TEST REPORT

PO 12.3 Testing of LVRT behaviour

Verification, validation and certification procedure annex III of the P.O. 12.3 requirements for solar installations to the LVRT. (PVVC Version 10)

Report reference number ....:	**21TH0192_PO12.3_0**
Date of issue ....:	2021-03-15
Total number of pages ....:	90
Testing laboratory name.................:	**Bureau Veritas Consumer Products Services Germany GmbH**
Address ....:	Businesspark A96, 86842 Türkheim, Germany
Accreditation.....................................:	DAkkS Deutsche Akkreditierungsstelle D-PL-12024-03-03
Applicant's name............................:	**Shenzhen SOFARSOLAR Co., Ltd.**
Address ....:	401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China
Test specification	
Standard ....:	PVVC, Version 10 Procedure for verification, validation and certification of the requirements of the PO 12.3 on the response of wind farms and photovoltaic plant in the event of voltage dips
Test report form number....................:	PVVC
Master TRF ....:	Bureau Veritas Consumer Products Services Germany GmbH
Test item description ....:	**Grid-tied Solar Inverter**
Trademark ....:	SOFAR SOLAR
Model / Type......................................:	SOFAR 15KTLX-G3, SOFAR 17KTLX-G3, SOFAR 20KTLX-G3, SOFAR 22KTLX-G3, SOFAR 24KTLX-G3.

Ratings ....:	**SOFAR 15KTLX-G3**	**SOFAR 17KTLX-G3**	**SOFAR 20KTLX-G3**
MPP DC voltage range [V] ....:	140 - 1000		
Input DC voltage range [V] ....:	max. 1100		
Input DC current [A].........................:	max. 2x26A		
Output AC voltage [V].......................:	400, 3~ + N + PE, 50/60Hz		
Output AC current [A] ....:	max. 3x23,9A	max. 3x27,1A	max. 3x31,9A
Nominal Output power [kW] ....:	15,0	17,0	20,0
Maximum Output power [kVA] ....:	16,5	18,7	22,0

Ratings ....:	**SOFAR 22KTLX-G3**	**SOFAR 24KTLX-G3**
MPP DC voltage range [V] ....:	140 - 1000	
Input DC voltage range [V] ....:	max. 1100	
Input DC current [A].........................:	max. 2x26A	
Output AC voltage [V].......................:	400, 3~ + N + PE, 50/60Hz	
Output AC current [A] ....:	max. 3x35,1A	max. 3x38,3A
Nominal Output power [kW] ....:	22,0	24,0
Maximum Output power [kVA] ....:	24,2	26,4

Testing Location.............................:	**Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch**	
Address ....:	No. 96, Guantai Road (Houjie Section), Houjie Town, Dongguan City, Guangdong Province, 523942, People's Republic of China	
Tested by (name and signature).......................:	Weizhao Zheng	Zheng. Weizhao.
Approved by (name and signature).......................:	Georg Loritz	Georg Loritz
Manufacturer's name ....:	**Shenzhen SOFARSOLAR Co., Ltd.**	
Manufacturer address ....:	401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China	
Factory's name ....:	**Dongguan SOFAR SOLAR Co., Ltd.**	
Factory address...............................:	1F - 6F, Building E, No. 1 JinQi Road, Bihu Industrial Park, Wulian Village, Fenggang Town, Dongguan City	

Contents of Test Report

Document History

Date	Internal reference	Modification / Change / Status	Revision
2021-03-15	Weizhao Zheng	Initial report was written	0

Test items particulars	
Equipment mobility ....:	Permanent connection
Operating condition ....:	Continuous
Class of equipment ....:	Class I
Protection against ingress of water ..:	IP65 according to EN 60529
Mass of equipment [kg] ....:	SOFAR 15KTLX-G3: Approx. 20kg SOFAR 17KTLX-G3, SOFAR 20KTLX-G3: Approx. 22kg SOFAR 22KTLX-G3, SOFAR 24KTLX-G3: Approx. 23kg
Test case verdicts	
Test case does not apply to the test object ....:	N/A
Test item does meet the requirement ....:	P(ass)
Test item does not meet the requirement ....:	F(ail)
Testing	
Date of receipt of test item ....:	2020-11-20
Date(s) of performance test ....:	2020-11-20 till 2021-02-04

Copy of marking plate

SOFAR SOLAR Solar Grid-tied Inverter

Model No:	SOFAR 15KTLX-G3
Max.DC Input Voltage	1100V
Operating MPPT Voltage Range	140~1000V
Max. Input Current	26A/26A
Max. PV Isc	36A/36A
Nominal Grid Voltage	3/N/PE,380/400V
Max.Output Current	3x23.9A
Nominal Grid Frequency	50/60Hz
Nominal Output Power	15000W
Max.Output Power	16500VA
Power Factor	1(adjustable+/-0.8)
Ingress Protection	IP65
Operating Temperature Range	-30℃~+60℃
Protective Class	Class I
Made in China	

Manufacturer : Shenzhen SOFARSOLAR Co.,Ltd.
Address : 401, Building 4, AnTong Da Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China
VDE0126-1-1,VDE-AR-N4105,G99,IEC61727
IEC62116,UTE C15-712-1,AS4777

SOFAR SOLAR Solar Grid-tied Inverter

Model No:	SOFAR 17KTLX-G3
Max.DC Input Voltage	1100V
Operating MPPT Voltage Range	140~1000V
Max. Input Current	26A/26A
Max. PV Isc	36A/36A
Nominal Grid Voltage	3/N/PE,380/400V
Max.Output Current	3x27.1A
Nominal Grid Frequency	50/60Hz
Nominal Output Power	17000W
Max.Output Power	18700VA
Power Factor	1(adjustable+/-0.8)
Ingress Protection	IP65
Operating Temperature Range	-30℃~+60℃
Protective Class	Class I
Made in China	

Manufacturer : Shenzhen SOFARSOLAR Co.,Ltd.
Address : 401, Building 4, AnTong Da Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China
VDE0126-1-1,VDE-AR-N4105,G99,IEC61727
IEC62116,UTE C15-712-1,AS4777

SOFAR SOLAR Solar Grid-tied Inverter

Model No:	SOFAR 20KTLX-G3
Max.DC Input Voltage	1100V
Operating MPPT Voltage Range	140~1000V
Max. Input Current	26A/26A
Max. PV Isc	36A/36A
Nominal Grid Voltage	3/N/PE,380/400V
Max.Output Current	3x31.9A
Nominal Grid Frequency	50/60Hz
Nominal Output Power	20000W
Max.Output Power	22000VA
Power Factor	1(adjustable+/-0.8)
Ingress Protection	IP65
Operating Temperature Range	-30℃~+60℃
Protective Class	Class I
Made in China	

Manufacturer : Shenzhen SOFARSOLAR Co.,Ltd.
Address : 401, Building 4, AnTong Da Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China
VDE0126-1-1,VDE-AR-N4105,G99,IEC61727
IEC62116,UTE C15-712-1,AS4777

SOFAR SOLAR Solar Grid-tied Inverter

Model No:	SOFAR 22KTLX-G3
Max.DC Input Voltage	1100V
Operating MPPT Voltage Range	140~1000V
Max. Input Current	26A/26A
Max. PV Isc	36A/36A
Nominal Grid Voltage	3/N/PE,380/400V
Max.Output Current	3x35.1A
Nominal Grid Frequency	50/60Hz
Nominal Output Power	22000W
Max.Output Power	24200VA
Power Factor	1(adjustable+/-0.8)
Ingress Protection	IP65
Operating Temperature Range	-30℃~+60℃
Protective Class	Class I
Made in China	

Manufacturer : Shenzhen SOFARSOLAR Co.,Ltd.
Address : 401, Building 4, AnTong Da Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China
VDE0126-1-1,VDE-AR-N4105,G99,IEC61727
IEC62116,UTE C15-712-1,AS4777

Copy of marking plate

SOFAR SOLAR Solar Grid-tied Inverter

Model No:	SOFAR 24KTLX-G3
Max.DC Input Voltage	1100V
Operating MPPT Voltage Range	140~1000V
Max. Input Current	26A/26A
Max. PV Isc	36A/36A
Nominal Grid Voltage	3/N/PE,380/400V
Max.Output Current	3x38.3A
Nominal Grid Frequency	50/60Hz
Nominal Output Power	24000W
Max.Output Power	26400VA
Power Factor	1(adjustable+/-0.8)
Ingress Protection	IP65
Operating Temperature Range	-30℃~+60℃
Protective Class	Class I

Made in China

Manufacturer : Shenzhen SOFARSOLAR Co.,Ltd.
Address : 401, Building 4, AnTong Da Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China
VDE0126-1-1,VDE-AR-N4105,G99,IEC61727
IEC62116,UTE C15-712-1,AS4777

General product information

General product information:

The Grid-tied Solar Inverter converts DC voltage, generated by photovoltaic modules into AC voltage.

The Grid-tied Solar Inverter is a three-phase type.

Equipment mobility.........................:	Permanent connection
Operating condition.........................:	Continuous
Class of equipment.........................:	Class I
Protection against ingress of water.:	IP65 according to EN 60529
Mass of equipment [kg]...................:	SOFAR 15KTLX-G3: Approx. 20kg SOFAR 17KTLX-G3, SOFAR 20KTLX-G3: Approx. 22kg SOFAR 22KTLX-G3, SOFAR 24KTLX-G3: Approx. 23kg

Testing

Date of receipt of test item ....:	2020-11-20
Date(s) of performance test ....:	2020-11-20 till 2021-02-04

Description of test object(s):

The tests were performed on EUT *SOFAR 24KTLX-G3* with:

Hardware version: V101

and

Software version: V010000.

Description of the electrical circuit (Figure 1):

The input and output are protected by varistors to Earth. The unit is providing EMC filtering at the PV input and output toward mains. The unit does not provide galvanic separation from input to output (transformerless). The output is switched off redundantly by the high-power switching bridge and two relays. This assures that the opening of the output circuit will also operate in case of a single error.

The internal control is redundant built. It consists of Microcontroller Main DSP (U30) and slave DSP (U23).
The Main DSP (U30) control the relays by switching signals; measures the PV voltage, PV current, Bus voltage, grid voltage, frequency, AC current with injected DC and the array insulation resistance to ground. In addition, it tests the current sensors and the RCMU circuit before each start up.
The slave DSP (U23) is measures the grid voltage, grid frequency and residual current, also can switch off the relays independently, and communicate with Main DSP (U30) each other.
The current is measured by a current sensor. The AC current signal and the injected DC current signal are sent to the Main DSP(U30). The Main DSP(U30) tests and calibrates before each start up all current sensors.

The unit provides two relays in series in all output conductors. When single fault applied to one relay, alarm an error code in display panel, another redundant relay provides basic insulation maintained between the PV array and the mains. All the relays are tested before each start up.

General product information

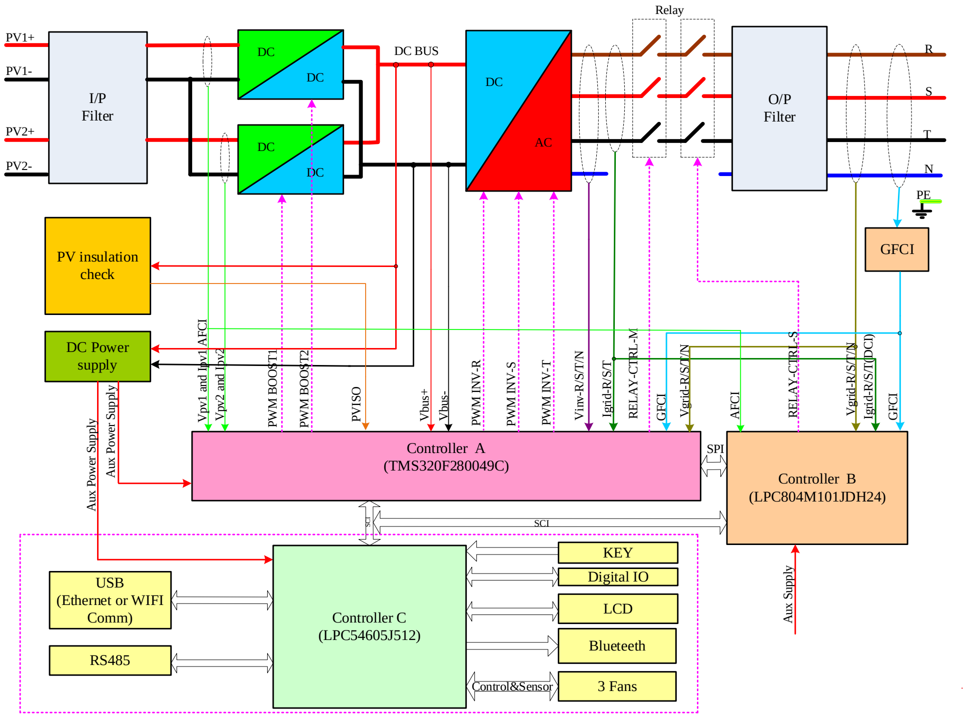


Figure 1 – Block diagram

Single Safety fault redundancy:

The slave ARM is using for sample the grid voltage and current, also can open the relays independently and communicate with master ARMeach other.

Description of the differences of the models within a series:

The units in der series are similar hardware platform except the components as listed below:

Model	SOFAR 15KTLX-G3	SOFAR 17KTLX-G3	SOFAR 20KTLX-G3	SOFAR 22KTLX-G3	SOFAR 24KTLX-G3
Thin-film capacitor of BUS	4pcs (110uF, 550V)	6pcs (110uF, 550V)			
INV IGBT (Q60, Q67, Q71 Q72, Q75, Q76)	6pcs 40A, 1200V	6pcs 75A, 1200V			
External Fan	1		2		

The implemented control and software are identical in all units. There is no difference regarding AC behaviour between the PGU-types apart from the power rating / output voltage deviation and current limitation of each unit.

General remarks

Preface:

The test results presented in this report relate only to the object(s) tested.

This report must not be reproduced in part or in full without the written approval of the issuing testing laboratory.

“(see Annex #)” refers to additional information appended to the report.

“(see appended table)” refers to a table appended to the report.

Throughout this report a comma "," is used as decimal separator and a period "." as thousands separator.

Weather conditions were within the typical range of laboratory conditions and are logged in the measurement log document

The test equipment list can be found in Annex 0.

Acronyms:

PGU: power generating unit

PGS: power generating system

P: Pass - Test object does meet the requirement

F: Fail - Test object does not meet the requirement

N/A: Test case does not apply to the test object

Description of the vector system to depict test results:

The regarded system of the voltage and current vectors is the generator reference system:

- If the inverter feeds to the grid the active power is measured with positive sign.
- If the inverter generates inductive reactive power the reactive power has a positive sign.
- If the inverter generates capacitive reactive power the reactive power has a negative sign.

In the diagrams, the worst-case values are marked by a red “X”.

General remarks		
Notes on calculations:	Used formula	Remarks
General remarks: The average grid frequency over the measured interval is calculated from zero-crossings of the sine function. Only 10 cycles before the dip are used for this calculation. RMS-Calculations are performed with a moving window, which is determined by T = 1/f and must remain constant. The number of samples N per calculation window is determined by the sampling rate f_s. N has to be even and an integer number nearest to the product T*f_s.	$\underline{U}_1 = \frac{\sqrt{2}}{N} \cdot \sum_{n=0}^{N} u(n) \cdot e^{-j(\frac{2 \cdot \pi \cdot n}{N})}$ $\underline{I}_1 = \frac{\sqrt{2}}{N} \cdot \sum_{n=0}^{N} i(n) \cdot e^{-j(\frac{2 \cdot \pi \cdot n}{N})}$	- Calculated for each phase A, B, C - N: Amount of samples per window - n: number of samples
Performed Calculation	$\underline{U}^+ = \frac{1}{3} \cdot (\underline{U}_{1A} + \underline{U}_{1B} \cdot e^{+j\frac{2\pi}{3}} + \underline{U}_{1C} \cdot e^{-j\frac{2\pi}{3}})$ $\underline{I}^+ = \frac{1}{3} \cdot (\underline{I}_{1A} + \underline{I}_{1B} \cdot e^{+j\frac{2\pi}{3}} + \underline{I}_{1C} \cdot e^{-j\frac{2\pi}{3}})$	
Complex values for the fundamental harmonic	$P = 3 \cdot U^+ \cdot I^+ \cdot \cos(\varphi)$ $Q = 3 \cdot U^+ \cdot I^+ \cdot \sin(\varphi)$	Phase-angle: Angular difference between current and voltage $\varphi = (\varphi_U - \varphi_I)$
Positive sequence component of the voltage and current	$I_r = I^+ \cdot \sin(\varphi)$ $I_{tot} = I^+$	
Power:	$U_{rms} = \sqrt{\frac{1}{N} \cdot \sum_{n=0}^{N} (u(n) - \bar{u})^2}$ $\bar{u} = \frac{1}{N} \cdot \sum_{n=0}^{N} u(n)$	- Calculated for each phase A, B, C or L1, L2, L3

Annex 1 – Test Results

Behaviour during grid disturbance

No load Test	No. of phases shorted	Test number
0	Three	0.1
	Two	0.2.A (for test A) 0.2.B (for test B) 0.2.C (for test C)
	One	0.2.1 (only for Single-phase system with single-phase monitoring)

Load Test	No. of phases shorted	Output power level			Duration of voltage sag	Test-number	Verdict*		
							A	B	C
Three-phase system									
1	Three	$P > 0{,}8P_n$	100%	$U_{res} < 20\%$	t > 500ms	1.1.1	P	P	P
		$0{,}1P_n < P < 0{,}3P_n$	20%			1.1.2	P	P	P
	Two	$P > 0{,}8P_n$	100%	$U_{res} < 60\%$		1.2.1	P	P	P
		$0{,}1P_n < P < 0{,}3P_n$	20%			1.2.2	P	P	P
Single-phase system with three-phase monitoring									
2	Three	$P > 0{,}8P_n$	100%	$U_{res} < 20\%$	t > 500ms	2.1.1	N/A	N/A	N/A
		$0{,}1P_n < P < 0{,}3P_n$	20%			2.1.2	N/A	N/A	N/A
	Two	$P > 0{,}8P_n$	100%	$U_{res} < 60\%$		2.2.1	N/A	N/A	N/A
		$0{,}1P_n < P < 0{,}3P_n$	20%			2.2.2	N/A	N/A	N/A
	Two*	$P > 0{,}8P_n$	100%			2.2.1	N/A	N/A	N/A
		$0{,}1P_n < P < 0{,}3P_n$	20%			2.2.2	N/A	N/A	N/A
Single-phase system with single-phase monitoring									
3	One	$P > 0{,}8P_n$	100%	$U_{res} < 20\%$	t > 500ms	3.2.1s	N/A	N/A	N/A
		$0{,}1P_n < P < 0{,}3P_n$	20%			3.2.2s	N/A	N/A	N/A
		$P > 0{,}8P_n$	100%	$U_{res} < 60\%$		3.2.3s	N/A	N/A	N/A
		$0{,}1P_n < P < 0{,}3P_n$	20%			3.2.4s	N/A	N/A	N/A

Notes on recording:

- Sample rate at least 5 kHz
- Record at least U and I per phase digitally
- Start of measuring at least 10s prior to the beginning of the dip and at least 5s after T_4

Note:

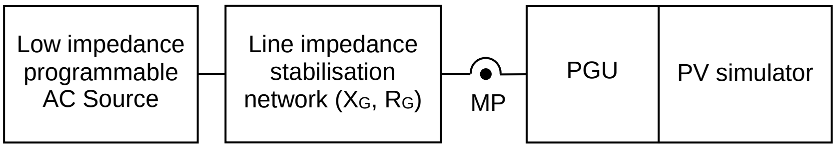
* Verdict:

- If PVCS (photovoltaic converter system) disconnection occurs during the application of the voltage dip in one of three (a, b, c) consecutive tests for each test category, the test of the PVCS shall not passed.
- U_{res}: P-N voltage of defective phase (Indication refers to MV-site)

The tests were carried out on the SOFAR 24KTLX-G3. The LVRT behaviour of the SOFAR 24KTLX-G3 can be applied to the SOFAR 15KTLX-G3, SOFAR 17KTLX-G3, SOFAR 20KTLX-G3 and SOFAR 22KTLX-G3.

Behaviour during grid disturbance

Schematic of test setup:



Note on test setup:

Instead of an LVRT test bench a low-voltage AC simulator was used.

Note:

Measurement points used: MP

Evaluation of data measured at MP.

Used sample rate: 10kHz

Description of the type of voltage dips:

Asymmetric voltage dips were simulated to mirror the behaviour during phase to phase faults (isolated) on a medium voltage grid separated by Dy5-transformer. Symmetric dips were simulated as three-phase faults (isolated) based on the same setup.

Grid parameters at MP	
Nominal voltage PCC // U_G [V]	230 V (P-N)
Nominal apparent power of test setup // S_n [kVA]	36
Grid impedance R_G [mΩ]	1,939
Grid reactance X_G [mΩ]	5,969
Test setup	
Grid simulator (grid conditions varied)	●
Test bench / free field test (internal limits of unit changed / status signal recorded)	○
Identifier of test setup	See *Annex 3 – Test equipment list*
Nominal apparent power of test setup // S_n [kVA]	N/A

Behaviour during grid disturbance

Note:

The values in the following tables are derived from the positive sequence component system of the corresponding dimension (with exception to the values which are derived from the time-series of the phases – see asterisk * in tables below).

Definition of the evaluated switching moments:

t_0: Opening of the bypass switch S1

t_1: $\boldsymbol{T_1}$ = Instant of start of the dip; one of the phases falls below the dip threshold

$\boldsymbol{T_2}$ = Instant of start of the bottom of the dip; moment in which one of the phases shows $U < U_{ref1}$

t_2: $\boldsymbol{T_3}$ = Instant of the end of the bottom of the dip, moment in, which all phases show $U > U_{ref2}$

$\boldsymbol{T_4}$ = Instant of the end of dip; moment in which the voltage in all of the channels measured is equal to or greater than the dip threshold.

Definition of zones to be evaluated:

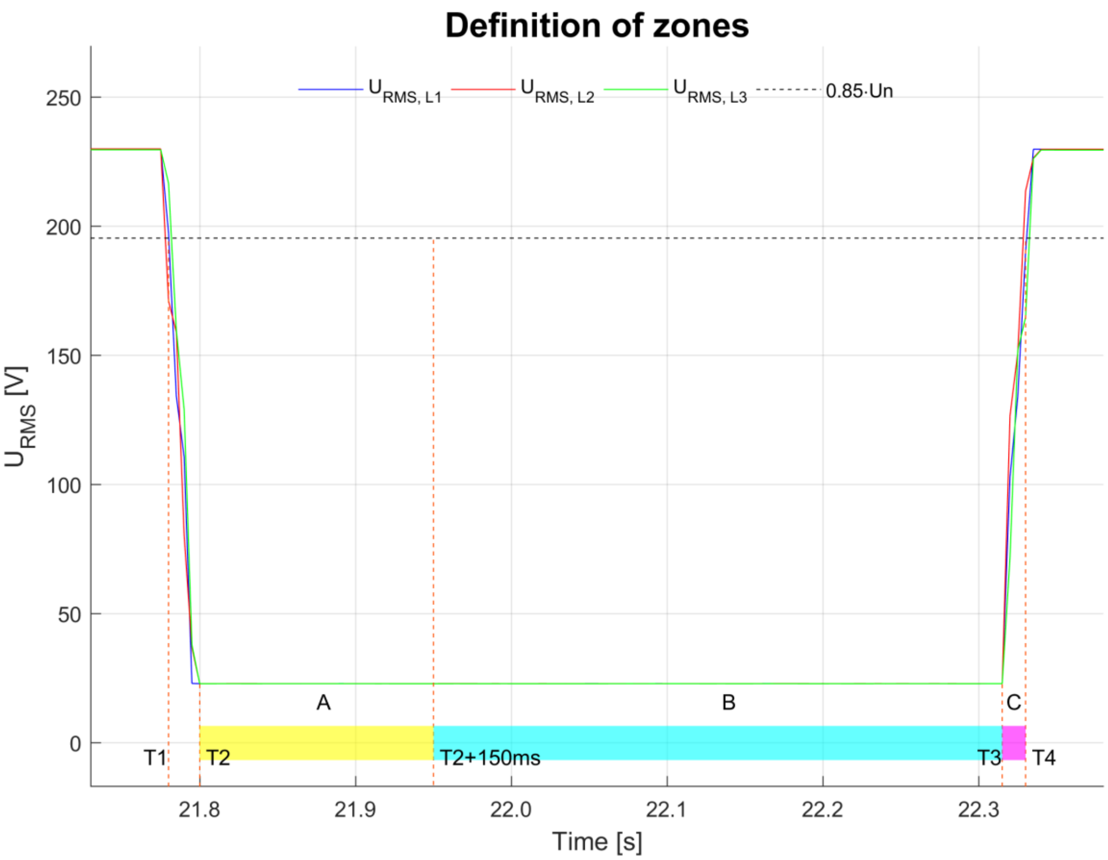
Zone A: From T_2 to T_2 + 150 ms

Zone B: From T_2 + 150 ms to T_3

Zone C: From T_3 to the lesser oft he following values, T_4 and T_3 + 150 ms

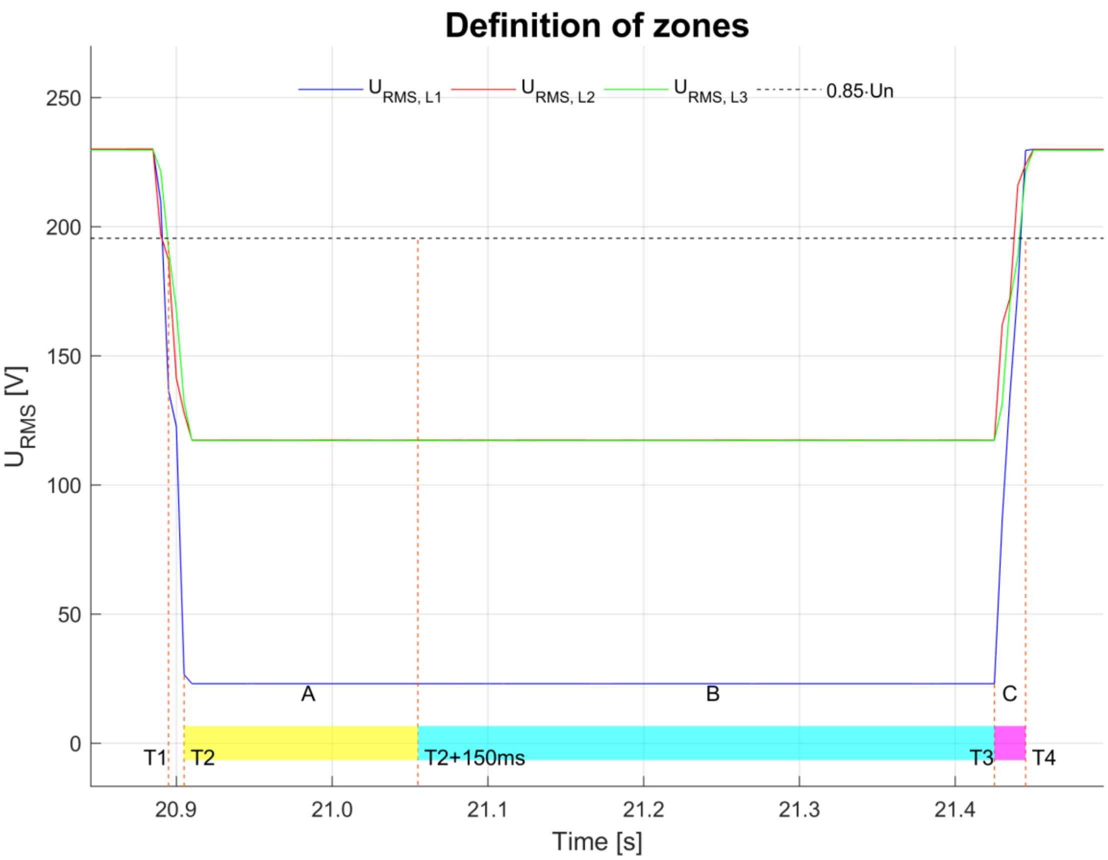
Behaviour during grid disturbance			
Test:			
Test no.	**0.1 (no load)**		
Phase no.	**1**	**2**	**3**
Fault duration t [ms]	>500	>500	>500
After evaluation			
Voltage $U_{Pre\text{-}Fault}$ [V] (Average of all phases)	229,7		
Fault condition:			
Residual voltage [V] (Average of all phases)	23,0		
Fault durationt [ms]	550,0		

RMS values of the phase-to-neutral voltages



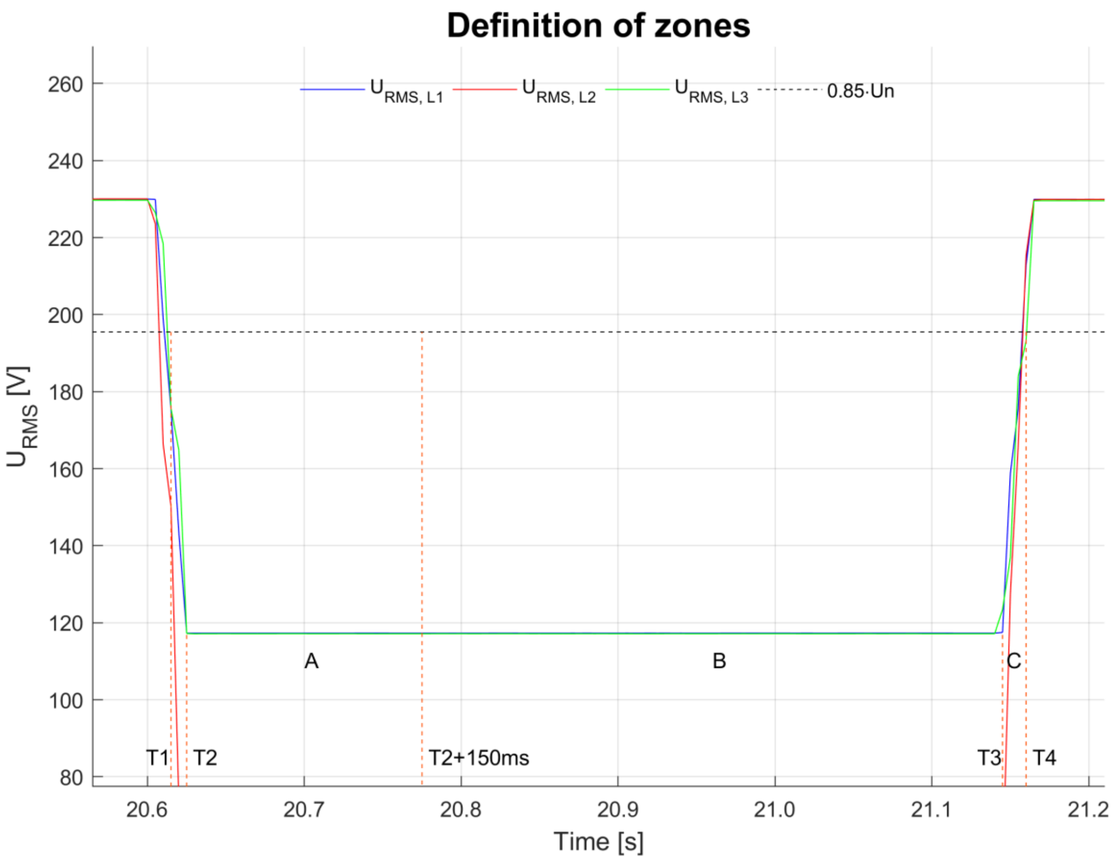
Behaviour during grid disturbance			
Test			
Test no.	**0.2.A (no load)**		
Phase no.	**1**	**2**	**3**
Fault duration t [ms]	>500	>500	>500
After evaluation			
Voltage $U_{Pre\text{-}Fault}$ [V] (Average of all phases)	229,7		
Fault condition:			
Residual voltage [V]	23,0	117,3	117,1
Fault duration t [ms]	550,0		

RMS values of the phase-to-neutral voltages



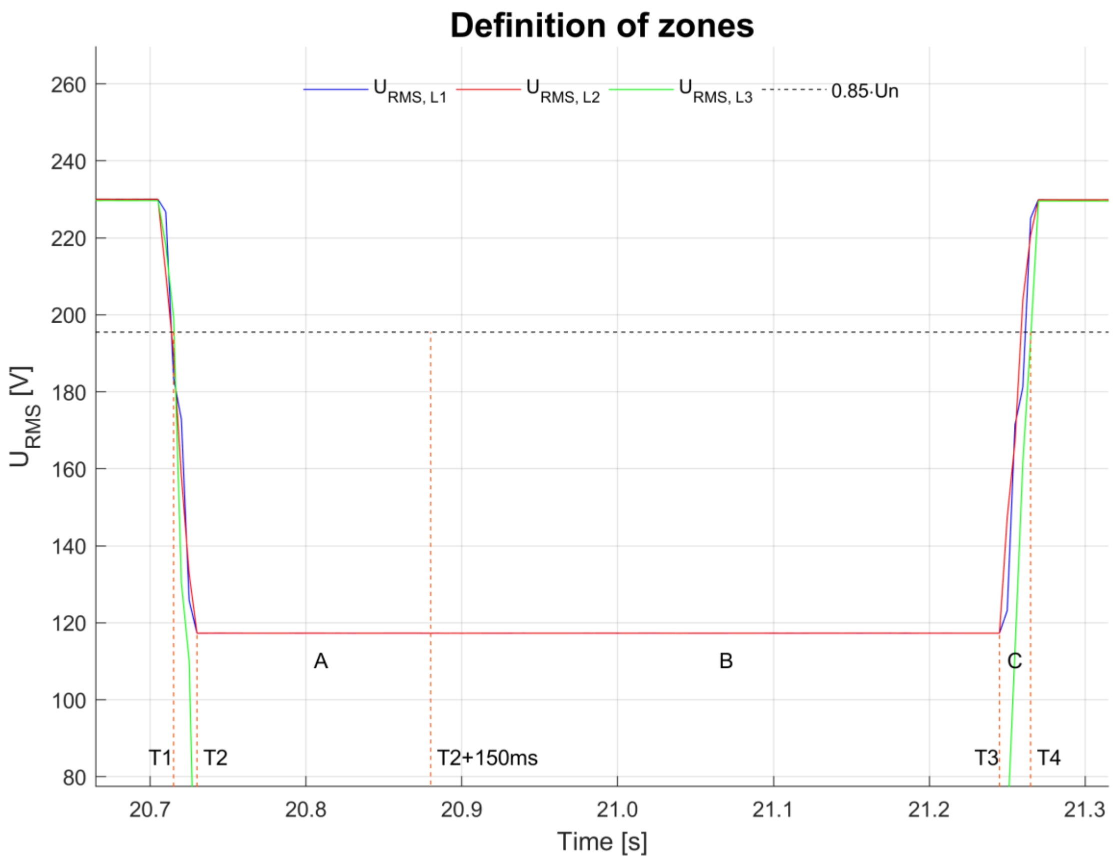
Behaviour during grid disturbance			
Test			
Test no.	**0.2.B (no load)**		
Phase no.	**1**	**2**	**3**
Fault duration t [ms]	>500	>500	>500
After evaluation			
Voltage $U_{Pre-Fault}$ [V] (Average of all phases)	229,7		
Fault condition:			
Residual voltage [V]	117,3	23,0	117,1
Fault duration t [ms]	545,0		

RMS values of the phase-to-neutral voltages



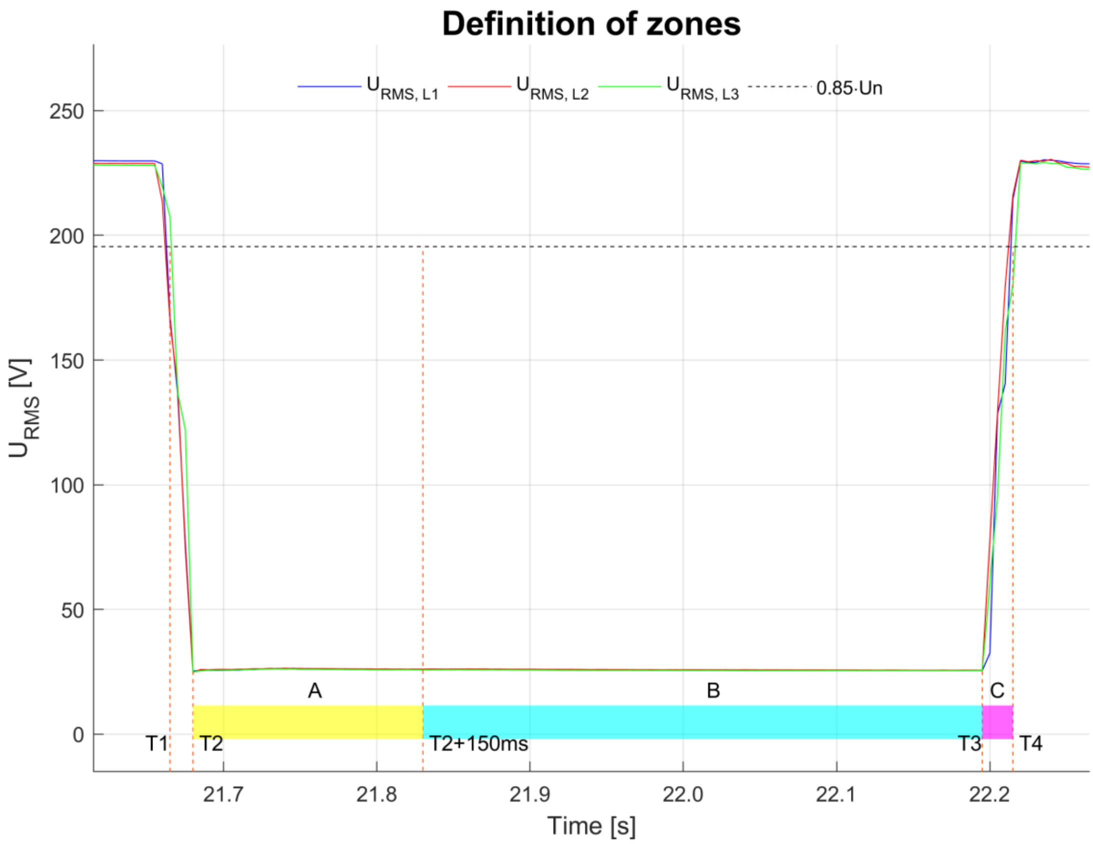
Behaviour during grid disturbance			
Test			
Test no.	**0.2.C (no load)**		
Phase no.	**1**	**2**	**3**
Fault duration t [ms]	>500	>500	>500
After evaluation			
Voltage $U_{Pre\text{-}Fault}$ [V] (Average of all phases)	229,7		
Fault condition:			
Residual voltage [V]	117,3	117,3	23,0
Fault duration t [ms]	550,0		

