



**BUREAU
VERITAS**

Type Certificate

Applicant: TRUMPF Hüttinger GmbH + Co. KG

Address: Bötzing Str. 80
79111 Freiburg am Breisgau
Germany

Type of power generating unit:	Grid-tied bi-directional battery inverter	TruConvert AC3025 (for details see <i>Supplement of certificate</i> on p.2)
Technical data:	Rated apparent power:	25 kVA
	Nominal output AC voltage:	400 V
	Nominal frequency:	50 Hz
Technical data determined by measurements:	Max. active power $P_{E_{max}}$ / Max. active power peak P_{600} :	(for details see <i>Supplement of Certificate</i> on p.2)
Firmware version:		V01.27.03
Software version:		IL14B008
Validated type model:	Model file:	Trumpf_TrucConvert_AC3025_rev2c_enc.pfd
	Identification number (MD5):	157f2c15d4a6e2d77db75d7609c9bc39

Grid connection regulation: VDE-AR-N 4110:2018-11 – Technical requirements for the connection and operation of customer installations to the medium voltage network (TCR medium voltage) [1]

Pertinent standards / Guidelines: Technical guidelines:
FGW TR 3 Rev. 25 [2], FGW TR 4 Rev. 09 [3], FGW TR 8 Rev. 09 [4]

The power generating units, stated in the certificate, were tested and certified according to the technical guidelines referenced to the grid connection regulation. The electrical characteristics fulfil the requirements of the grid connection regulation:

- Quasi-steady-state operation
- Dynamic network stability (reactive current characteristic according to TCR medium voltage)
- Active power output and network security management
- Active power adjustment as a function of the grid frequency
- Power quality

The manufacturer has provided proof of certification of the quality management system of his production facility in accordance with ISO 9001

Restrictions, deviations or notes on usage: see *Supplement of Certificate* on p.2.

The certificate includes the following information:

- technical data of the power generating unit, the auxiliary equipment used and the software version used;
- schematic structure of the power generating units;
- summarized information on the properties of the power generating unit.

The certificate is comprised of 77 pages (including Annex of 75 pages).

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BV project number : 19TH0414

Certificate no. : U22-0235_0

Issued : 2022-08-31

Certification scheme : NSOP-0032-DEU-ZE-V01

Valid until : 2027-08-30

Certification body

Alf Assenkamp



Certification body of Bureau Veritas Consumer Products Services Germany GmbH accredited according to DIN EN ISO/IEC 17065
A partial representation of the certificate requires the written approval of Bureau Veritas Consumer Products Services Germany GmbH



BUREAU VERITAS

Supplement of Certificate (U22-0235_0)

Type of power generating unit:	Grid-tied bi-directional battery inverter	TruConvert AC3025
Technical data:	Nominal active output power ¹⁾	25 kW
	Rated apparent / active output power:	25 kVA / 25 kW
	Nominal voltage:	400 V
	Nominal frequency:	50 Hz
Technical data determined by measurements:	Max. active power $P_{E_{max}}$ / Max. active power peak P_{600} ^{2), 3)} :	28,8 kW
	Firmware version:	V01.27.03
Software version:		IL14B008

Note:

- ¹⁾ The nominal active output power P_n is just a nominal value defined by manufacturer, for details see p.6
- ²⁾ The $P_{E_{max}}$ is the highest 10-min mean of the active power of a power generating unit defined according to VDE-AR-N 4110:2018 [1]. The P_{600} is the maximum active power peak of the overall system (averaging period 10 min) defined according to FGW TR 3 Rev. 25 [2].
- ³⁾ The stated measurement results were determined according to test 4.1.1, FGW TR 3 Rev. 25 [2].

Restrictions, deviations or notes on usage:

- Measurement results of reactive power capability are below -1% PrE of manufacturer specifications. For plant certification the measurement results have to be used (see manufacturer declaration)
- In the event the communication with the PGS controller is disturbed, PGU cannot be operated with a predefined value or process and is switched off instead. This behaviour requires the approval of the network operator as part of the plant certification process.
- The PGU provides no reactive power control functions. These have to be implemented on the plant level e.g. in a superimposed PGS controller.
- The functionality of the active power gradient in the case of connections in accordance with 10.4, setpoint specifications by third parties (e.g. direct marketing) and grid security management in accordance with 10.2.4.2 is not implemented in the PGU. This must be implemented at the plant level, e.g. in a superimposed PGS controller.
- Only one Interface for specifying active power implemented on the PGU. Separate specifying active power by grid operator and direct seller is not possible. For prioritization of different setpoints must be carried out at plant level e.g. in the superimposed PGS controller.
- Reconnection conditions after tripping of a protection device are not implemented in the unit. This functionality has to be implemented on the plant level e.g. in an external protection device.
- The PGU does not have an integrated protection device. An additional, certified device must be used.
- The coupling switch of the unit is not part of the scope of the certificate. An assessment of the requirements must be done at plant certification
- The PGU follows reactive power set points without delay and does not provide PT1 filtering effect. This functionality has to be implemented at plant level e.g. in a superimposed PGS controller.

The certificate is comprised of 77 pages (including Annex of 75 pages).

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Description of the revisions of certificate U22-0235_0

Rev. 0	First issue
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Annexes included in certificate U22-0235_0

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1. Annex 1 – Guidelines, test reports and documents

This certificate is based on following guidelines, test reports and documents:

Reference	Guidelines
[1]	Technische Regeln für den Anschluss von Kundenanlagen an das Mittelspannungsnetz und deren Betrieb (TAR Mittelspannung), VDE-AR-N 4110:2018-11 / <i>Technical requirements for the connection and operation of customer installations to the medium voltage network (TCR medium voltage), VDE-AR-N 4110:2018-11</i>
[2]	Technische Richtlinien für Erzeugungseinheiten und –anlagen TEIL 3 (TR3), Bestimmung der elektrischen Eigenschaften von Erzeugungseinheiten und -anlagen, Speicher sowie für deren Komponenten am Mittel-, Hoch- und Höchstspannungsnetz, Revision 25, Stand 01.09.2018 / <i>Technical Guidelines for Power Generating Units and Systems PART 3 (TG3), Determination of the Electrical Characteristics of Power Generating Units and Systems, Storage Systems as well for their Components in Medium-, High- and Extra-High Voltage Grids, Revision 25, Dated 01/09/2018</i>
[3]	Technische Richtlinien für Erzeugungseinheiten und –anlagen TEIL 4 (TR4), Anforderungen an Modellierung und Validierung von Simulationsmodellen der elektrischen Eigenschaften von Erzeugungseinheiten und -anlagen, Speicher sowie deren Komponenten, Revision 09, Stand 01.02.2019 / <i>Technical Guidelines for Power Generating Units and Systems PART 4 (TG4), Demands on Modelling and Validating Simulation Models of the Electrical Characteristics of Power Generating Units and Systems, Storage Systems as well as their Components, Revision 09, Dated 01/02/2019</i>
[4]	Technische Richtlinien für Erzeugungseinheiten, -anlagen und Speicher sowie für deren Komponenten TEIL 8 (TR8), Zertifizierung der elektrischen Eigenschaften von Erzeugungseinheiten und -anlagen, Speicher sowie für deren Komponenten am Stromnetz, Revision 09, Stand 01.02.2019 / <i>Technical Guidelines for for Power Generating Units, Systems and Storage Systems as well as for their Components PART 8 (TG8), Determination of the Electrical Characteristics of Power Generating Units and Systems, Storage Systems as well for their Components in Medium-, High- and Extra-High Voltage Grids, Revision 09, Dated 01/02/2019</i>
[5]	Kurzschlussströme in Drehstromnetzen Teil 0: Berechnung der Ströme, DIN EN 60909-0 (VDE 0102):2016-12 / <i>Short-circuit currents in three-phase a.c. systems Part 0: Calculation of currents (IEC 60909-0:2016)</i>

Reference	Test reports
[6]	19TH0414_TR3_Rev25_0 TG3 test report according to FGW TG3 Rev.25, issued by Bureau Veritas Consumer Products Services Germany GmbH on 05.May.2022
[7]	19TH0414_TR4_0 TG4 test report according to FGW TG4 Rev.09, issued by Bureau Veritas Consumer Products Services Germany GmbH on 29.Aug.2022
[8]	19TH0414_TR8_0 TG8 evaluation report according to FGW TG8 Rev.09, issued by Bureau Veritas Consumer Products Services Germany GmbH on 30. Aug. 2022
[9]	19TH0414_TR3_Rev25_0_excerpt-part_1_0 Extract from the TG3 test report, issued by Bureau Veritas Consumer Products Services Germany GmbH on 05.May.2022
[10]	19TH0414_TR3_Rev25_0_excerpt-part_2_0 Extract from the TG3 test report, issued by Bureau Veritas Consumer Products Services Germany GmbH on 05.May.2022

1. Annex 1 – Guidelines, test reports and documents

The compliance to the grid connection regulation of the power generating units is shown by the results in the test report (19TH0414_TR3_Rev25_0) which includes all type tests stated in the certificate. The type tests were conducted by Bureau Veritas Consumer Products Services Germany GmbH.

The compliance to the grid connection regulation of the simulation models is verified by the validation report (19TH0414_TR4_0). The simulations were conducted by Bureau Veritas Consumer Products Services Germany GmbH.

The summary of the grid connection regulation compliant certification of the units


- TruConvert AC3025

is stated in the certification report (19TH0414_TR8_0).

