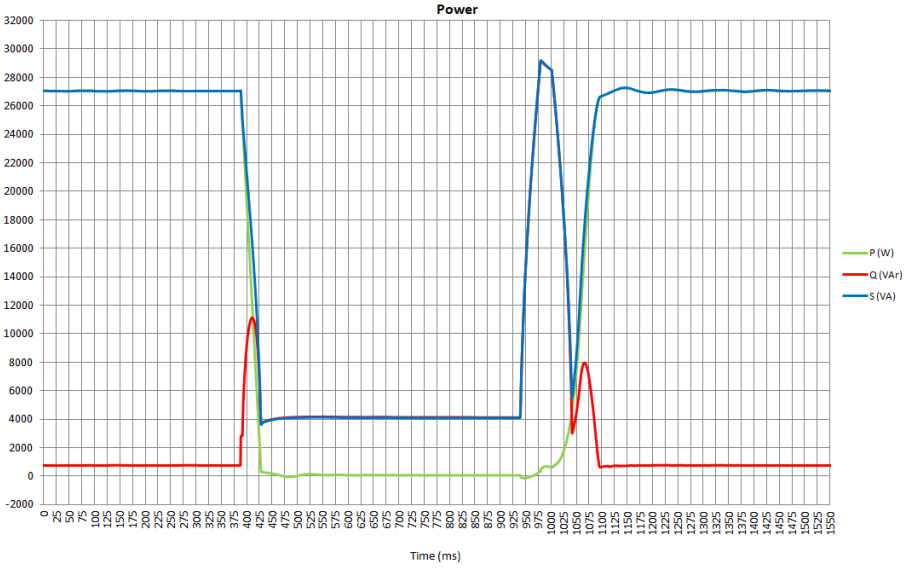






Third Test at P > 80% Pn



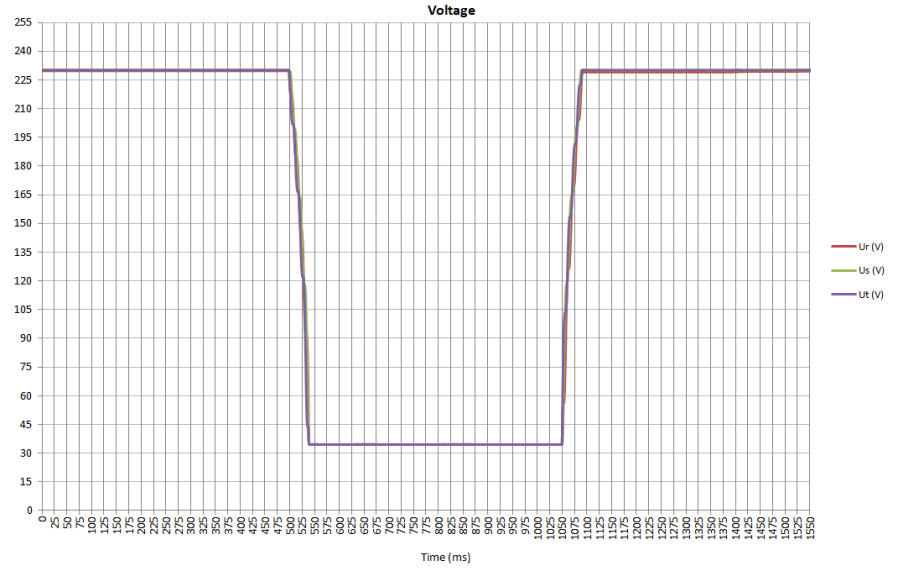


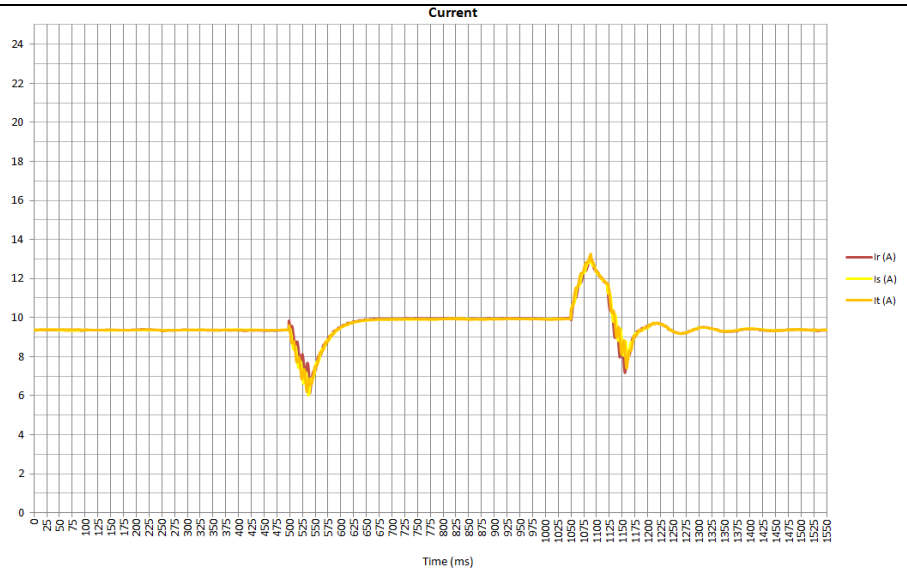
First Test at 10% < P < 30% Pn					
Power Desired / Measured		Voltage Level Desired / Measured		Time Desired / Measured	
20% Pn	19,58 %	< 20% Un	15,01 %	> 500	559,6
P.O. 12.3 Requirements				**Results**	
ZONE A					
Q < 60 % Pn (20 ms)		-0,6 p.u.		0,022 p.u	
ZONE B					
P < 10 % Pn (20 ms)		-0,1 p.u.		0,0004 p.u	
Ir/Itot average		0,9 p.u.		0,999 p.u	
ZONE C					
Er < 60 % Pn * 150 ms		-90 ms.pu		4,057 ms p.u	
Ir < 1,5 In (20 ms)		-1,5 p.u.		0,234 p.u	