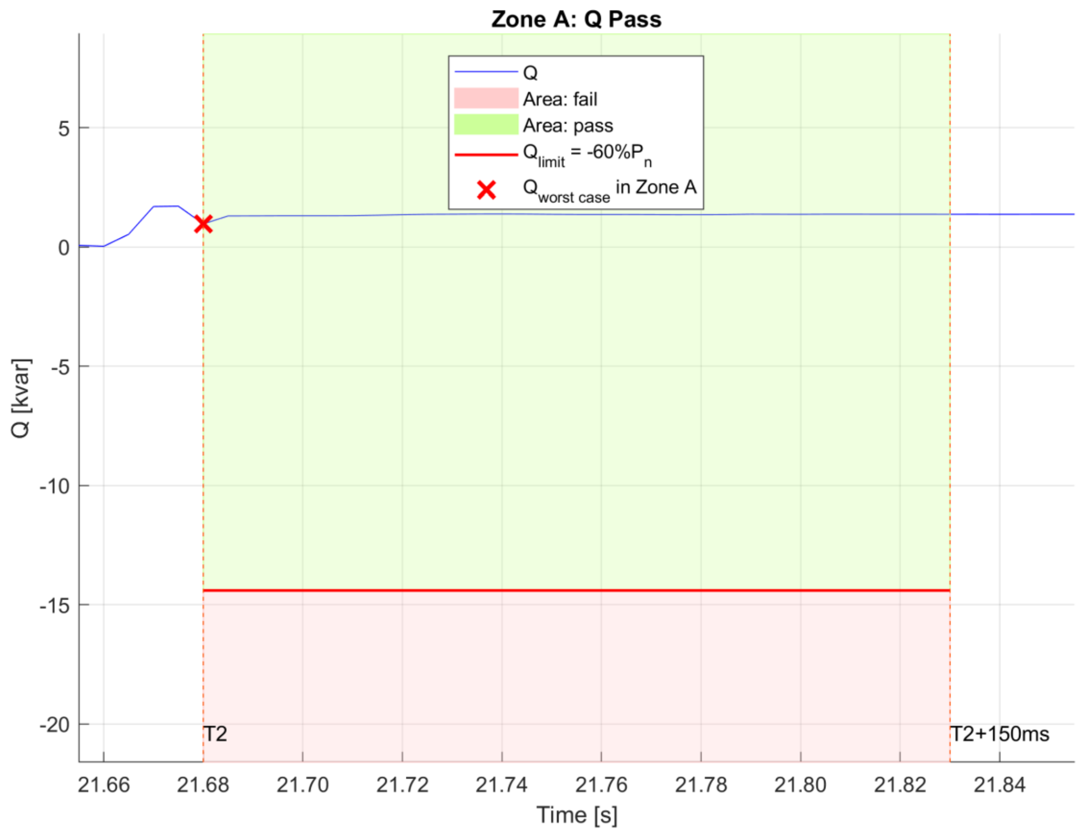
RMS values of the phase-to-neutral voltages



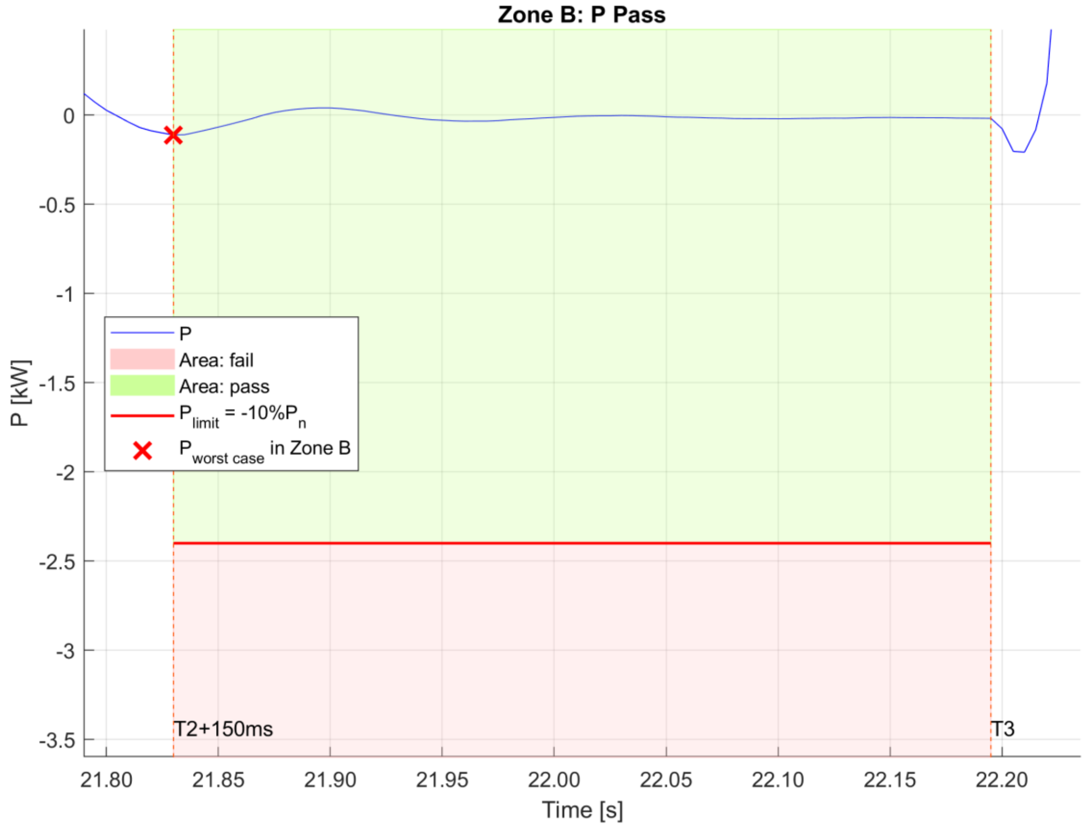
Behaviour during grid disturbance		
Three-phase-system		
1.1 Symmetric faults		
Measurement A		**P**
Test no. 1.1.1		
SOFAR 24KTLX-G3		
	P.O.12.3 Requirement	**Result**
A ZONE		
Net consumption Q < 60% P_n (20 ms)	-0,6 p.u.	0,04 p.u.
B ZONE		
Net consumption P < 10% P_n (20 ms)	-0,1 p.u.	-0,005 p.u.
Average I_r/I_{tot}	0,9 p.u.	1 p.u.
C ZONE		
Net consumption E_r < 60% P_n *150 ms	-90·ms·p.u.	3,376 ms·p.u.
Net consumption I_r < 1.5 I_n (20 ms)	-1,5 p.u.	0,277 p.u.

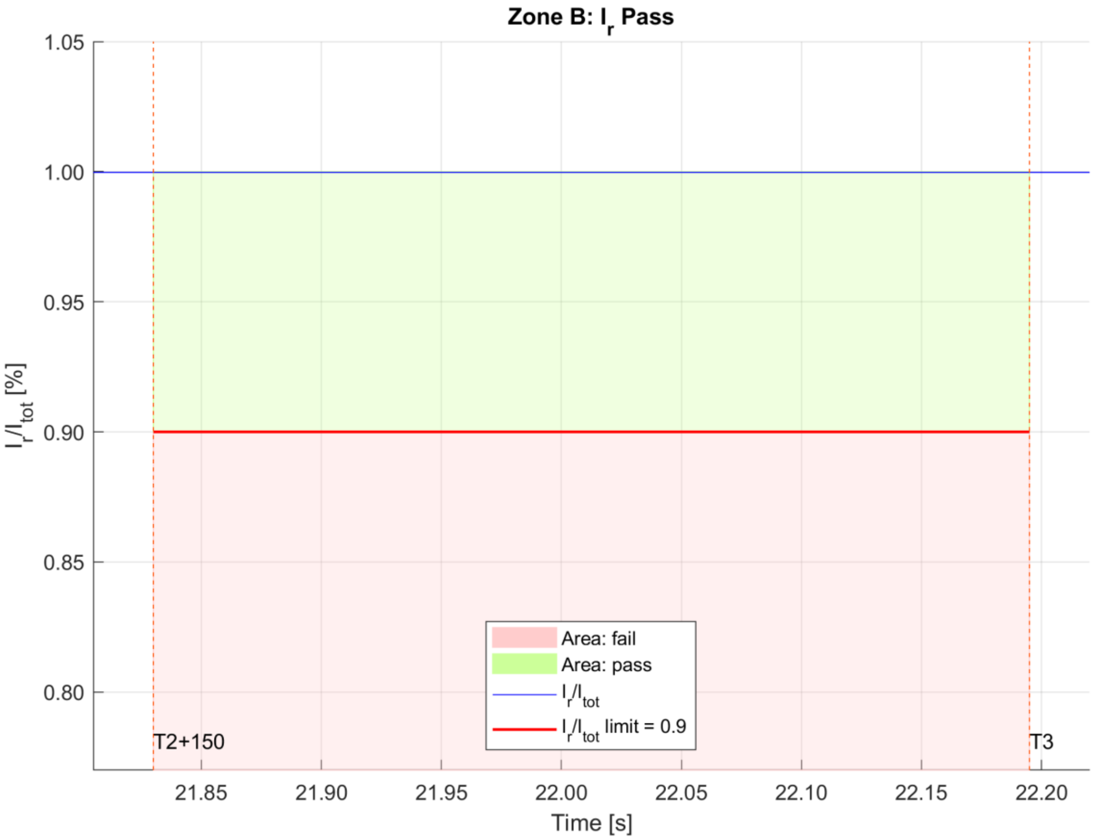
Behaviour during grid disturbance



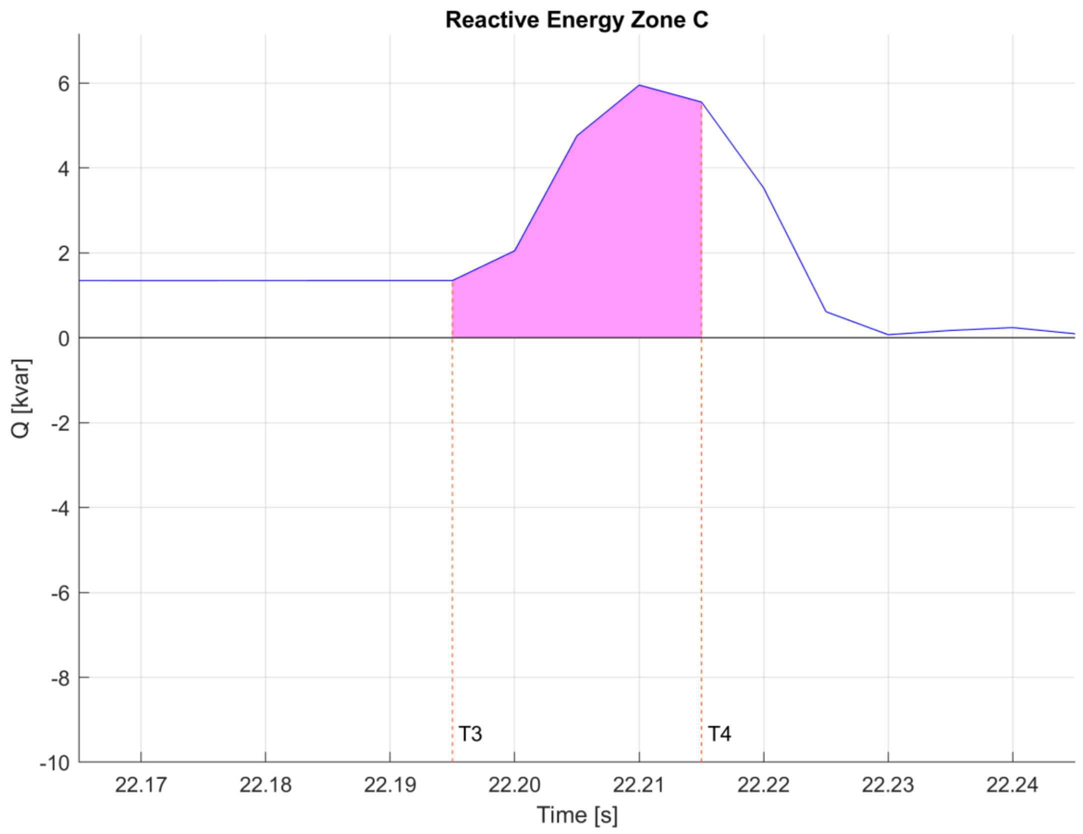


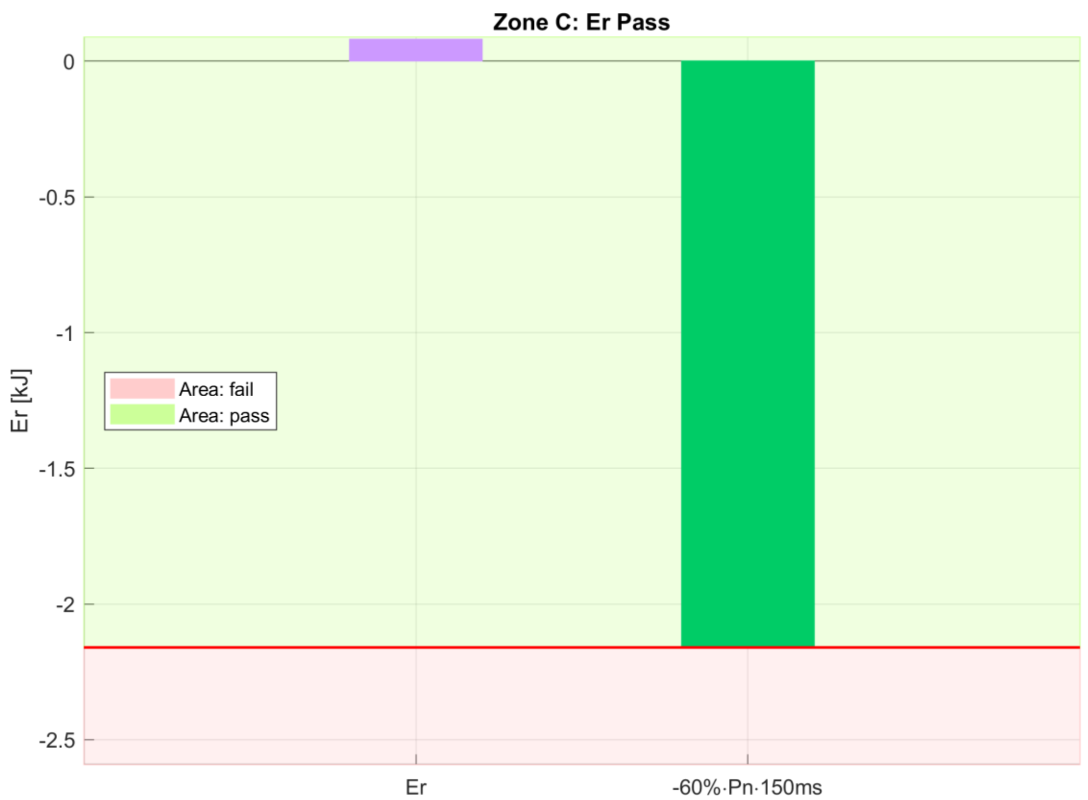
Behaviour during grid disturbance



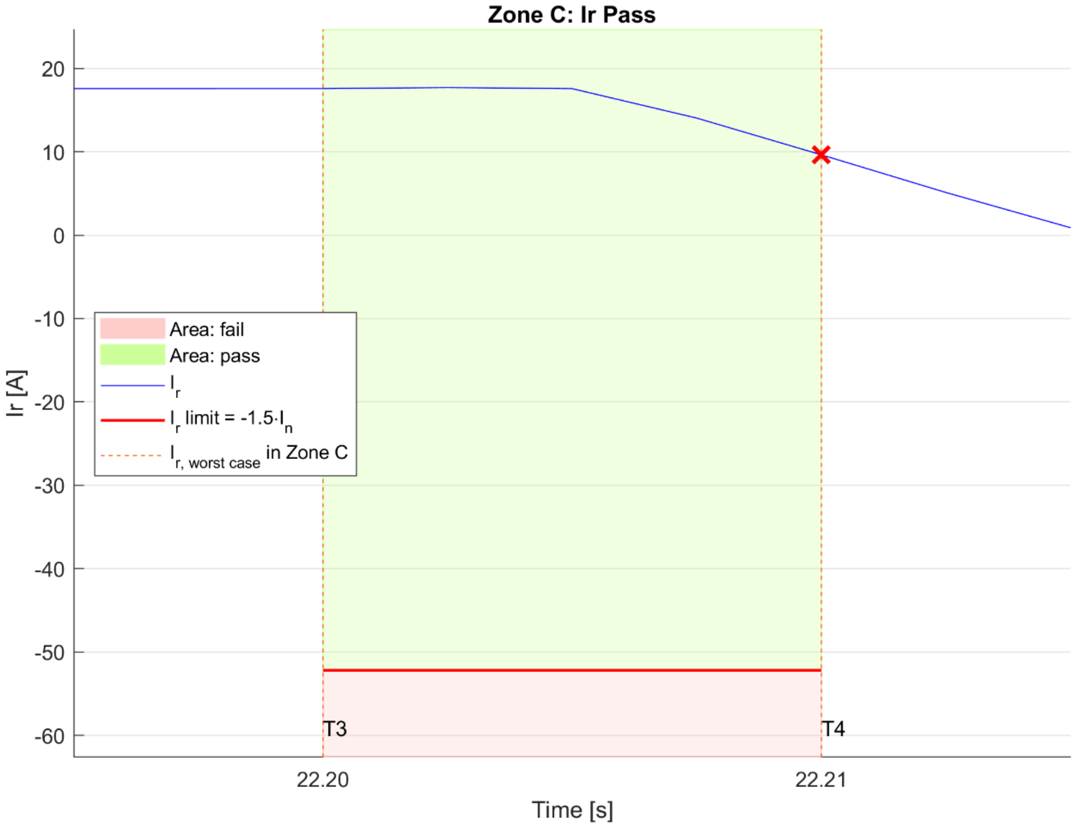


Behaviour during grid disturbance



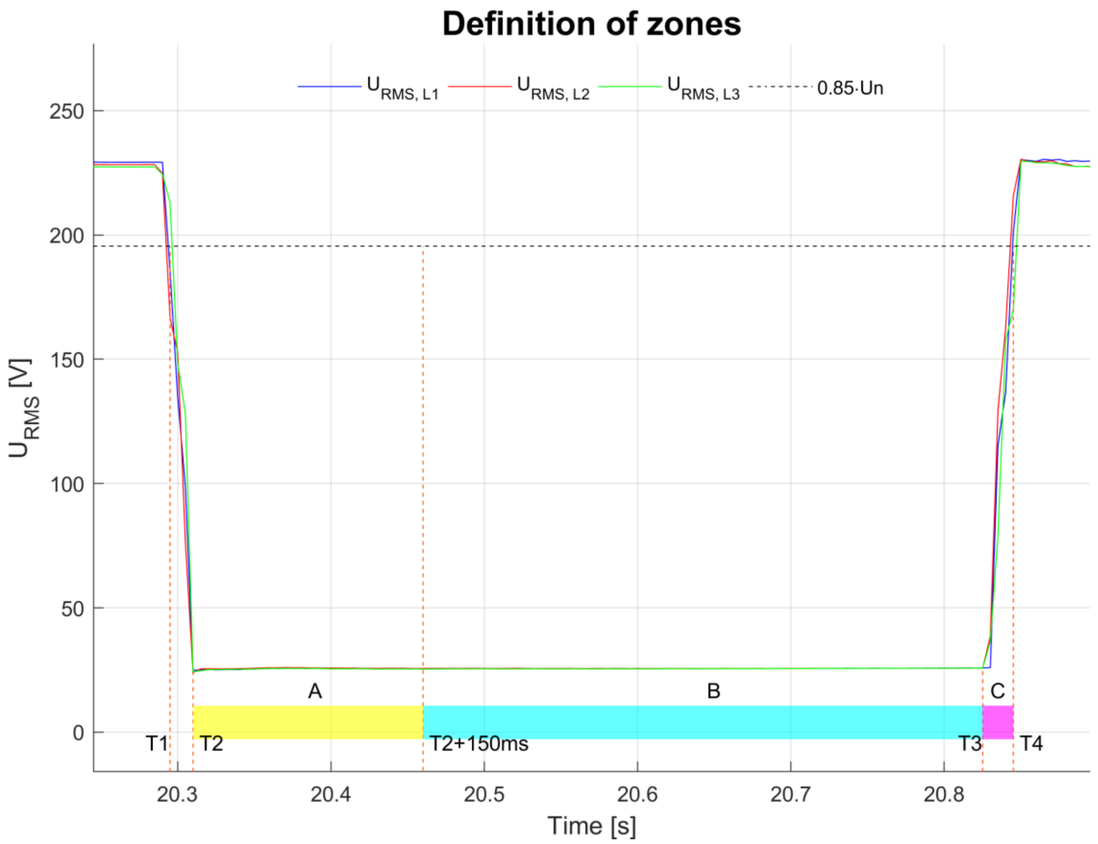


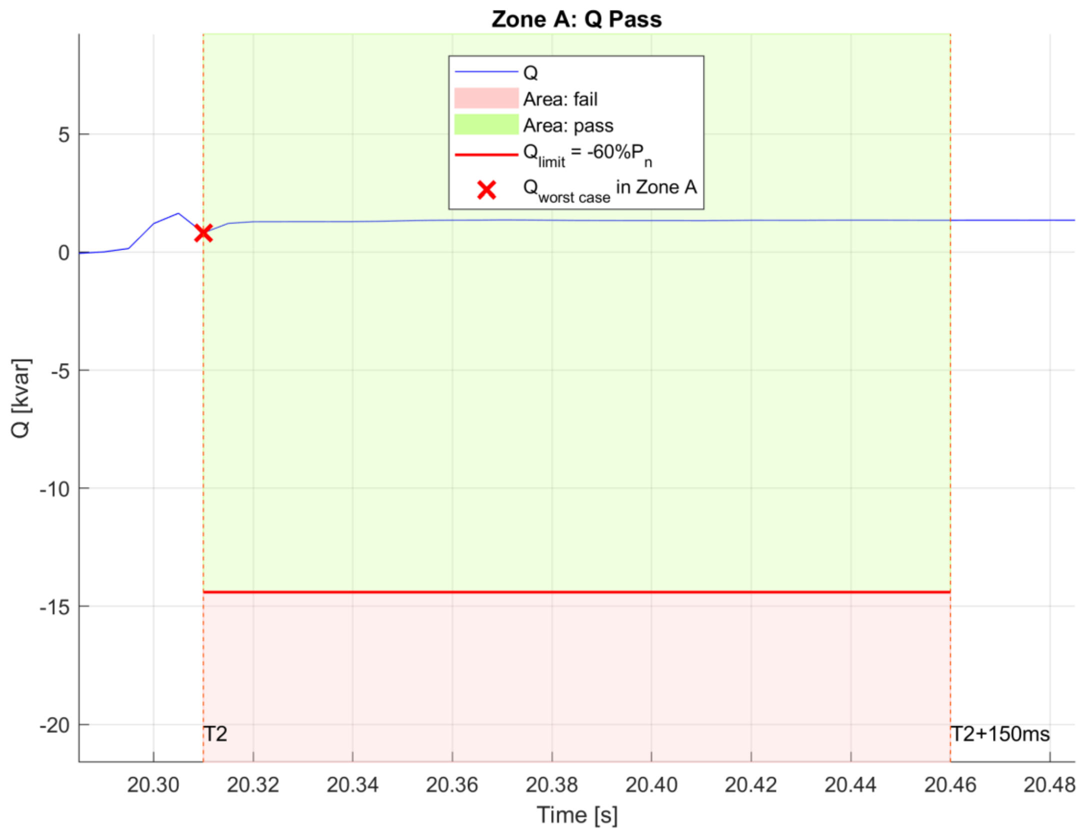
Behaviour during grid disturbance



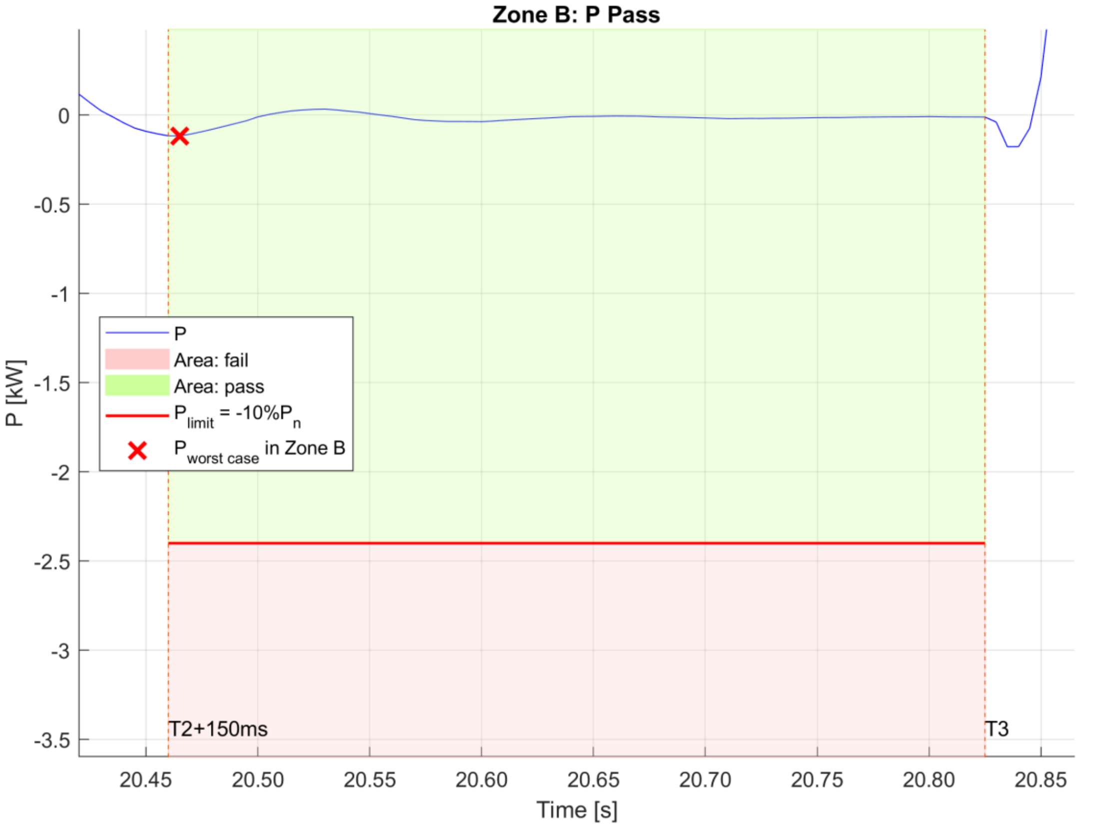
Behaviour during grid disturbance		
Three-phase-system		
1.1 Symmetric faults		
Measurement B		**P**
Test no. 1.1.1		
SOFAR 24KTLX-G3		
	P.O.12.3 Requirement	**Result**
A ZONE		
Net consumption Q < 60% P_n (20 ms)	-0,6 p.u.	0,034 p.u.
B ZONE		
Net consumption P < 10% P_n (20 ms)	-0,1 p.u.	-0,005 p.u.
Average I_r/I_{tot}	0,9 p.u.	1 p.u.
C ZONE		
Net consumption E_r < 60% P_n *150 ms	-90·ms·p.u.	3,263 ms·p.u.
Net consumption I_r < 1.5 I_n (20 ms)	-1,5 p.u.	0,32 p.u.