Reference	Certification-relevant documents provided by manufacturer
[11]	Manufacturer's certificate on specific data of a battery storage converter of the type TruConvert AC3025, dated 07.Mar.2022: F.0_TRUMPF_HUETTINGER_AC3025_TR3_Manufacturer certificate_Final_signed
[12]	Manufacturer's declaration type testing, dated 07.Mar.2022: F.1_TRUMPF_HUETTINGER_AC3025_TR3_Manufacturer certificate_Final_signed_print
[13]	Parameter list of PGU/storage system or series, dated 26.Oct.2021: F.2_TRUMPF_HUETTINGER_AC3025_TR3_Manufacturer certificate_Final
[14]	Herstellereklärungen Elektrische Eigenschaften des Batteriewechselrichters TruConvert AC 3025 für die Zertifizierung gemäß VDE-AR-N 4110:2018-11, dated 12.Jul.2022: VDE-AR-N 4110_Herstellererklärung_rev1.5_AC
[15]	Model change notification Trumpf Hüttinger GmbH & Co. KG. - Tru-Convert AC 3025, issued by FGH GmbH, Date: 02.Aug.2022 Model_Rev2c-Änderungsvermerk_Trumpf_TrucConvert AC 3025_FGH
[16]	Model Implementation report Trumpf Hüttinger GmbH & Co. KG.TrucConvert AC 3025, issued by FGH GmbH, Date: 02.Aug.2022 Trumpf_TrucConvertAC3025_Model-Report-rev2c

2. Annex 2 – Technical characteristics of the power generating unit (Manufacturer’s data)

2.1. Technical data of the power generating unit (Manufacturer’s data)

Herstellerbescheinigung zu spezifischen Daten eines Speicherumrichters vom Typ TruConvert AC3025			
Manufacturer’s certificate on specific data of a battery storage converter of the type TruConvert AC3025			
Datum / Date: 2022-03-07		Seite/Page 1/2	
1	Allgemeines und Ausgangsgrößen	General and Output values	
1	Hersteller	TRUMPF Hüttinger GmbH + Co. KG	manufacturer
2	Typenbezeichnung	TruConvert AC 3025	type name
3	Einspeisung (einphasig/dreiphasig)	3/N/PE	no. of phases (single-phase/three-phase)
4	Nennscheinleistung	25,0	kVA rated apparent power
5	Nennwirkleistung	25,0	kW rated active power
6	AC-Nennspannung	400	V rated AC-voltage
7	AC-Nennfrequenz	50	Hz rated frequency
8	Beitrag zum Stoßkurzschlussstrom (i _p nach IEC 60909-0)	45,6	A contribution to initial short circuit current (i _p according to IEC 60909-0)
2	DC Eingangsgrößen	DC Input	
1	Min. DC-Spannung	750	V min. DC voltage
2	Max. DC-Spannung	950	V max.DC voltage
3	Max. DC-Eingangsspannung		V max.DC input voltage
4	Max. DC-Eingangsstrom		A max.DC input current
5	Max. Speicherleistung (Laden/Entladen)		kW max. power (charge/discharge)
3	Wechselrichter-Leistungsteil	Converter-Power section	
1	Hersteller	TRUMPF Hüttinger GmbH + Co. KG	manufacturer
2	Typenbezeichnung	TruConvert AC 3025	type name
3	Nennscheinleistung	25,0	kVA rated apparent power
4	Art (HF/NF-Trafo, trafoles)	trafoles	generic type (HF/LF-transformer, without)
5	Taktfrequenz	20	kHz pulse rate of inverter
6	Art der Leistungsregelung (MPPT)	Kein MPPT	generic type of power control (MPPT)
7	Software-Version		software version
4	Sonstige elektrische Komponenten	Other electric components	
1	Art der Netzkopplung	3/N/PE	generic type of interconnection
2	- Hersteller	TRUMPF Hüttinger GmbH + Co. KG	- manufacturer
3	- Typenbezeichnung	TruConvert System Control	- type
4	Netzschutz integriert (Ja/Nein)	Nein	integrated grid protection (Yes/No)
5	Netzschutzhersteller	ARN4110 Konform z.B. ZIEHL	grid protection manufacturer
6	- Typenbezeichnung	ARN4110 Konform z.B. UFR1001E	- type
7	Typenbezeichnung der Abschalteneinheit (angesteuert vom Netzschutz)	Anwendungsspezifisch z.B. DILMP125(RDC24)	circuit breaker type controlled by the grid protection
8	Oberschwingungsfiler (ja/nein)	NEIN	harmonic filter (yes/no)
9	EZA-Regler	ARN4110 Konform z.B. WAGO Power Plant Control auf PFC200	EZA Controller
5	Typenprüfung	Type test	
1	Prüfbehörde		testing authority
2	Aktenzeichen		reference
3	Seriennummer des Wechselrichters		serial number of converter

2. Annex 2 – Technical characteristics of the power generating unit (Manufacturer's data)

TRUMPF Höttinger
GmbH + Co. KG
Bötzingen Straße 80, 79111 Freiburg
Tel. +49 761 8971-0

i.A. 

Anschrift des Herstellers
Address of manufacturer

Stempel, Datum, Unterschrift
stamp, date, signature

Der Hersteller des PV-Wechselrichters / Speicherumrichters bestätigt, dass der PV-Wechselrichter / Speicherumrichter, dessen elektrischen Eigenschaften in den Prüfberichten abgebildet sind, hinsichtlich seiner technischen Daten mit den o.g. Positionen identisch ist.

The manufacturer of the PV-Converter / Battery storage converter confirms that the PV-Converter / Battery storage converter whose power quality is measured and depicted in the test reports, is identical with the above entries with regard to its technical data

Figure 1 – Manufacturer's certificate on specific data from [11]

2. Annex 2 – Technical characteristics of the power generating unit (Manufacturer’s data)

2.2. Description of the power generating unit

The bidirectional battery inverter (*TruConvert AC3025*) adapts current from DC voltage bus bar, generated by battery modules, into AC current on grid voltage level for both charging and discharging operation of the batteries. The units are three-phase. Information regarding the application that controls the unit for energy feed in and supply is given in Manufacturer’s declaration with the inverter connection plan and its overview block diagram [14].

The intended scope of certification concerns the (*TruConvert AC 3025*) inverter unit together with the control unit System Control (SysCon), outlined in red in Fig 2.

The (*TruConvert AC 3025*) inverter unit is not directly controlled by a primary energy supply, an application is required that provides the unit with corresponding setpoints for feeding into the grid or drawing energy from the grid. This application is customer specific and usually consists of an energy and/or battery management system. This unit is called control shield, see in Fig 2.

From a technical point of view, the application can be implemented on the same Programmable Logic Controller (PLC) as the certified DCA controller. The application does not influence the EZA controller and does not add any delay to the specifications of the network operator.

External additional components are required for operation as a complete EZE, as shown in Fig 2 and Fig 3

- VDE AR-N-4110 (Valid version) Certified NA protection
- VDE AR-N-4110 (Valid version) Certified EZA controller with associated measuring transformers
- FRT capable 24V power supply
- Grid-side and inverter-side switch (CB1 and CB1_1 in Fig. 2).

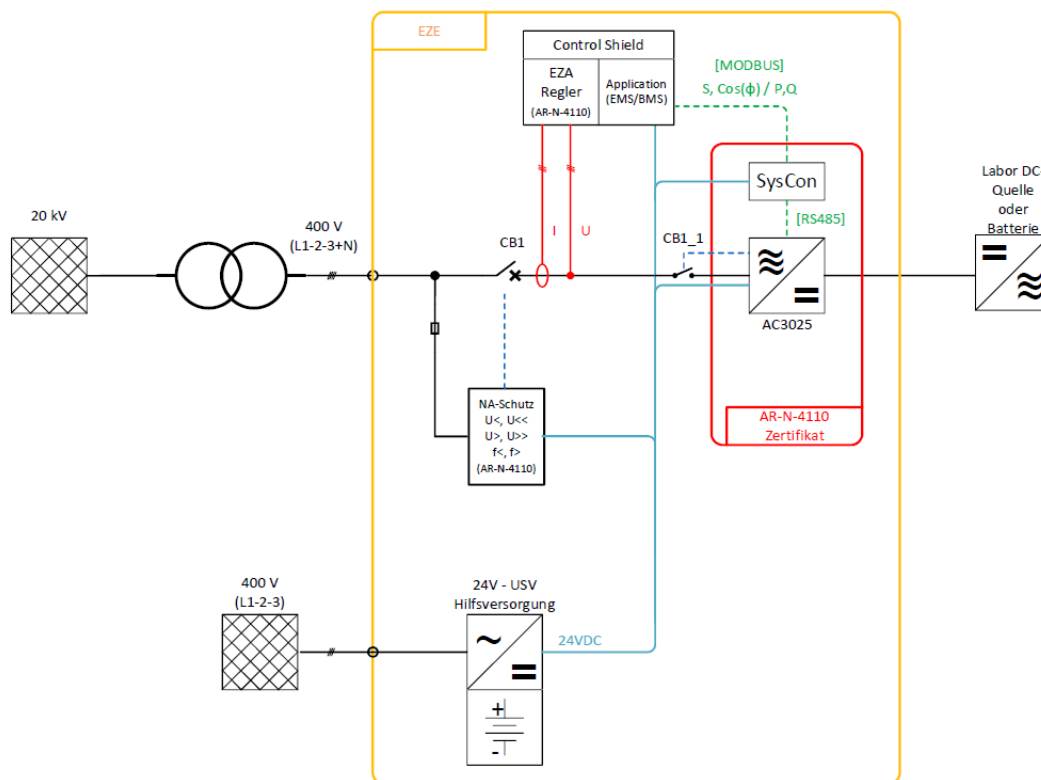


Figure 2 – Overview block diagram [14]

2. Annex 2 – Technical characteristics of the power generating unit (Manufacturer’s data)

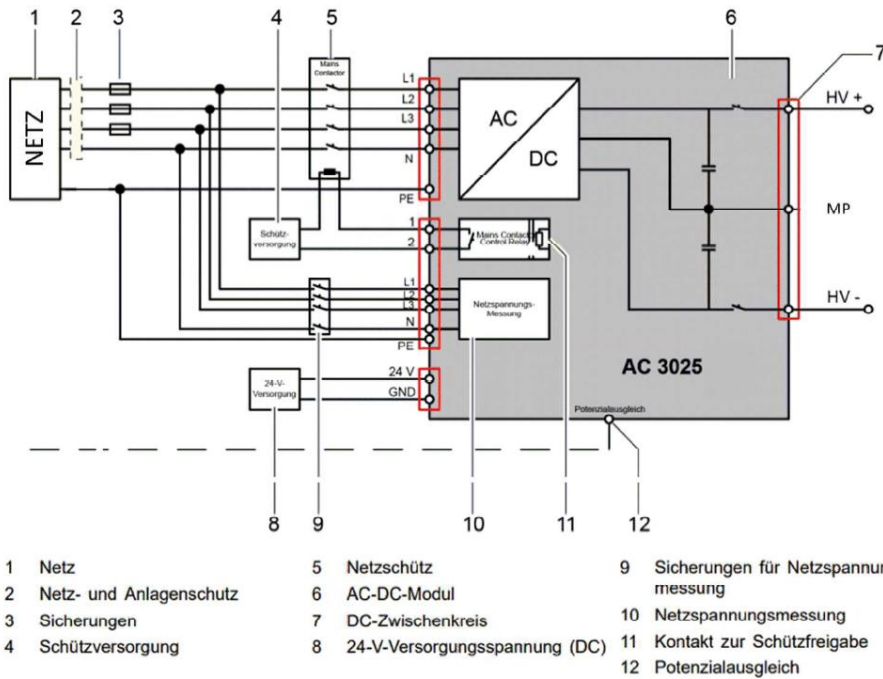


Figure 3 – Inverter connection plan (TruConvert AC3025) [14]

Description of the power circuit (Figure 4)

Dimension of EUT: 437 by 129 by 500 mm. (W x H x D)

The bidirectional battery inverter converts DC voltage into AC voltage and vice-versa.