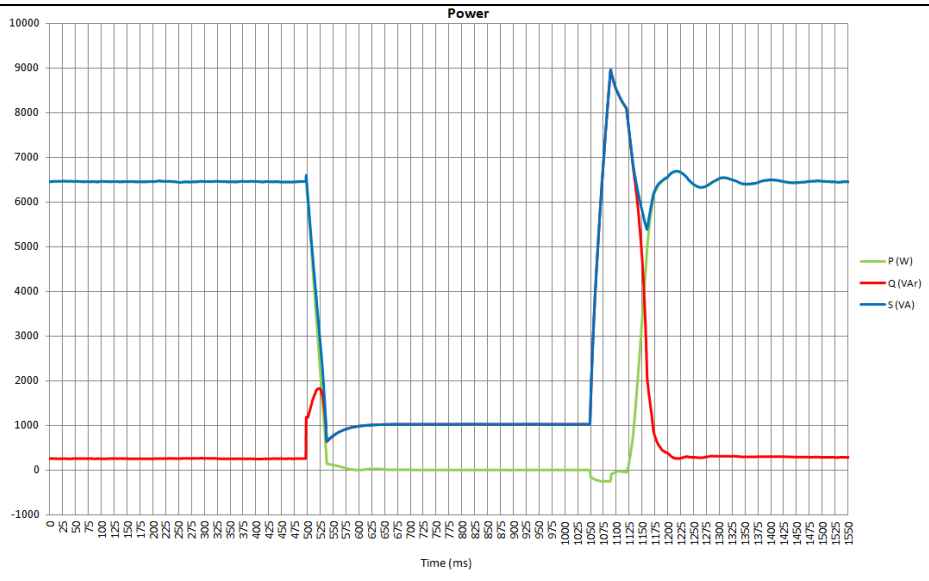
Second Test at 10% < P < 30% Pn					
Power Desired / Measured		Voltage Level Desired / Measured		Time Desired / Measured	
20% Pn	19,58 %	< 20% Un	15,02 %	> 500	568,9
P.O. 12.3 Requirements				**Results**	
ZONE A					
Q < 60 % Pn (20 ms)		-0,6 p.u.		0,021 p.u	
ZONE B					
P < 10 % Pn (20 ms)		-0,1 p.u.		0,002 p.u	
Ir/Itot average		0,9 p.u.		0,999 p.u	
ZONE C					
Er < 60 % Pn * 150 ms		-90 ms.pu		4,062 ms p.u	
Ir < 1,5 In (20 ms)		-1,5 p.u.		0,234 p.u	

Third Test at 10% < P < 30% Pn					
Power Desired / Measured		Voltage Level Desired / Measured		Time Desired / Measured	
20% Pn	19,56 %	< 20% Un	15,04 %	> 500	568,9
P.O. 12.3 Requirements				**Results**	
ZONE A					
Q < 60 % Pn (20 ms)		-0,6 p.u.		0,022 p.u	
ZONE B					
P < 10 % Pn (20 ms)		-0,1 p.u.		0,0002 p.u	
Ir/Itot average		0,9 p.u.		0,999 p.u	
ZONE C					
Er < 60 % Pn * 150 ms		-90 ms.pu		2,413 ms p.u	
Ir < 1,5 In (20 ms)		-1,5 p.u.		0,216 p.u	