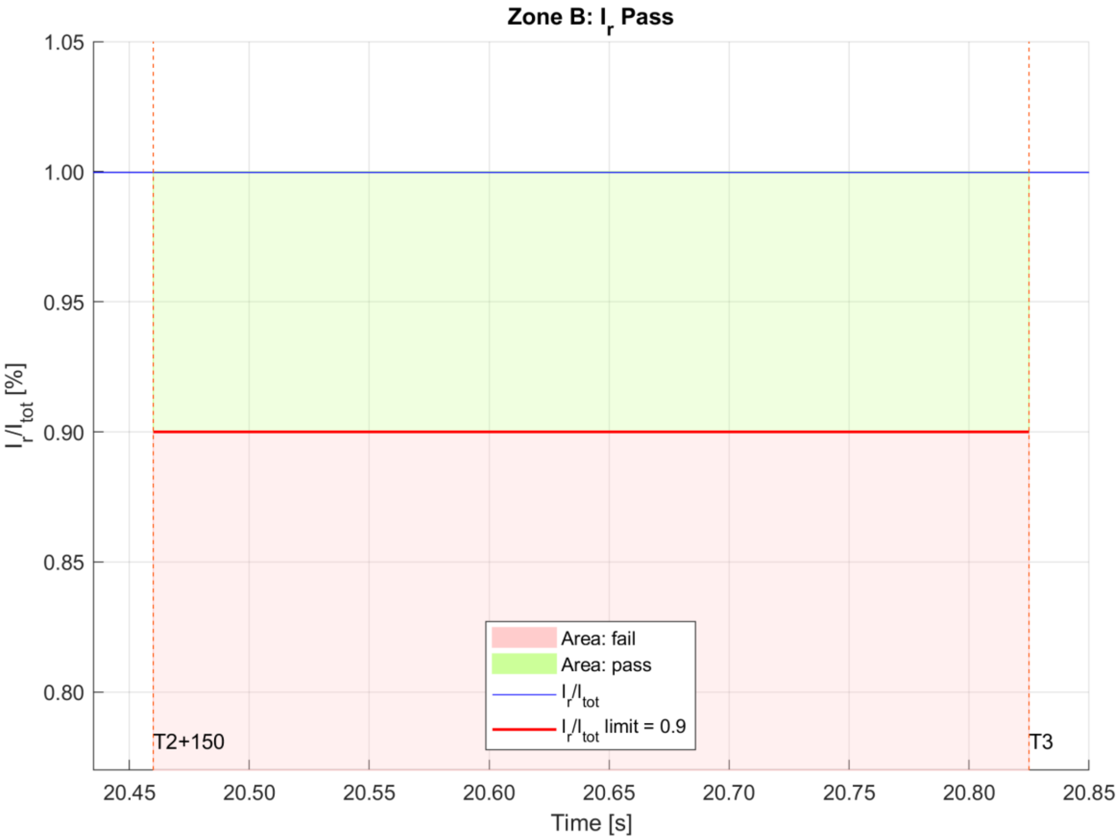
Behaviour during grid disturbance



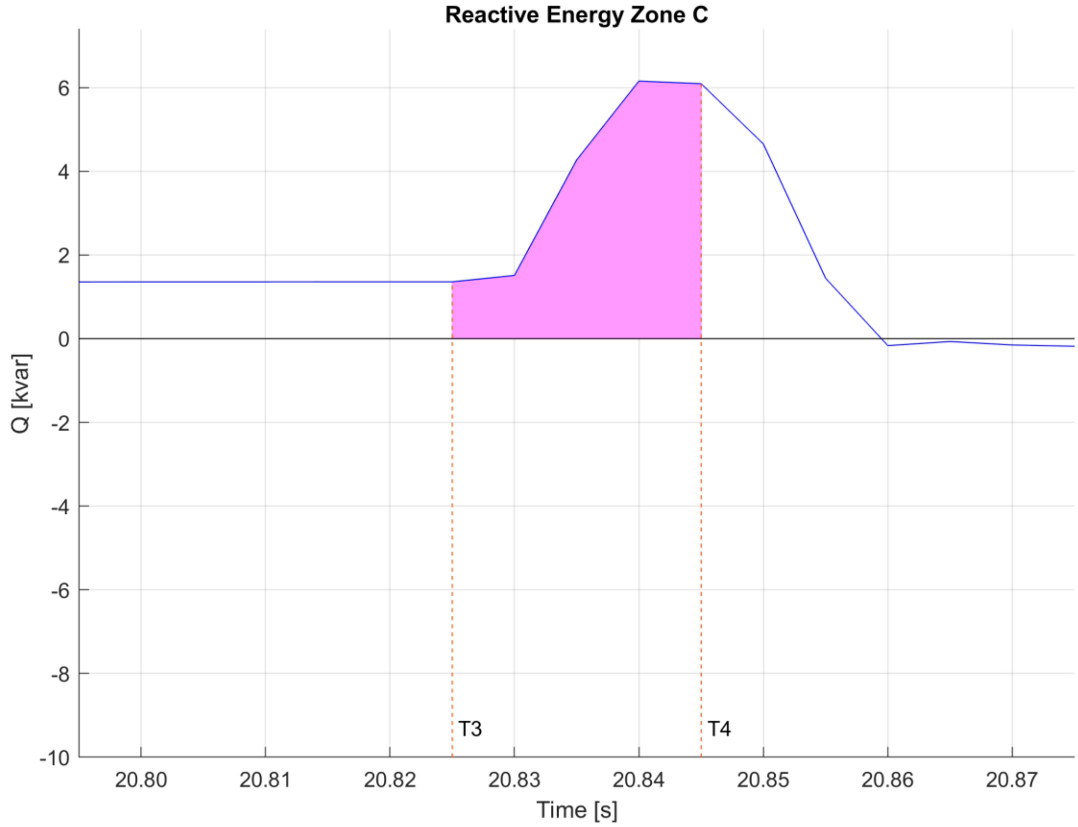


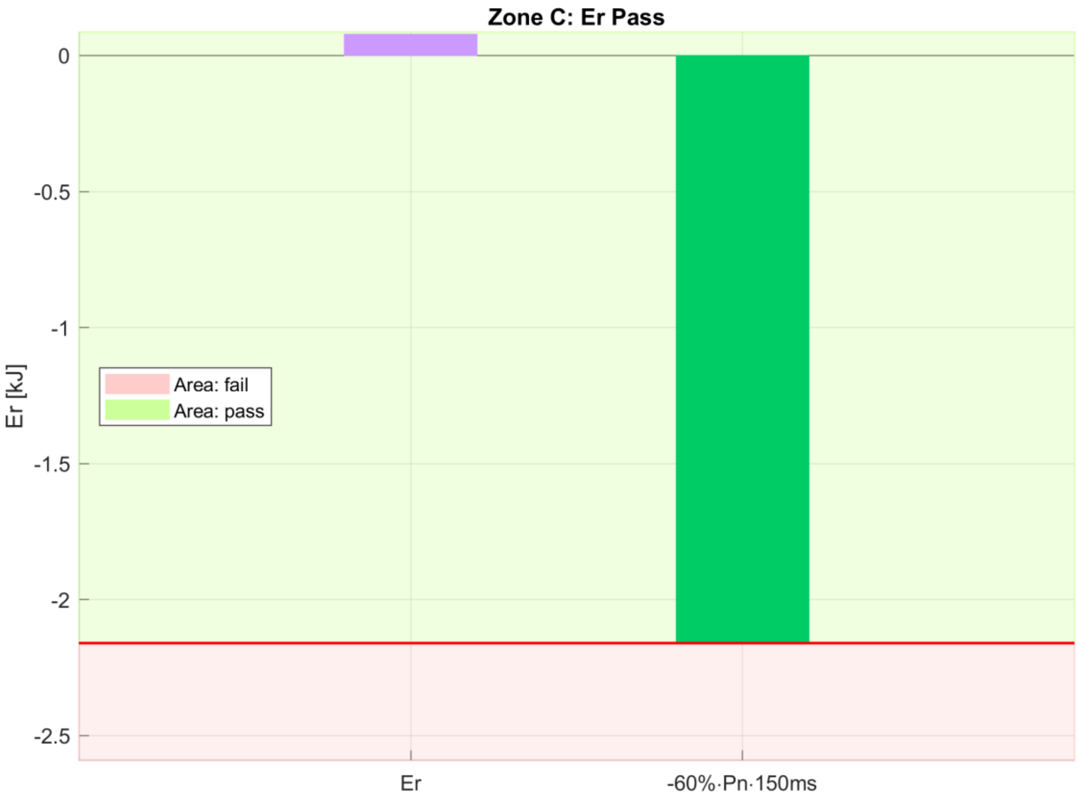
Behaviour during grid disturbance



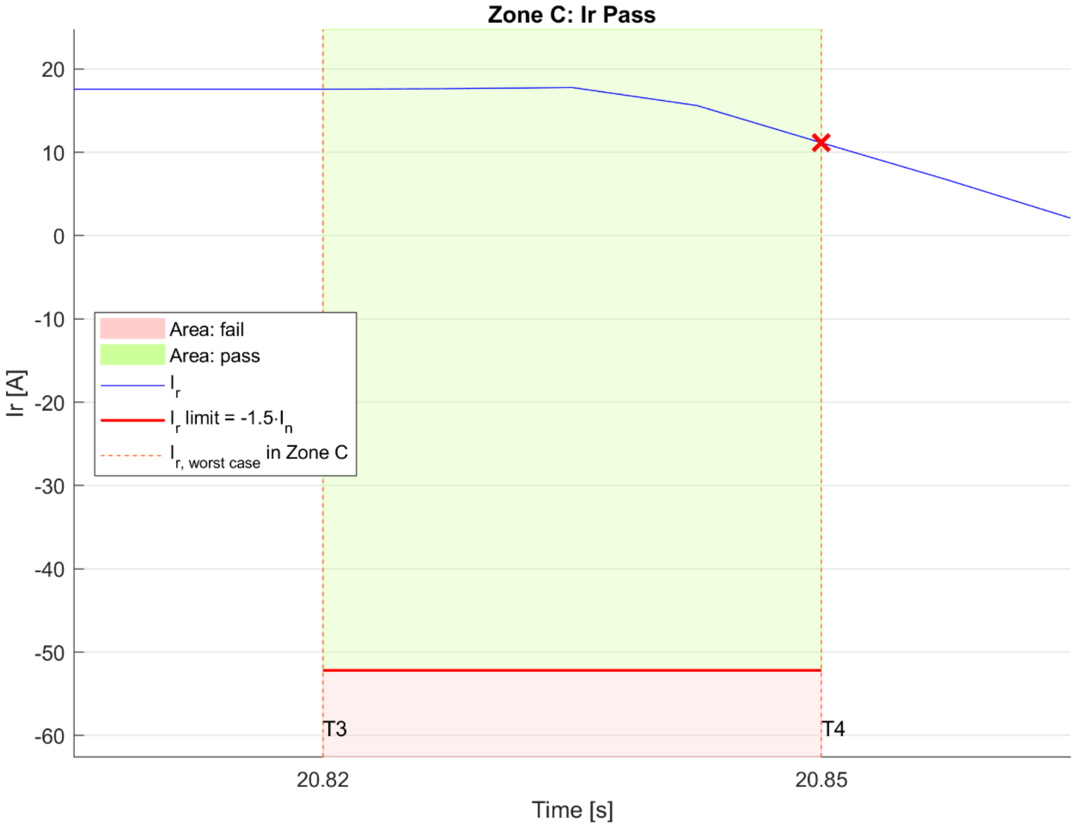


Behaviour during grid disturbance



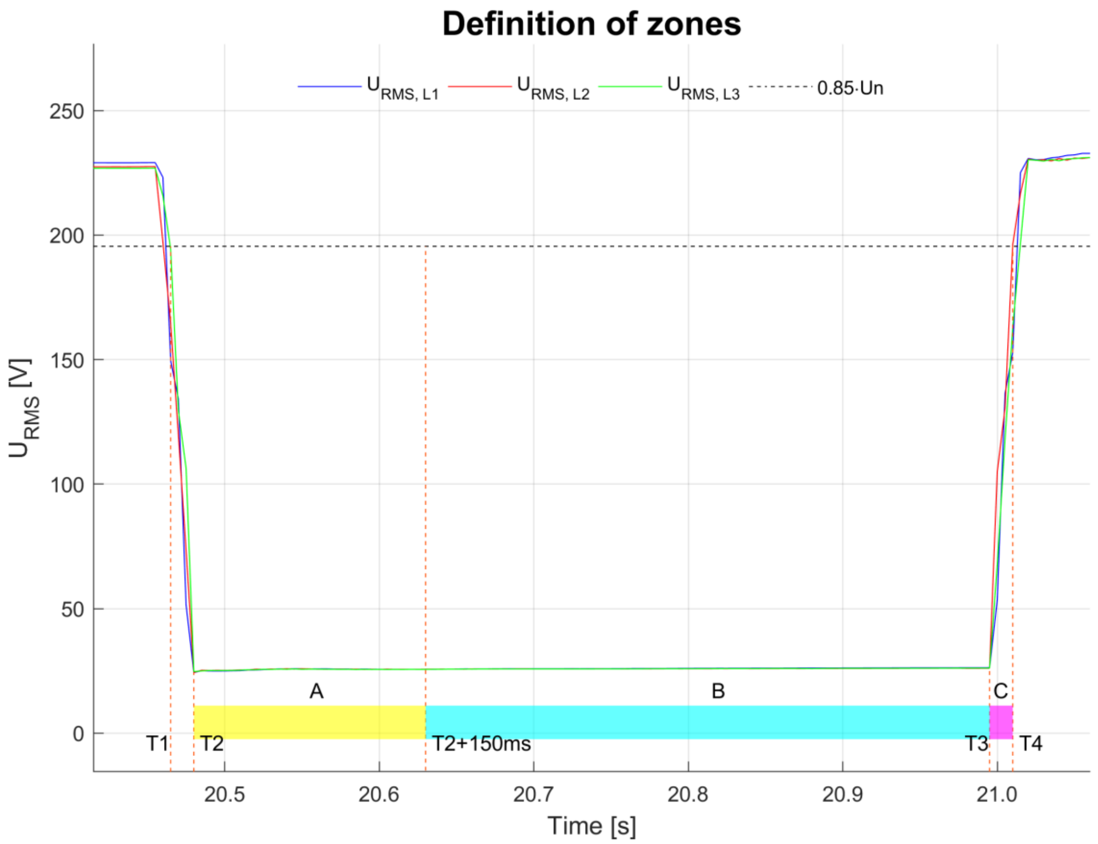


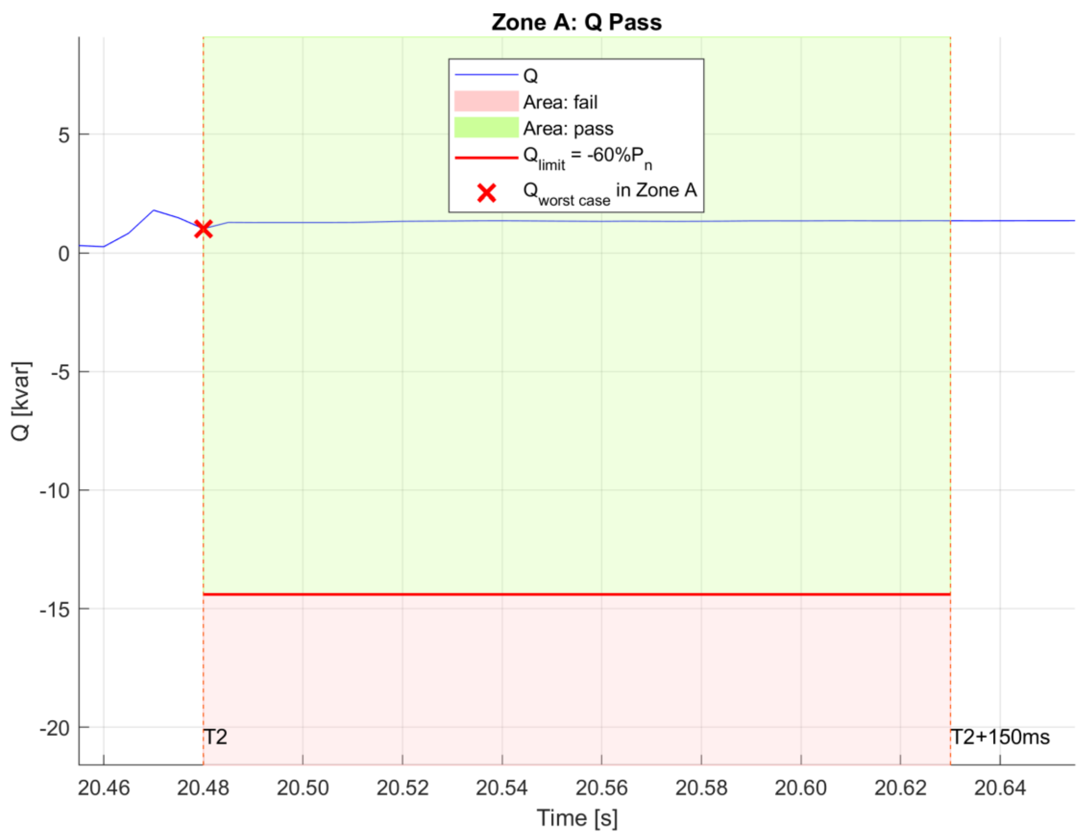
Behaviour during grid disturbance



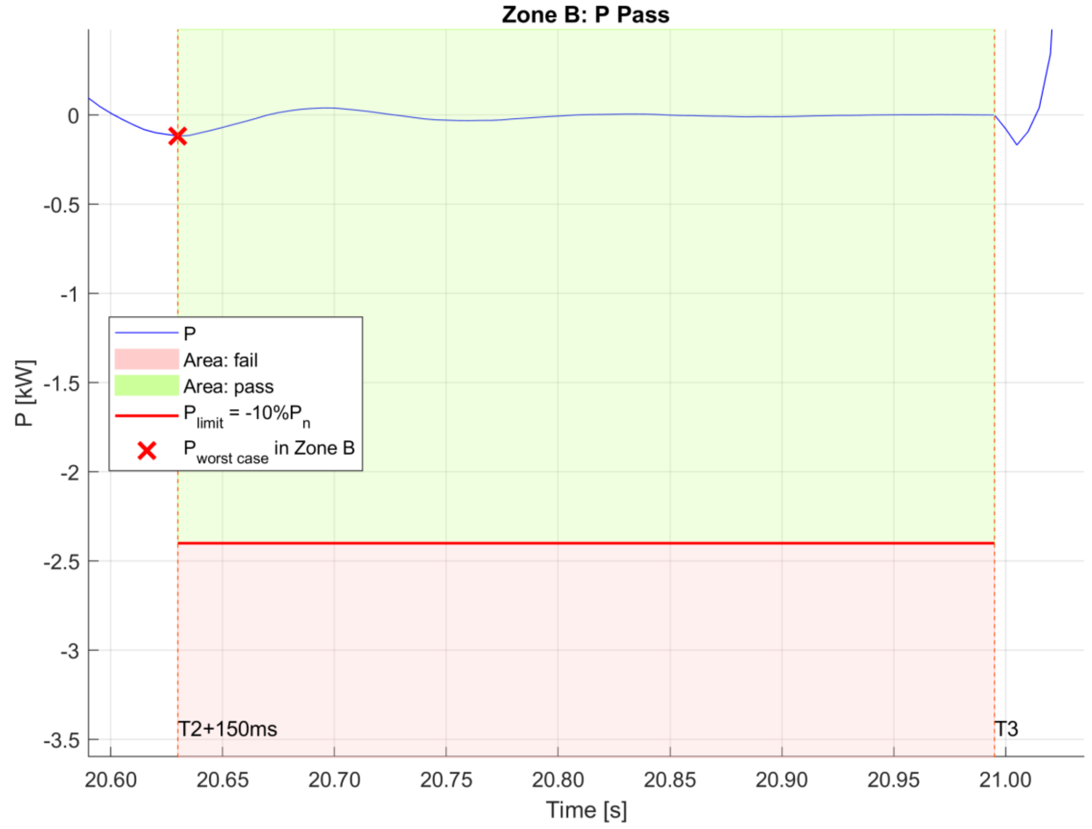
Behaviour during grid disturbance		
Three-phase-system		
1.1 Symmetric faults		
Measurement C		**P**
Test no. 1.1.1		
SOFAR 24KTLX-G3		
	P.O.12.3 Requirement	**Result**
A ZONE		
Net consumption Q < 60% P_n (20 ms)	-0,6 p.u.	0,042 p.u.
B ZONE		
Net consumption P < 10% P_n (20 ms)	-0,1 p.u.	-0,005 p.u.
Average I_r/I_{tot}	0,9 p.u.	1 p.u.
C ZONE		
Net consumption E_r < 60% P_n *150 ms	-90·ms·p.u.	2,439 ms·p.u.
Net consumption I_r < 1.5 I_n (20 ms)	-1,5 p.u.	0,38 p.u.

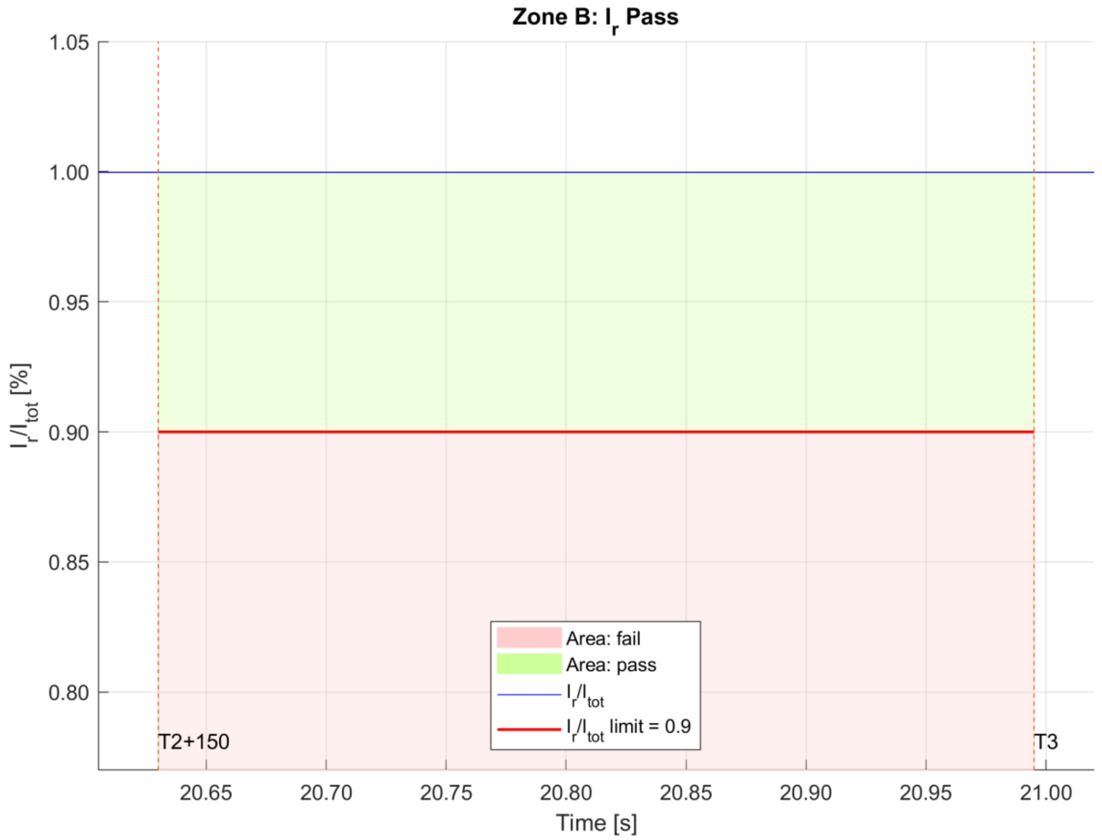
Behaviour during grid disturbance



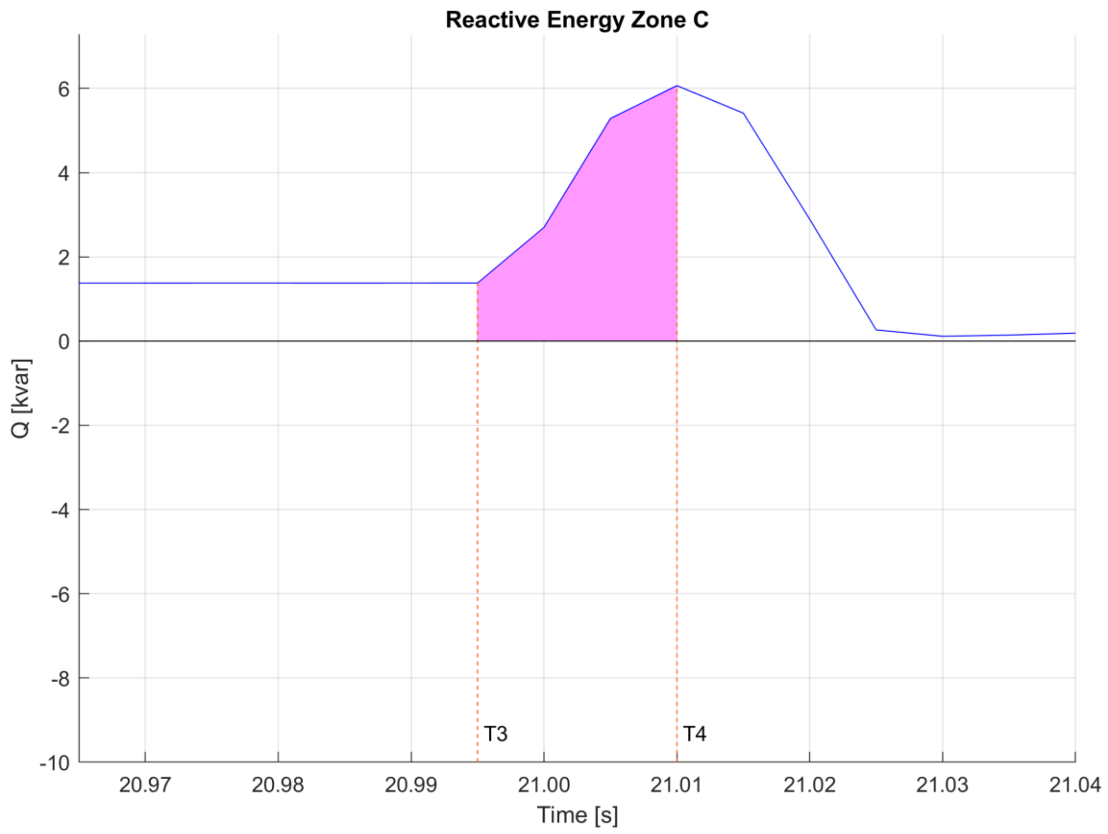


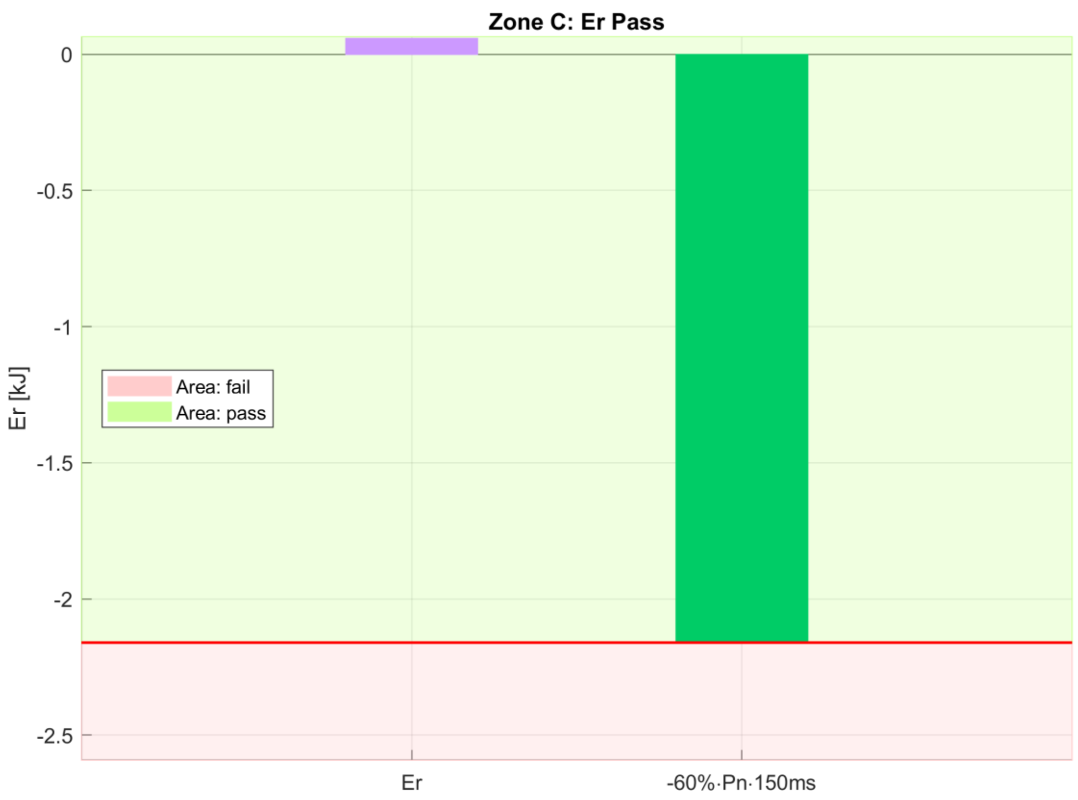
Behaviour during grid disturbance



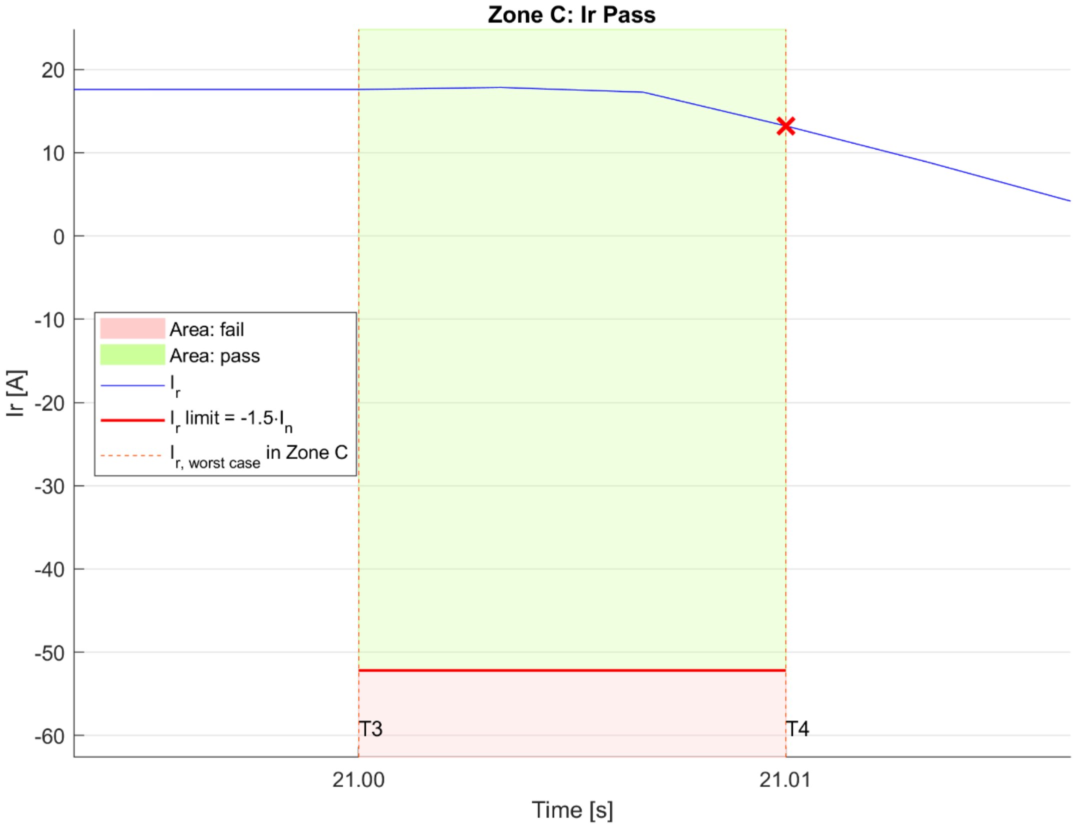


Behaviour during grid disturbance



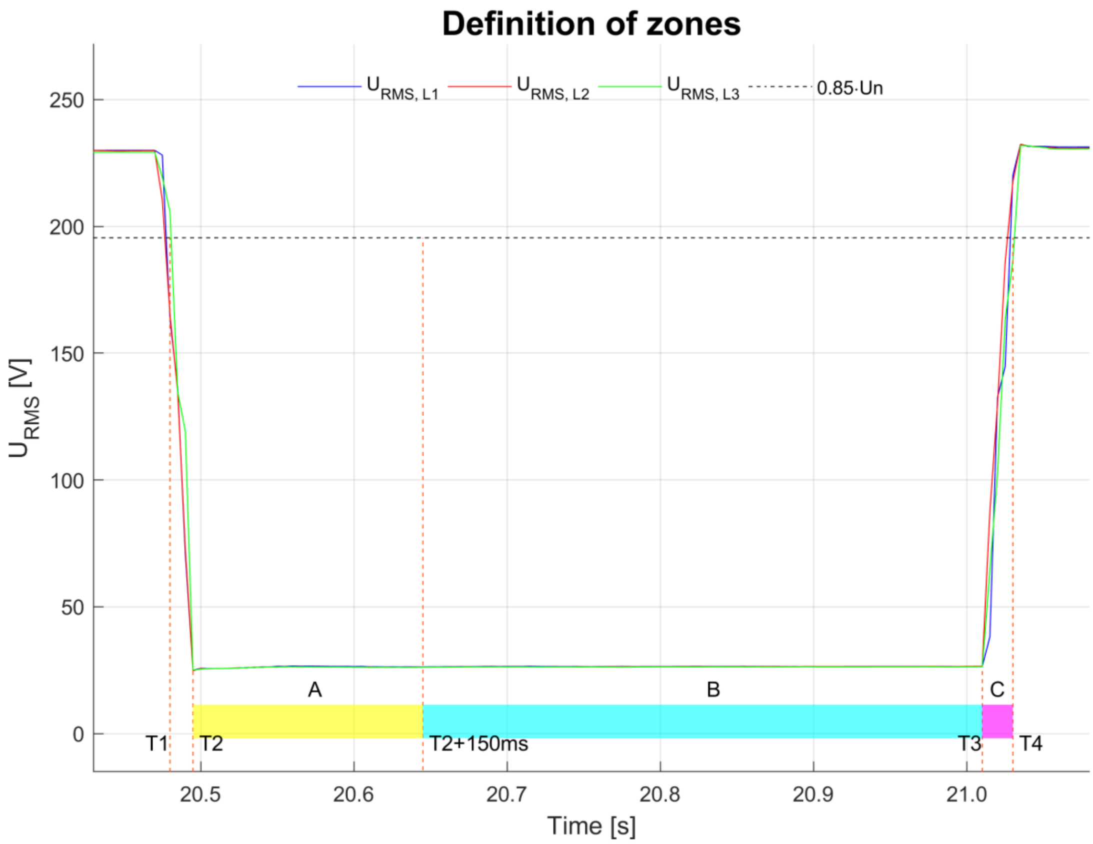


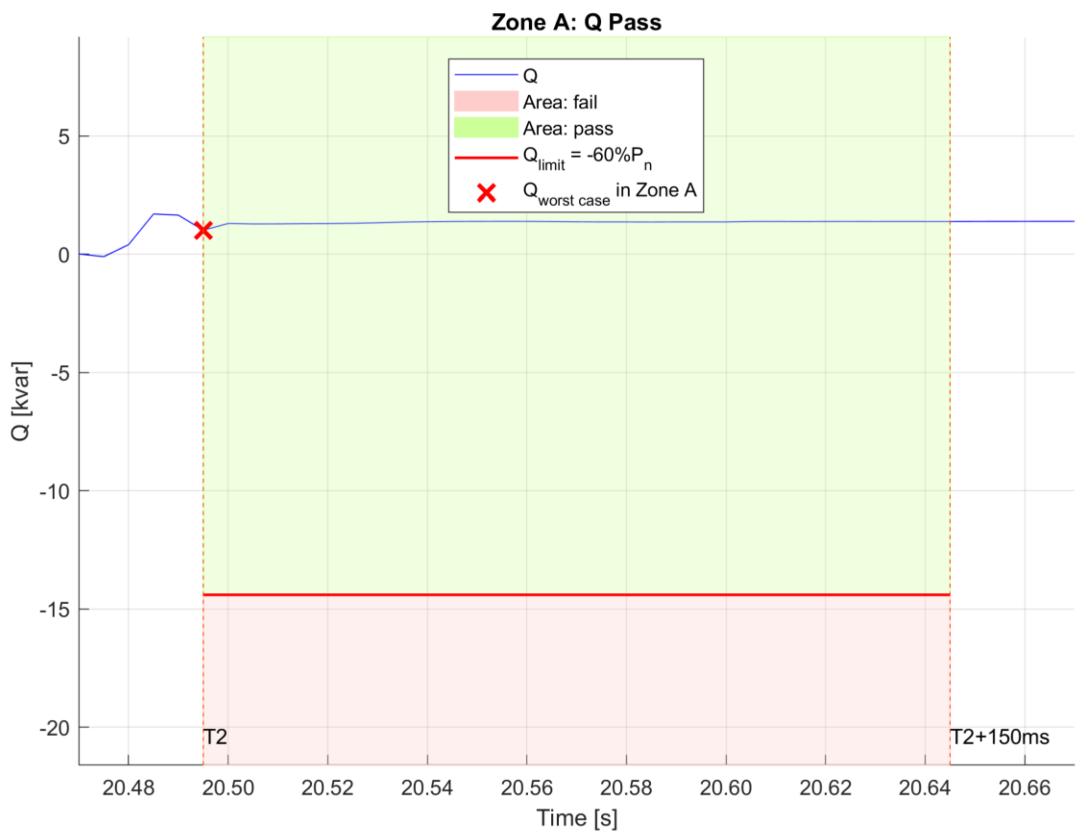
Behaviour during grid disturbance



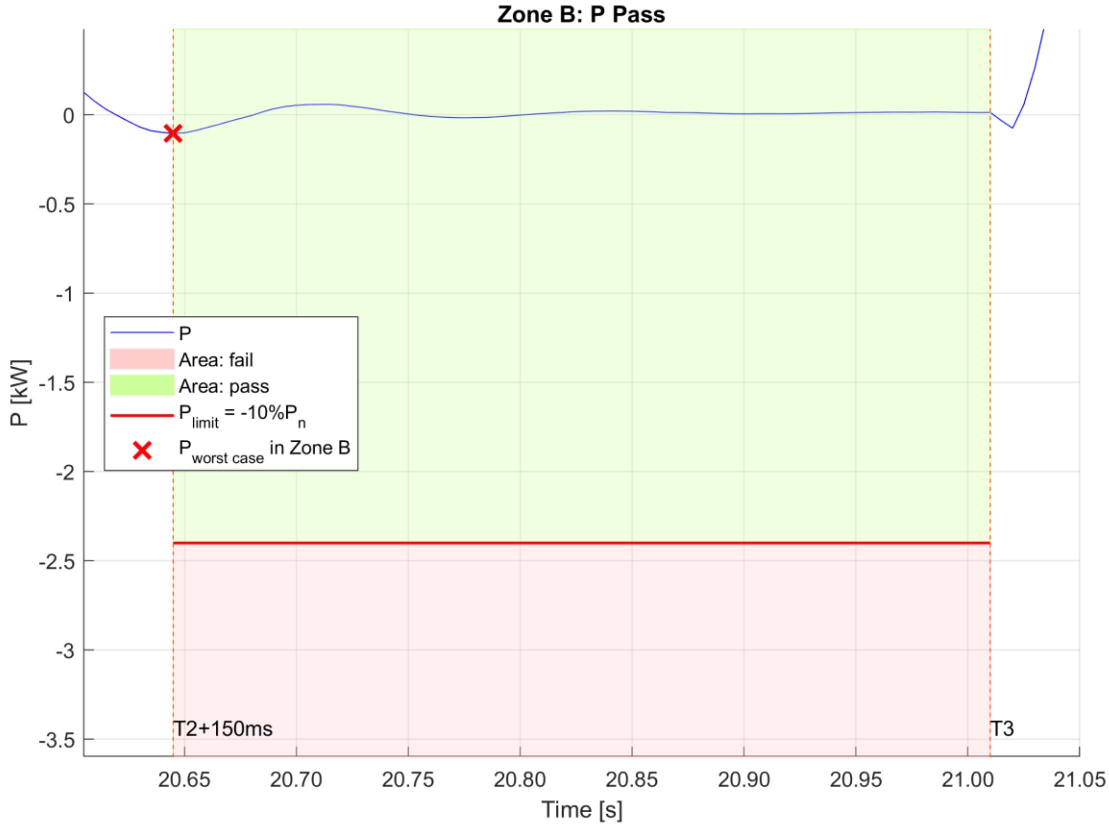
Behaviour during grid disturbance		
Three-phase-system		
1.1 Symmetric faults		
Measurement A		**P**
Test no. 1.1.2		
SOFAR 24KTLX-G3		
	P.O.12.3 Requirement	**Result**
A ZONE		
Net consumption Q < 60% P_n (20 ms)	-0,6 p.u.	0,042 p.u.
B ZONE		
Net consumption P < 10% P_n (20 ms)	-0,1 p.u.	-0,004 p.u.
Average I_r/I_{tot}	0,9 p.u.	1 p.u.
C ZONE		
Net consumption E_r < 60% P_n *150 ms	-90·ms·p.u.	3,528 ms·p.u.
Net consumption I_r < 1.5 I_n (20 ms)	-1,5 p.u.	0,276 p.u.