The unit is providing EMC filtering at the output toward mains. The unit does not provide galvanic separation from input to output. The output is switched off redundant by the high power switching bridge and a relay. This assures that the opening of the output circuit will also operate in case of one error.

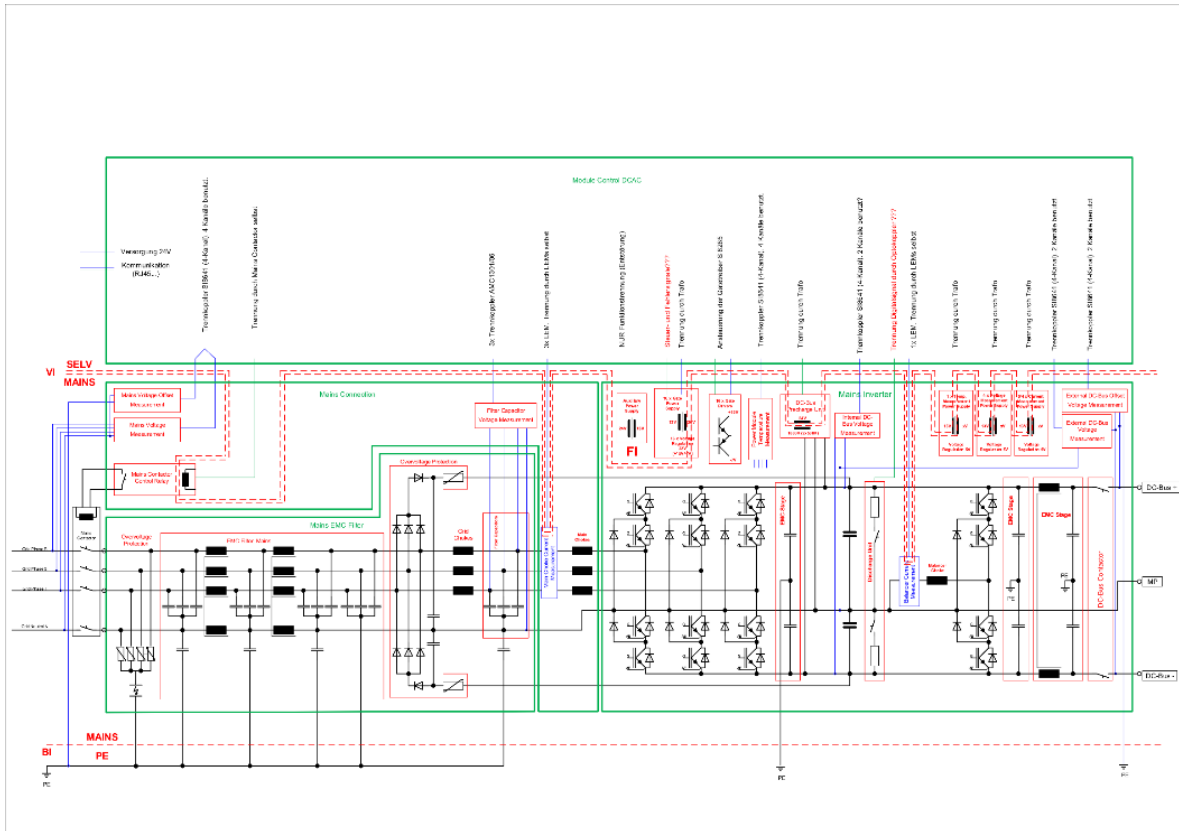


Figure 4 – Block diagram of the utility interactive inverter

2. Annex 2 – Technical characteristics of the power generating unit (Manufacturer’s data)

2.3. Description of software version and interfaces

Following is the software and firmware version used for the TG3 testing [13]:

Main components of the control system with firmware and software	
Main component(s) of the control system (Hardware on which the control software is operated)	PCB Control AC Sunny
Firmware version (clear identification of the firmware)	V01.27.03 (Inverter)
Software version (clear identification of the software)	V04.25.01 (System Control)
Parameter set (clear identification of the parameter set)	REV94643

Die Software für den Leistungsteil und für die Steuerung wird zu einem Paket gebündelt, auch IL (Integration Level) genannt.

Wechselrichter, die mit der nach FGW TR3 / TR4 qualifizierte Software IL14B008 betrieben werden, entsprechen den Anforderungen der AR-N-4110.]

Figure 5 – Software and firmware version used for the TG3 testing from [13]

Note:

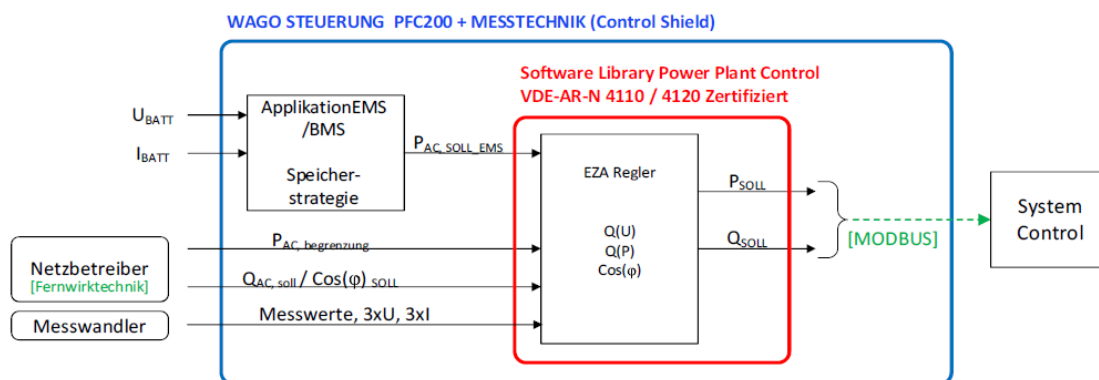
if not specified otherwise, the following applies:

(Any updates have influence on the verified AC electrical behaviour of the PGU need to be informed and approved by Bureau Veritas Consumer Products Services Germany GmbH.)

2. Annex 2 – Technical characteristics of the power generating unit (Manufacturer's data)

Following are the interfaces provided on the PGU level for active and reactive power setting, and behaviour of the PGU in the event of a communication failure with the PGS controller [14]:

Die Umsetzung der statischen Netzstützung bzw. die Aufbereitung der Sollwerte zur Blindleistungsfahrweisen und Wirkleistungsbegrenzung wird durch einen sog. „EZA-Regler“ übernommen. Dieser EZA-Regler ist im Kern ein Softwarebaustein (Rot umrandet in Bild 3) der auf einer SPS läuft. Dieser Software Baustein priorisiert und koordiniert die Vorgaben vom Netzbetreiber und von der Applikation und erzeugt passende Wirk- und Blindleistungssollwerte die Anschließend in der SPS in Scheinleistung und $\cos(\varphi)$ umgerechnet werden. Diese Umrechnung entspricht dem Block „Sollwert Umrechnung“ in Bild 3 und wird in der gleichen Berechnungsiteration durchgeführt wie die Sollwertvorgabe des zertifizierten EZA-Reglers. Dadurch entsteht keine zusätzliche Zeitverzögerung. Diese Umrechnung ist im Allgemeinen bei der Verwendung eines EZA-Reglers mit dem TruConvert AC 3025 in der Form (Bild 3) umzusetzen.



Gemäß Herstellerangaben kann der Ausgewählte EZA-Regler über Zusatz-Kommunikationsmodule folgende Schnittstellen für den Netzbetreiber anbieten:

- Fernwirkprotokoll IEC 61850
- Rundfunkempfänger über Digitale Eingänge
- Analogeingänge

Weitere Schnittstellen werden in der Dokumentation des EZA-Reglers [2] Seite 35/35 erläutert. Lösungen von alternativen Anbietern sind zulässig, mindestens eine der vom Netzbetreiber geforderten Fernwirk-Möglichkeiten für die EZA-Anbindung muss vorhanden sein.

An der EZE ist kein Fern/Ort- Umschalter vorgesehen.

Die Verfahren zur statischen Netzstützung werden vom EZA-Regler als externe Komponente und zertifizierter Software-Baustein umgesetzt.

Folgende Wirk- und Blindleistungssollwertvorgaben sind gemäß VDE AR-N-4110:2018-11 implementiert:

- Blindleistung als Funktion der Netzspannung $Q(U)$
- Blindleistung als Funktion der Wirkleistung $Q(P)$
- Blindleistung als Funktion der Netzspannung mit Begrenzungsfunktion $Q(U_{db})$
- Fester Verschiebungsfaktor $\cos(\varphi)$
- Feste Blindleistungssollwertvorgabe Q_{soll}
- Wirkleistungssollwertvorgabe P_{soll}
- Wirkleistungsgradient nach Spannungslosigkeit $P(U)$

Bei der Umsetzung der Wirkleistungsvorgabe gibt es technisch keine nennenswerte Zeitverzögerung. Die Vorgabe wird innerhalb von weniger als 200 ms umgesetzt. Die Genauigkeit der Frequenzmessung beträgt 10 mHz, siehe Tabelle 33.

Figure 6 – Interfaces provided on the PGU level for active and reactive power setting from [14]

2. Annex 2 – Technical characteristics of the power generating unit (Manufacturer's data)

Als Kommunikationsschnittstelle zu Drittkomponenten sowie zu einem EZA-Regler besitzt das TruConvert System bzw. die TruConvert System Control lediglich eine Modbus Schnittstelle und unterstützt die Protokolle TCP/UDP. Über diese Schnittstelle können Wirk- und Blindleistungsvorgaben zum TruConvert AC3025 wie in Bild 3 dargestellt. Bei Ausfall der Kommunikation zwischen EZA-Regler und der TruConvert System Control wird das System runter gefahren und abgeschaltet. Dies ist nicht zu verwechseln mit dem Verhalten bei Ausfall der Fernwirkverbindung, das im EZA-Regler eingestellt wird.