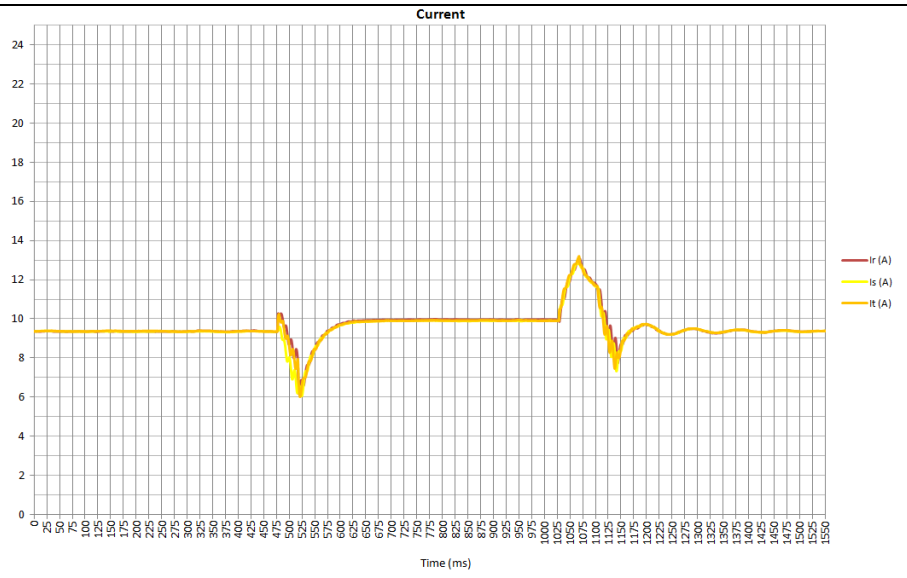
First Test at 10% < P < 30% Pn

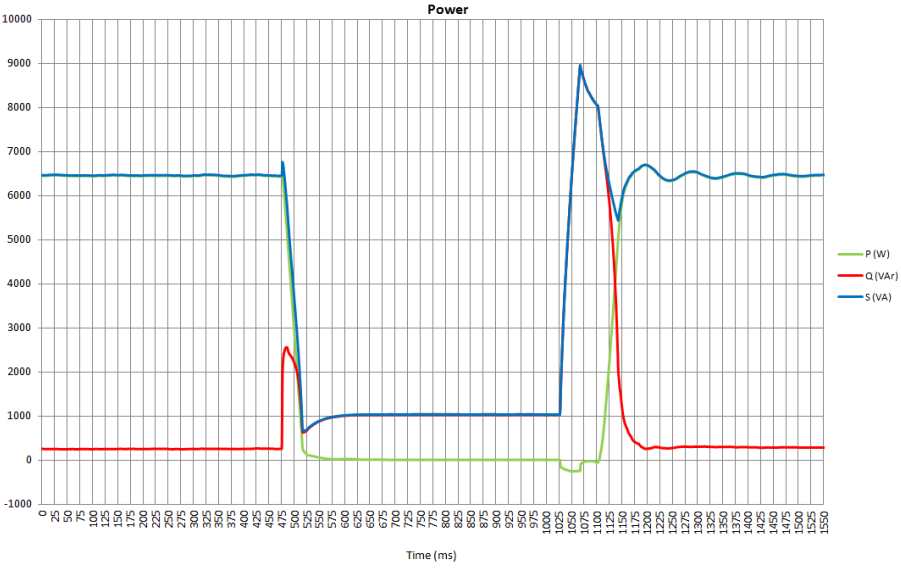




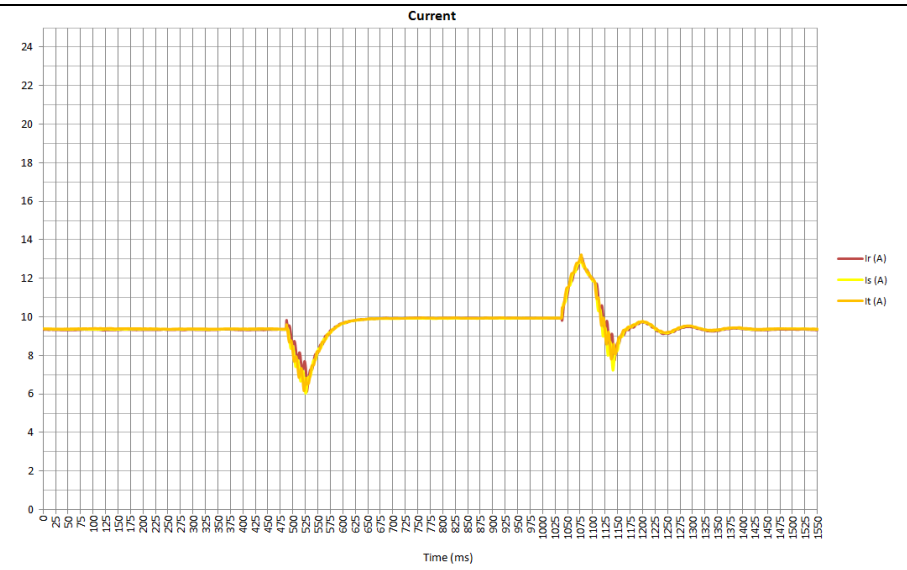


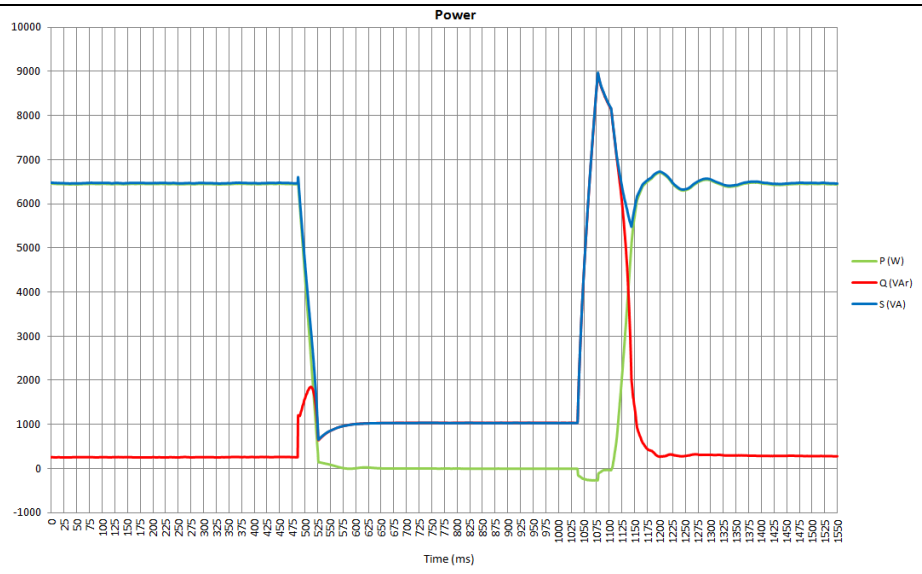
Second Test at 10% < P < 30% Pn





Third Test at 10% < P < 30% Pn





4.1.2 Asymmetrical faults

The test has been performed at two power levels. Each power level is repeated three times ensuring a voltage level lower than 20% of Un and a fault duration higher than 500 ms.

- Requirements for A zone:

  No requirements.

- Requirements for B zone:

  Er consumption has to be lower than 40% of Pn measured during 100 ms.
  Q consumption has to be lower than 40% of Pn measured during 20 ms.
  Ea consumption has to be lower than 45% of Pn measured during 100 ms.
  P consumption has to be lower than 10% of Pn measured during 20 ms.