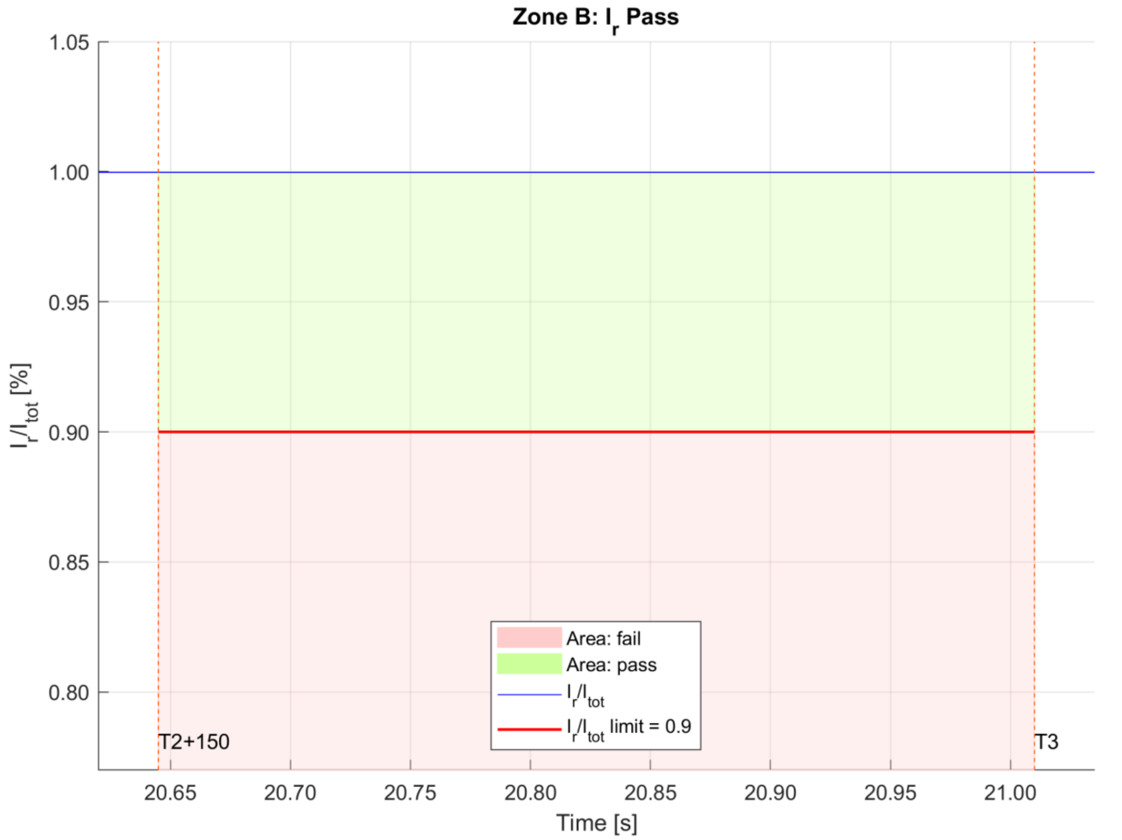
Behaviour during grid disturbance



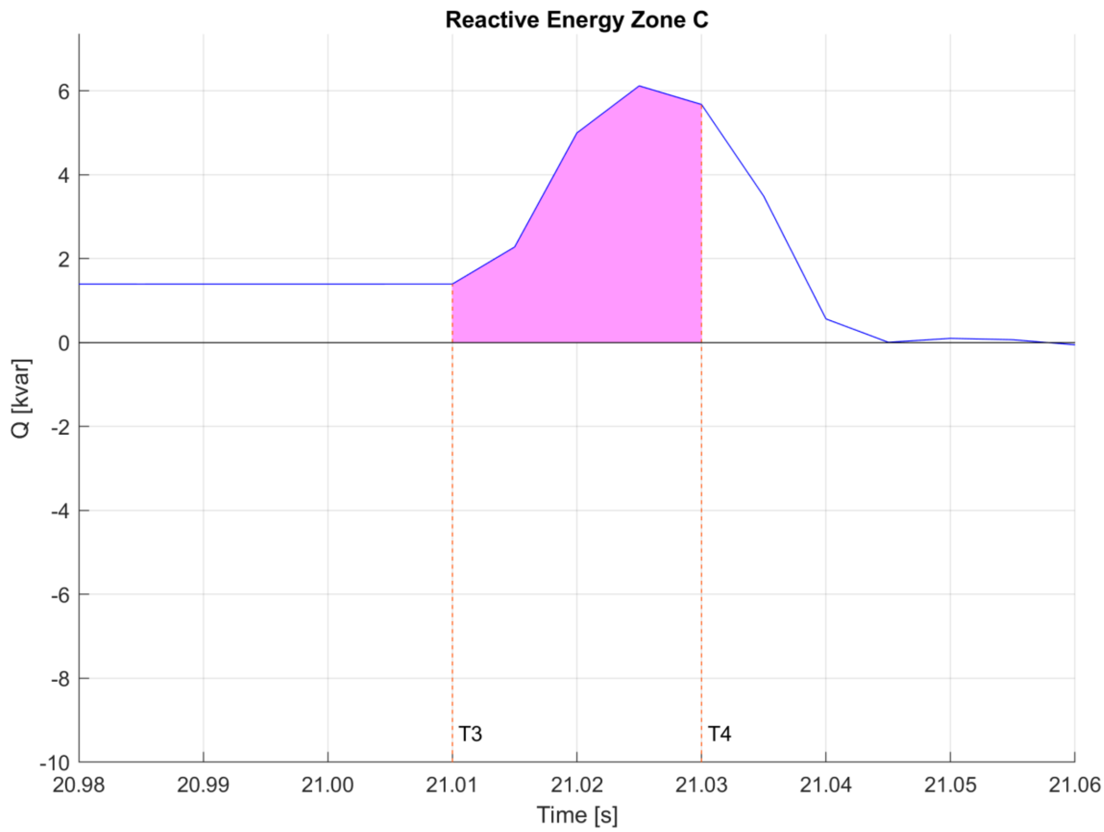


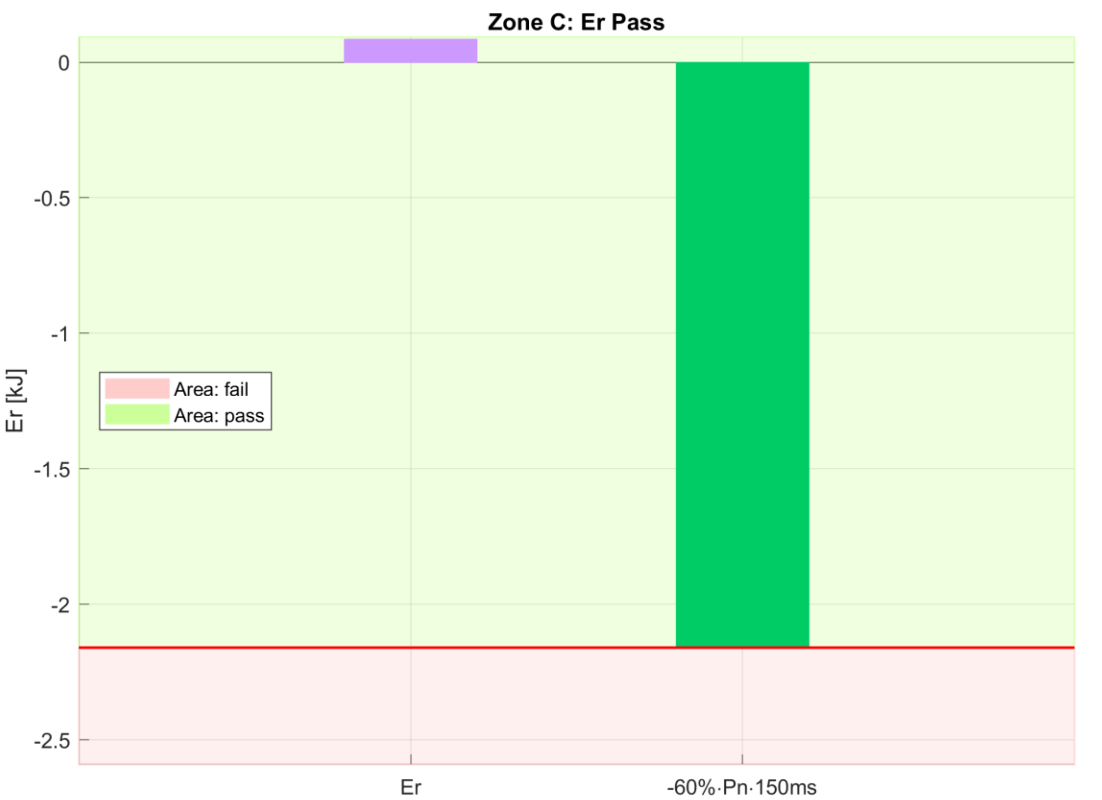
Behaviour during grid disturbance



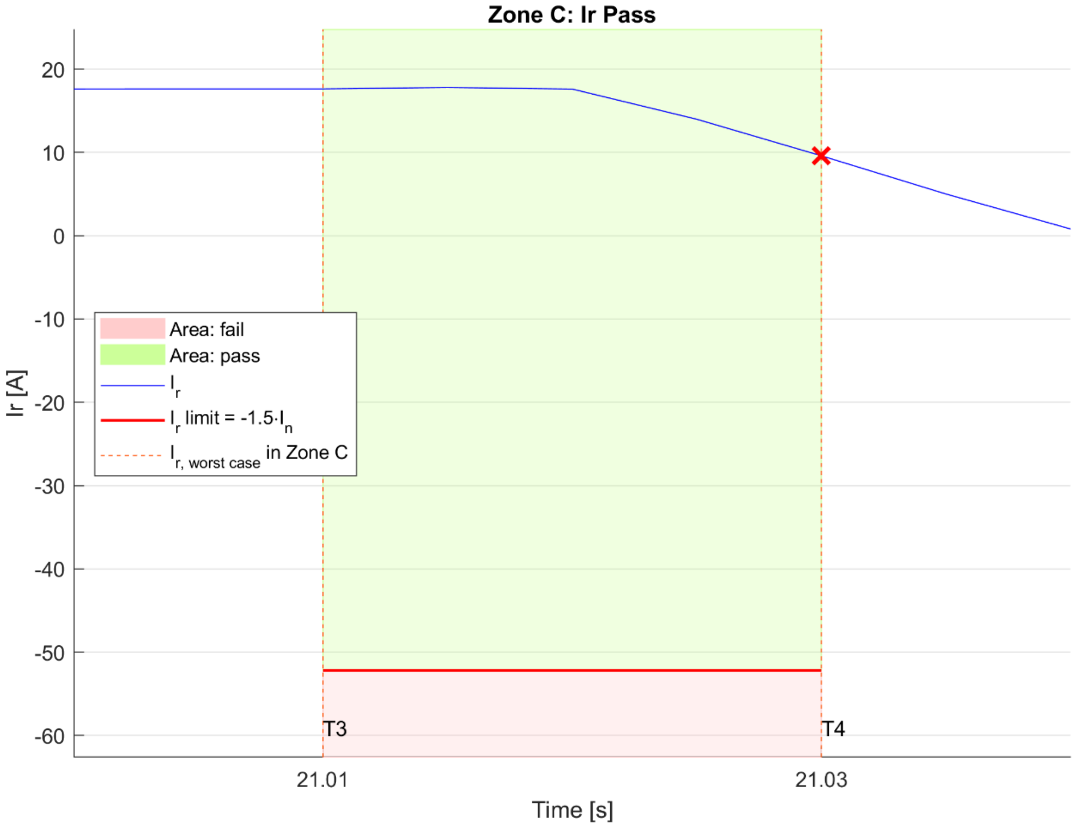


Behaviour during grid disturbance



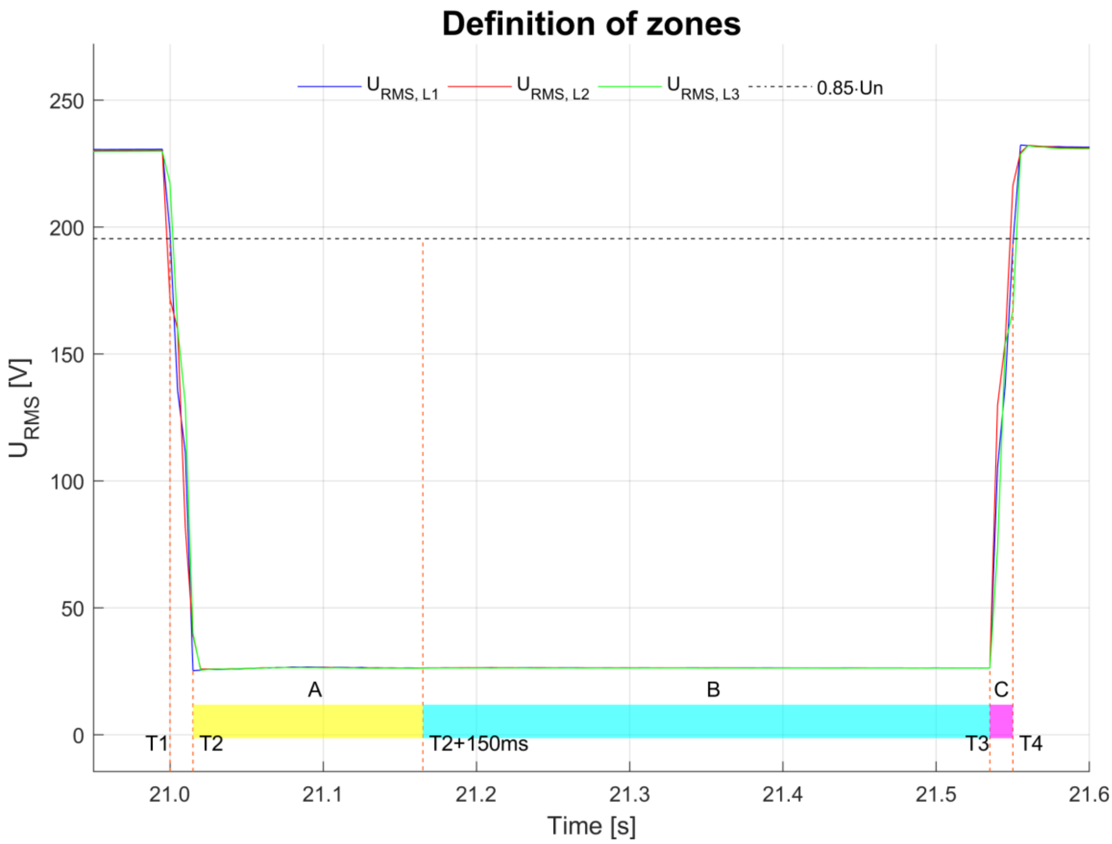


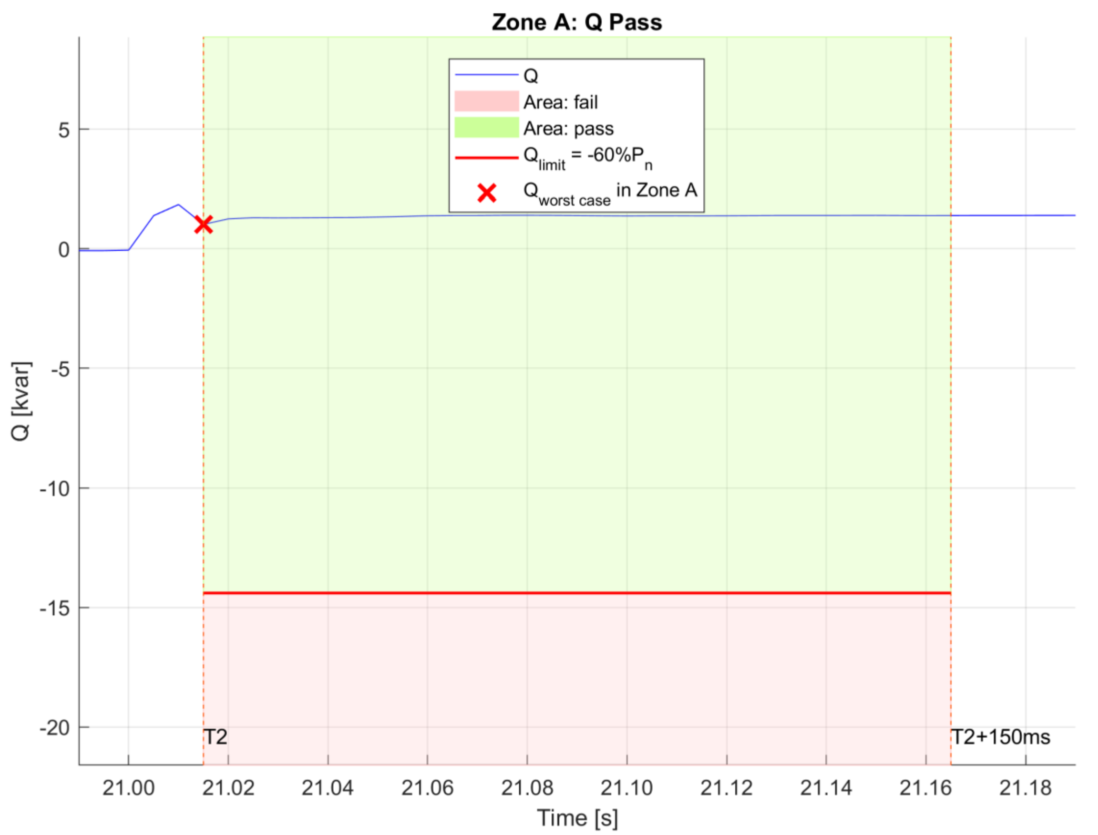
Behaviour during grid disturbance



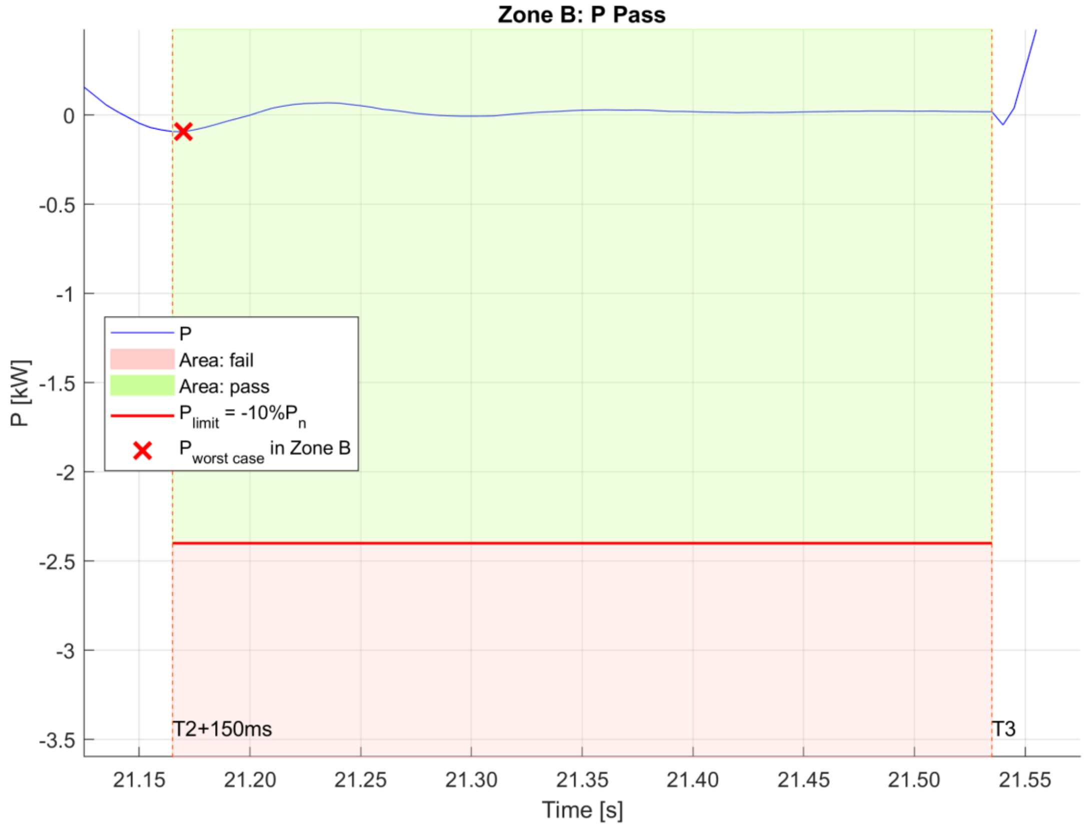
Behaviour during grid disturbance		
Three-phase-system		
1.1 Symmetric faults		
Measurement B		**P**
Test no. 1.1.2		
SOFAR 24KTLX-G3		
	P.O.12.3 Requirement	**Result**
A ZONE		
Net consumption Q < 60% P_n (20 ms)	-0,6 p.u.	0,042 p.u.
B ZONE		
Net consumption P < 10% P_n (20 ms)	-0,1 p.u.	-0,004 p.u.
Average I_r/I_{tot}	0,9 p.u.	1 p.u.
C ZONE		
Net consumption E_r < 60% P_n *150 ms	-90·ms·p.u.	2,821 ms·p.u.
Net consumption I_r < 1.5 I_n (20 ms)	-1,5 p.u.	0,318 p.u.

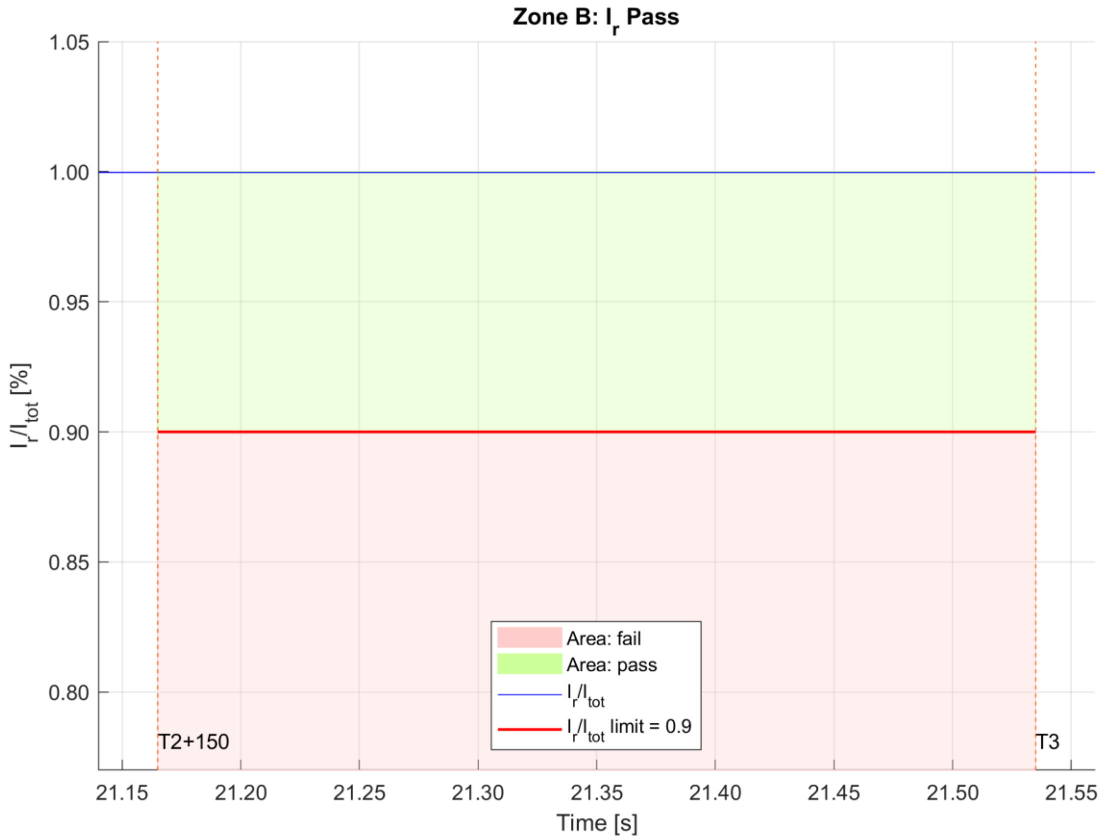
Behaviour during grid disturbance



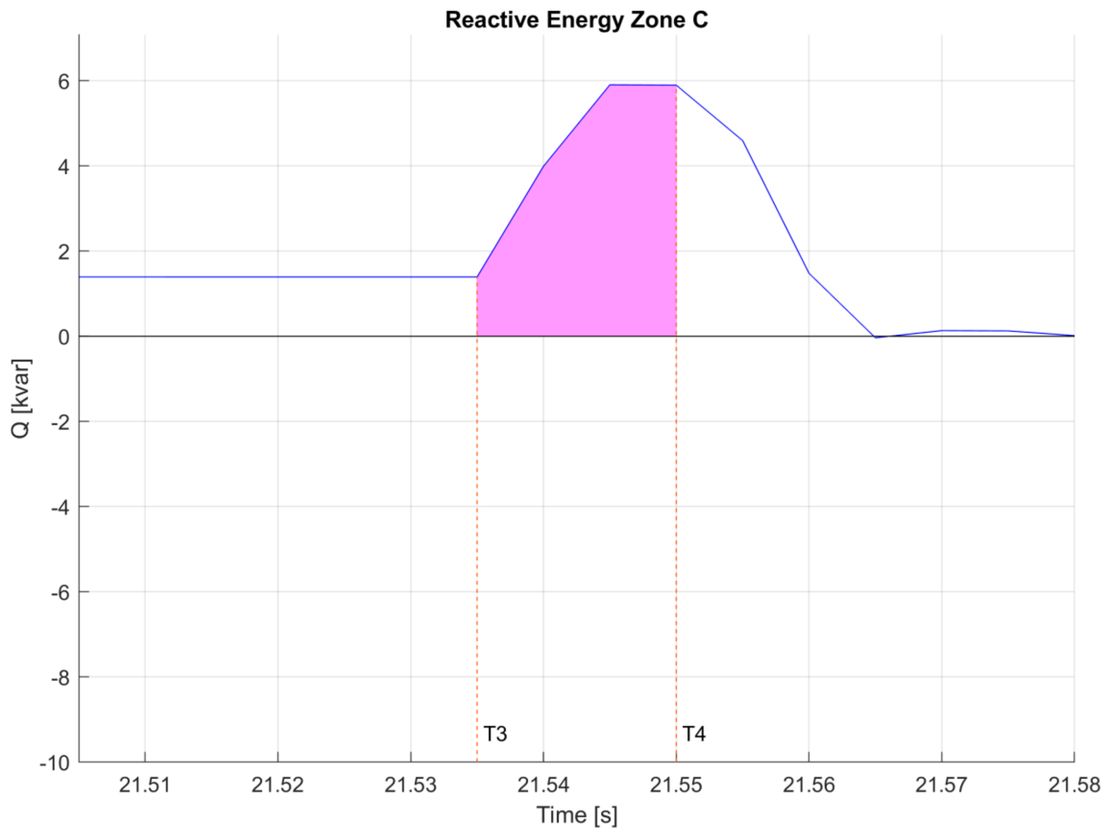


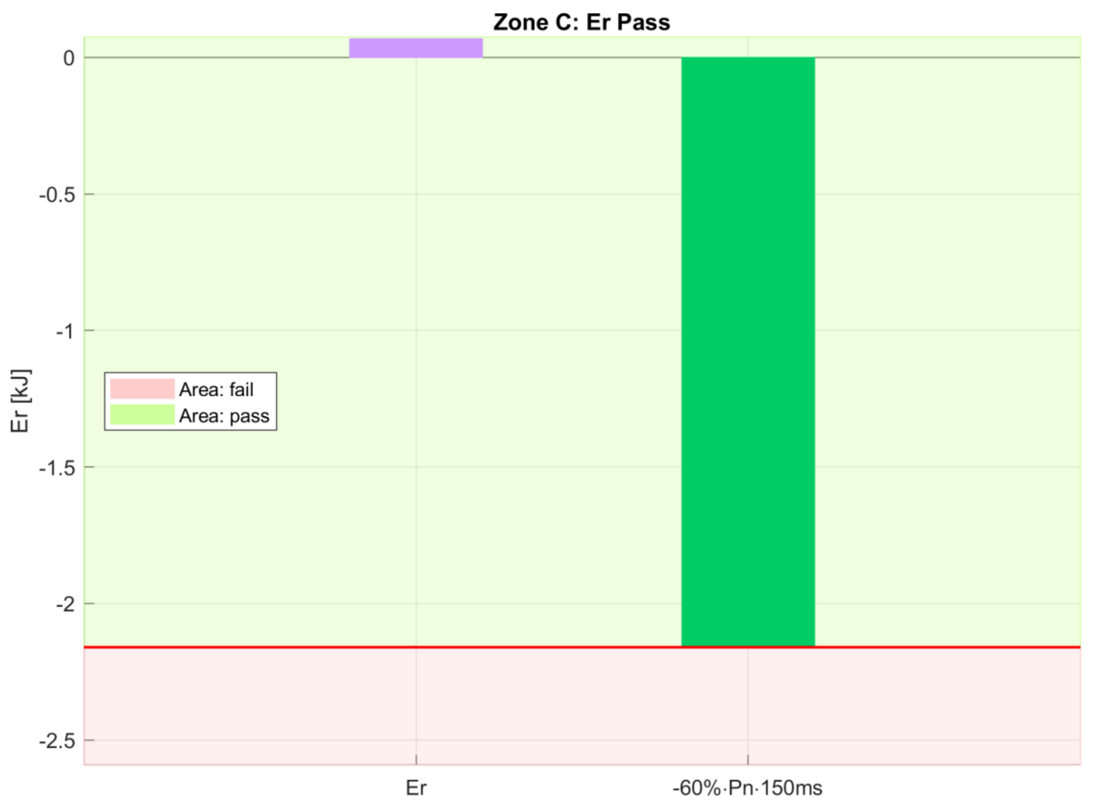
Behaviour during grid disturbance



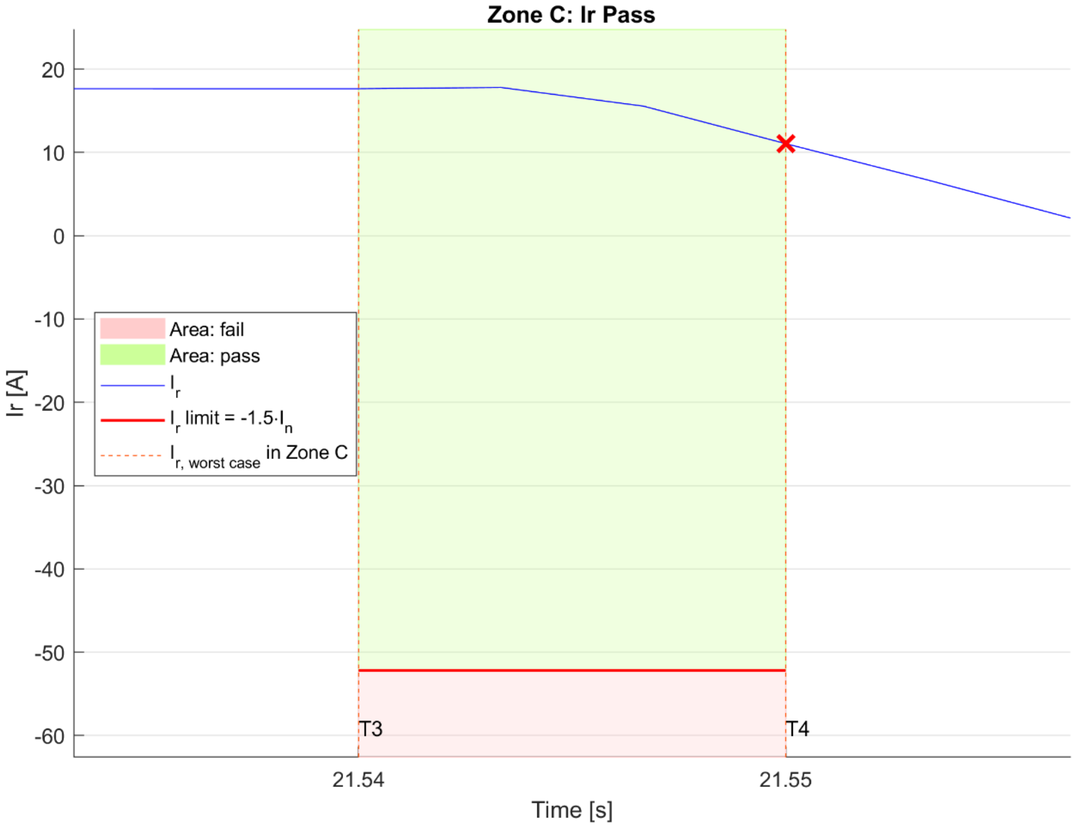


Behaviour during grid disturbance



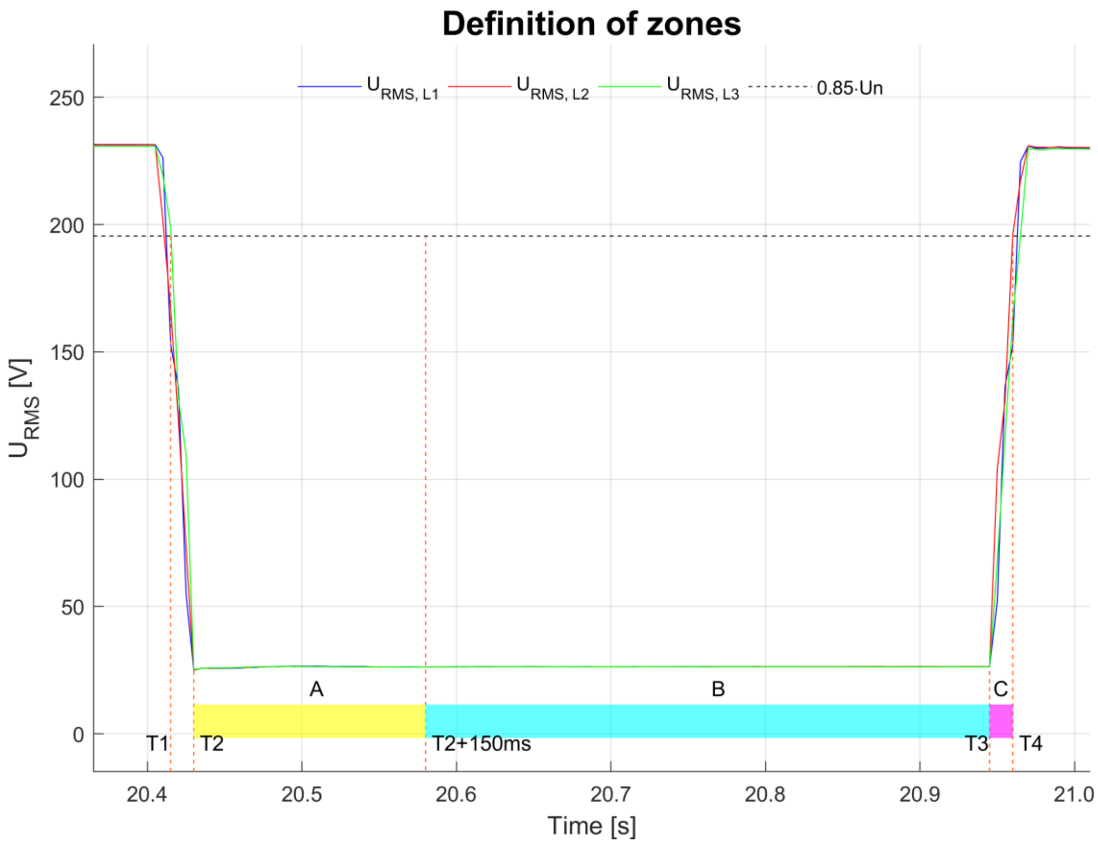


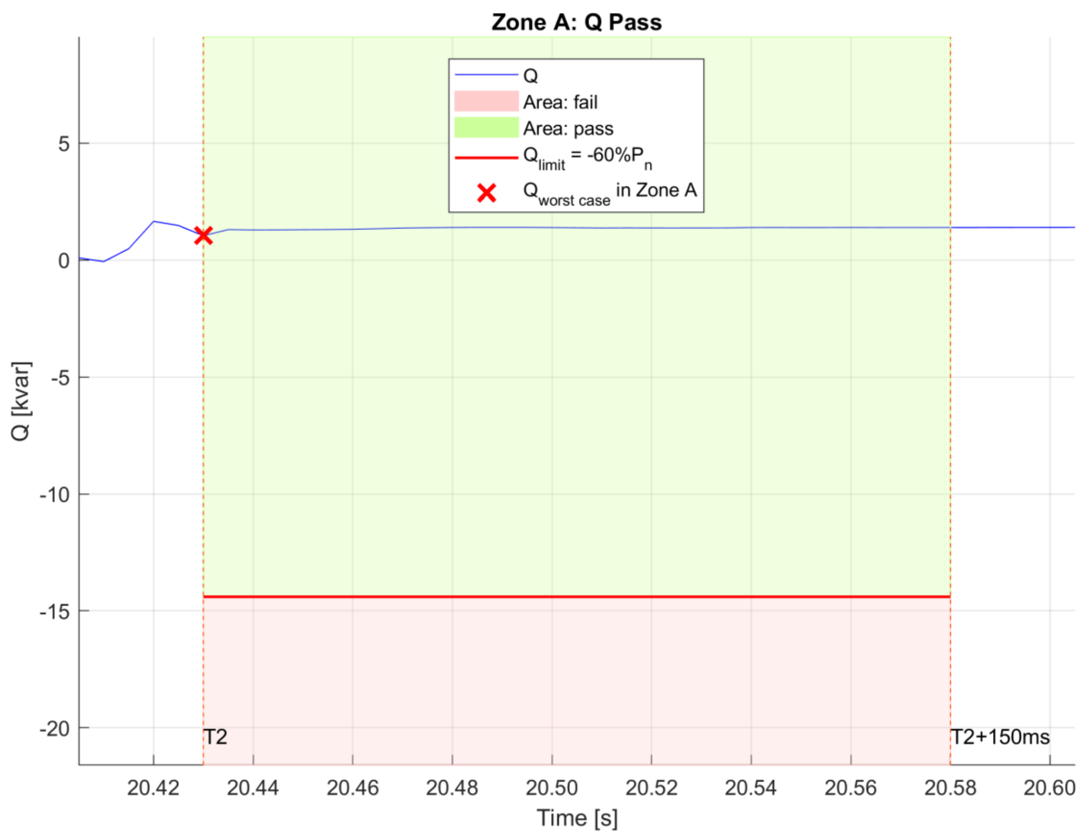
Behaviour during grid disturbance



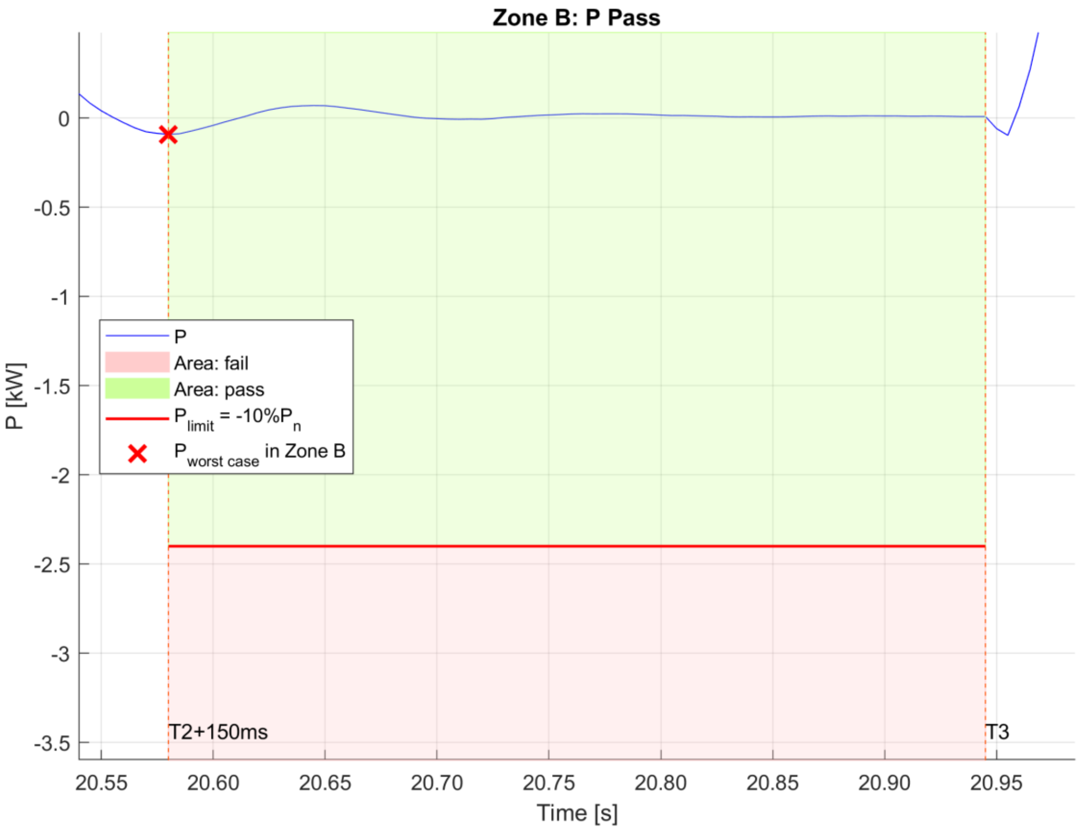
Behaviour during grid disturbance		
Three-phase-system		
1.1 Symmetric faults		
Measurement C		**P**
Test no. 1.1.2		
SOFAR 24KTLX-G3		
	P.O.12.3 Requirement	**Result**
A ZONE		
Net consumption Q < 60% P_n (20 ms)	-0,6 p.u.	0,043 p.u.
B ZONE		
Net consumption P < 10% P_n (20 ms)	-0,1 p.u.	-0,004 p.u.
Average I_r/I_{tot}	0,9 p.u.	1 p.u.
C ZONE		
Net consumption E_r < 60% P_n *150 ms	-90·ms·p.u.	2,481 ms·p.u.
Net consumption I_r < 1.5 I_n (20 ms)	-1,5 p.u.	0,399 p.u.