Figure 7 – Behaviour of the PGU in the event of a communication failure with the PGS controller [14]

3. Annex 3 – Extract from the test report

3.1. Power quality



Extract from the test report - Part 1: Power Quality

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Report No.:

4.3 SYSTEM PERTURBATIONS / NETZRÜCKWIRKUNGEN				
4.3.2 Switching operations / Schalthandlungen				
TruConvert AC3025 (V01.27.03)				
Case of switching operation / Art der Schalthandlung	Start-up at $P_{available} < 10\%P_n$ / Einschalten bei $P_{verfügbar} < 10\%P_n$			
Max. number of switching operations / Max. Anzahl Schalthandlungen, N_{10} (Manufacturer's data / Herstellerangabe)	10			
Max. number of switching operations / Max. Anzahl Schalthandlungen, N_{120} (Manufacturer's data / Herstellerangabe)	120			
Grid impedance angle / Netzimpedanzwinkel, ψ_k	30°	50°	70°	85°
Flicker step factor / Flickerformfaktor, $k_f(\psi_k)$	0,27	0,57	0,84	0,96
Voltage change factor / Spannungsänderungsfaktor, $k_u(\psi_k)$	0,40	0,74	1,01	1,10
Case of switching operation / Art der Schalthandlung	Switch-on at $P_{available} = 100\%P_n$ / Einschalten bei $P_{verfügbar} = 100\%P_n$			
Max. number of switching operations / Max. Anzahl Schalthandlungen, N_{10} (Manufacturer's data / Herstellerangabe)	10			
Max. number of switching operations / Max. Anzahl Schalthandlungen, N_{120} (Manufacturer's data / Herstellerangabe)	120			
Grid impedance angle / Netzimpedanzwinkel, ψ_k	30°	50°	70°	85°
Flicker step factor / Flickerformfaktor, $k_f(\psi_k)$	0,55	0,52	0,59	0,64
Voltage change factor / Spannungsänderungsfaktor, $k_u(\psi_k)$	0,98	0,77	0,79	0,77
Case of switching operation / Art der Schalthandlung	Service shutdown at $P_{available} = 100\%P_n$ / Serviceabschaltung bei Nennleistung			
Max. number of switching operations / Max. Anzahl Schalthandlungen, N_{10} (Manufacturer's data / Herstellerangabe)	10			
Max. number of switching operations / Max. Anzahl Schalthandlungen, N_{120} (Manufacturer's data / Herstellerangabe)	120			
Grid impedance angle / Netzimpedanzwinkel, ψ_k	30°	50°	70°	85°
Flicker step factor / Flickerformfaktor, $k_f(\psi_k)$	0,83	0,62	0,33	0,14
Voltage change factor / Spannungsänderungsfaktor, $k_u(\psi_k)$	0,91	0,70	0,41	0,17

3. Annex 3 – Extract from the test report



Extract from the test report - Part 1: Power Quality

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Report No.: 19TH0414_TR3_Rev25_0_excerpt-part_1_0

4.3 SYSTEM PERTURBATIONS / NETZRÜCKWIRKUNGEN

Description of the service disconnection procedure / Beschreibung der Durchführung einer Serviceabschaltung

Disconnection from the grid takes places in two steps / Die Netztrennung erfolgt in zwei Schritte

- a) Switching off the pulse signals (PWM) of the power electronics / Ausschalten der Pulssignale (PWM) der Leistungselektronik
- b) Opening the main switch / Öffnen des Hauptschalters

Note / Anmerkung:

$S_{k,sc}/S_n$ in the fictitious grid was set to / Das Kurzschlussverhältnis im fiktiven Netz wurde gesetzt zu: 20.

3. Annex 3 – Extract from the test report



Extract from the test report - Part 1: Power Quality

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4.3 SYSTEM PERTURBATIONS / NETZRÜCKWIRKUNGEN				
4.3.3 Flicker				
TruConvert AC3025 (V01.27.03)				
Grid impedance angle / Netzimpedanzwinkel, ψ_s	30°	50°	70°	85°
Operating point / Betriebspunkt, [%P _n]	Flicker coefficient / Flickerkoeffizient, $c(\psi_s)$			
0 - 5	0,64	1,28	1,87	2,07
10	0,60	1,34	2,03	2,29
20	0,81	1,81	2,74	3,10
30	1,14	2,43	3,60	4,03
40	0,66	1,49	2,29	2,62
50	0,48	1,08	1,66	1,89
60	0,46	0,94	1,38	1,56
70	0,46	0,93	1,39	1,57
80	0,48	0,97	1,45	1,66
90	0,41	0,8	1,31	1,55
100	0,42	0,85	1,39	1,64
Max. Flicker coefficient / Max. Flickerkoeffizient, $c(\psi_s)$	1,14	2,43	3,60	4,03
Max. Short-term flicker / Max. Kurzzeitflickerstörfaktor, P _{st}	0,06	0,12	0,18	0,2
Reactive power setpoint during testing / Blindleistungsvorgabe während der Prüfungen [kvar]:	0			
Ratio S _{v,ref} /S _n in the fictitious grid used for analysis / Das für die Auswertung genutzte Verhältnis S _{v,ref} /S _n :	20			

3. Annex 3 – Extract from the test report



Extract from the test report - Part 1: Power Quality

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4.3 SYSTEM PERTURBATIONS / NETZRÜCKWIRKUNGEN

4.3.4 Harmonics / Oberschwingungen

TruConvert AC3025 (V01.27.03)

Harmonics / Harmonische

Rated current / Nennstrom [A]: 36

P [%P _n]	0 - 5	10	20	30	40	50	60	70	80	90	100	Max
Order / Ordnung	I _n [%I _n]											
1	4.94	9.96	20.05	30.47	40.63	50.57	60.72	70.68	80.74	90.83	99.86	99.86
2	0.05	0.07	0.10	0.06	0.07	0.06	0.06	0.05	0.08	0.08	0.08	0.10
3	0.69	0.12	0.83	1.09	1.04	0.77	0.77	0.77	0.77	0.77	0.82	1.09
4	0.08	0.11	0.07	0.07	0.08	0.07	0.06	0.06	0.06	0.05	0.05	0.11
5	0.36	0.48	0.34	0.69	0.84	0.86	0.71	0.54	0.45	0.42	0.54	0.86
6	0.09	0.14	0.06	0.08	0.10	0.08	0.07	0.07	0.07	0.06	0.06	0.14
7	0.36	0.33	0.39	0.43	0.62	0.71	0.66	0.55	0.43	0.38	0.40	0.71
8	0.13	0.08	0.06	0.07	0.09	0.08	0.08	0.07	0.08	0.08	0.07	0.13
9	0.67	0.53	0.38	0.22	0.39	0.47	0.43	0.39	0.31	0.24	0.24	0.67
10	0.13	0.07	0.08	0.07	0.07	0.08	0.08	0.09	0.09	0.08	0.08	0.13
11	0.61	0.47	0.13	0.38	0.17	0.40	0.42	0.39	0.35	0.25	0.25	0.61
12	0.16	0.07	0.06	0.08	0.11	0.07	0.08	0.08	0.07	0.08	0.08	0.16
13	0.61	0.33	0.31	0.35	0.31	0.20	0.35	0.36	0.34	0.30	0.28	0.61
14	0.10	0.06	0.07	0.06	0.08	0.08	0.07	0.08	0.09	0.09	0.08	0.10
15	0.46	0.43	0.44	0.13	0.30	0.13	0.24	0.27	0.26	0.18	0.18	0.46
16	0.11	0.10	0.07	0.05	0.09	0.07	0.06	0.06	0.08	0.08	0.08	0.11
17	0.25	0.20	0.22	0.20	0.29	0.24	0.11	0.22	0.26	0.21	0.20	0.29
18	0.12	0.05	0.06	0.06	0.06	0.07	0.06	0.06	0.06	0.08	0.08	0.12
19	0.24	0.38	0.23	0.31	0.20	0.26	0.10	0.15	0.21	0.21	0.17	0.38
20	0.08	0.08	0.05	0.06	0.05	0.07	0.06	0.07	0.06	0.06	0.06	0.08
21	0.21	0.17	0.38	0.32	0.05	0.28	0.13	0.08	0.14	0.16	0.14	0.38
22	0.06	0.04	0.06	0.05	0.05	0.06	0.06	0.05	0.04	0.06	0.06	0.06
23	0.20	0.26	0.26	0.22	0.14	0.23	0.17	0.05	0.12	0.15	0.14	0.26
24	0.07	0.05	0.04	0.04	0.05	0.05	0.04	0.04	0.04	0.05	0.05	0.07
25	0.16	0.14	0.13	0.08	0.24	0.20	0.20	0.09	0.08	0.12	0.10	0.24
26	0.06	0.05	0.05	0.04	0.06	0.04	0.05	0.04	0.04	0.04	0.05	0.06
27	0.17	0.17	0.25	0.17	0.24	0.13	0.20	0.11	0.06	0.13	0.12	0.25
28	0.05	0.04	0.04	0.04	0.06	0.03	0.05	0.04	0.03	0.04	0.05	0.06
29	0.16	0.12	0.23	0.23	0.20	0.08	0.19	0.12	0.05	0.09	0.09	0.23
30	0.04	0.05	0.04	0.03	0.04	0.03	0.04	0.04	0.03	0.04	0.04	0.05
31	0.14	0.13	0.12	0.20	0.16	0.07	0.18	0.15	0.03	0.10	0.10	0.20
32	0.05	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.04	0.04	0.05
33	0.14	0.12	0.15	0.15	0.10	0.12	0.17	0.16	0.04	0.06	0.07	0.17
34	0.04	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.04	0.04	0.04
35	0.12	0.12	0.17	0.09	0.11	0.14	0.14	0.16	0.06	0.08	0.10	0.17
36	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04
37	0.12	0.12	0.13	0.13	0.14	0.14	0.12	0.15	0.07	0.06	0.07	0.15
38	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04
39	0.13	0.10	0.09	0.17	0.16	0.16	0.12	0.16	0.08	0.05	0.07	0.17
40	0.03	0.03	0.02	0.02	0.03	0.03	0.02	0.03	0.03	0.03	0.04	0.04
41	0.11	0.12	0.13	0.13	0.14	0.13	0.09	0.14	0.09	0.04	0.06	0.14
42	0.03	0.02	0.02	0.02	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.03
43	0.12	0.09	0.13	0.10	0.13	0.12	0.09	0.14	0.09	0.04	0.07	0.14
44	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03
45	0.13	0.15	0.10	0.13	0.12	0.12	0.11	0.15	0.12	0.04	0.06	0.15
46	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03
47	0.12	0.11	0.12	0.15	0.12	0.11	0.11	0.13	0.12	0.05	0.05	0.15
48	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03
49	0.14	0.15	0.14	0.17	0.17	0.14	0.15	0.14	0.15	0.07	0.06	0.17
50	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04
THC [%I _n]	1.69	1.37	1.49	1.74	1.82	1.74	1.65	1.51	1.38	1.23	1.30	1.82