- Requirements for C zone:

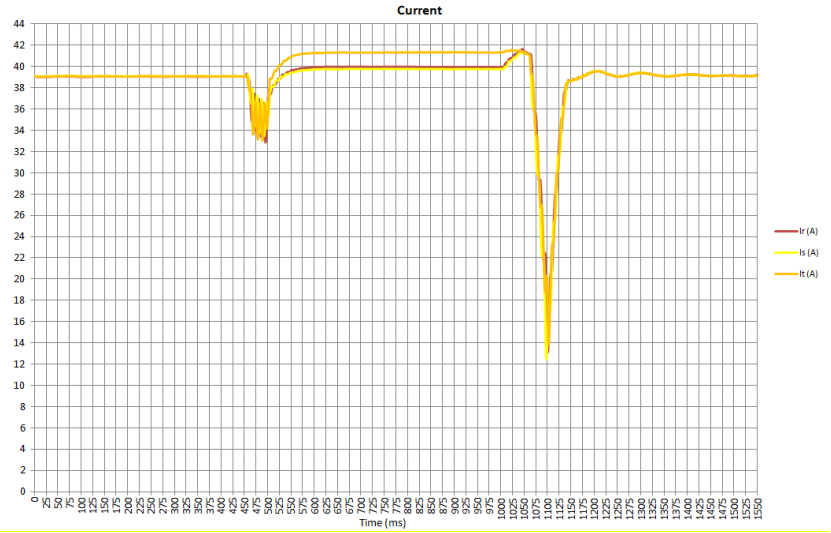
  No requirements.

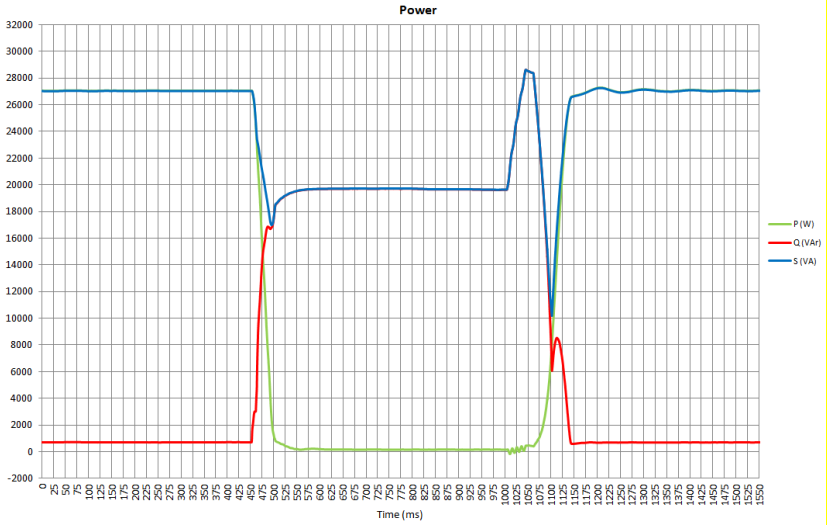
First Test at P > 80% Pn					
Power Desired / Measured		Voltage Level Desired / Measured		Time Desired / Measured	
> 80% Pn	81,93 %	< 60% Un	55,24%	> 500	559,1ms
P.O. 12.3 Requirements				**Results**	
ZONE B					
Er < 40 % Pn * 100 ms		-40 ms.pu		59,818 ms.pu	
Q < 40 % Pn (20 ms)		-0,4 p.u.		0,598 p.u	
Ea < 45 % Pn * 100 ms		-45 ms.pu		0,541 ms.pu	
P < 30 % Pn (20 ms)		-0,3 p.u.		0,006 ms p.u	

Second Test at P > 80% Pn					
Power Desired / Measured		Voltage Level Desired / Measured		Time Desired / Measured	
> 80% Pn	81,97 %	< 60% Un	55,27%	> 500	559,2ms
P.O. 12.3 Requirements				**Results**	
ZONE B					
Er < 40 % Pn * 100 ms		-40 ms.pu		59,897 ms.pu	
Q < 40 % Pn (20 ms)		-0,4 p.u.		0,598 p.u	
Ea < 45 % Pn * 100 ms		-45 ms.pu		0,596 ms.pu	
P < 30 % Pn (20 ms)		-0,3 p.u.		0,006 ms p.u	

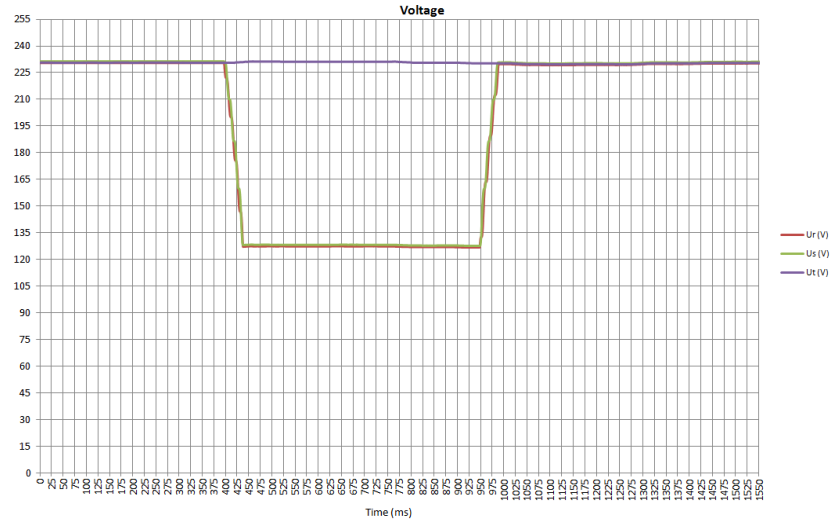
Third Test at P > 80% Pn					
Power Desired / Measured		Voltage Level Desired / Measured		Time Desired / Measured	
> 80% Pn	81,88 %	< 60% Un	55,11%	> 500	559,4 ms
P.O. 12.3 Requirements				**Results**	
ZONE B					
Er < 40 % Pn * 100 ms		-40 ms.pu		59,767 ms.pu	
Q < 40 % Pn (20 ms)		-0,4 p.u.		0,597 p.u	
Ea < 45 % Pn * 100 ms		-45 ms.pu		0,590 ms.pu	
P < 30 % Pn (20 ms)		-0,3 p.u.		0,006 ms p.u	