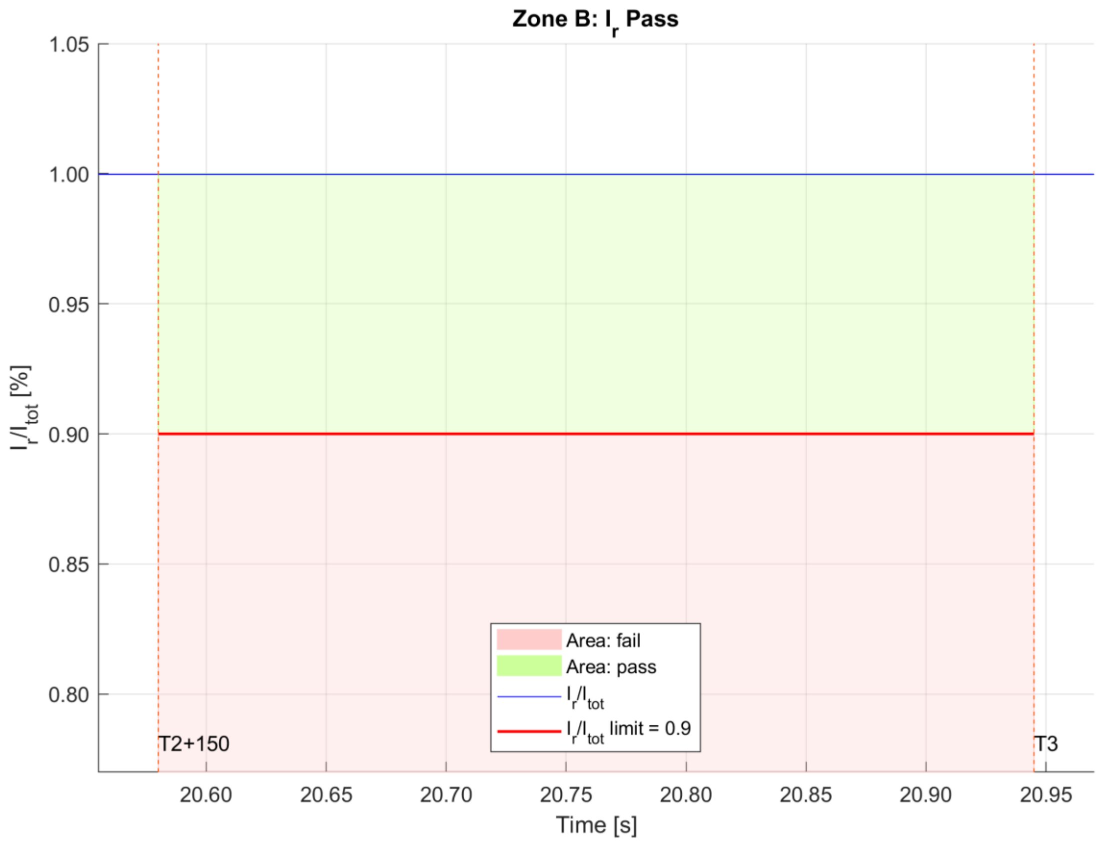
Behaviour during grid disturbance



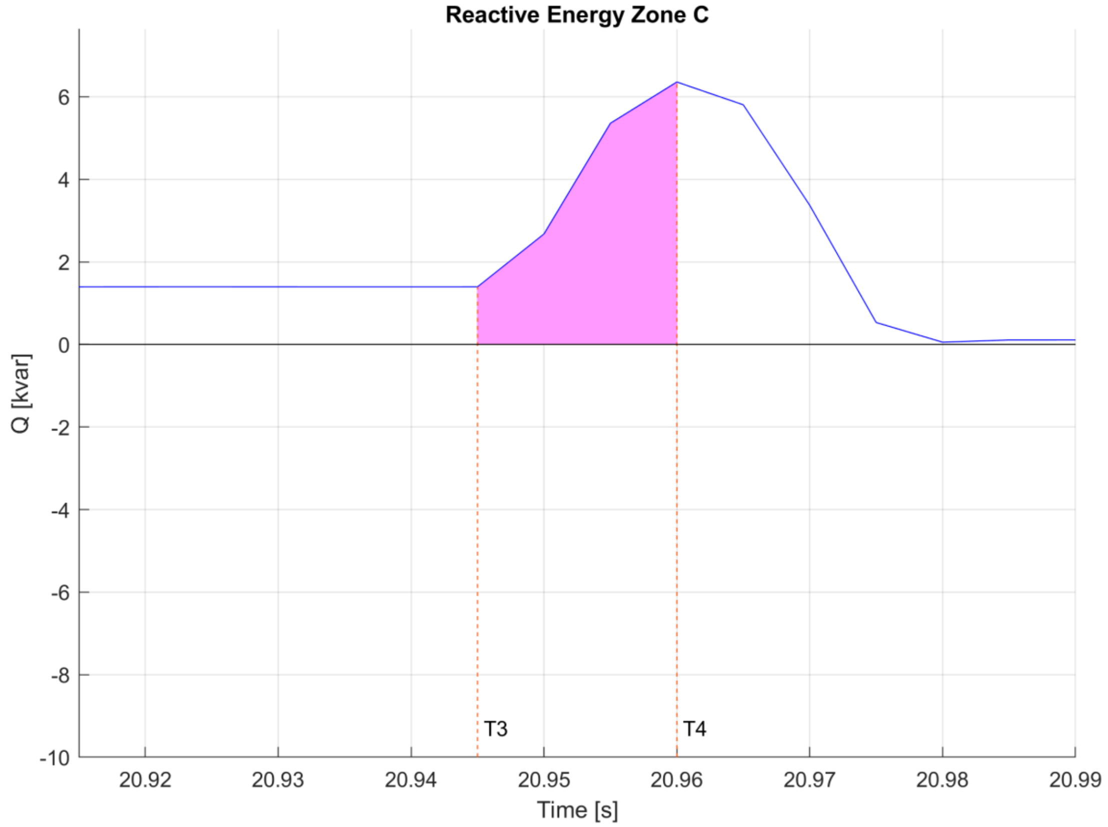


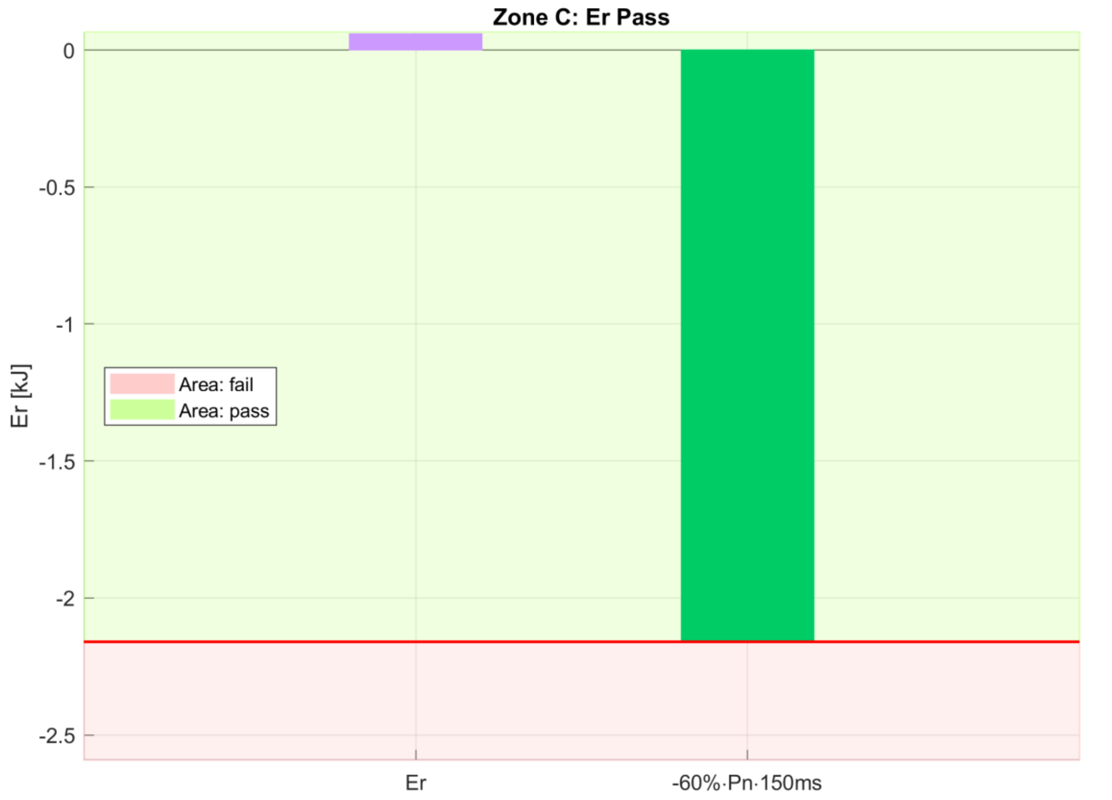
Behaviour during grid disturbance



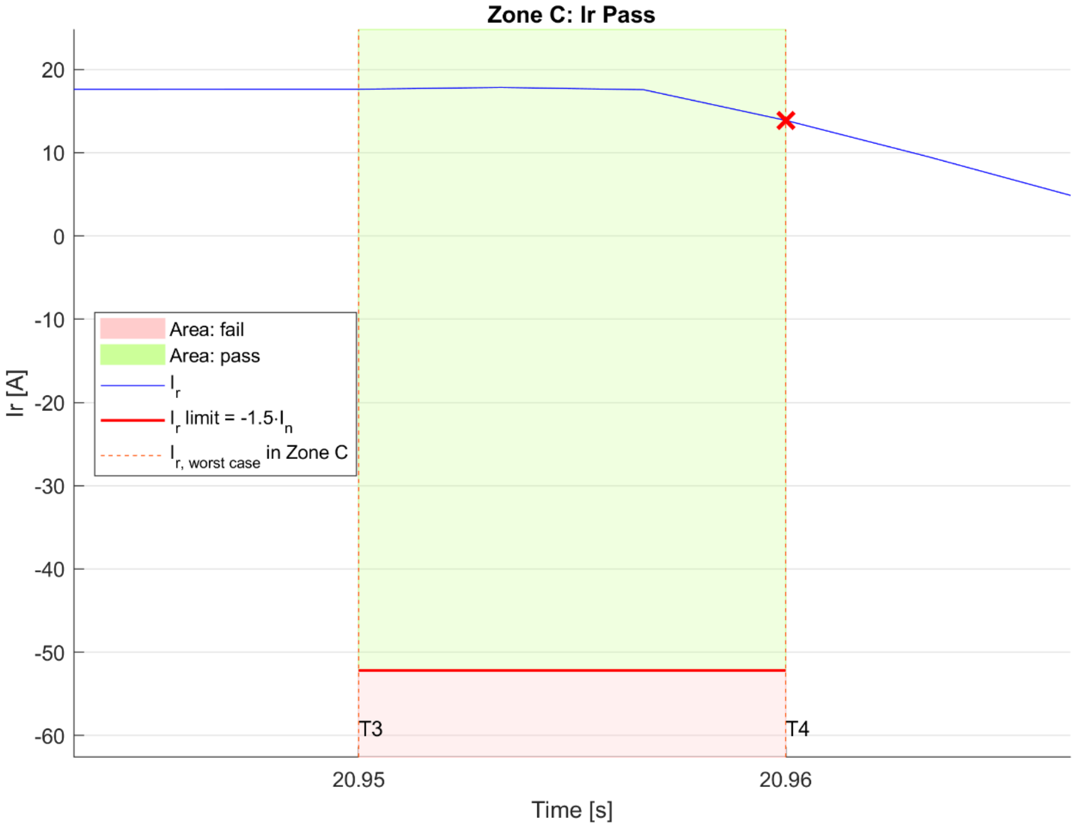


Behaviour during grid disturbance



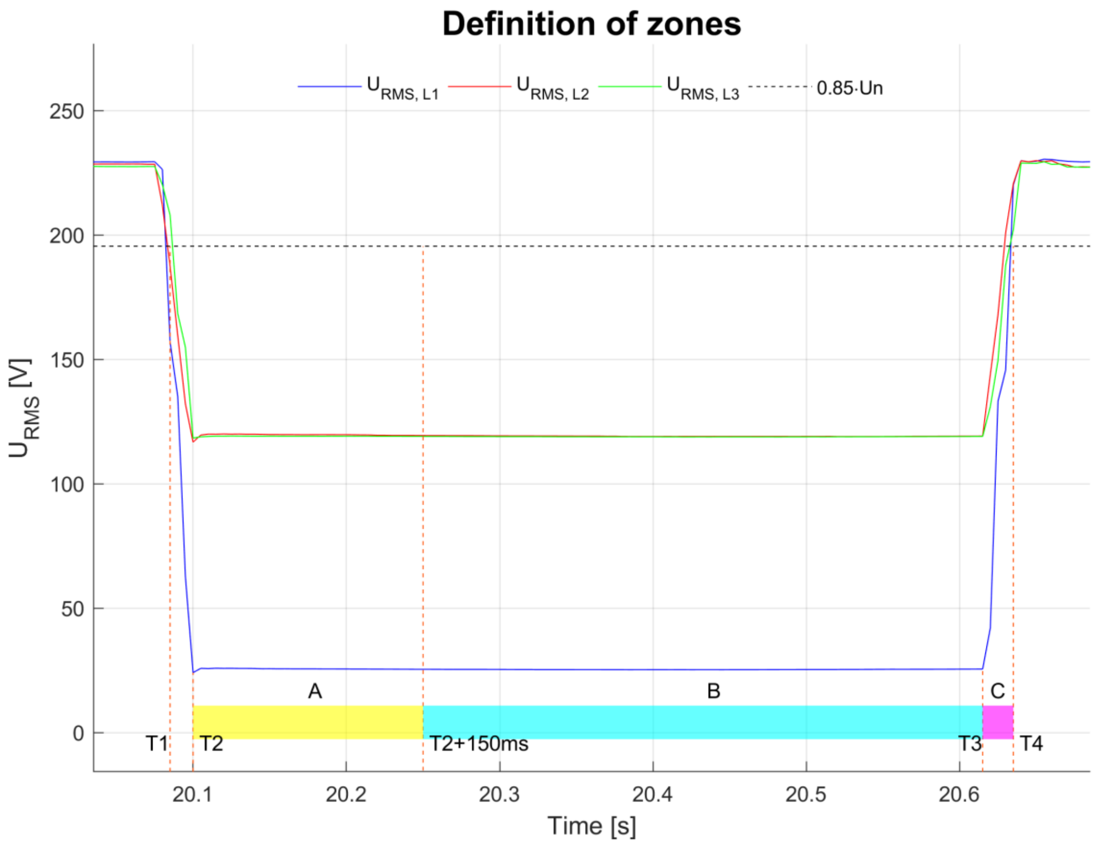


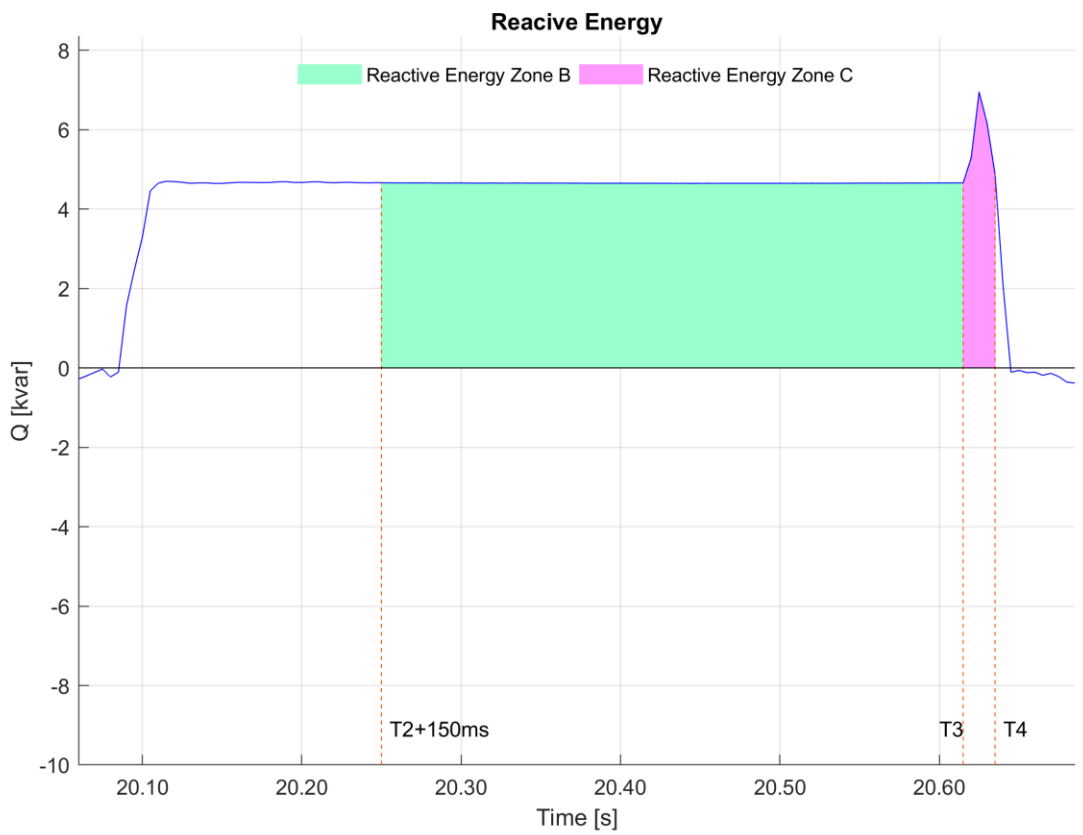
Behaviour during grid disturbance



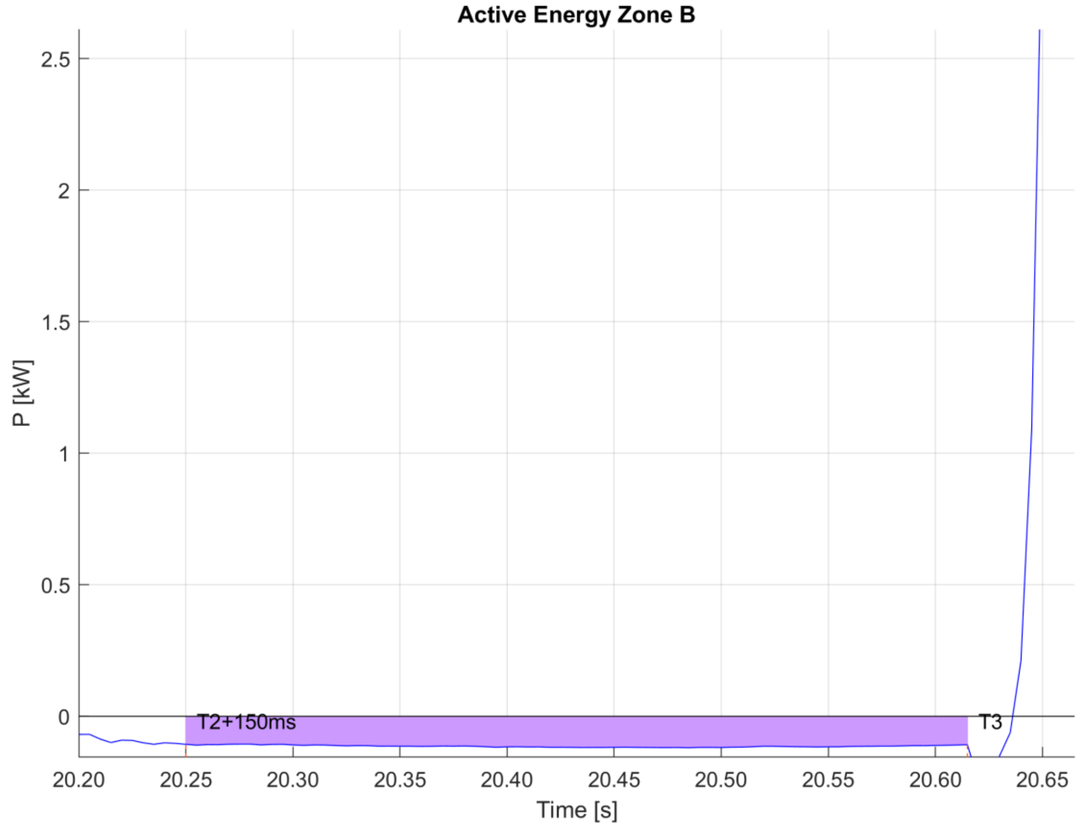
Behaviour during grid disturbance		
Three-phase-system		
1.2 Asymmetric faults		
Measurement A		**P**
Test no. 1.2.1		
SOFAR 24KTLX-G3		
	P.O.12.3 Requirement	**Result**
B ZONE		
Net consumption E_r < 40% P_n *100 ms	-40·ms·p.u.	70,749 ms·p.u.
Net consumption Q < 40% P_n (20 ms)	-0,4 p.u.	0,194 p.u.
Net consumption E_a < 45% P_n *100 ms	-45·ms·p.u.	-1,735 ms·p.u.
Net consumption P< 30% P_n (20 ms)	-0,3 p.u.	-0,005 p.u.

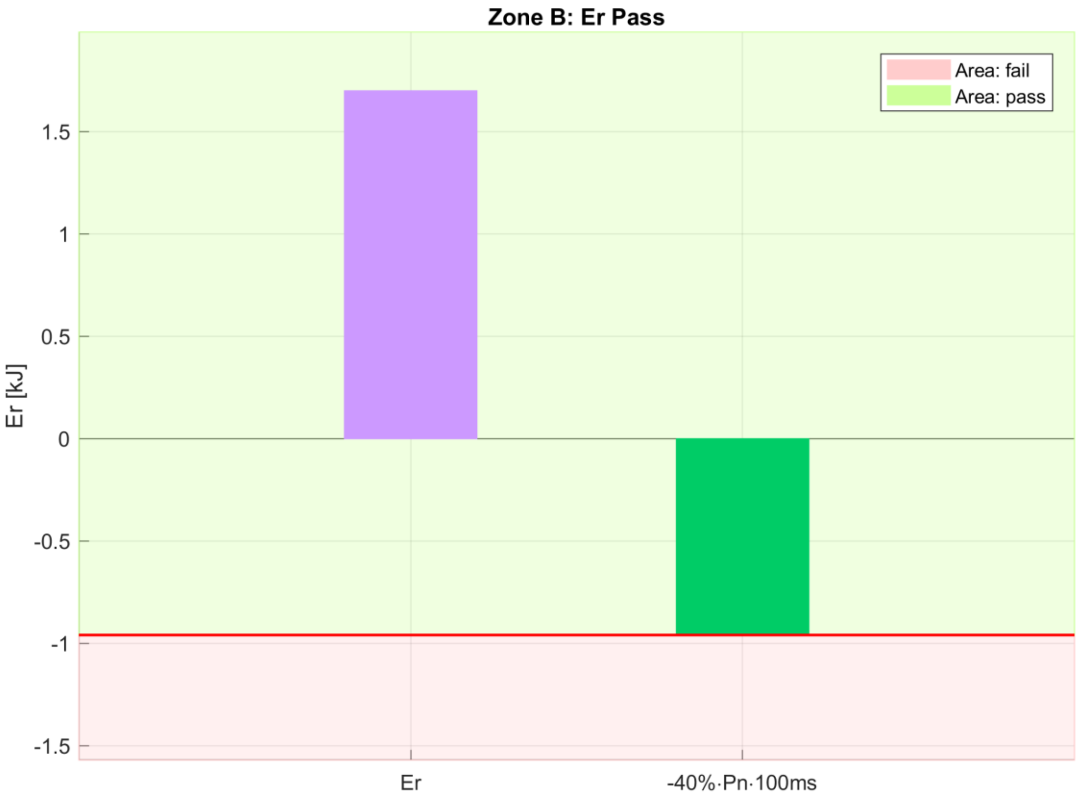
Behaviour during grid disturbance



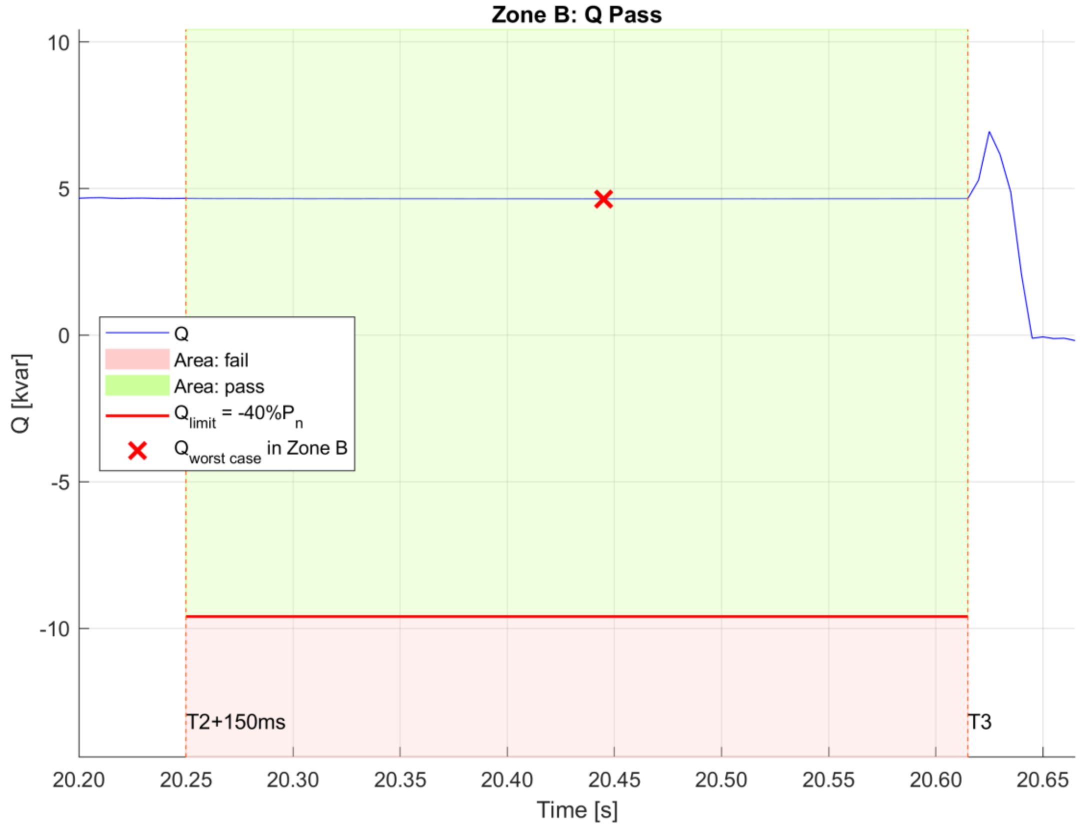


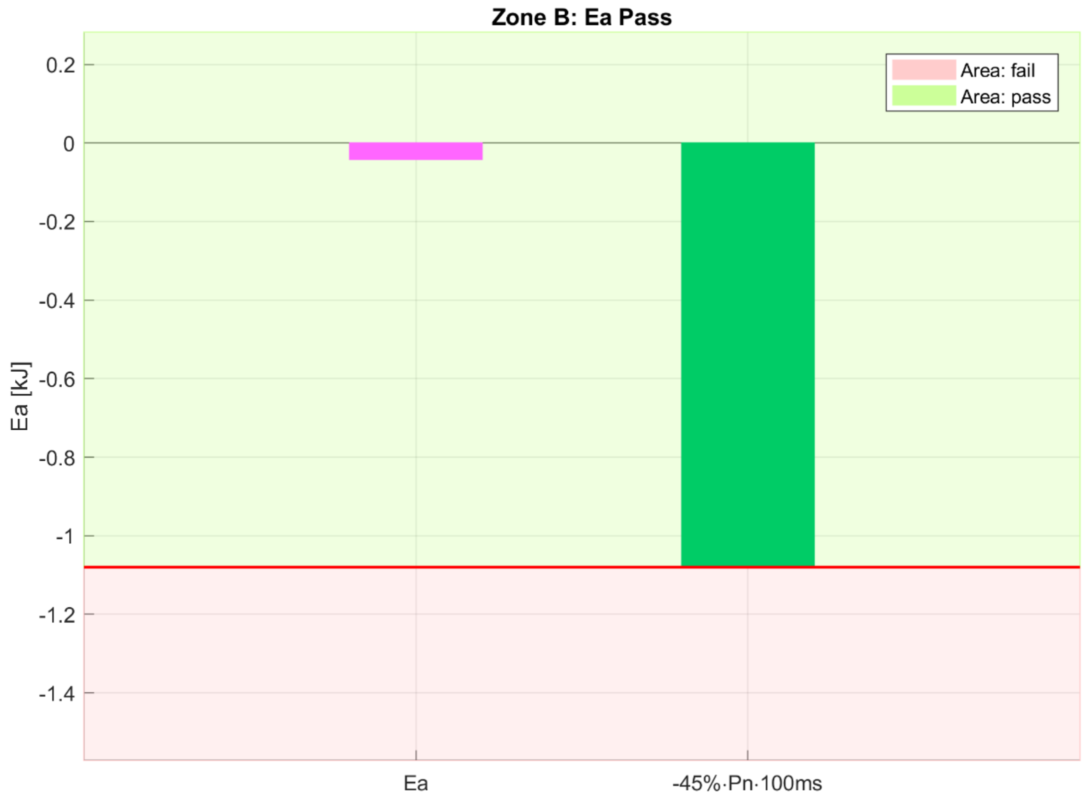
Behaviour during grid disturbance



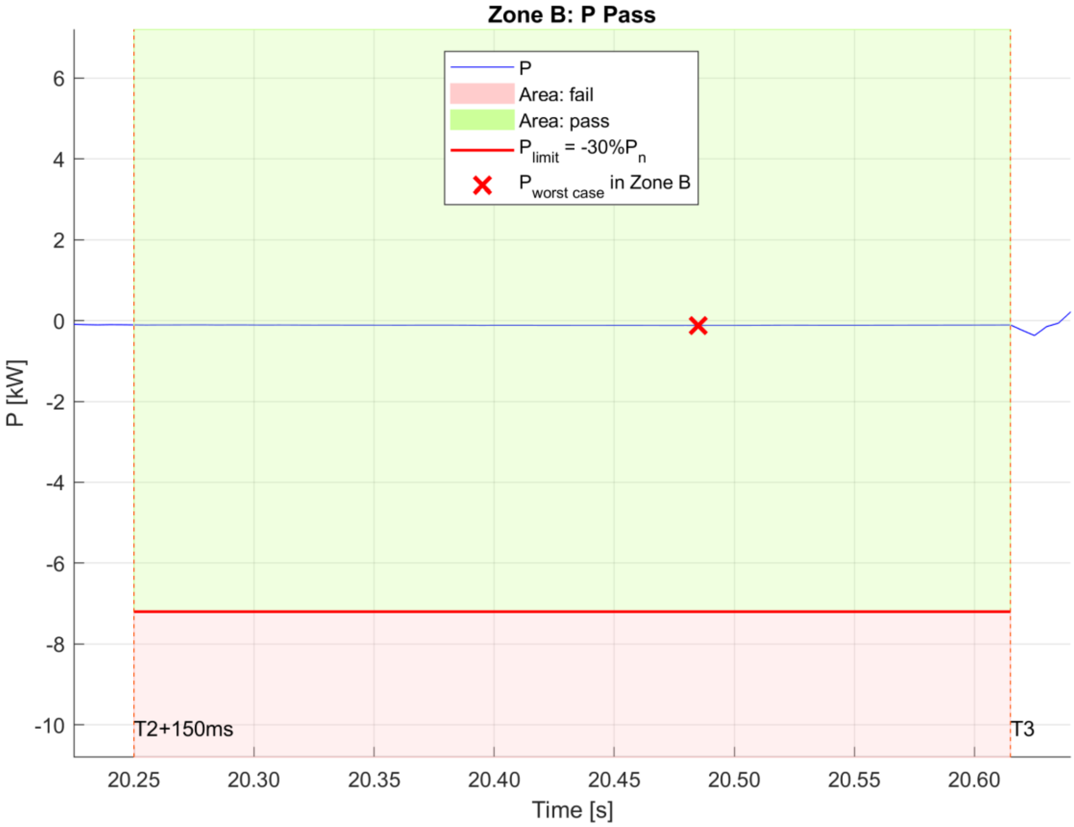


Behaviour during grid disturbance



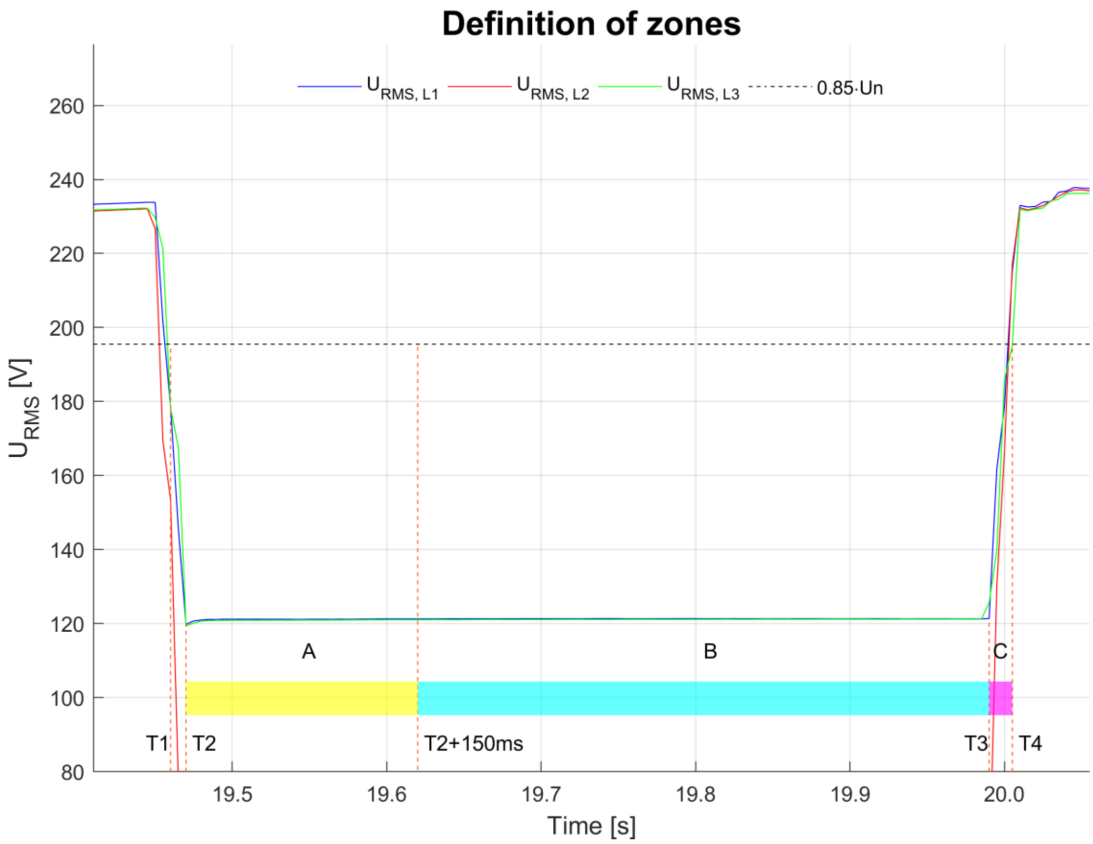


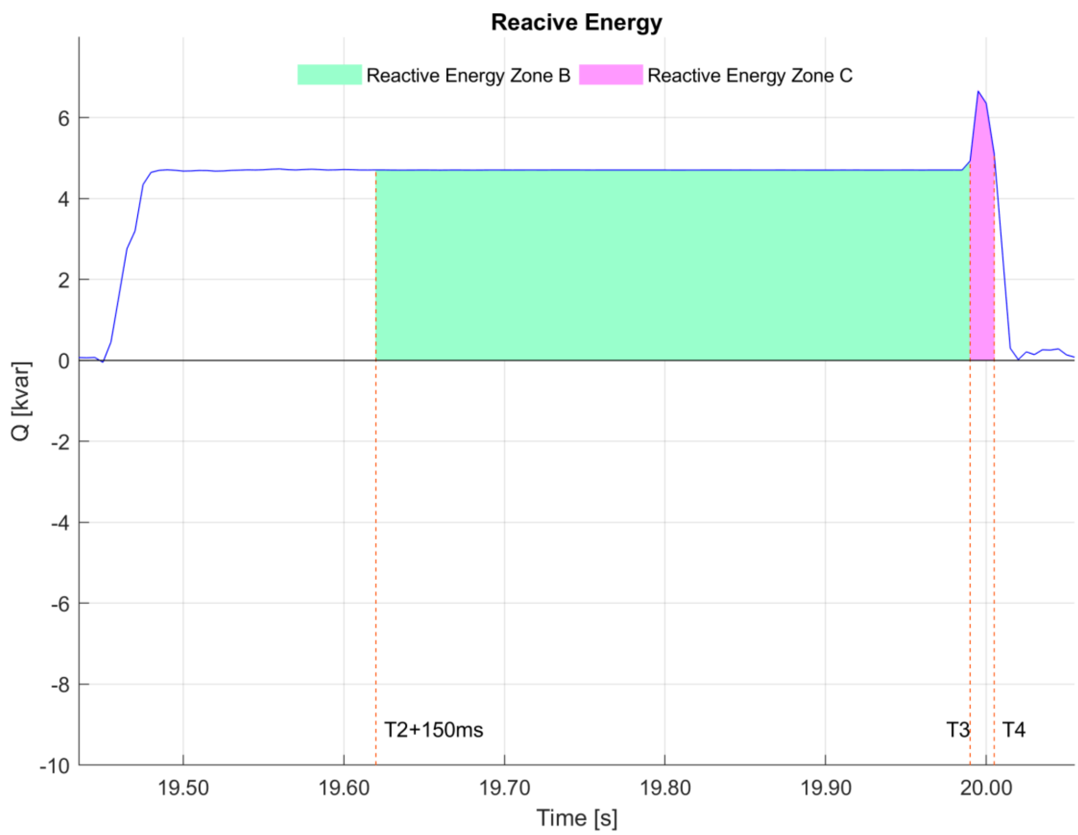
Behaviour during grid disturbance



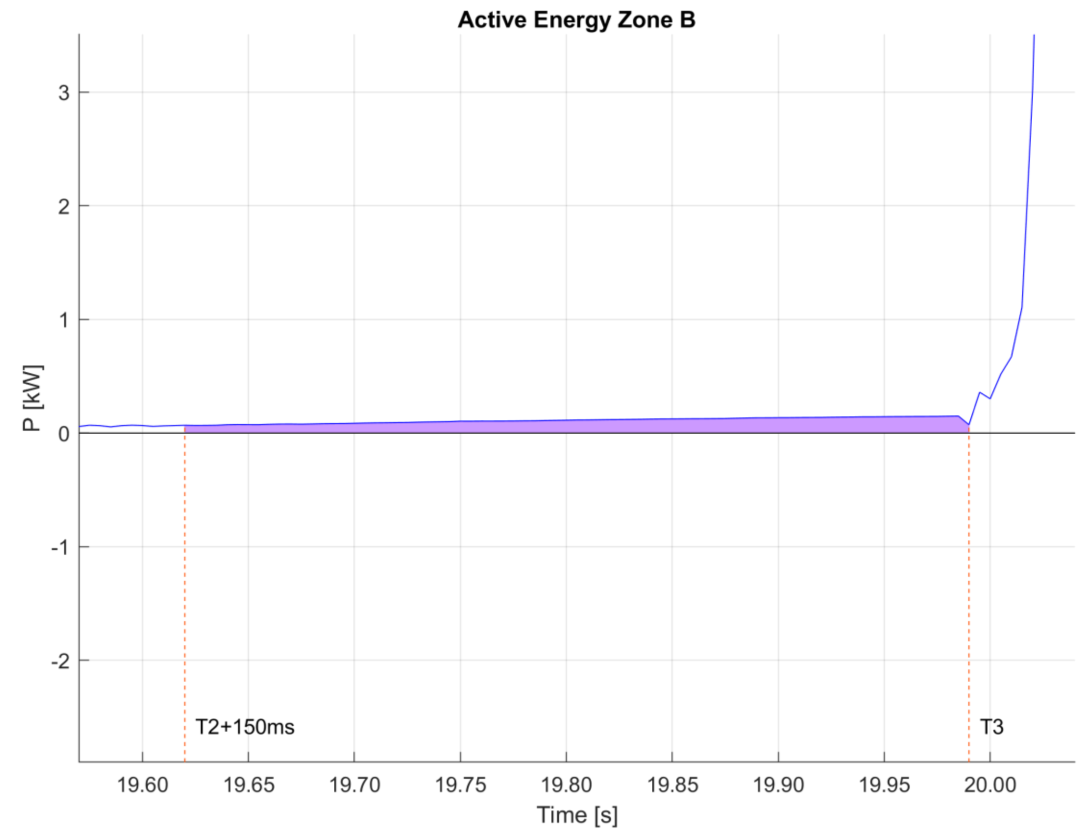
Behaviour during grid disturbance		
Three-phase-system		
1.2 Asymmetric faults		
Measurement B		**P**
Test no. 1.2.1		
SOFAR 24KTLX-G3		
	P.O.12.3 Requirement	**Result**
B ZONE		
Net consumption E_r < 40% P_n *100 ms	-40·ms·p.u.	72,556 ms·p.u.
Net consumption Q < 40% P_n (20 ms)	-0,4 p.u.	0,196 p.u.
Net consumption E_a < 45% P_n *100 ms	-45·ms·p.u.	1,715 ms·p.u.
Net consumption P< 30% P_n (20 ms)	-0,3 p.u.	0,003 p.u.