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3. Annex 3 – Extract from the test report



Extract from the test report - Part 1: Power Quality

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Interharmonics / Zwischenharmonische												
Rated current / Nennstrom [A]: 36												
P [%P _n]	0 - 5	10	20	30	40	50	60	70	80	90	100	Max.
f [Hz]	h [%I _n]											
75	0.02	0.02	0.03	0.04	0.04	0.05	0.06	0.06	0.07	0.08	0.09	0.09
125	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04
175	0.03	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05
225	0.04	0.03	0.03	0.04	0.04	0.03	0.03	0.03	0.04	0.04	0.05	0.05
275	0.05	0.04	0.04	0.04	0.04	0.03	0.04	0.04	0.04	0.05	0.05	0.05
325	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05
375	0.06	0.04	0.05	0.05	0.04	0.04	0.05	0.04	0.05	0.06	0.05	0.06
425	0.05	0.04	0.05	0.05	0.05	0.05	0.06	0.05	0.06	0.05	0.06	0.06
475	0.06	0.05	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06
525	0.05	0.05	0.04	0.05	0.05	0.06	0.07	0.06	0.07	0.05	0.06	0.07
575	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06
625	0.05	0.06	0.05	0.07	0.06	0.07	0.07	0.06	0.07	0.05	0.06	0.07
675	0.05	0.05	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06
725	0.05	0.06	0.06	0.06	0.07	0.06	0.07	0.07	0.06	0.05	0.06	0.07
775	0.06	0.05	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06
825	0.06	0.07	0.05	0.06	0.06	0.05	0.06	0.06	0.05	0.05	0.06	0.07
875	0.06	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.06
925	0.06	0.06	0.05	0.07	0.05	0.05	0.05	0.06	0.05	0.04	0.05	0.07
975	0.06	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.06
1025	0.05	0.06	0.05	0.05	0.04	0.04	0.04	0.05	0.04	0.04	0.05	0.06
1075	0.05	0.04	0.04	0.03	0.04	0.03	0.03	0.04	0.04	0.03	0.04	0.05
1125	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.04	0.05
1175	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04
1225	0.04	0.04	0.03	0.03	0.04	0.03	0.03	0.03	0.03	0.03	0.04	0.04
1275	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04
1325	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04
1375	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.04
1425	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.03
1475	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03
1525	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.03	0.03
1575	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03
1625	0.03	0.02	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03
1675	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03
1725	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03
1775	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03
1825	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
1875	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03
1925	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
1975	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03

3. Annex 3 – Extract from the test report



Extract from the test report - Part 1: Power Quality

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Higher Frequencies components / Höhere Frequenzen												
Rated current / Nennstrom [A]: 36												
P [%P _n]	0 - 5	10	20	30	40	50	60	70	80	90	100	Max.
f [Hz]	I _h [%I _n]											
2,1	0,18	0,16	0,19	0,18	0,2	0,19	0,14	0,21	0,14	0,09	0,11	0,21
2,3	0,19	0,19	0,16	0,21	0,18	0,17	0,16	0,21	0,18	0,09	0,1	0,21
2,5	0,23	0,25	0,22	0,26	0,3	0,25	0,26	0,24	0,26	0,14	0,12	0,30
2,7	0,22	0,26	0,28	0,31	0,3	0,32	0,31	0,28	0,29	0,19	0,18	0,32
2,9	0,19	0,22	0,18	0,25	0,24	0,27	0,28	0,26	0,28	0,17	0,18	0,28
3,1	0,14	0,14	0,16	0,16	0,18	0,19	0,18	0,21	0,21	0,15	0,16	0,21
3,3	0,16	0,17	0,16	0,19	0,2	0,2	0,2	0,23	0,23	0,19	0,17	0,23
3,5	0,29	0,33	0,28	0,23	0,28	0,32	0,3	0,33	0,31	0,33	0,3	0,33
3,7	0,6	0,67	0,75	0,87	0,75	0,65	0,56	0,53	0,5	0,51	0,52	0,87
3,9	0,35	0,38	0,42	0,42	0,43	0,45	0,47	0,41	0,38	0,41	0,41	0,47
4,1	0,15	0,15	0,17	0,15	0,17	0,17	0,21	0,2	0,22	0,27	0,26	0,27
4,3	0,1	0,09	0,12	0,12	0,11	0,13	0,13	0,11	0,14	0,14	0,13	0,14
4,5	0,07	0,07	0,09	0,08	0,07	0,08	0,07	0,06	0,08	0,08	0,08	0,09
4,7	0,04	0,04	0,05	0,05	0,05	0,06	0,05	0,06	0,07	0,08	0,08	0,08
4,9	0,03	0,04	0,05	0,05	0,04	0,04	0,05	0,06	0,06	0,06	0,06	0,06
5,1	0,03	0,03	0,04	0,04	0,03	0,04	0,05	0,06	0,06	0,07	0,07	0,07
5,3	0,02	0,02	0,03	0,03	0,03	0,03	0,04	0,04	0,05	0,05	0,06	0,06
5,5	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,04	0,04	0,04	0,04	0,04
5,7	0,01	0,01	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,04	0,04	0,04
5,9	0,01	0,01	0,01	0,02	0,02	0,02	0,03	0,03	0,04	0,04	0,04	0,04
6,1	0,01	0,01	0,01	0,01	0,02	0,02	0,03	0,04	0,04	0,04	0,04	0,04
6,3	0,01	0,01	0,01	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,04	0,04
6,5	0,01	0,01	0,01	0,01	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03
6,7	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,03	0,03	0,03	0,03
6,9	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,02	0,03	0,03
7,1	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,03	0,03	0,03	0,03
7,3	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,02	0,03	0,03
7,5	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02
7,7	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02
7,9	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02
8,1	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,02
8,3	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,02
8,5	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,02
8,7	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02
8,9	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,02

Note / Anmerkung:

The stated harmonics are maximum values of all 3 phases. / Die angegebenen Harmonischenwerte sind Maximalwerte über alle 3 Phasen.

3. Annex 3 – Extract from the test report

Extract from the test report - Part 1: Power Quality

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4.3.5 Unbalances of the current / Umsymmetrien des Stroms

TruConvert AC3025 (V01.27.03)

P [%P _n]	P ₁ * [kW]	U ₁ * [V]	U ₂ * [V]	I ₁ * [A]	I ₂ * [A]	u ₁ * [%I ₁]
5	-1,22	230,25	0,80	1,77	0,11	5,98
10	-2,44	230,32	0,82	3,55	0,04	1,05
20	-4,94	230,42	0,84	7,14	0,04	0,60
30	-7,51	230,37	0,80	10,87	0,12	1,08
40	-10,05	231,09	0,85	14,50	0,14	0,96
50	-12,52	231,12	0,83	18,05	0,13	0,74
60	-15,03	231,18	0,83	21,67	0,17	0,77
70	-17,50	231,22	0,82	25,23	0,14	0,56
80	-19,99	231,28	0,81	28,81	0,25	0,86
90	-22,50	231,33	0,81	32,42	0,20	0,61
100	-24,74	231,50	0,86	35,62	0,21	0,59
Maximum unsymmetry / maximale Unsymmetrie u _{max} (≥10%P _n)					1,08	

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Figure 8 – Results of power quality from [9]

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3.2. Active power



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Report No.:

4.1 ACTIVE POWER OUTPUT / WIRKLEISTUNGSABGABE

4.1.1 Active power peaks / Wirkleistungsspitzen

TruConvert AC3025

Active power peaks / Wirkleistungsspitzen [kW]	Normalised active power peaks / Normierte Wirkleistungsspitzen [p.u. base / Basis P _n]	Number of 10-minute records used / Anzahl der verwendeten 10- Minuten-Datensätze
P _{0,2}	-28,8	2
P ₅₀	-28,8	
P ₅₀₀	-28,8	

Note / Anmerkung:

The tests were conducted under normal operation (Q = 0).

At cosφ = 1 the active power equals the apparent power.

The maximum active power of the PGU is 29,7kW. After running at maximum power for 10mins, the PGU reduces its maximum power to the nominal power of 25kW

3. Annex 3 – Extract from the test report



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4.1 ACTIVE POWER OUTPUT / WIRKLEISTUNGSABGABE		
4.1.2 Operating power limited by grid operator / Leistungsbegrenzter Betrieb durch den Netzbetreiber		
The unit is able to run at reduced power. / Die EZE können mit reduzierter Leistung betrieben werden.	<input checked="" type="checkbox"/> Yes / Ja	<input type="checkbox"/> No / Nein
Disconnection from the grid at external active power set-points at / Trennung vom Netz bei Wirkleistungswertvorgabe von:	At 0% setpoint the PGU stays connected without power feeding. The unit can be disconnected using the parameter "release to start" = 0 -> immediate shut-down. / Bei 0% Sollwertvorgabe bleibt die EZE am Netz ohne Einspeisung. Die EZE über den Parameter "release to start" = 0 -> vom Netz getrennt werden.	
TruConvert AC3025		
Max. deviation of power setting / Maximale Sollwertabweichung der Wirkleistung	Exceeding / Überschreitung: 0,2 %P _n	Undercut / Unterschreitung: -1,2 %P _n
Settling time of the power output after a change in set-point with minimal gradient: / Einschwingzeit der Leistung für einen Sollwertsprung mit minimalem Gradienten: ±0,350%P _{max} /s	P _{70%} → P _{30%}	Time / Zeit: 0,074 s Gradient: -1211,1%P _n /s
	P _{30%} → P _{70%}	Time / Zeit: 0,067 s Gradient: 1180,4%P _n /s
Settling time of the power output after a change in set-point with maximum gradient / Einschwingzeit der Leistung für einen Sollwertsprung mit maximalem Gradienten: ±0,640%P _{max} /s	P _{90%} → P _{10%}	Time / Zeit: 0,07 s Gradient: - 4543,8%P _n /s
	P _{10%} → P _{90%}	Time / Zeit: 0,066 s Gradient: 4532,4%P _n /s
<p>Note:</p> <p>The PGU follows an external setpoint change without delay. A limiting active power increase/reduction rate must be imposed by a PGS controller.</p>		