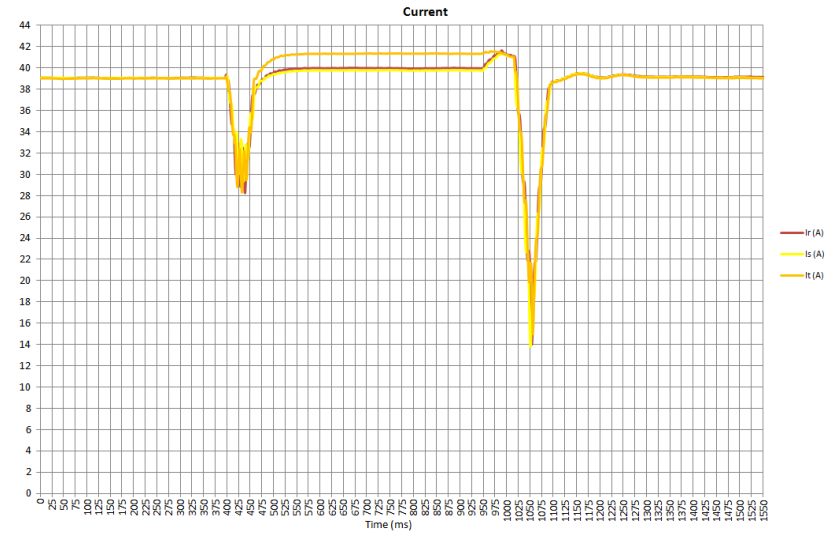
First Test at P > 80% Pn

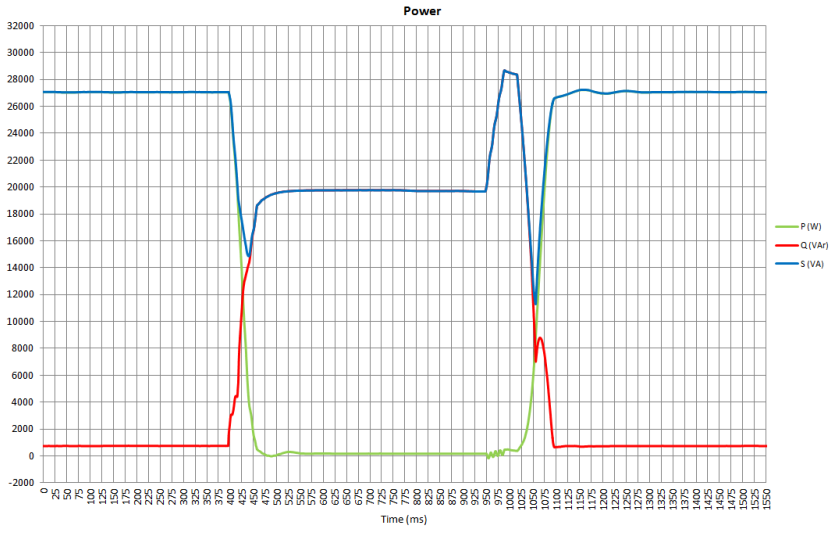




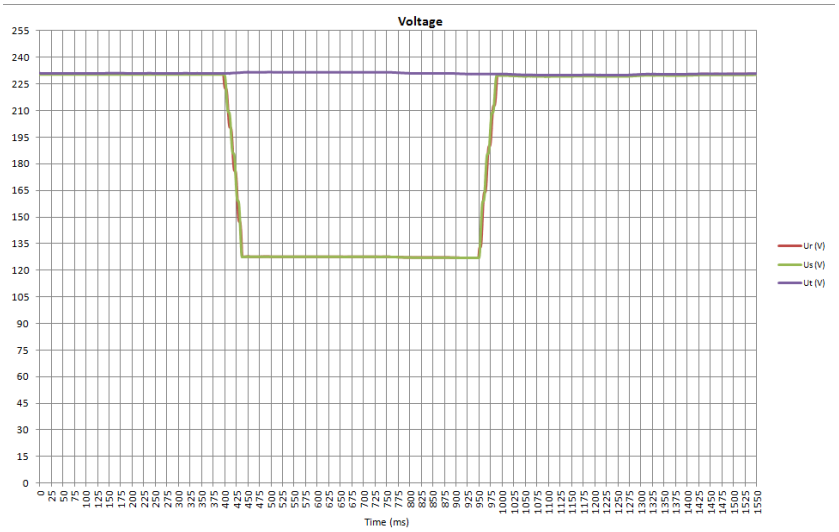
Second Test at P > 80% Pn

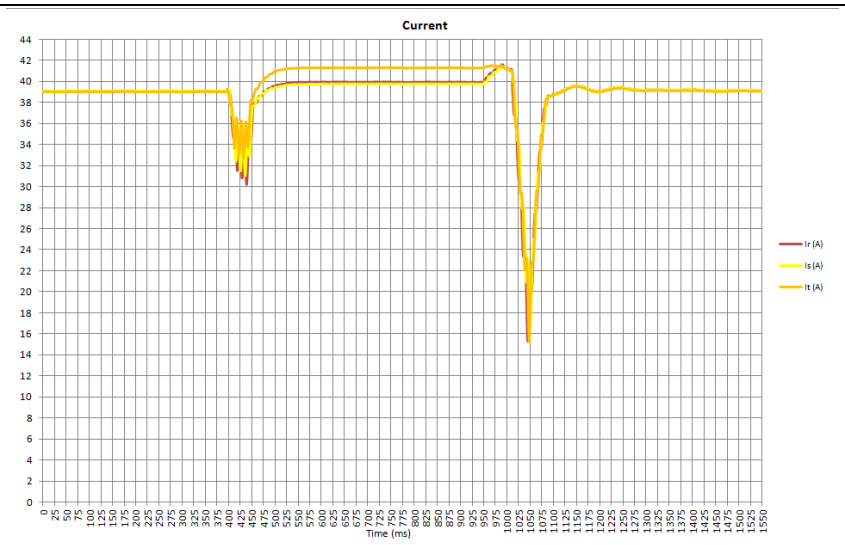


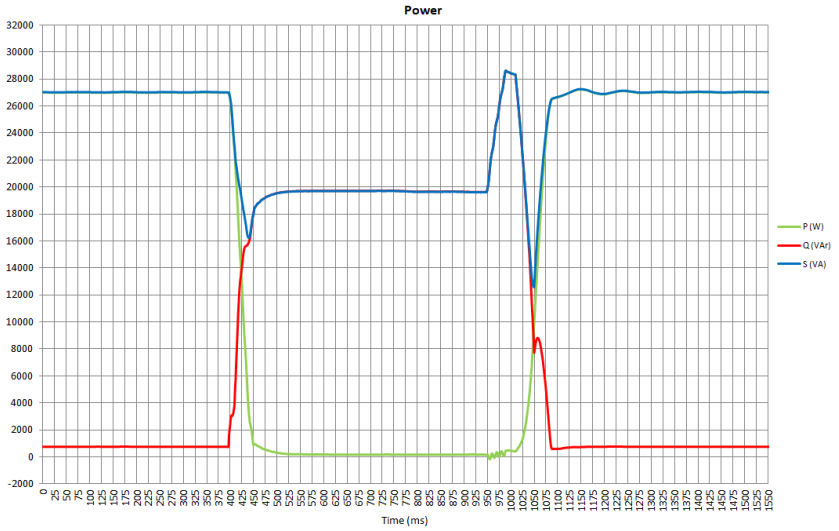




Third Test at P > 80% Pn





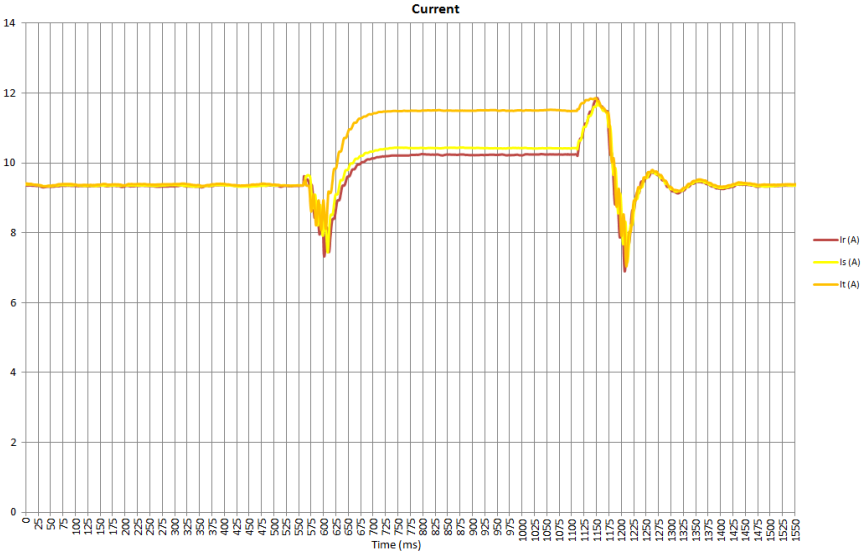


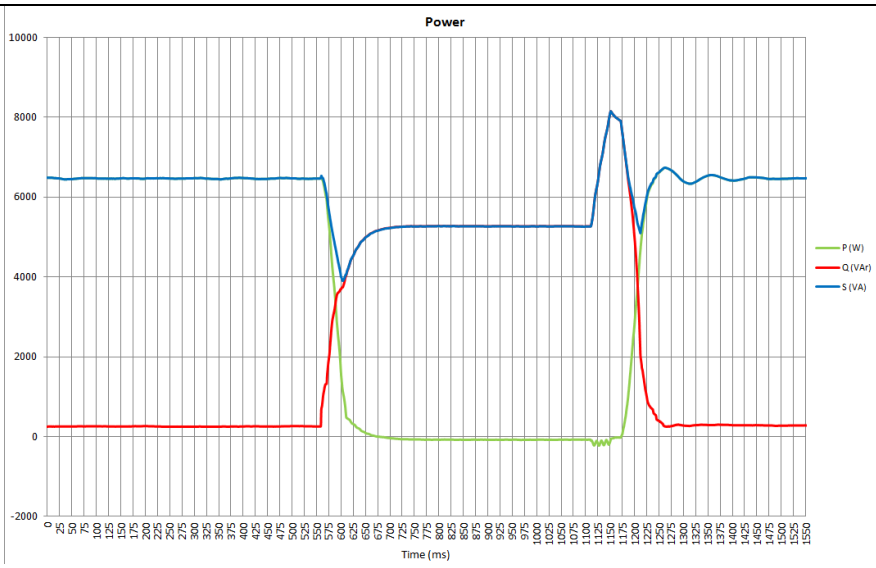
First Test at 10% < P < 30% Pn					
Power Desired / Measured		Voltage Level Desired / Measured		Time Desired / Measured	
20% Pn	19,64 %	< 60% Un	55,16%	> 500	559,4ms
P.O. 12.3 Requirements				**Results**	
ZONE B					
Er < 40 % Pn * 100 ms		-40 ms.pu		15,983 ms.pu	
Q < 40 % Pn (20 ms)		-0,4 p.u.		0,160 p.u	
Ea < 45 % Pn * 100 ms		-45 ms.pu		-0,256 ms.pu	
P < 30 % Pn (20 ms)		-0,3 p.u.		-0,002 ms p.u	