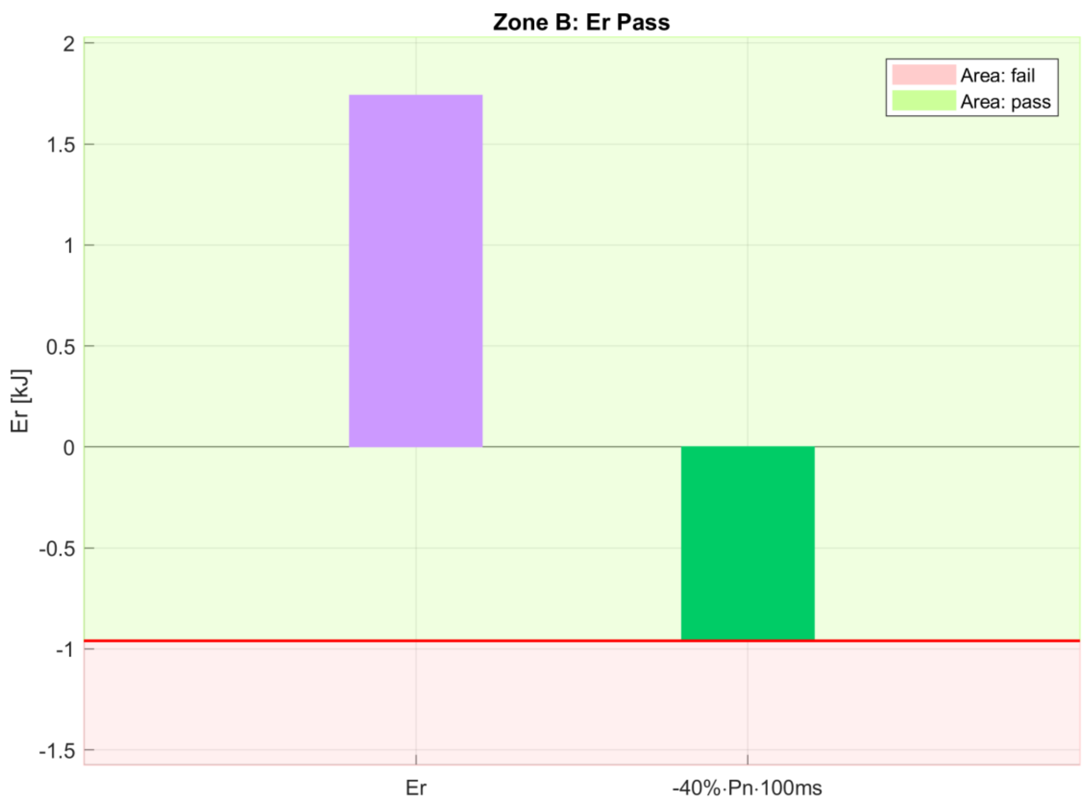
Behaviour during grid disturbance



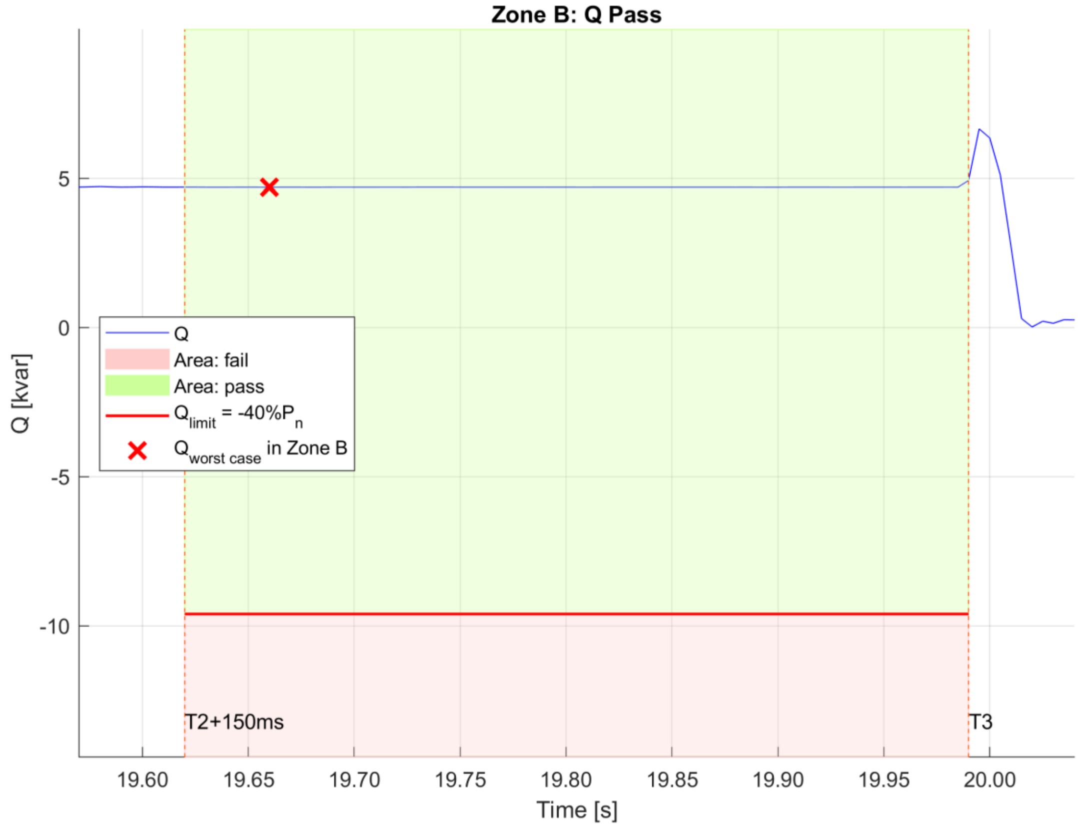


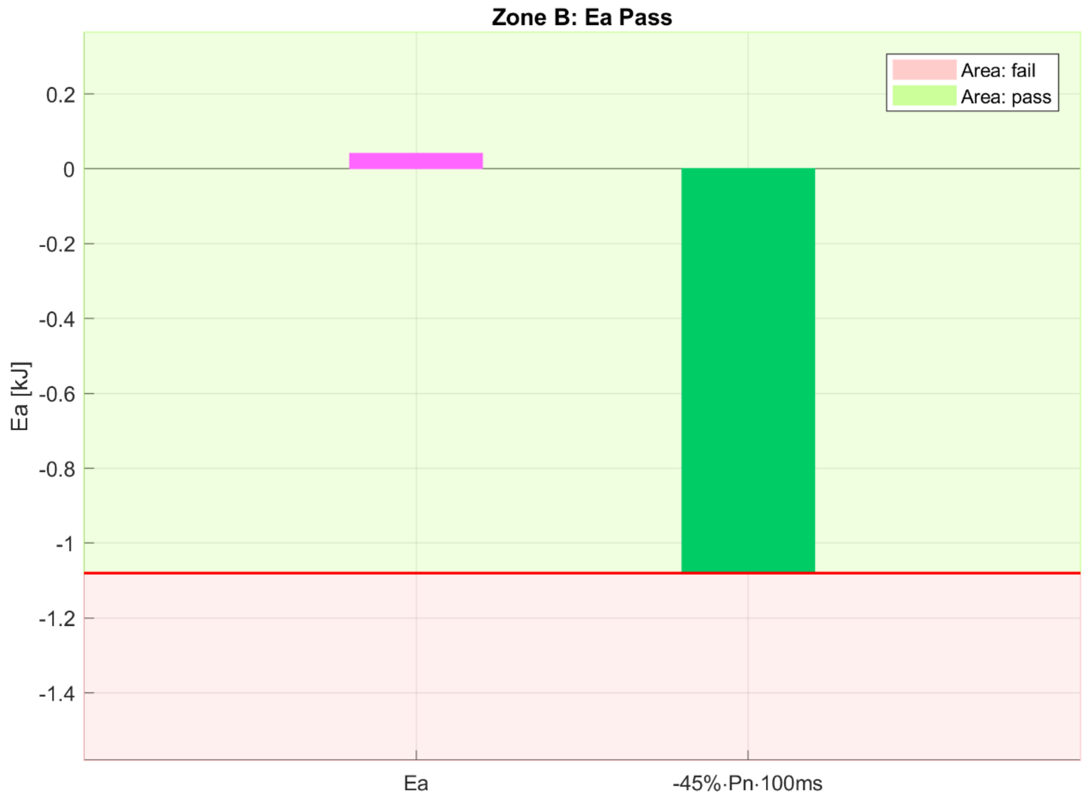
Behaviour during grid disturbance



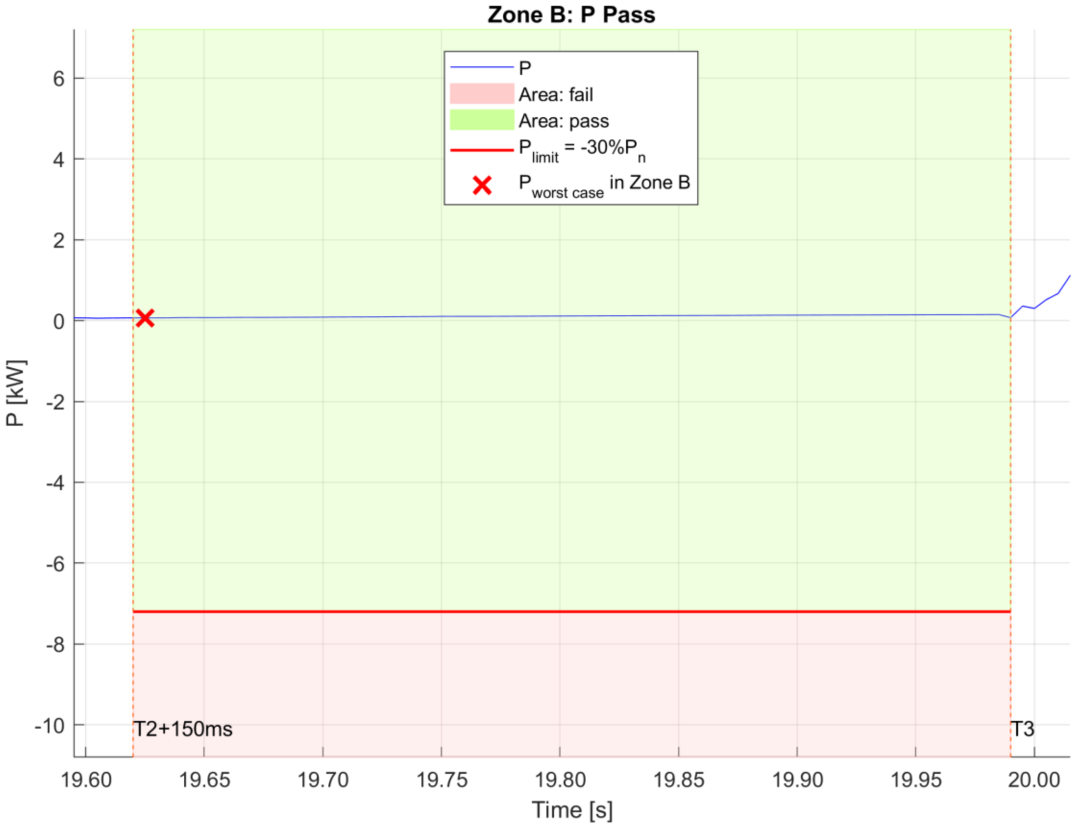


Behaviour during grid disturbance



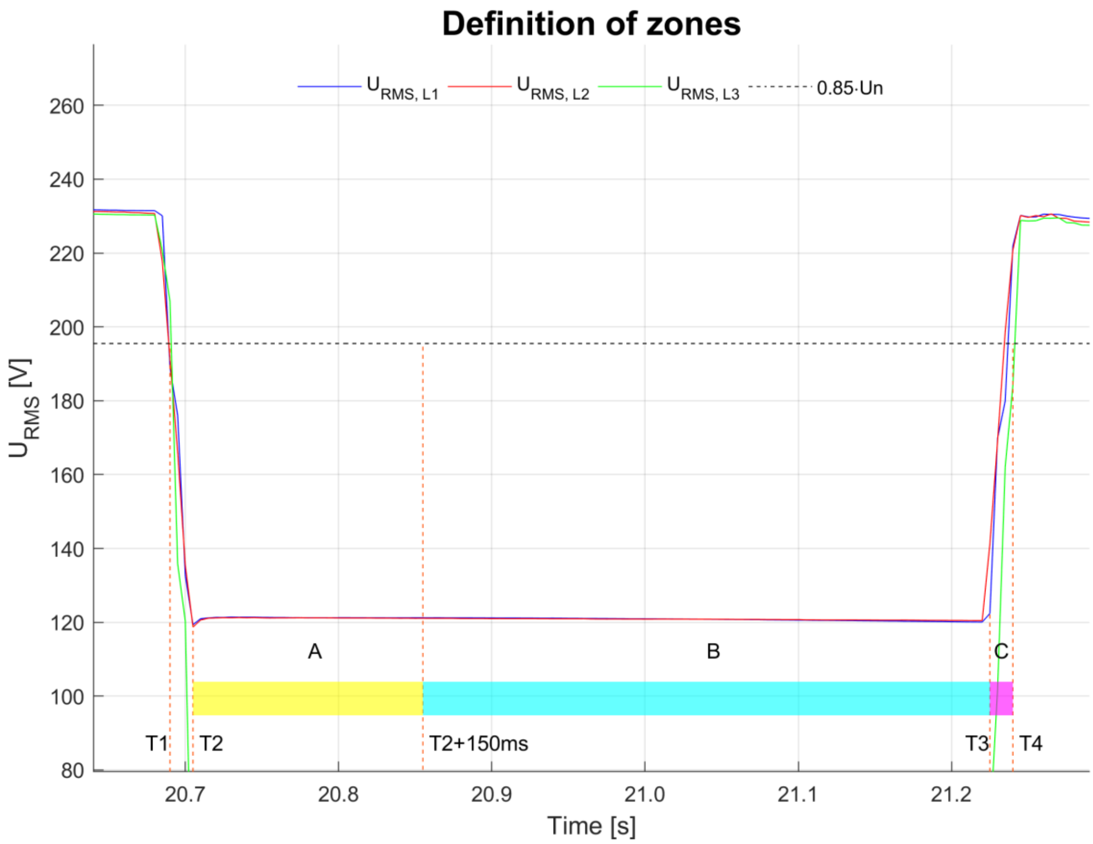


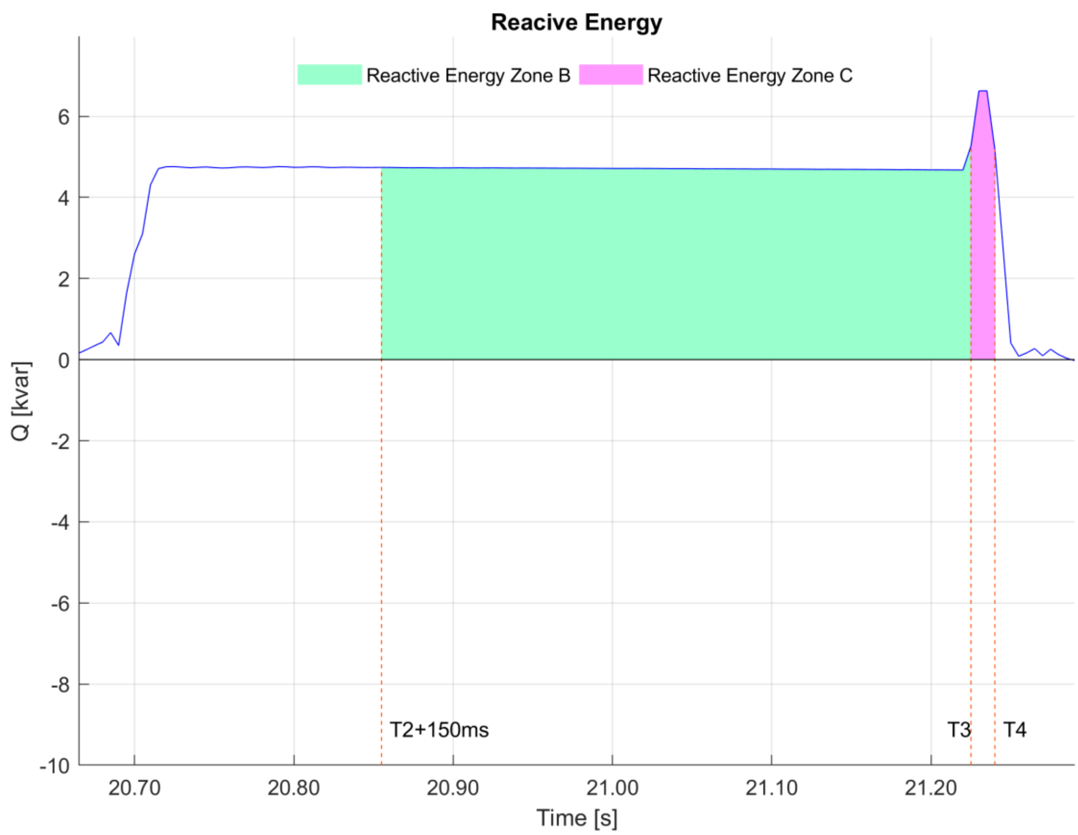
Behaviour during grid disturbance



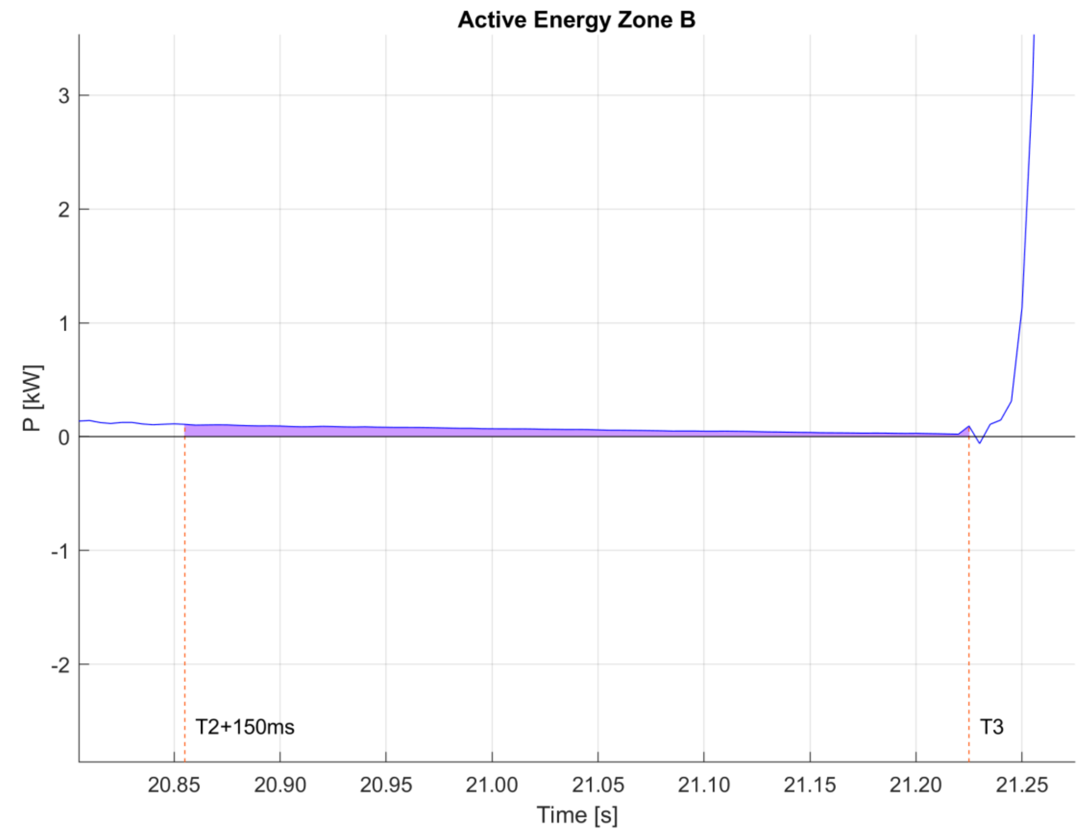
Behaviour during grid disturbance		
Three-phase-system		
1.2 Asymmetric faults		
Measurement C		**P**
Test no. 1.2.1		
SOFAR 24KTLX-G3		
	P.O.12.3 Requirement	**Result**
B ZONE		
Net consumption E_r < 40% P_n *100 ms	-40·ms·p.u.	72,635 ms·p.u.
Net consumption Q < 40% P_n (20 ms)	-0,4 p.u.	0,195 p.u.
Net consumption E_a < 45% P_n *100 ms	-45·ms·p.u.	0,96 ms·p.u.
Net consumption P< 30% P_n (20 ms)	-0,3 p.u.	0,001 p.u.

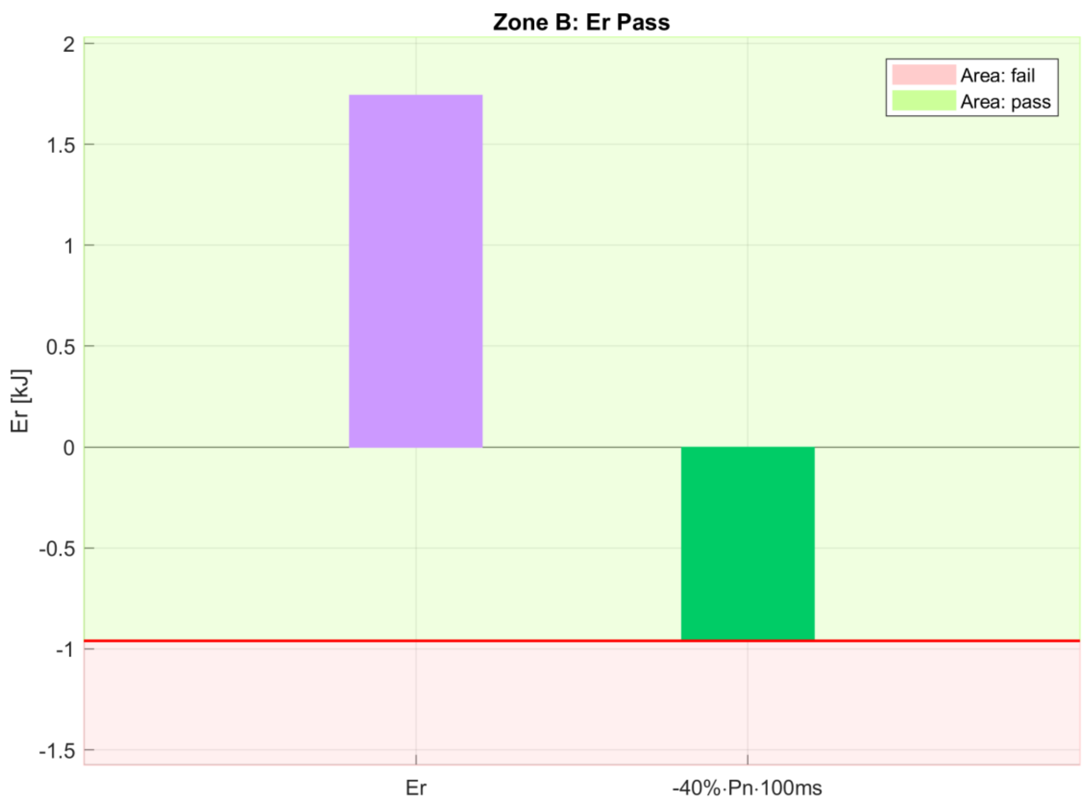
Behaviour during grid disturbance



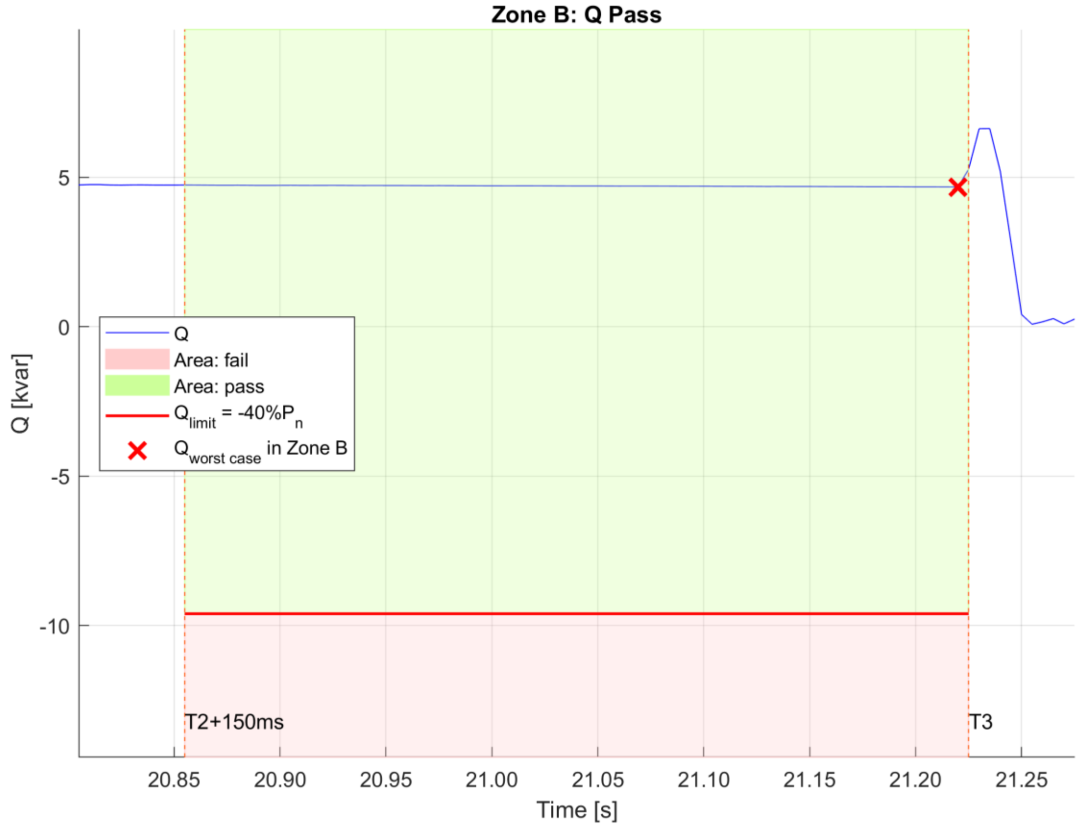


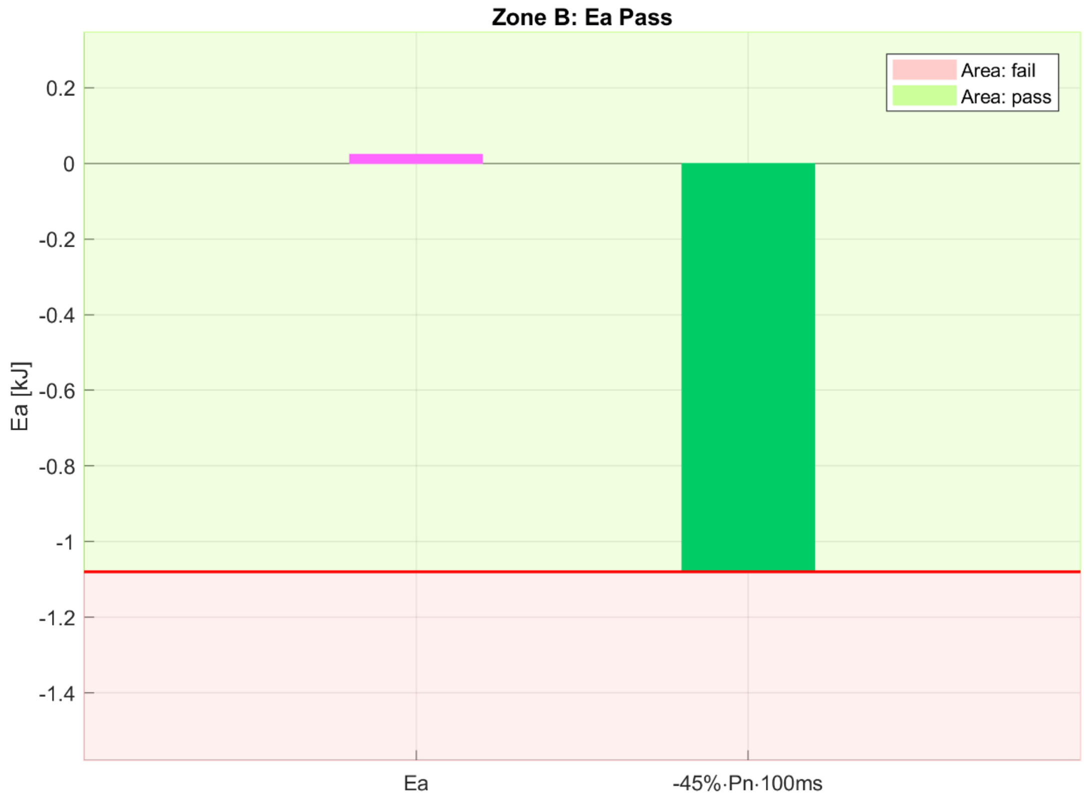
Behaviour during grid disturbance



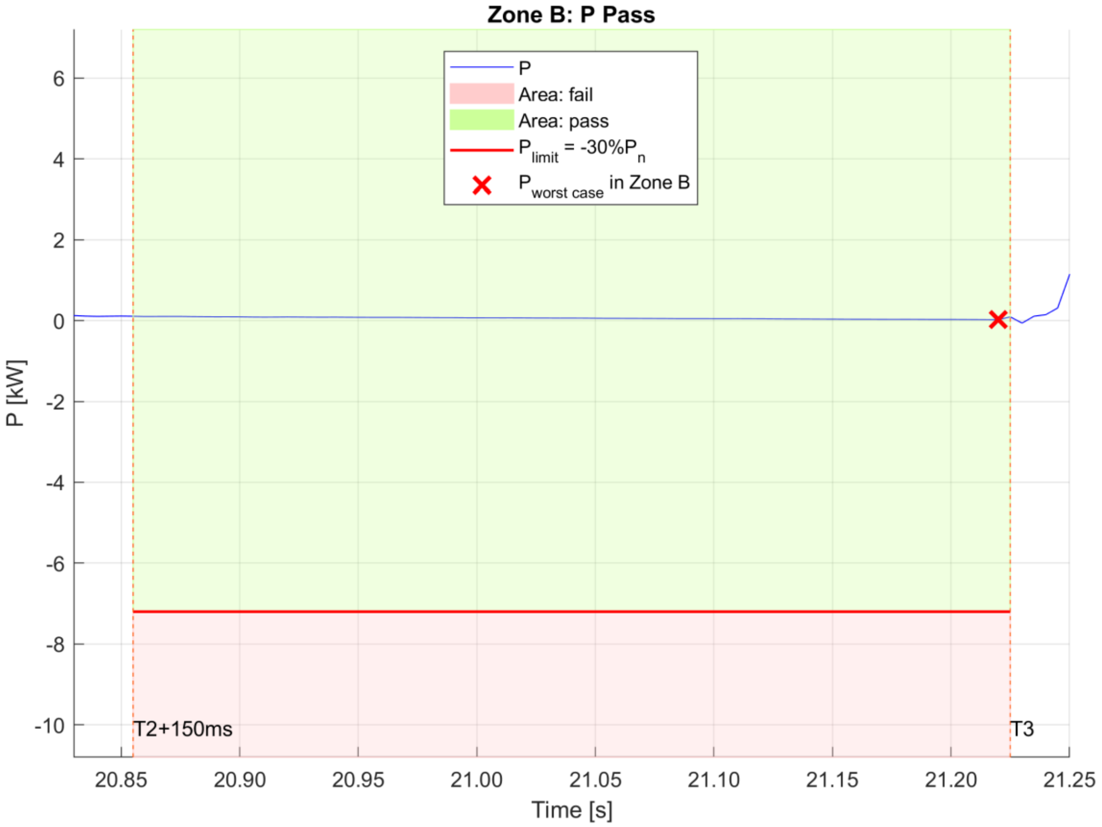


Behaviour during grid disturbance



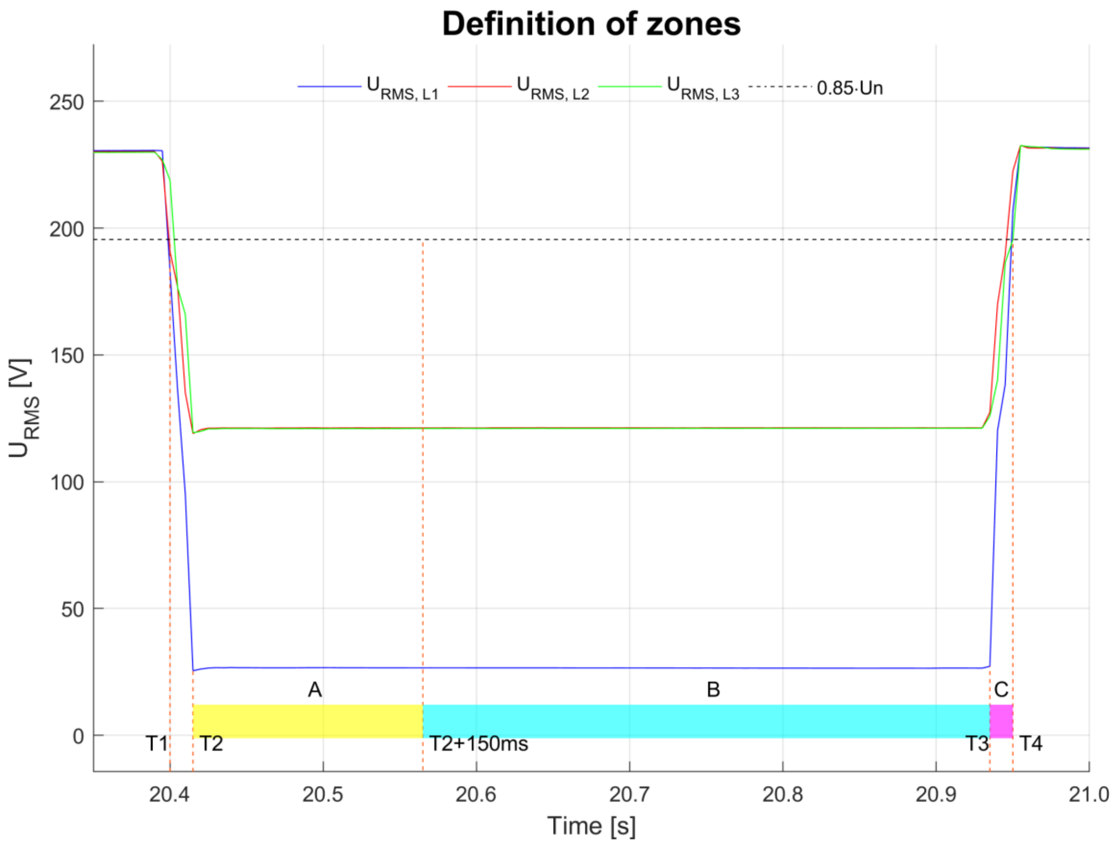


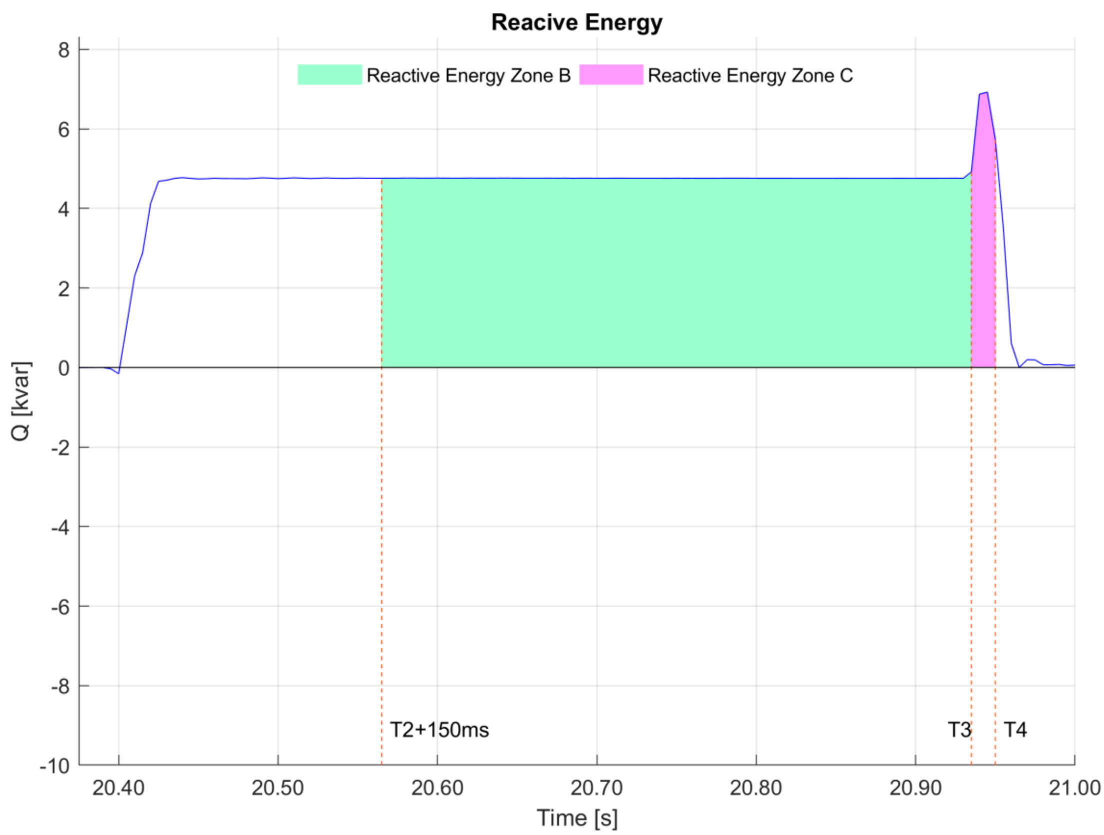
Behaviour during grid disturbance



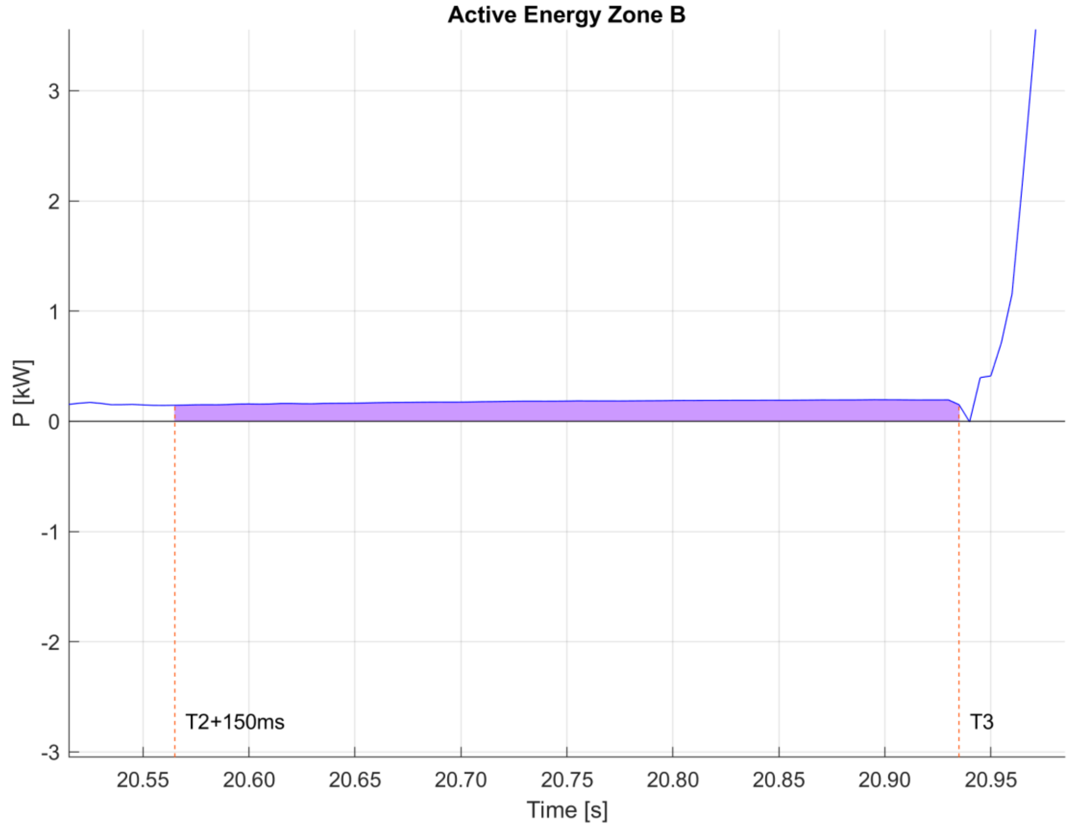
Behaviour during grid disturbance		
Three-phase-system		
1.2 Asymmetric faults		
Measurement A		**P**
Test no. 1.2.2		
SOFAR 24KTLX-G3		
	P.O.12.3 Requirement	**Result**
B ZONE		
Net consumption E_r < 40% P_n *100 ms	-40·ms·p.u.	73,395 ms·p.u.
Net consumption Q < 40% P_n (20 ms)	-0,4 p.u.	0,198 p.u.
Net consumption E_a < 45% P_n *100 ms	-45·ms·p.u.	2,746 ms·p.u.
Net consumption P< 30% P_n (20 ms)	-0,3 p.u.	0,006 p.u.