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4.1 ACTIVE POWER OUTPUT / WIRKLEISTUNGSABGABE

4.1.3 Active power feed-in as a function of grid frequency / Wirkleistungseinspeisung in Abhängigkeit der Netzfrequenz

TruConvert AC3025

Overfrequency / Überfrequenz	Mean power gradient at overfrequency / Mittlerer Gradient der Wirkleistung zum Zeitpunkt der Frequenzüberhöhung	Mean gradient / Mittlerer Gradient 101,09%P _{nom} /Hz
	Max. Settling time / Max. Einschwingzeit	0,6 s
	Power gradient after recovery of overfrequency / Gradient der Wirkleistung nach Rückkehr aus Überfrequenz	Mean gradient / Mittlerer Gradient: -7,65%P _n /min Max. gradient / Max. Gradient: -7,65%P _n /min
Underfrequency / Unterfrequenz	Mean power gradient at underfrequency / Mittlerer Gradient der Wirkleistung zum Zeitpunkt der Frequenzunterschreitung	Mean gradient / Mittlerer Gradient 100,01%P _{nom} /Hz
	Max. Settling time / Max. Einschwingzeit	0,6 s
	Power gradient after recovery of underfrequency / Gradient der Wirkleistung nach Rückkehr aus Unterfrequenz	Mean gradient / Mittlerer Gradient: 7,6%P _n /min Max. gradient / Max. Gradient: 7,8%P _n /min

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Figure 9 – Results of active power control from [10]

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4.1 Active power

b) Active power setting accuracy

Setpoint power bin [%P _n]	Setpoint P _{set}		Measured value P ₆₀		Deviation	
	[kW]	[%P _n]	[kW]	[%P _n]	[kW]	[%P _n]
100	-25,0	100,0	-24,4	98,0	0,5	-0,2
90	-22,5	90,0	-21,	88,4	0,4	-0,6
80	-20,0	80,0	-19,6	78,4	0,4	-1,2
70	-17,5	70,0	-17,2	68,8	0,3	-1,2
60	-15,0	60,0	-14,7	58,8	0,3	-1,2
50	-12,5	50,0	-12,3	49,2	0,2	-0,8
40	-10,0	40,0	-9,8	39,2	0,2	-0,8
30	-7,5	30,0	-7,4	29,6	0,1	-0,4
20	-5,0	20,0	-4,9	19,6	0,1	-0,4
10	-2,5	10,0	-2,4	9,6	0,1	-0,4
0	-0,0	0,0	-0,05	0,2	-0,05	0,2

Results according to TG3, Table 4-2

Note:

No disconnection at 0% setpoint during measurements.

Test results shown in generator view.

Method for remote disconnection via setpoint provision	The unit can be disconnected using the parameter "release to start" = 0 -> immediate shut-down
--	--

		Setpoint power bin [%P _n]	Deviation [%P _n]
Max. deviation (P ₆₀ - P _{set})	positive	0,2	0,2
	negative	-0,5	-1,2

DC characteristics for test 4.1.2

DC-Einstellung [V]	850
Power Setpoint P (kW)	30
Current limit	60Adc
Internal impedance [Ω]	0

Figure 10 – Results of active power control from [6]

3. Annex 3 – Extract from the test report

There are no parameters for maximum power reduction/increase rate after external setpoint change. The maximum power reduction/increase rates must be set by the PGS controller.

The max. active power output of the PGU is dependent on ambient temperature [14]:

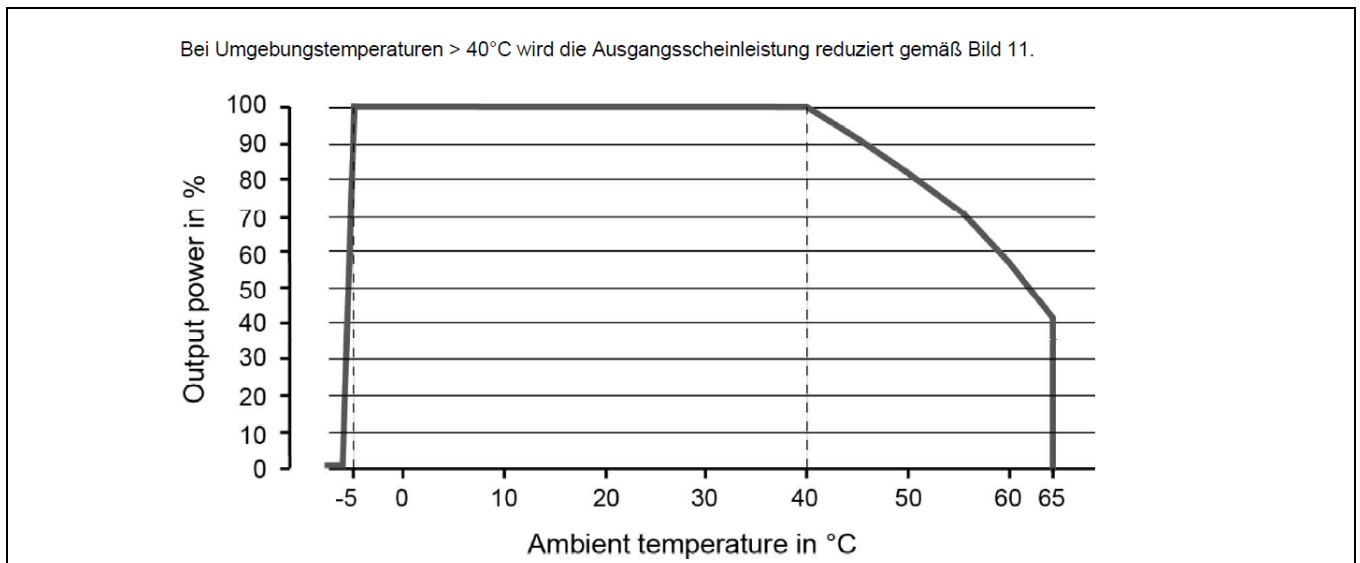


Figure 11 – Active power output dependent on ambient temperature from [14]

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3.3. Reactive power



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Report No.:

4.2 Reactive power provision / Blindleistungsbereitstellung

4.2.1 Reactive power response in the normal operation (Q = 0 kvar) / Blindleistungsverhalten im Normalbetrieb (Q = 0 kvar)

4.2.2 Measuring the maximum reactive power range (PQ diagram) / Vermessung des maximalen Blindleistungsstellbereich (PQ-Diagramm)

TruConvert AC3025

	P/P _n [%]	Q _{ind}	Q ₀ [kvar]	Q _{cap}	P/P _n [%]	Q _{ind}	Q ₀ [kvar]	Q _{cap}
Control of reactive power in normal operation mode and maximum reactive power range / <i>Blindleistungsverhalten im Normalbetrieb und maximaler Blindleistungsstellbereich</i>	0 ... 5	24,67	0,12	-24,56	60	24,84	0,10	-24,54
	10	24,70	0,20	-24,57	70	24,06	0,18	-23,74
	20	24,73	-0,11	-24,56	80	21,96	0,21	-21,60
	30	24,77	-0,04	-24,57	90	19,60	0,14	-19,21
	40	24,74	0,18	-24,51	100	16,58	0,29	-16,16
	50	24,84	0,10	-24,58	Pmax	---	---	---

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Report No.:

4.2 Reactive power provision / Blindleistungsbereitstellung

4.2.3 Measuring separate operating points in the voltage-dependent PQ diagram / Vermessung einzelner Arbeitspunkte des spannungsabhängigen PQ-Diagramms

TruConvert AC3025

WP / AP	U _{1,60,ind} [V]*	P _{1,60,ind} [p.u. P _n]	Q _{1,60,ind} [p.u. P _n]
1 ind.	207,39	-0,98	0,40
2 ind.	207,36	-0,87	0,60
3 ind.	207,33	-0,77	0,72
4 ind.	207,31	-0,68	0,81
5 ind.	207,3	-0,57	0,89
6 ind.	207,28	-0,48	0,94
7 ind.	207,27	-0,38	0,98
8 ind.	207,28	-0,28	0,99
9 ind.	207,27	-0,08	0,99
10 ind.	207,27	-0,08	0,99
11 ind.	207,27	0,01	0,99
1 cap. / kap.	207,51	-0,98	-0,38
2 cap. / kap.	207,55	-0,88	-0,58
3 cap. / kap.	207,54	-0,88	-0,71
4 cap. / kap.	207,58	-0,69	-0,80
5 cap. / kap.	207,57	-0,58	-0,88
6 cap. / kap.	207,58	-0,49	-0,93
7 cap. / kap.	207,58	-0,39	-0,98
8 cap. / kap.	207,57	-0,29	-0,98
9 cap. / kap.	207,56	-0,19	-0,98
10 cap. / kap.	207,55	-0,09	-0,98
11 cap. / kap.	207,54	0	-0,98

WP / AP	U _{1,60,ind} [V]*	P _{1,60,ind} [p.u. P _n]	Q _{1,60,ind} [p.u. P _n]
1 ind.	253,37	-0,97	0,85
2 ind.	253,34	-0,87	0,95
3 ind.	253,33	-0,77	1,00
4 ind.	253,31	-0,68	0,99
5 ind.	253,31	-0,58	0,99
6 ind.	253,31	-0,47	0,99
7 ind.	253,3	-0,38	0,99
8 ind.	253,31	-0,28	0,99
9 ind.	253,3	-0,18	0,99
10 ind.	253,29	-0,08	0,99
11 ind.	253,28	0,01	0,99
1 cap. / kap.	253,56	-0,98	-0,83
2 cap. / kap.	253,56	-0,88	-0,94
3 cap. / kap.	253,59	-0,69	-0,98
4 cap. / kap.	253,57	-0,69	-0,98
5 cap. / kap.	253,59	-0,59	-0,98
6 cap. / kap.	253,59	-0,49	-0,98
7 cap. / kap.	253,59	-0,4	-0,98
8 cap. / kap.	253,59	-0,29	-0,98
9 cap. / kap.	253,59	-0,19	-0,98
10 cap. / kap.	253,6	-0,09	-0,98
11 cap. / kap.	253,6	0	-0,98