Second Test at 10% < P < 30% Pn					
Power Desired / Measured		Voltage Level Desired / Measured		Time Desired / Measured	
20% Pn	19,57 %	< 60% Un	55,01%	> 500	559,6ms
P.O. 12.3 Requirements				**Results**	
ZONE B					
Er < 40 % Pn * 100 ms		-40 ms.pu		15,996 ms.pu	
Q < 40 % Pn (20 ms)		-0,4 p.u.		0,160 p.u	
Ea < 45 % Pn * 100 ms		-45 ms.pu		-0,249 ms.pu	
P < 30 % Pn (20 ms)		-0,3 p.u.		-0,002 ms p.u	

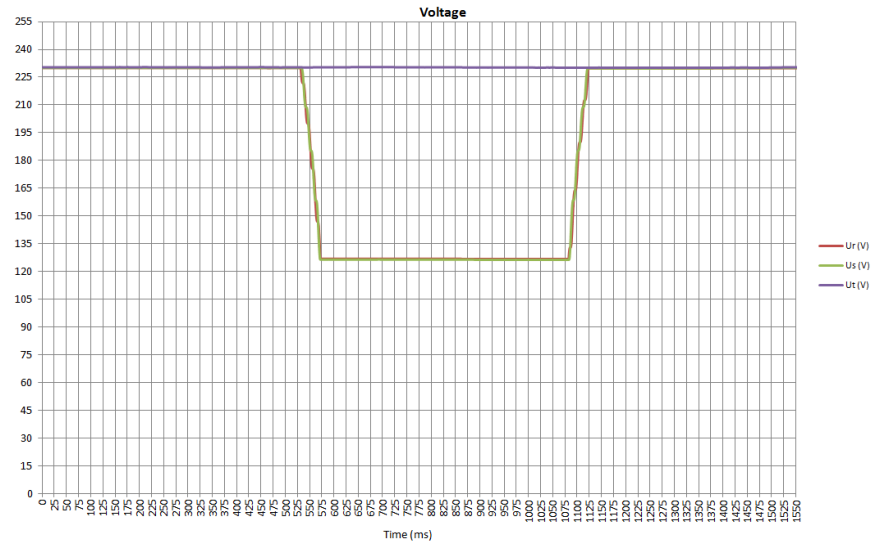
Third Test at 10% < P < 30% Pn					
Power Desired / Measured		Voltage Level Desired / Measured		Time Desired / Measured	
20% Pn	19,56 %	< 60% Un	55,00%	> 500	559,7ms
P.O. 12.3 Requirements				**Results**	
ZONE B					
Er < 40 % Pn * 100 ms		-40 ms.pu		15,999 ms.pu	
Q < 40 % Pn (20 ms)		-0,4 p.u.		0,160 p.u	
Ea < 45 % Pn * 100 ms		-45 ms.pu		-0,259 ms.pu	
P < 30 % Pn (20 ms)		-0,3 p.u.		-0,002 ms p.u	