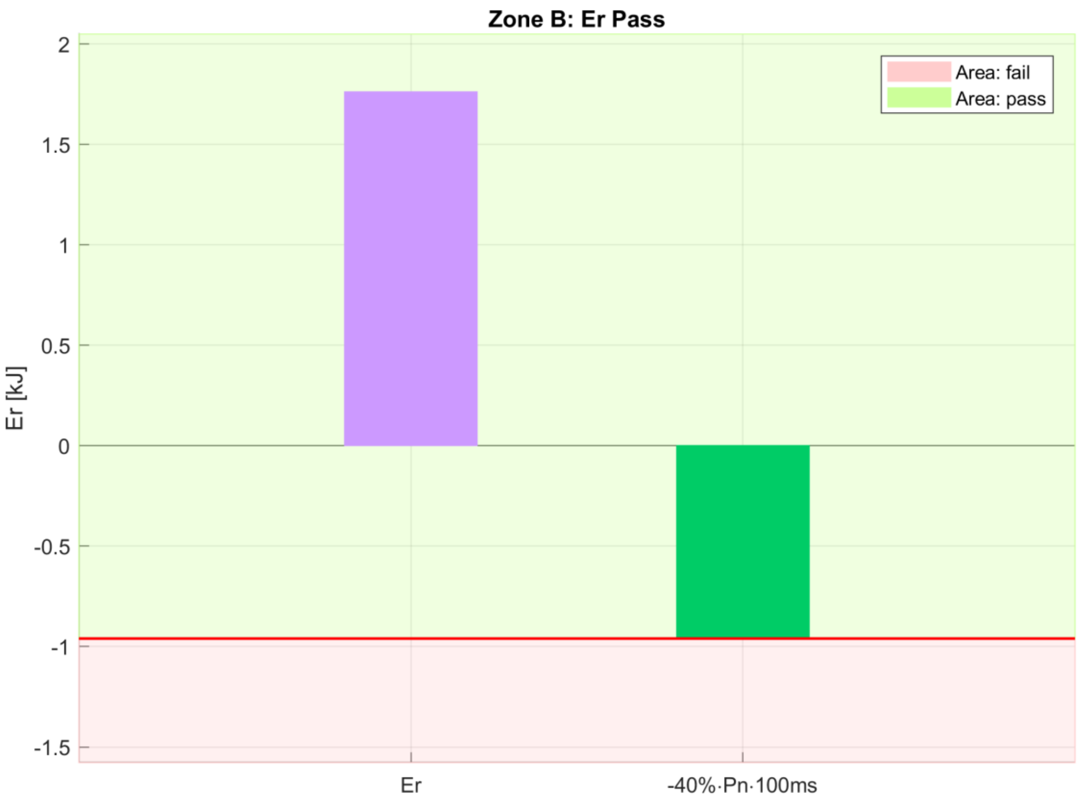
Behaviour during grid disturbance



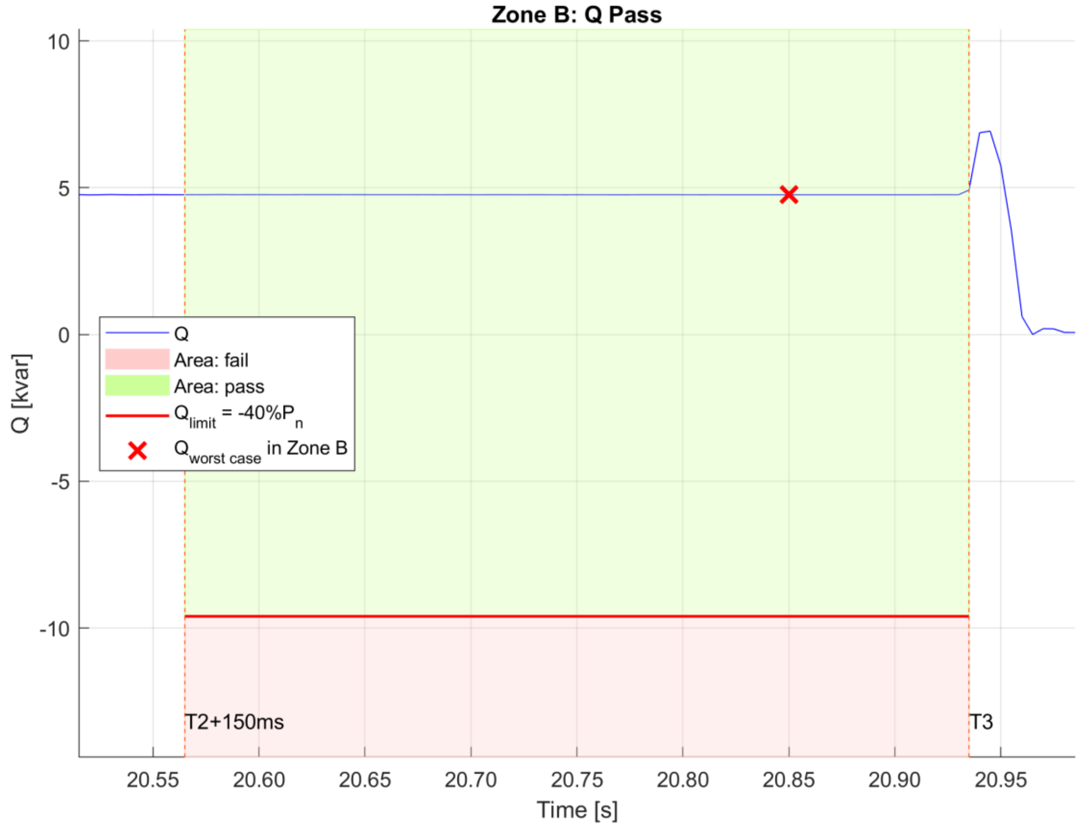


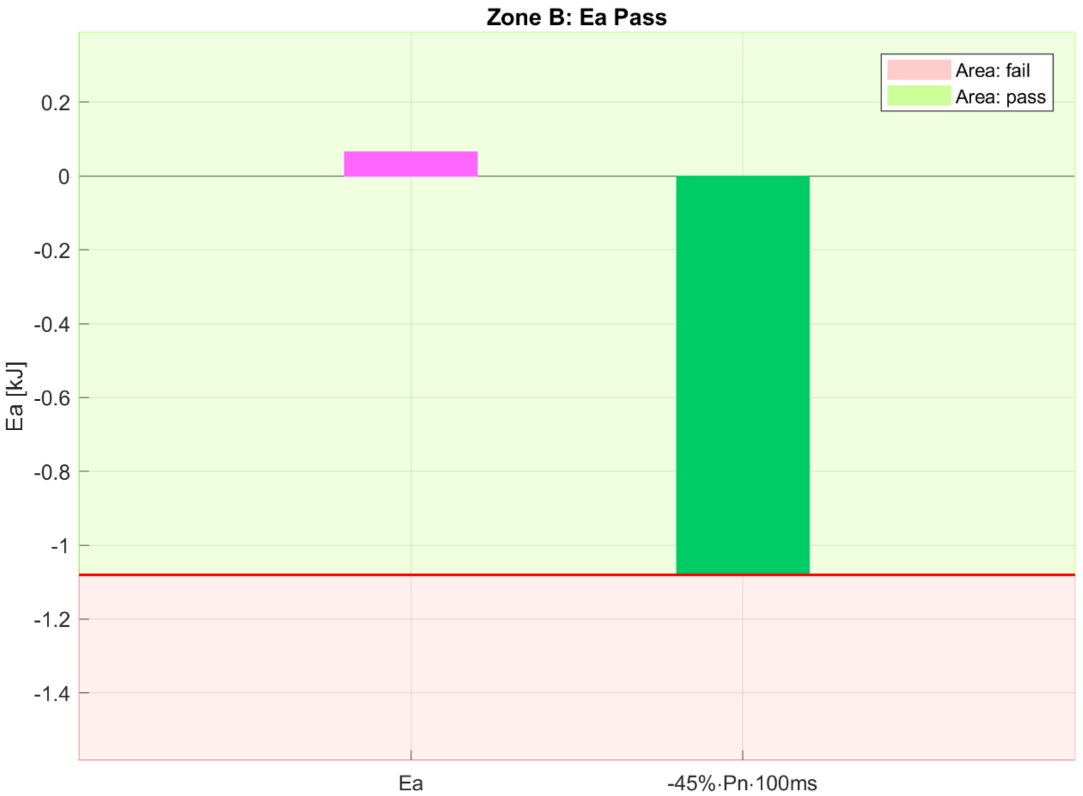
Behaviour during grid disturbance



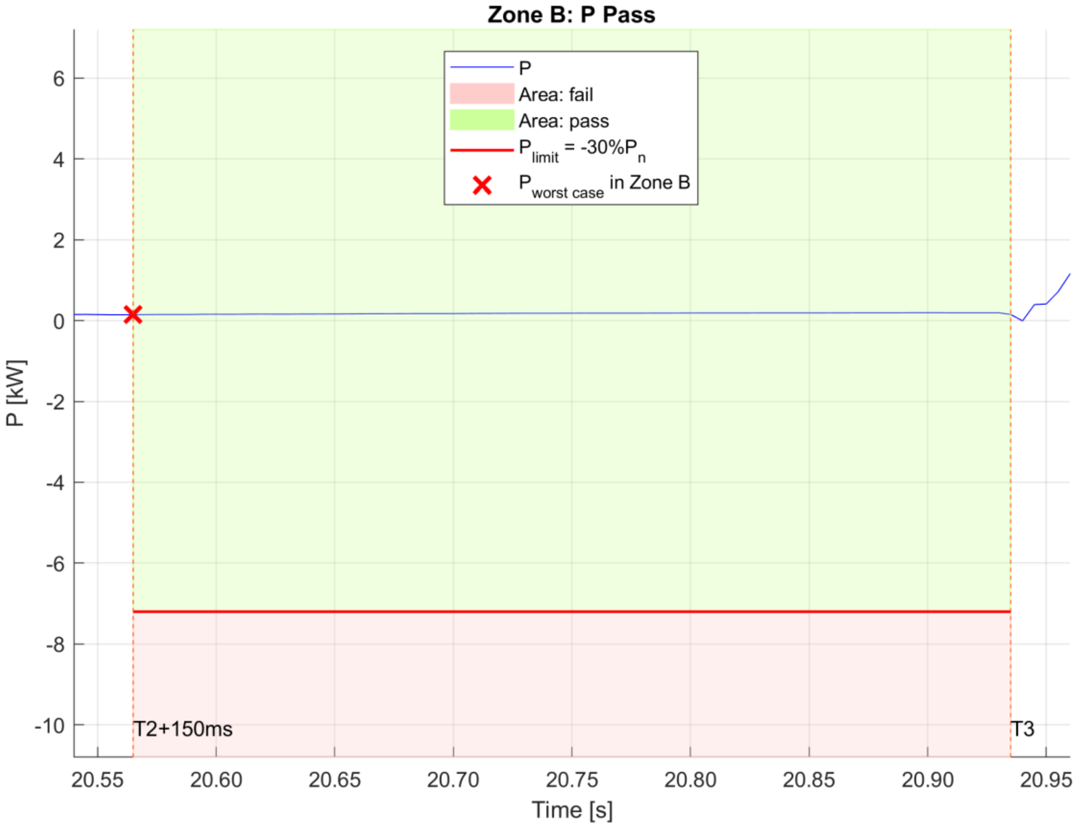


Behaviour during grid disturbance



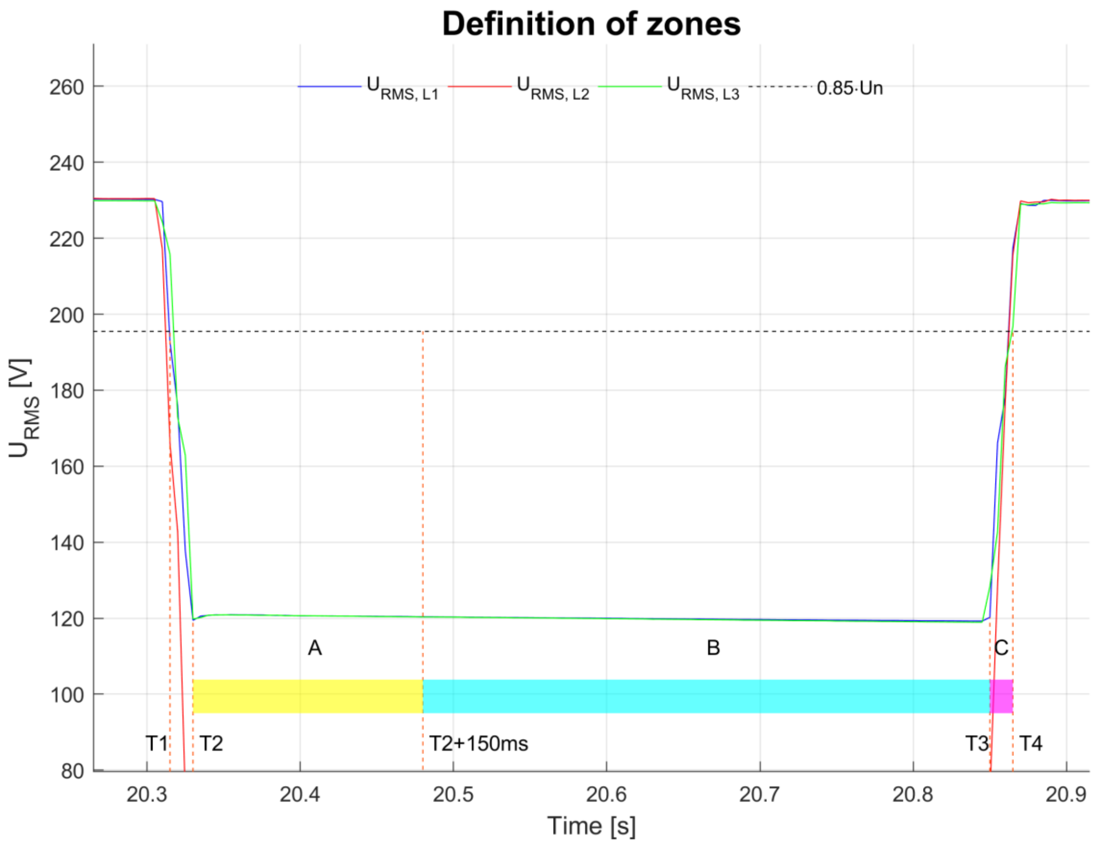


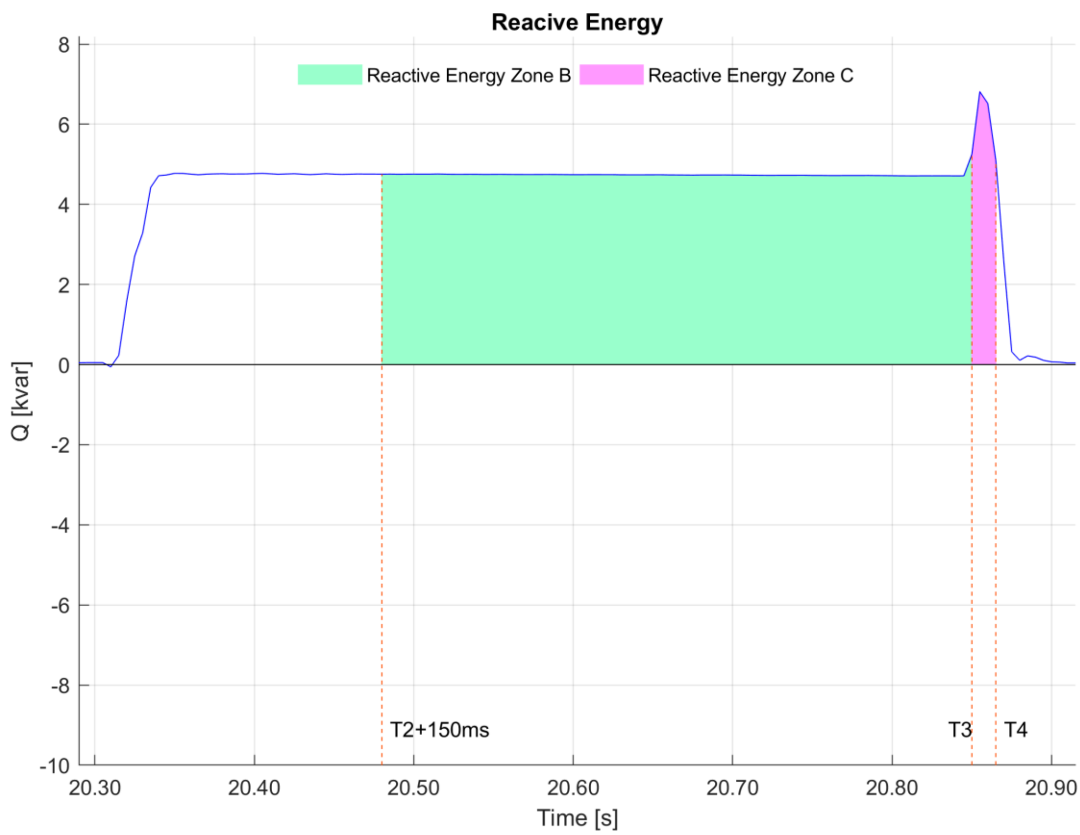
Behaviour during grid disturbance



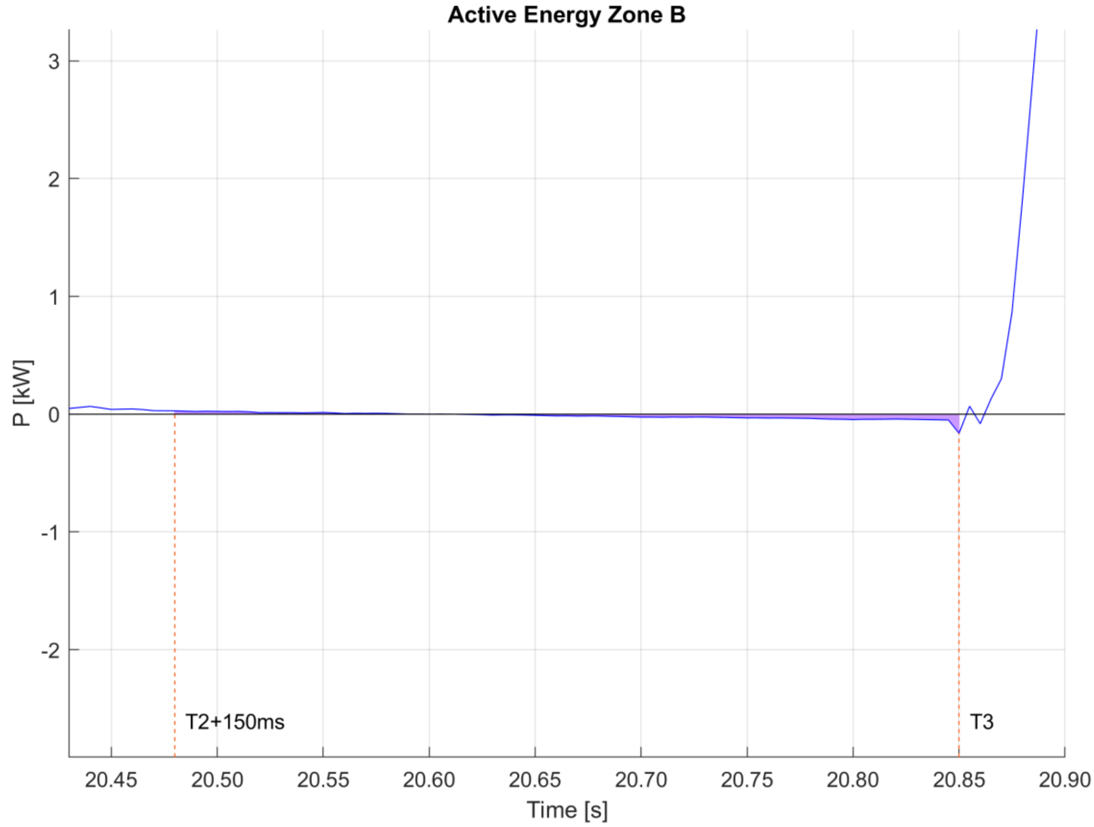
Behaviour during grid disturbance		
Three-phase-system		
1.2 Asymmetric faults		
Measurement B		**P**
Test no. 1.2.2		
SOFAR 24KTLX-G3		
	P.O.12.3 Requirement	**Result**
B ZONE		
Net consumption E_r < 40% P_n *100 ms	-40·ms·p.u.	73,036 ms·p.u.
Net consumption Q < 40% P_n (20 ms)	-0,4 p.u.	0,196 p.u.
Net consumption E_a < 45% P_n *100 ms	-45·ms·p.u.	-0,211 ms·p.u.
Net consumption P< 30% P_n (20 ms)	-0,3 p.u.	-0,007 p.u.