Working points of the voltage dependent P-Q-diagram /
Arbeitspunkte des spannungsabhängigen P-Q-Diagramms

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4.2 Reactive power provision / Blindleistungsbereitstellung		
4.2.4 Reactive power following setpoint / Blindleistung nach Sollwertvorgabe		
TruConvert AC3025		
Control of reactive power through set-point signal / Blindleistungsregelung durch Sollwertvorgabe	<input type="checkbox"/> Power factor / Verschiebungsfaktor	<input checked="" type="checkbox"/> Reactive power / Blindleistung
	P_{bin} at / bei Q_{max}	50% P_n
Longest settling time / Längste Einschwingzeit	Parameter	Settling time / Einschwingzeit
		0,086 s (+ Q_{max} → - Q_{max})
Control of reactive power through set-point signal / Blindleistungsregelung durch Sollwertvorgabe	<input checked="" type="checkbox"/> Power factor / Verschiebungsfaktor ¹⁾	<input type="checkbox"/> Reactive power / Blindleistung
	P_{bin} at / bei Q_{max}	50% P_n
Longest settling time / Längste Einschwingzeit	Parameter	Settling time / Einschwingzeit
		0,101 s (+ Q_{max} → - Q_{max})
Control of reactive power through set-point signal / Blindleistungsregelung durch Sollwertvorgabe	<input type="checkbox"/> Power factor / Verschiebungsfaktor	<input checked="" type="checkbox"/> Reactive power / Blindleistung
	P_{bin} at / bei Q_{max}	50% P_n
Set-point accuracy of reative power / Einstellgenauigkeit der Blindleistung	Set-point / Sollwert	Measured value / Istwert
	-12,5 kvar	-12,335 kvar
	0,00 kvar	-0,98 kvar
	12,500 kvar	12,611 kvar

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4.2 Reactive power provision / Blindleistungsbereitstellung		
Control of reactive power through set-point signal / Blindleistungsregelung durch Sollwertvorgabe	<input type="checkbox"/> Power factor / Verschiebungsfaktor	<input checked="" type="checkbox"/> Reactive power / Blindleistung
	P_{bin} at / bei Q_{max}	100% P_n
Set-point accuracy of reactive power / Einstellgenauigkeit der Blindleistung	Set-point / Sollwert	Measured value / Istwert
	-12,500 kvar	-12,379 kvar
	0,00 kvar	0,210 kvar
	12,500 kvar	12,798 kvar
Control of reactive power through set-point signal / Blindleistungsregelung durch Sollwertvorgabe	<input checked="" type="checkbox"/> Power factor / Verschiebungsfaktor	<input type="checkbox"/> Reactive power / Blindleistung
	P_{bin} at / bei Q_{max}	50% P_n
Set-point accuracy of power factor / Einstellgenauigkeit des Verschiebungsfaktors	Set-point / Sollwert	Measured value / Istwert
	0,890 (ind.)	0,893 (ind.)
	1,000	1,000
	0,890 (cap.)	0,886 (cap.)
Control of reactive power through set-point signal / Blindleistungsregelung durch Sollwertvorgabe	<input checked="" type="checkbox"/> Power factor / Verschiebungsfaktor	<input type="checkbox"/> Reactive power / Blindleistung
	P_{bin} at / bei Q_{max}	100% P_n
Set-point accuracy of power factor / Einstellgenauigkeit des Verschiebungsfaktors	Set-point / Sollwert	Measured value / Istwert
	0,455 (ind.)	0,450 (ind.)
	1,000	1,000
	0,450 (cap.)	0,442 (cap.)

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4.2 Reactive power provision / Blindleistungsbereitstellung

Note / Anmerkung:


Reactive power gradients must be limited by PGS controller. Without PGS controller reactive power set points changes happens as fast as possible.

Die Blindleistungsgradienten müssen durch den PGS-Regler begrenzt werden. Ohne PGS-Regler ändern sich die Blindleistungswerte so schnell wie möglich.

The reactive power setpoint control function does not provide PT1 (1st order lowpass) filtering effect. The settling time was determined using a tolerance band of $\pm 5\%P_n$.

Die Blindleistungs-Sollwertvorgabe bietet keinen PT1-Filtereffekt, die Blindleistungsänderung erfolgt mit dem vordefinierten Gradient. Die Einschwingzeit wurde mit einem Toleranzband von $\pm 5\%P_n$ bestimmt.

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 <p>Extract from the test report - Part 2: grid control capability</p> <p style="text-align: right;">Report No.: 19TH0414_TR3_Rev25_0_excerpt-part_2_0</p> <p style="text-align: center;">Page 16 of 17</p>	
<p>4.2 Reactive power provision / Blindleistungsbereitstellung</p> <p>4.2.5 Q(U) control / Q(U) Regelung</p> <p>4.2.6 Q(P) control / Q(P) Regelung</p> <p>4.2.7 Reactive power Q with voltage limitation function / Blindleistung Q mit Spannungsbegrenzungsfunktion</p>	
<p>Remark / Anmerkung:</p>	<p>The Q(U), Q(P) and reactive power Q with voltage limitation functions were not tested. These control functions must be carried out on the plant level using a superimposed plant controller please see test report. / Die Funktionen Q(U), Q(P) und Blindleistung Q mit Spannungsbegrenzung wurden nicht geprüft. Diese Steuerungsfunktionen müssen auf der Anlagenebene mit einem übergeordneten Anlagenregler durchgeführt werden.</p>

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Figure 12 – Results of reactive power control from [10]

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Description of methods for the reactive power supply [6]:

Following is the data about reactive power provision from the manufacturer declaration



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3.6 Blindleistungsbereitstellung in Abhängigkeit von der Wirkleistung

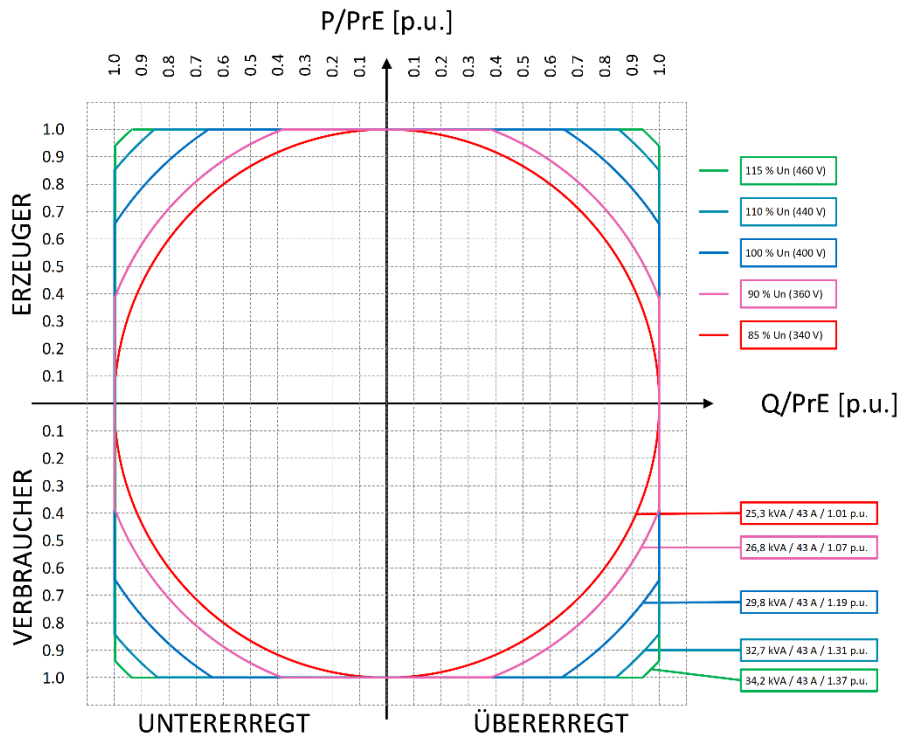


Bild 10: P-Q Diagramm für die Funktion als Speicher im Spannungsbereich 0.85 bis 1.15 p.u.

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The resulting voltage dependent PQ operating points as follows [14]:



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Spannung [p.u]	Wirkleistung P/ PrE [p.u]	Qmax unter/übererregt [p.u]
1,15	1	0,93
1,15	0,93	1
1,15	-0,93	1
1,15	-1	0,93
1,1	1	0,84
1,1	0,84	1
1,1	-0,84	1
1,1	-1	0,84
1	1	0,65
1	0,65	1
1	-0,65	1
1	-1	0,65
0,9	1	0,38
0,9	0,38	1
0,9	-0,38	1
0,9	-1	0,38
0,85	1	0
0,85	0	1
0,85	0	1
0,85	-1	0

Tabelle 13: Maximale Blindleistung bei Eckpunkten von Spannung und Wirkleistung

Die EZE ist so ausgelegt, dass die nominale Scheinleistung von 25 KVA bei jeder Betriebsspannung von 0.85 bis 1.15 p.u. und über den gesamten Wirk- Blindleistungskreis erbracht wird.

Sollte die Wirkleistungsvorgabe kombiniert mit der Blindleistungsvorgabe des Netzbetreibers den gesamten Scheinleistungsvermögen der Einheit übersteigen, so wird in der Sollwertvorgabe der SPS Steuerung bzw. des EZA Reglers die Blindleistungsvorgabe priorisiert und die Wirkleistungsvorgabe entsprechend reduziert.