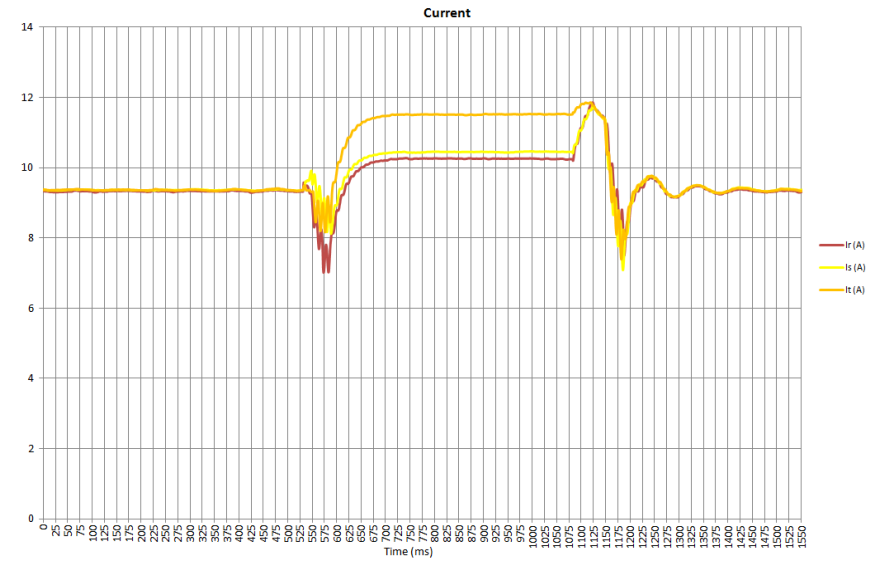
First Test at 10% < P < 30% Pn

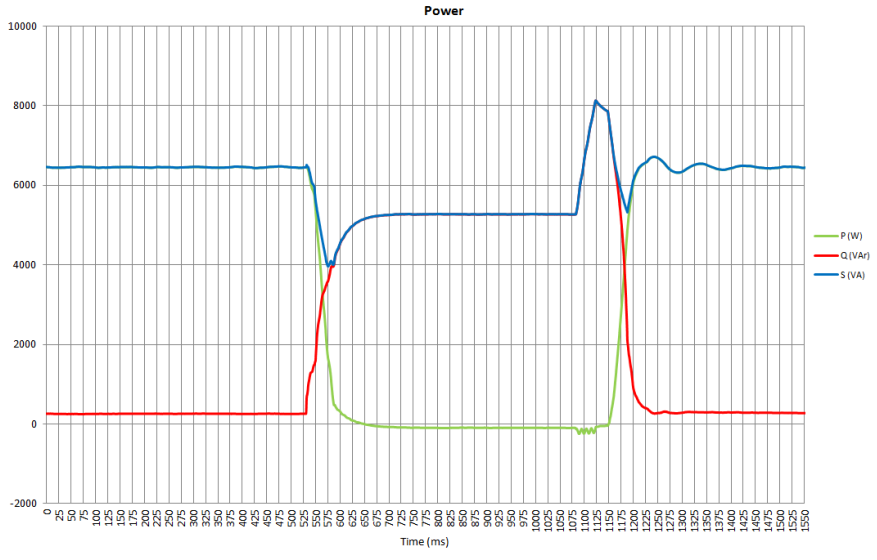




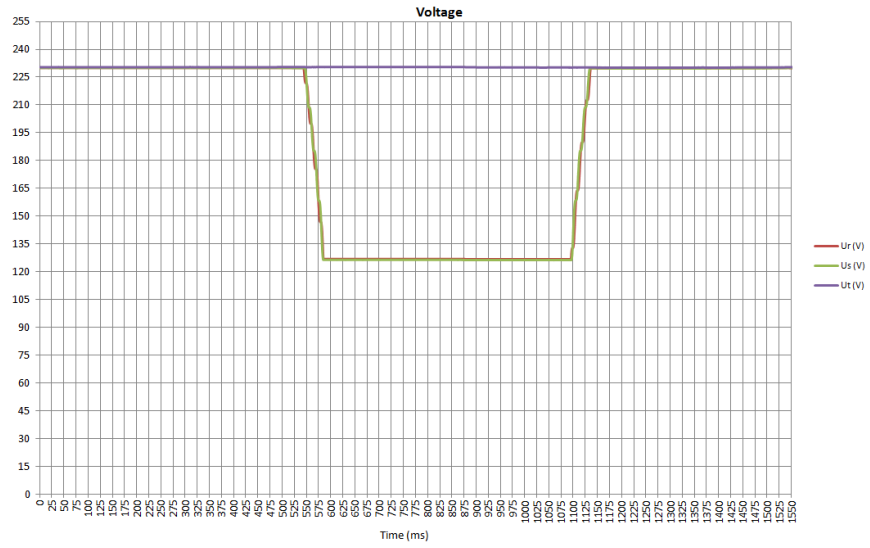
Second Test at 10% < P < 30% Pn

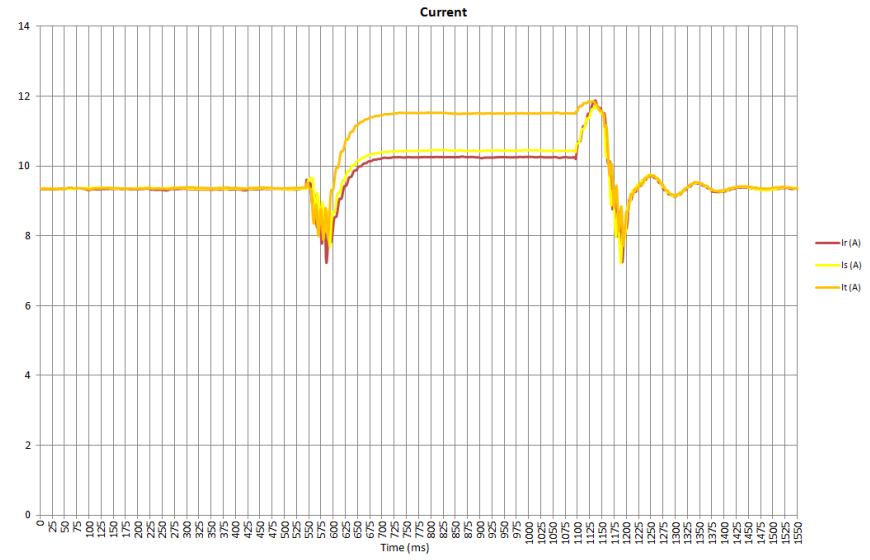


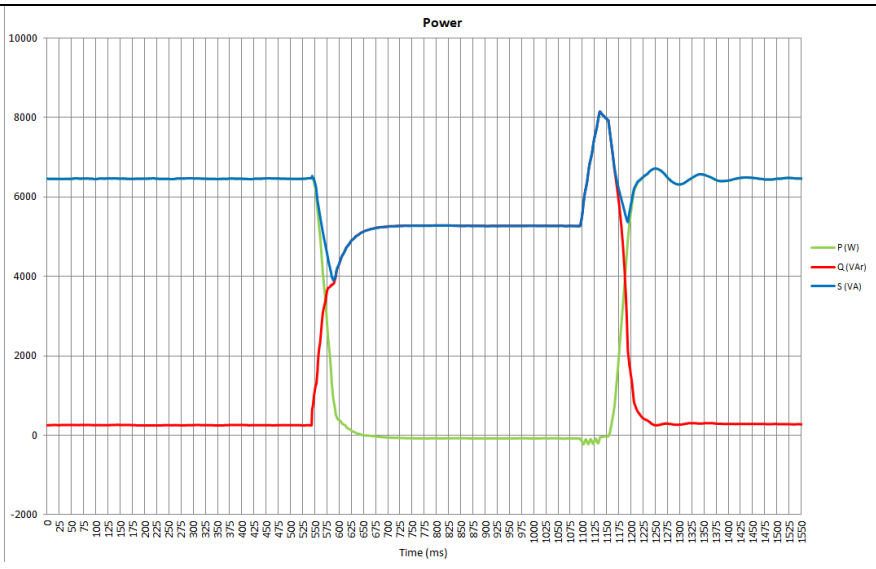




Third Test at 10% < P < 30% Pn







5 PICTURES