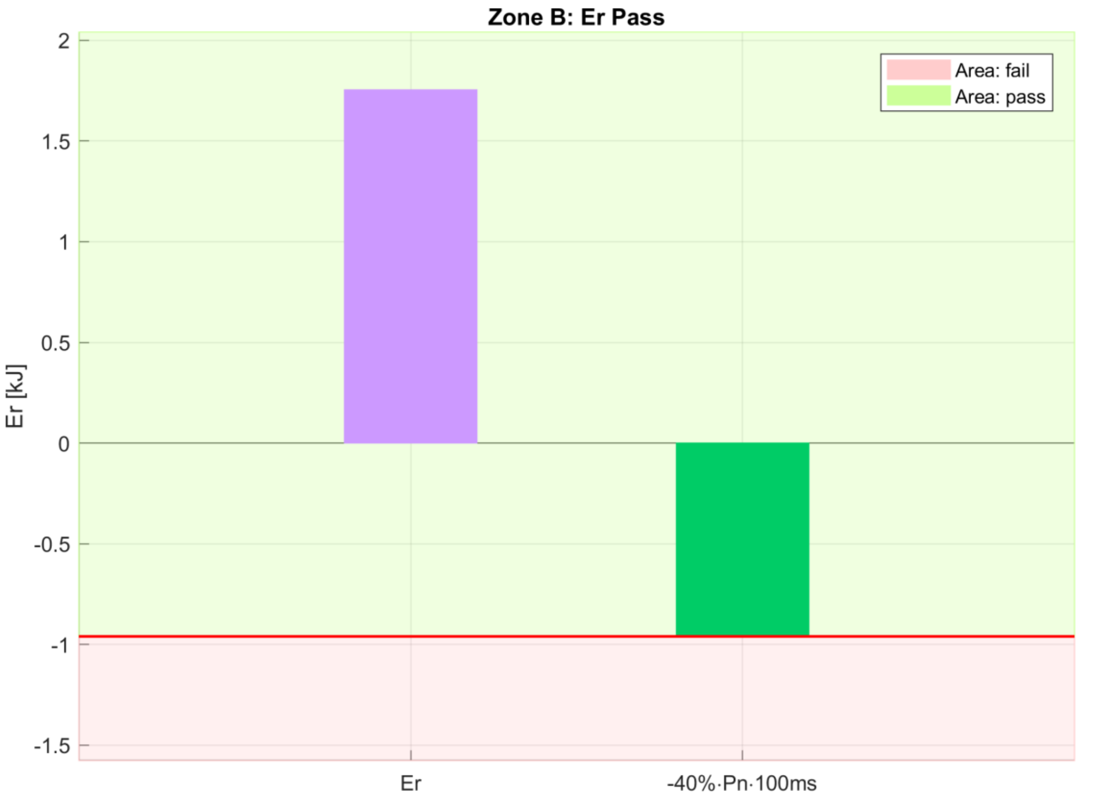
Behaviour during grid disturbance



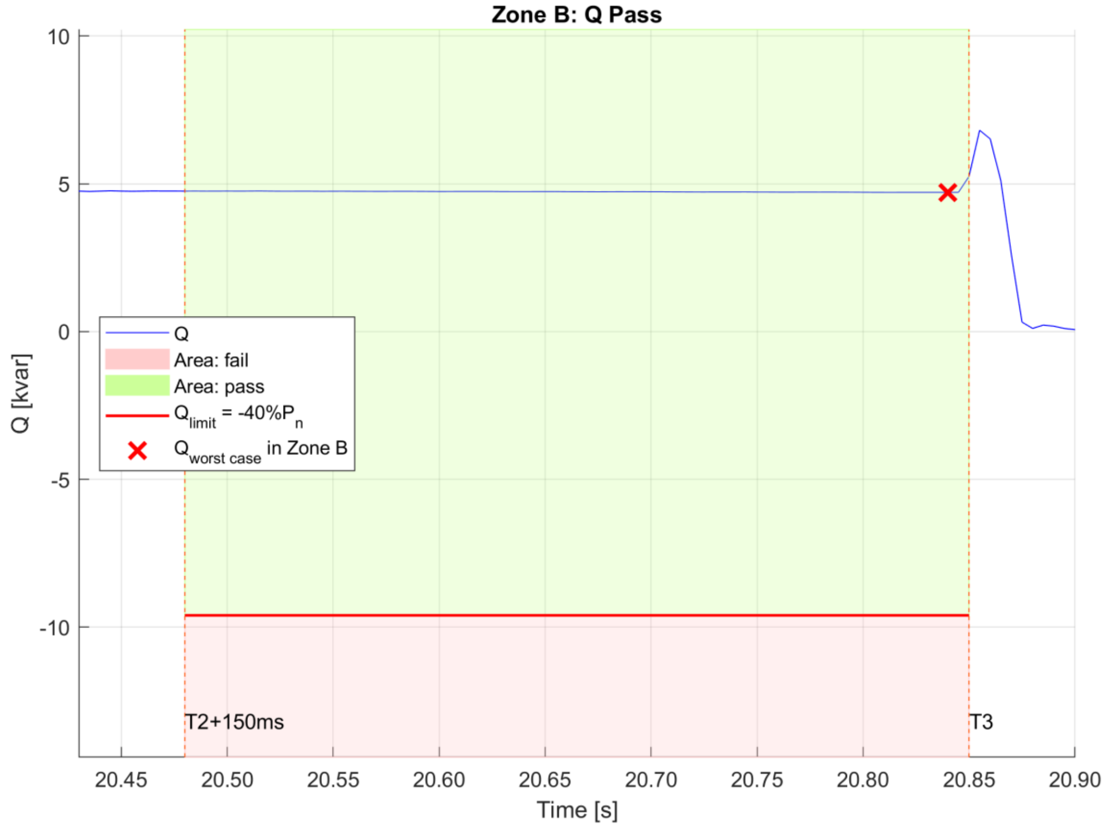


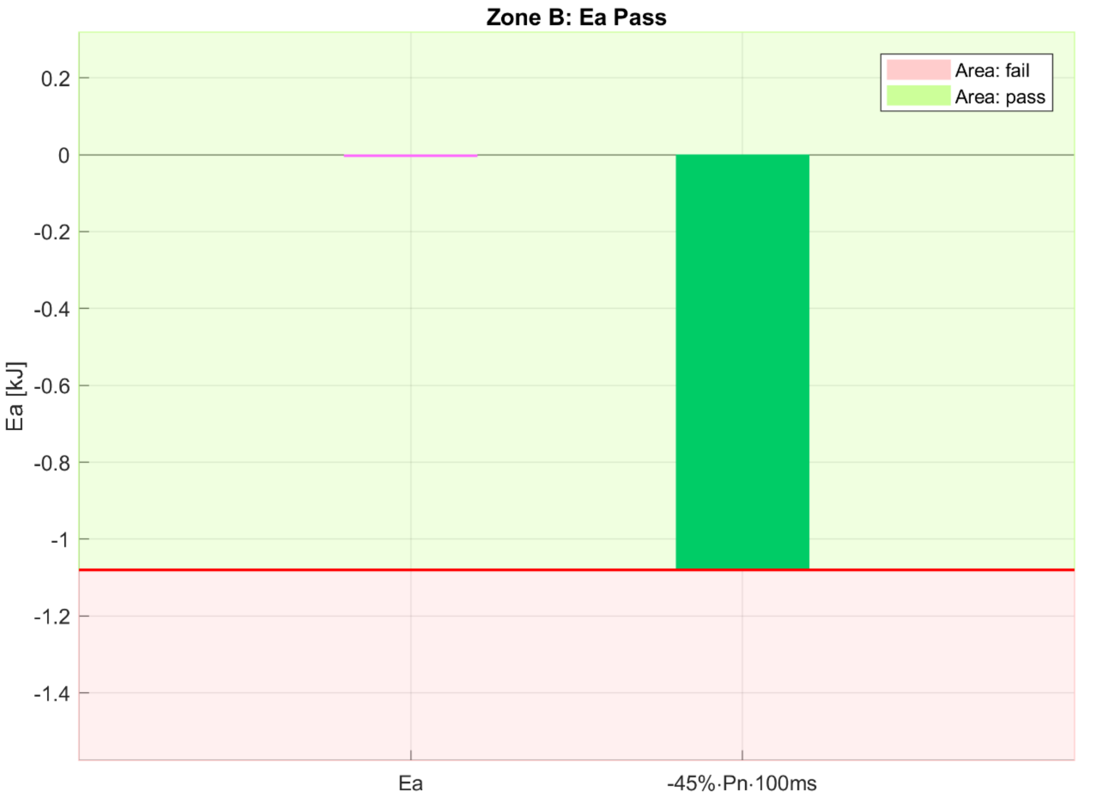
Behaviour during grid disturbance



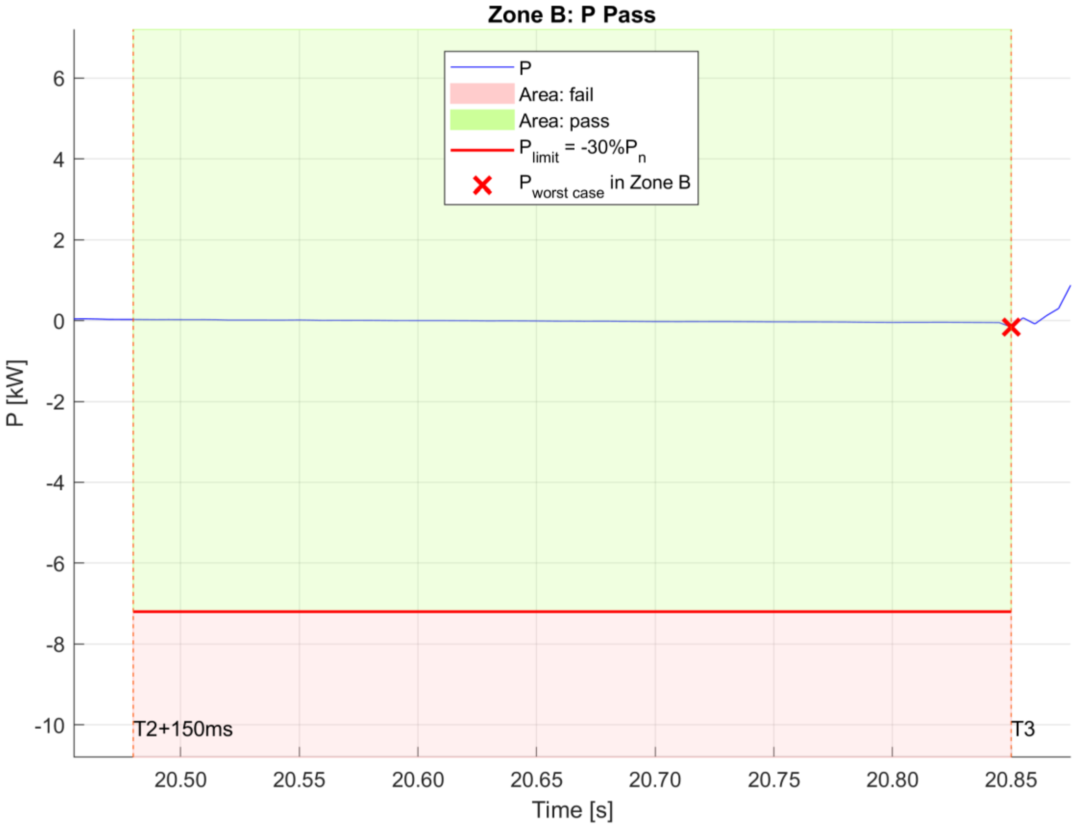


Behaviour during grid disturbance



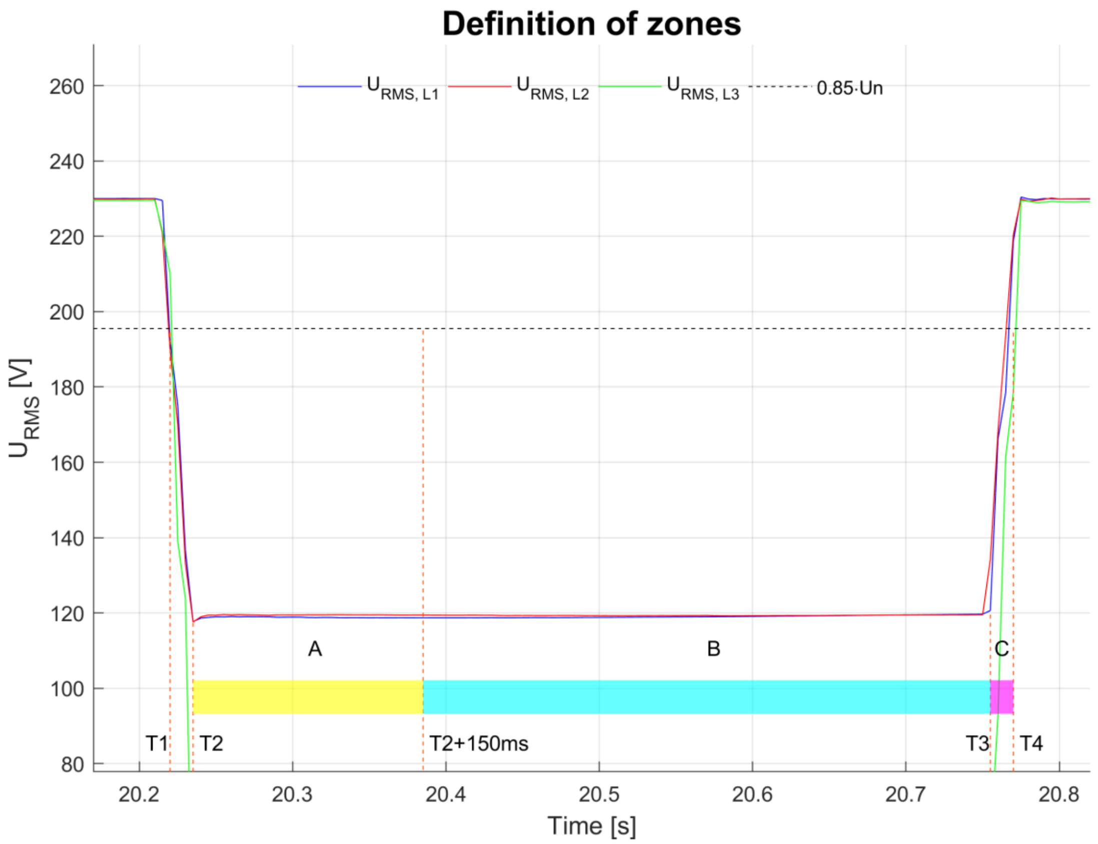


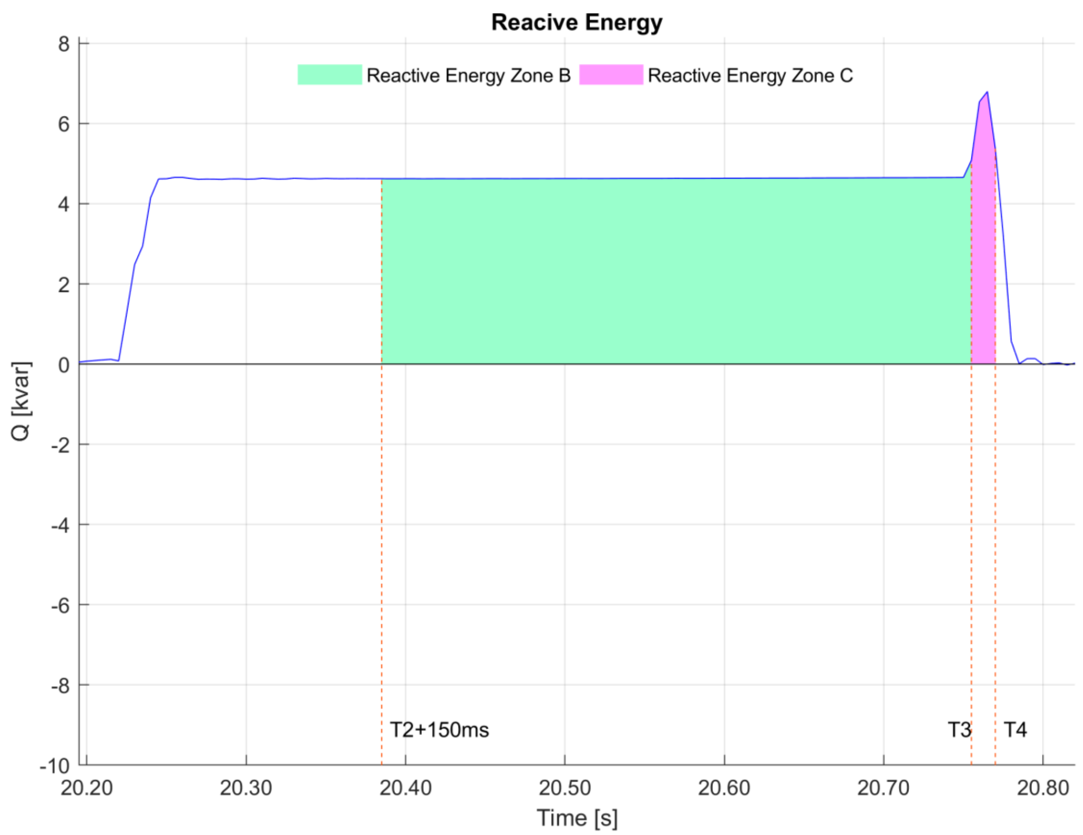
Behaviour during grid disturbance



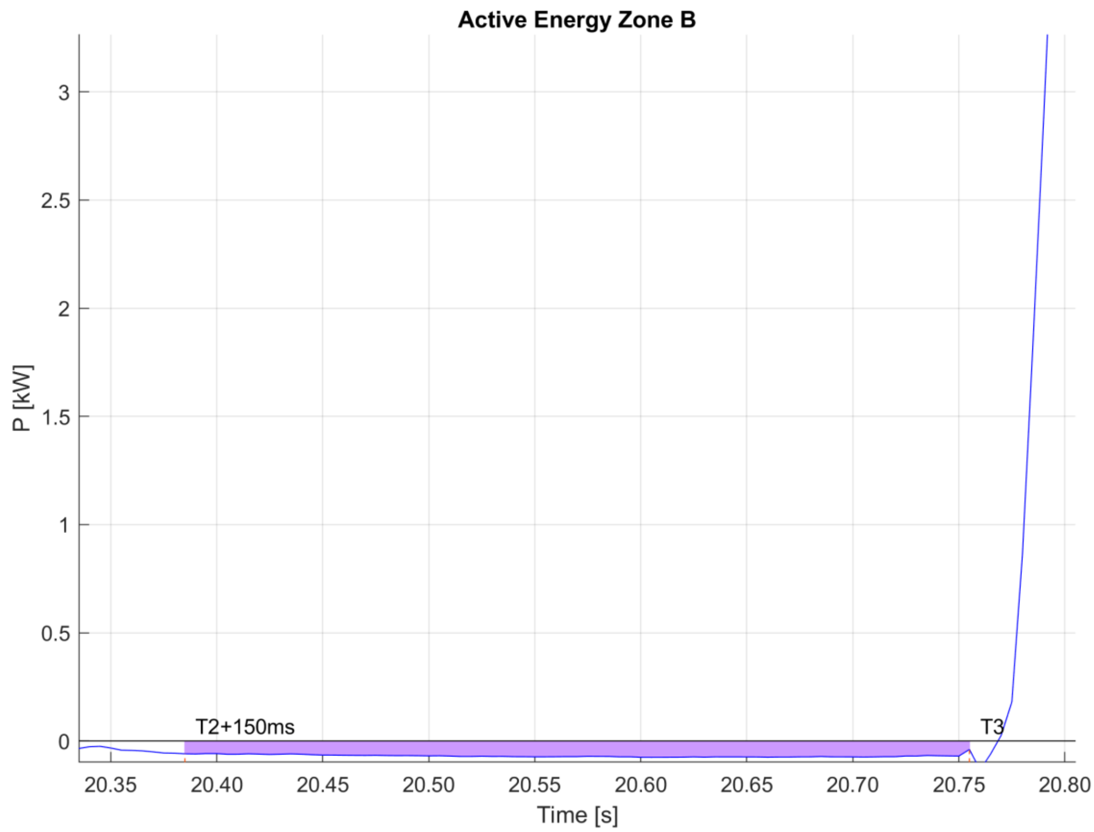
Behaviour during grid disturbance		
Three-phase-system		
1.2 Asymmetric faults		
Measurement C		**P**
Test no. 1.2.2		
SOFAR 24KTLX-G3		
	P.O.12.3 Requirement	**Result**
B ZONE		
Net consumption E_r < 40% P_n *100 ms	-40·ms·p.u.	71,483 ms·p.u.
Net consumption Q < 40% P_n (20 ms)	-0,4 p.u.	0,193 p.u.
Net consumption E_a < 45% P_n *100 ms	-45·ms·p.u.	-1,071 ms·p.u.
Net consumption P< 30% P_n (20 ms)	-0,3 p.u.	-0,003 p.u.

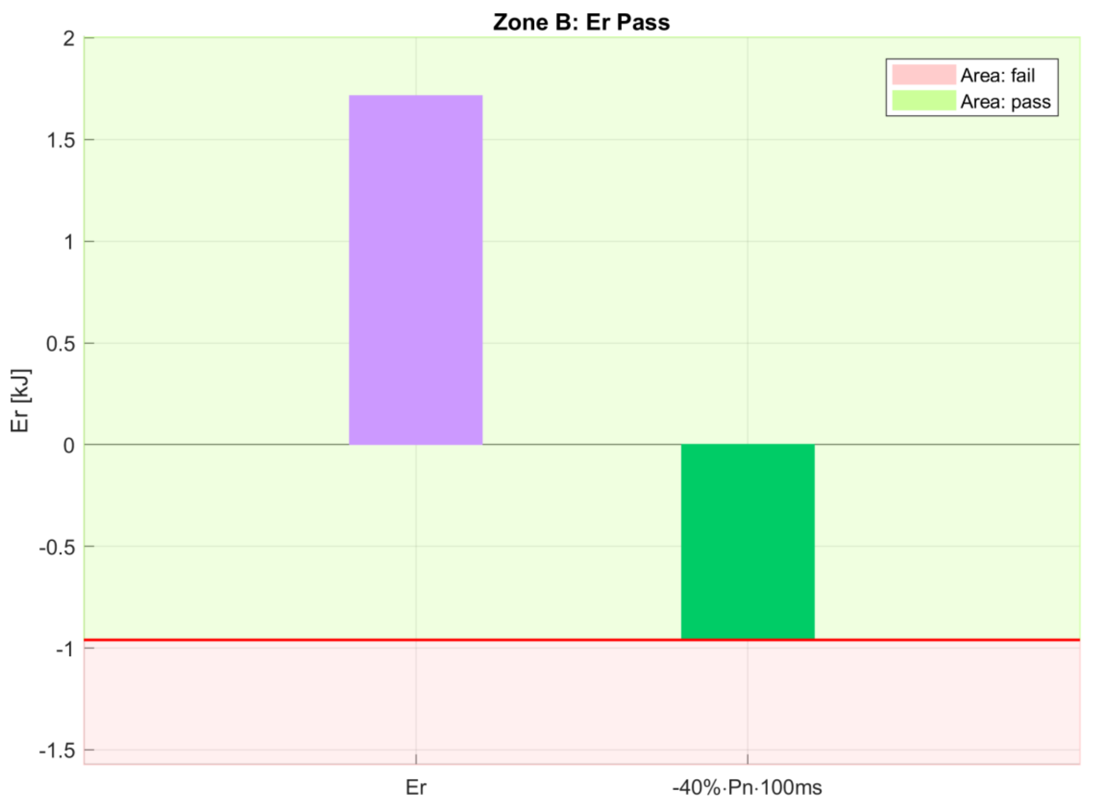
Behaviour during grid disturbance



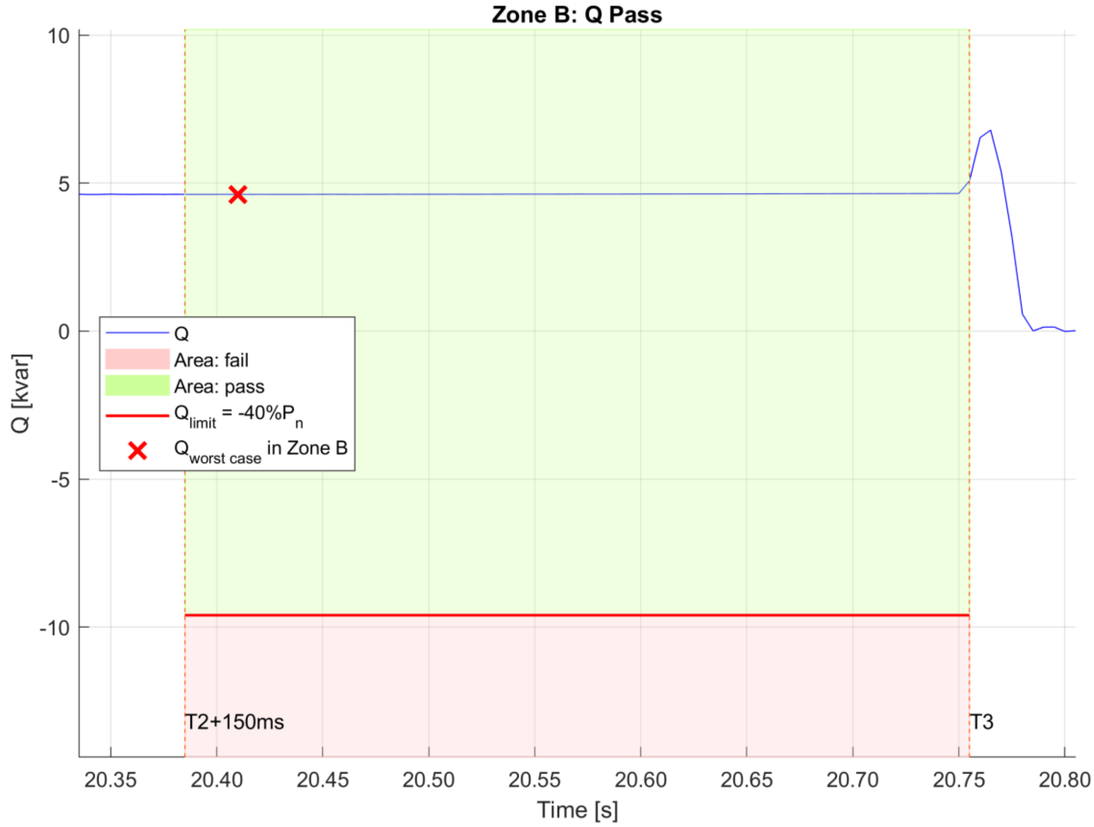


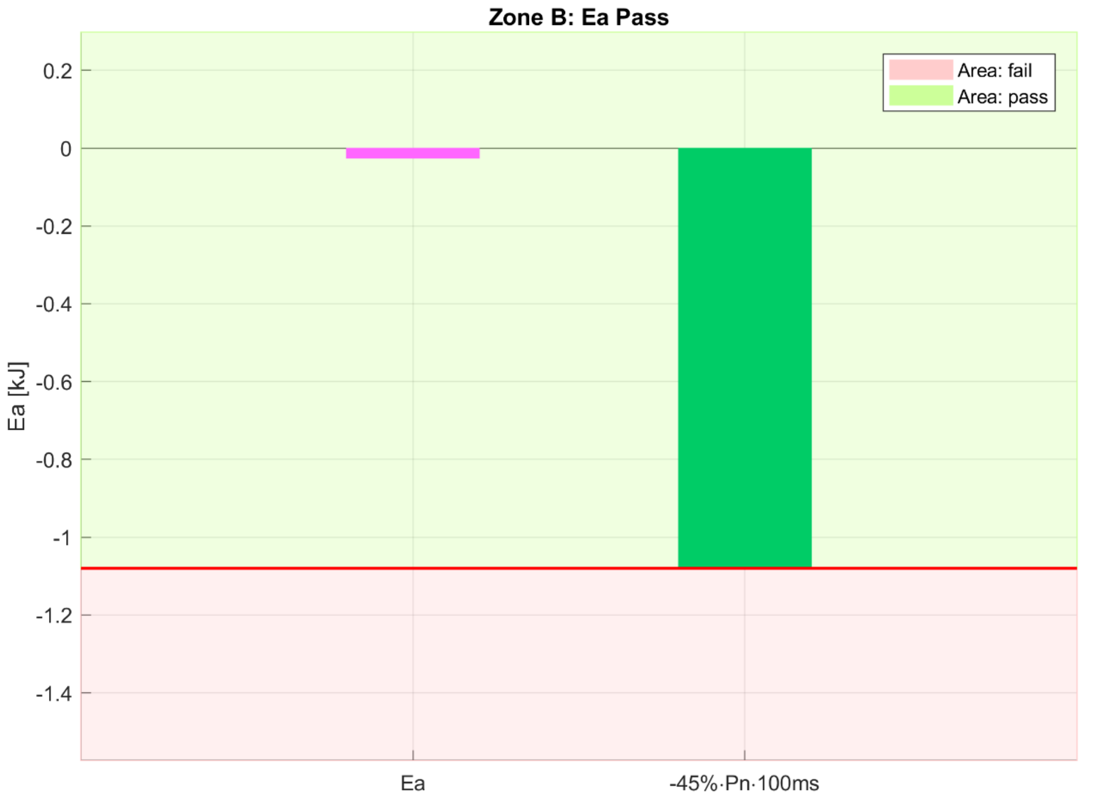
Behaviour during grid disturbance



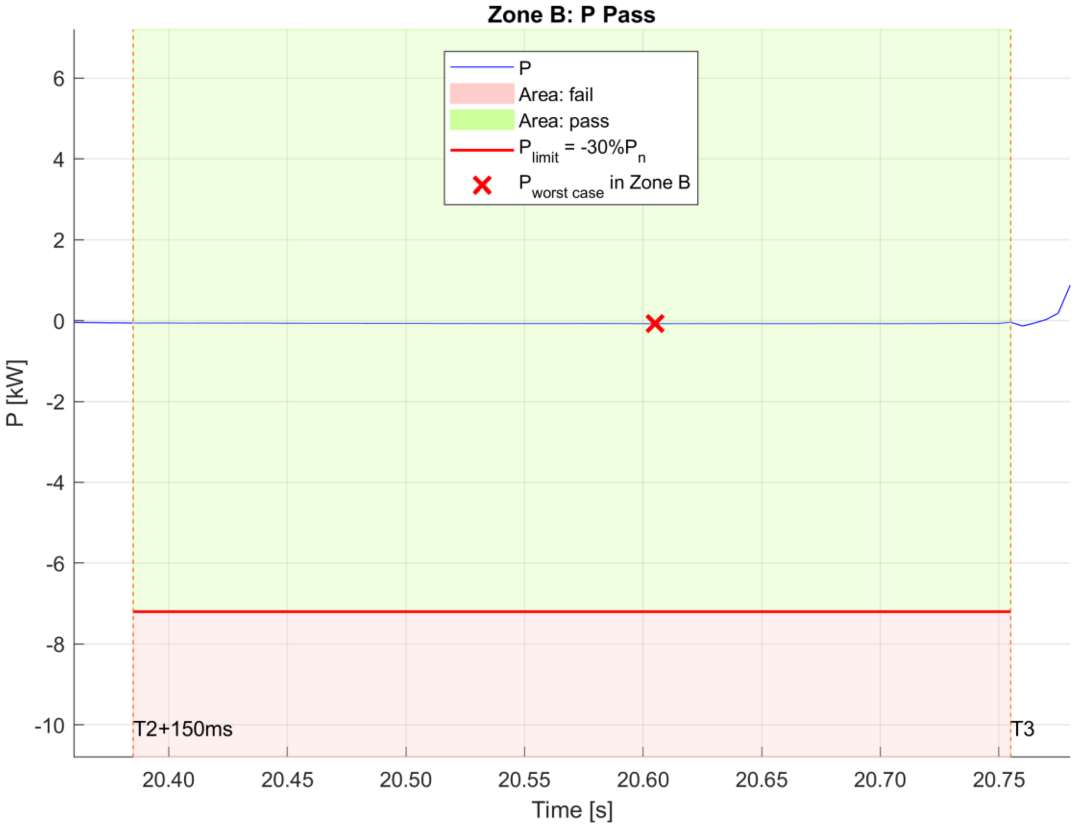


Behaviour during grid disturbance





Behaviour during grid disturbance



Annex 2 – Pictures of the unit

Enclosure front view

Enclosure side view

Enclosure rear view

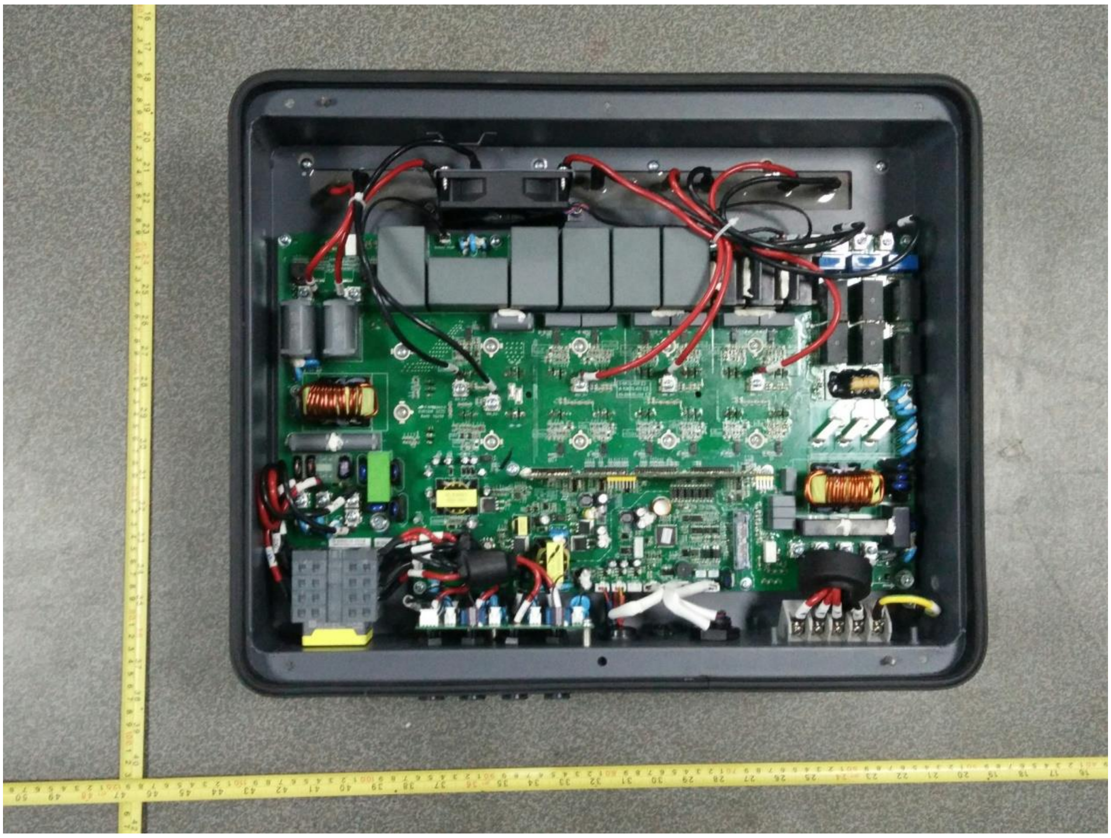
Enclosure bottom view

SOFAR 15KTLX-G3, SOFAR 17KTLX-G3

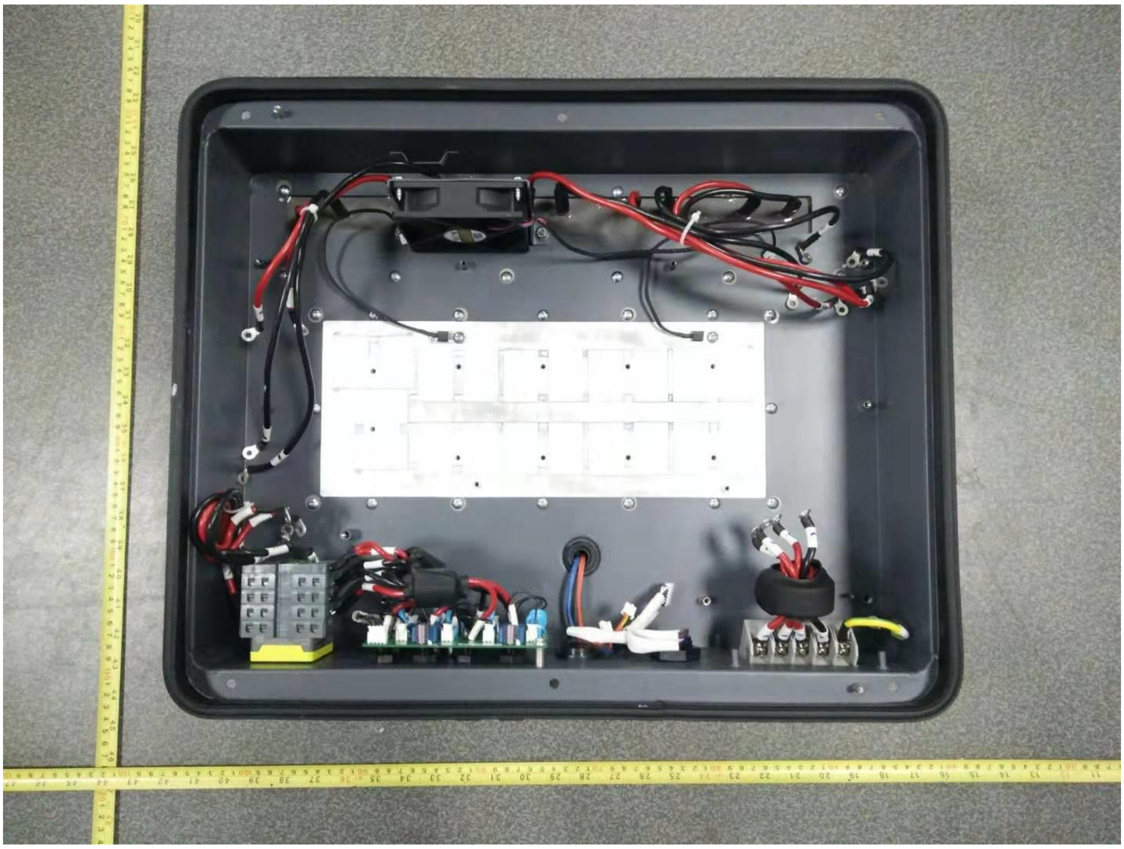
Enclosure bottom view

SOFAR 20KTLX-G3, SOFAR 22KTLX-G3, SOFAR 24KTLX-G3

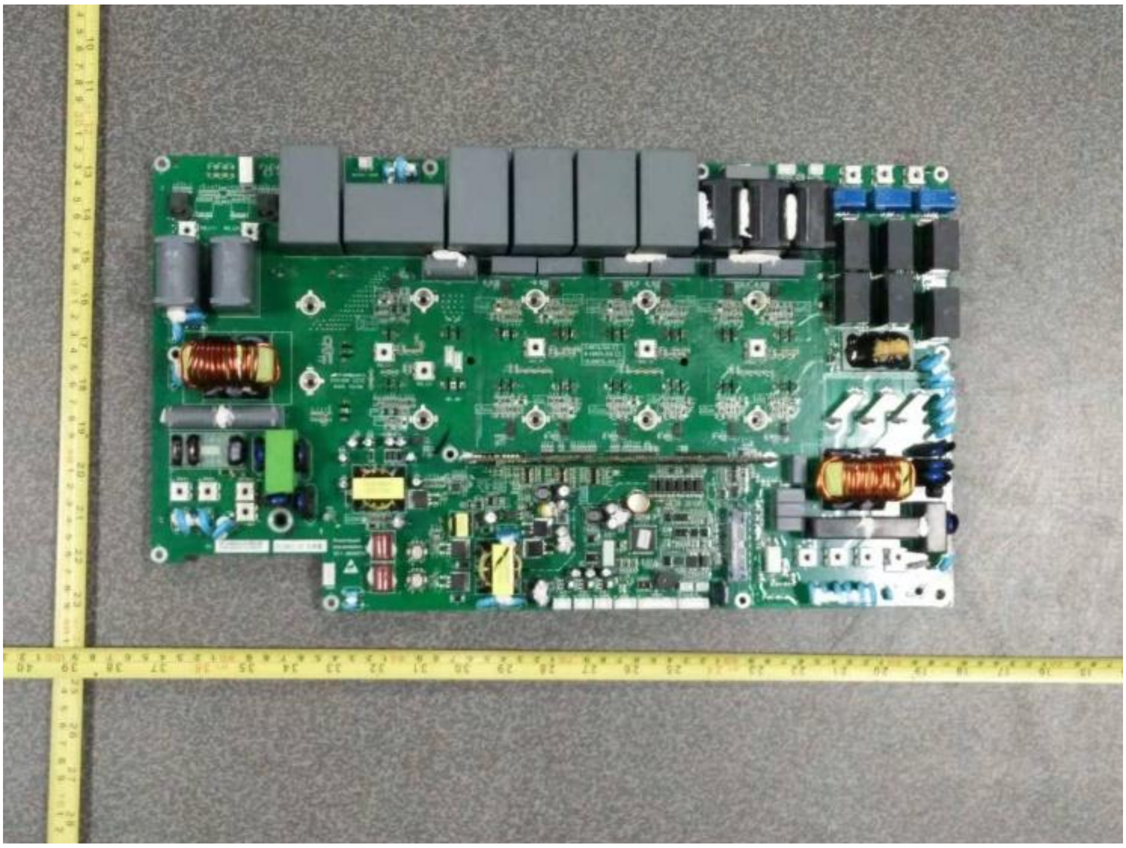
Internal view 1



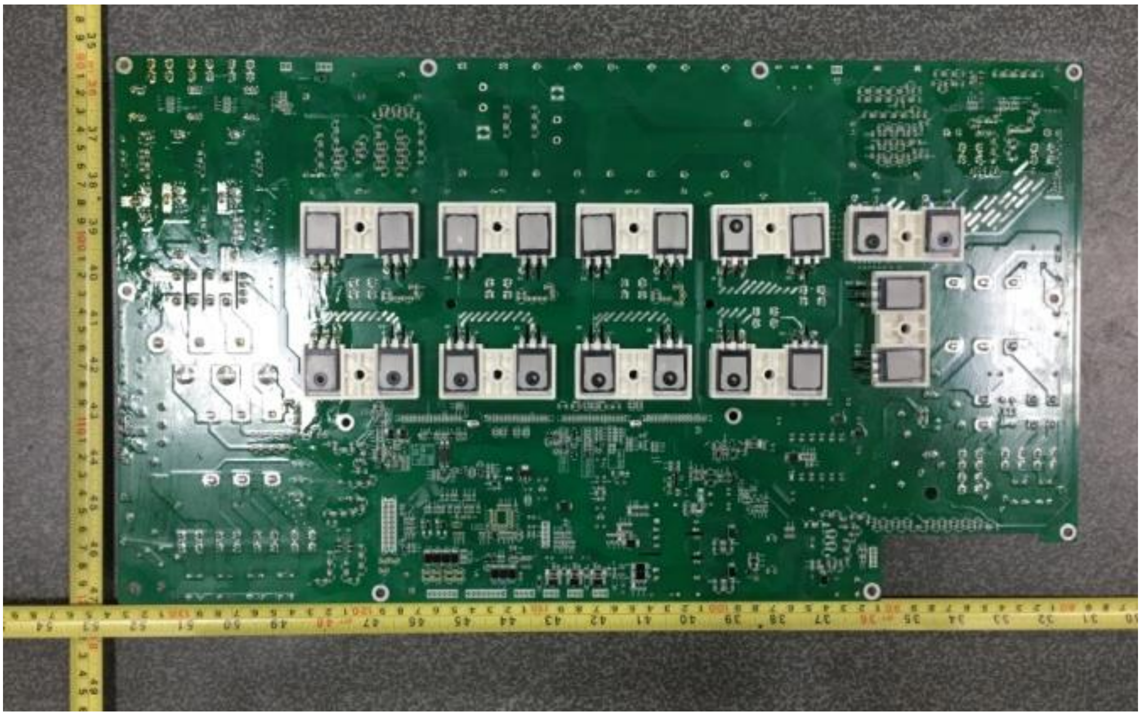
Internal view 2



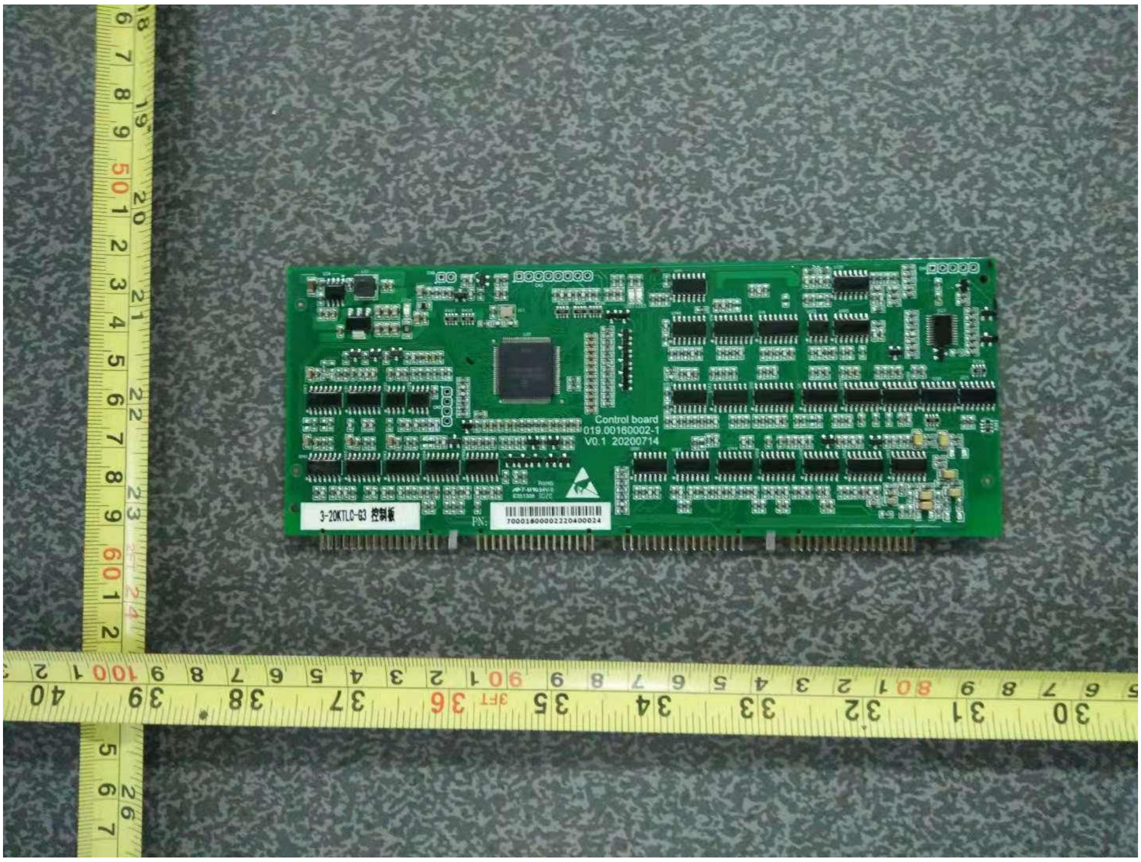
Power board-component side view



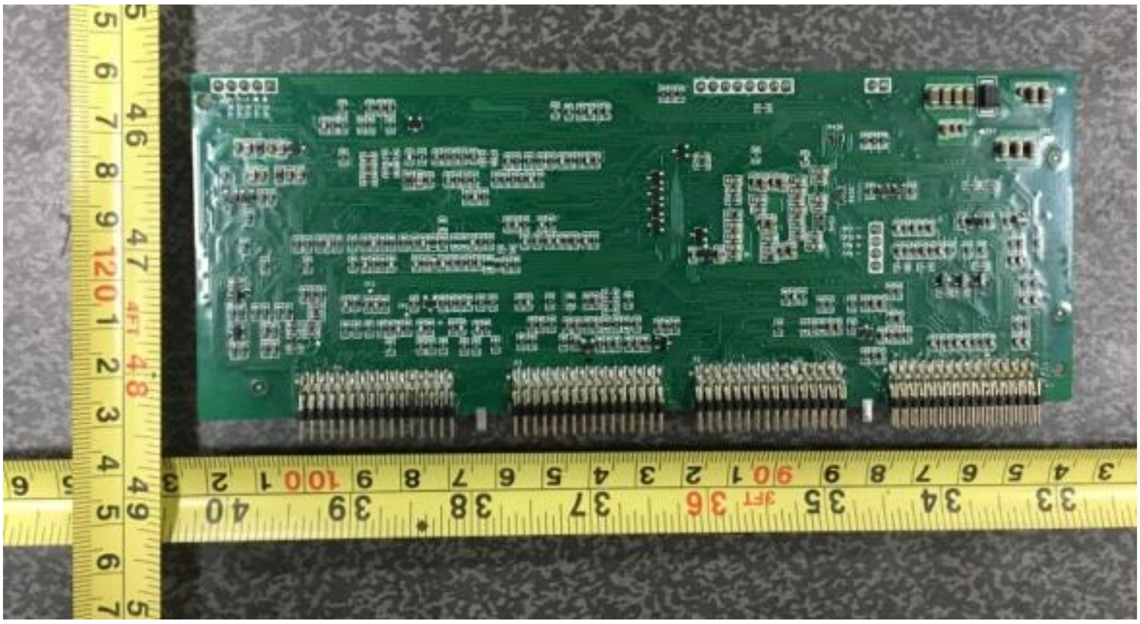
Power board-solder side view



Control board-component side view



Control board-solder side view



LCD board-component side view

LCD board-solder side view

General view of Grouding point

Annex 3 – Test equipment list

Testing Location: Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch
Date(s) of performance test: 2020-11-20 till 2021-02-04

Equipment	Internal No.	Manufacturer	Type	Serial No.	Next Calibration date
Power Analyser	A4080002DG	YOKOGAWA	WT3000	91M210852	Jun. 16, 2021
AC Source	A7040019DG	Chroma	61512	61512000439	Monitored by Power Analyser
	A7040020DG	Chroma	61512	61512000438	
DC Simulation Power Supply	A7040015DG	Chroma	62150H-1000S	62150EF00488	
	A7040016DG	Chroma	62150H-1000S	62150EF00490	
	A7040017DG	Chroma	620028	620028EF00120	
RLC Load	A7150027DG	Qunling	ACLT-3803H	93VOO2869	
Eight Channel Digital Phosphor Oscilloscope	A4089017DG	YOKOGAWA	DL850	91N726247	Sep. 02, 2021
Oscilloscope probe	A4089008DG	Tektronix	TPP1000	C008230	Aug. 10, 2021
	A4089010DG	Tektronix	TPP1000	C008228	Aug. 10, 2021
	A4089011DG	Tektronix	TPP1000	C008229	Aug. 10, 2021
Current transducer	A1060007DG	YOKOGAWA	CT200	1130700012	Sep. 02, 2021
	A1060008DG	YOKOGAWA	CT200	1130700017	Sep. 02, 2021
	A1060012DG	YOKOGAWA	CT200	1130700018	Sep. 02, 2021

End of Test Report