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3.9.1 Wirk- und Blindleistungsbereich bei Nennspannung

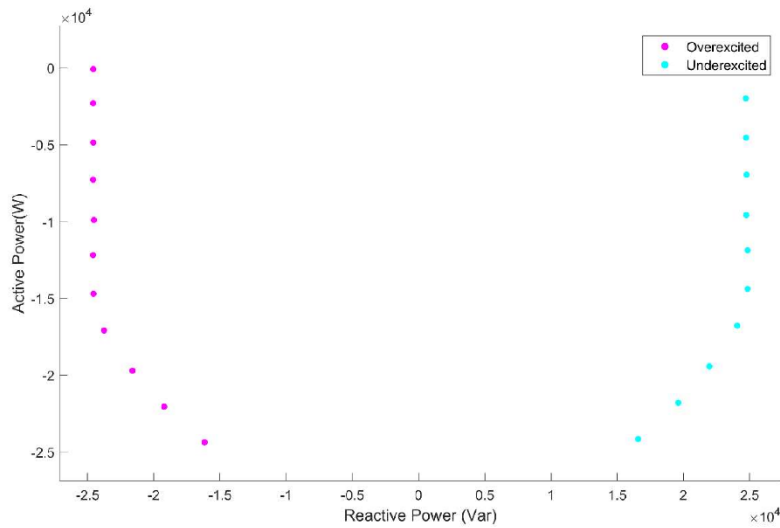


Bild 12: P(Q) Diagramm bei Nennspannung

Available power P[% Pn]	U = 100% Un (Overexcited)									
	P _{1,60,cap} [W]	P _{1,60,cap} [p.u.]	Q _{1,60,cap} [var]	Q _{1,60,cap} [p.u.]	Q _{expected} [var]	Q _{expected} [p.u.]	Deviation Q _{1,60,cap} - Q _{expected} [var]	Deviation Q _{1,60,cap} - Q _{expected} [p.u.]	Cosphi _{60,cap}	U _{+,60,cap} [V]
100	-24364	-0,97	-16161	-0,65	-17159	-0,69	998	0,04	0,83	230,6
90	-22038	-0,88	-19218	-0,77	-20059	-0,8	841	0,03	0,75	230,64
80	-19704	-0,79	-21605	-0,86	-22356	-0,89	751	0,03	0,67	230,62
70	-17079	-0,68	-23745	-0,95	-24421	-0,98	676	0,03	0,58	230,62
60	-14708	-0,59	-24550	-0,98	-25000	-1	450	0,02	0,51	230,63
50	-12180	-0,49	-24584	-0,98	-25000	-1	416	0,02	0,44	230,65
40	-9884	-0,4	-24519	-0,98	-25000	-1	481	0,02	0,37	230,67
30	-7272	-0,29	-24575	-0,98	-25000	-1	425	0,02	0,28	230,69
20	-4846	-0,19	-24565	-0,98	-25000	-1	435	0,02	0,19	230,67
10	-2301	-0,09	-24573	-0,98	-25000	-1	428	0,02	0,09	230,67
0---5	-74	0	-24565	-0,98	-25000	-1	435	0,02	0	230,66

Tabelle 14: Gemessen Wirk- und Blindleistung (Überregt) bei Nennspannung

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Available power P[% Pn]	U = 100% Un (Underexcited)									
	P _{1,60,cap} [W]	P _{1,60,cap} [p.u.]	Q _{1,60,cap} [var]	Q _{1,60,cap} [p.u.]	Q _{expected} [var]	Q _{expected} [p.u.]	Deviation Q _{1,60,cap} - Q _{expected} [var]	Deviation Q _{1,60,cap} - Q _{expected} [p.u.]	Cosphi 60,cap	U _{*,60,cap} [V]
100	-24151	-0,97	16583	0,66	17458	0,7	-876	-0,04	-0,82	230,42
90	-21784	-0,87	19606	0,78	20334	0,81	-728	-0,03	-0,74	230,4
80	-19422	-0,78	21962	0,88	22601	0,9	-639	-0,03	-0,66	230,38
70	-16772	-0,67	24068	0,96	24632	0,99	-564	-0,02	-0,57	230,36
60	-14391	-0,58	24842	0,99	25000	1	-158	-0,01	-0,5	230,36
50	-11861	-0,47	24844	0,99	25000	1	-156	-0,01	-0,43	230,35
40	-9565	-0,38	24748	0,99	25000	1	-252	-0,01	-0,36	230,34
30	-6953	-0,28	24774	0,99	25000	1	-226	-0,01	-0,27	230,34
20	-4528	-0,18	24732	0,99	25000	1	-268	-0,01	-0,18	230,33
10	-1987	-0,08	24709	0,99	25000	1	-291	-0,01	-0,08	230,34
0---5	239	0,01	24675	0,99	25000	1	-325	-0,01	0,01	230,34

Tabelle 15: Gemessen Wirk- und Blindleistung (Unterregt) bei Nennspannung

3.9.2 Wirk- und Blindleistungsbereich bei Unterspannung (90% Un)

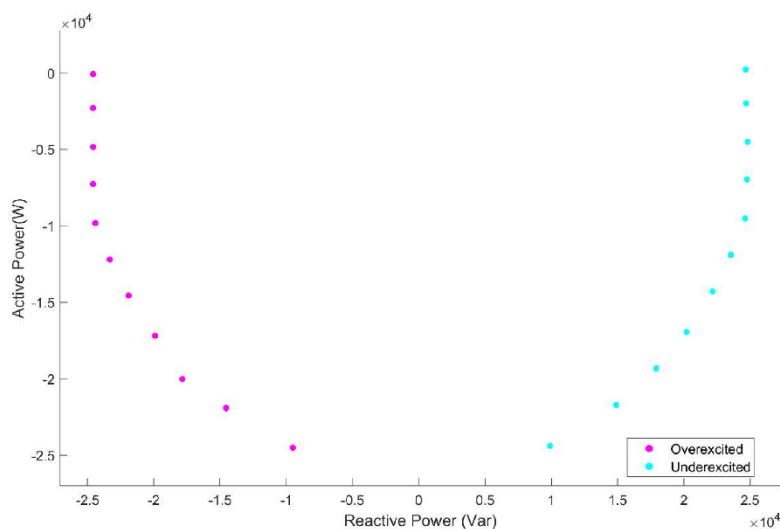


Bild 13: P(Q) Diagramm bei Unterspannung

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Available power P[% Pn]	U = 90% Un (Overexcited)									
	P _{1,60,cap} [W]	P _{1,60,cap} [p.u.]	Q _{1,60,cap} [var]	Q _{1,60,cap} [p.u.]	Q _{expected} [var]	Q _{expected} [p.u.]	Deviation Q _{1,60,cap} - Q _{expected} [var]	Deviation Q _{1,60,cap} - Q _{expected} [p.u.]	Cosphi 60,cap	U _{1,60,cap} [V]
100	-24501	-0,98	-9496	-0,38	-10909	-0,44	1412	0,06	-0,93	207,51
90	-21900	-0,88	-14532	-0,58	-15482	-0,62	950	0,04	-0,83	207,55
80	-20008	-0,8	-17831	-0,71	-17861	-0,71	30	0	-0,75	207,37
70	-17187	-0,69	-19896	-0,8	-20589	-0,82	694	0,03	-0,65	207,58
60	-14561	-0,58	-21898	-0,88	-22523	-0,9	625	0,03	-0,55	207,57
50	-12196	-0,49	-23307	-0,93	-23887	-0,96	580	0,02	-0,46	207,58
40	-9825	-0,39	-24400	-0,98	-24956	-1	556	0,02	-0,37	207,58
30	-7263	-0,29	-24577	-0,98	-25000	-1	423	0,02	-0,28	207,57
20	-4838	-0,19	-24567	-0,98	-25000	-1	433	0,02	-0,19	207,56
10	-2296	-0,09	-24575	-0,98	-25000	-1	425	0,02	-0,09	207,54
0---5	-70	0	-24569	-0,98	-25000	-1	431	0,02	0	207,53

Tabelle 16: Gemessen Wirk- und Blindleistung (Übererregt) bei Unterspannung

Available power P[% Pn]	U = 90% Un (Underexcited)									
	P _{1,60,cap} [W]	P _{1,60,cap} [p.u.]	Q _{1,60,cap} [var]	Q _{1,60,cap} [p.u.]	Q _{expected} [var]	Q _{expected} [p.u.]	Deviation Q _{1,60,cap} - Q _{expected} [var]	Deviation Q _{1,60,cap} - Q _{expected} [p.u.]	Cosphi 60,cap	U _{1,60,cap} [V]
100	-24377	-0,98	9908	0,4	11184	0,45	-1276	-0,05	-0,93	207,39
90	-21709	-0,87	14905	0,6	15750	0,63	-844	-0,03	-0,82	207,35
80	-19319	-0,77	17919	0,72	18604	0,74	-685	-0,03	-0,73	207,32
70	-16932	-0,68	20206	0,81	20800	0,83	-594	-0,02	-0,64	207,31
60	-14282	-0,57	22173	0,89	22701	0,91	-528	-0,02	-0,54	207,3
50	-11902	-0,48	23553	0,94	24034	0,96	-481	-0,02	-0,45	207,28
40	-9519	-0,38	24615	0,98	25000	1	-385	-0,02	-0,36	207,27
30	-6956	-0,28	24764	0,99	25000	1	-236	-0,01	-0,27	207,28
20	-4498	-0,18	24805	0,99	25000	1	-195	-0,01	-0,18	207,73
10	-1990	-0,08	24698	0,99	25000	1	-302	-0,01	-0,08	207,27
0---5	235	0,01	24664	0,99	25000	1	-336	-0,01	0,01	207,27

Tabelle 17: Gemessen Wirk- und Blindleistung (Untererregt) bei Unterspannung

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3.9.3 Wirk- und Blindleistungsbereich bei Überspannung (110% Un)

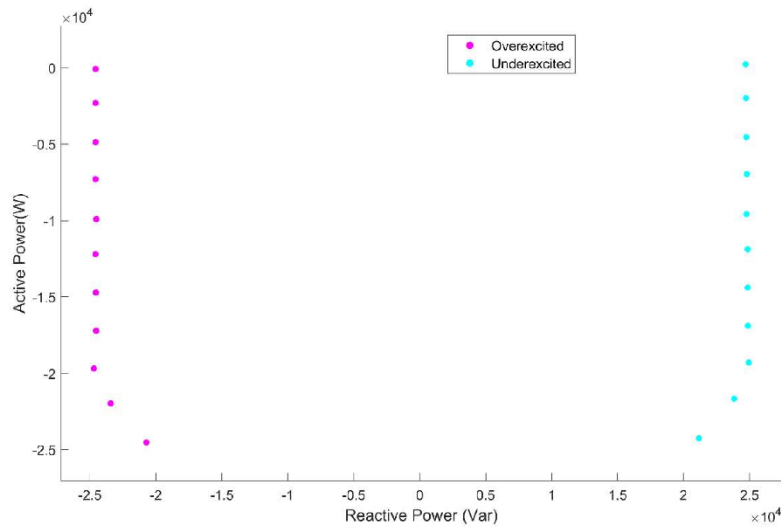


Bild 14: P(Q) Diagramm bei Überspannung

Available power P[% Pn]	U = 110% Un (Overexcited)									
	P _{1,60,cap} [W]	P _{1,60,cap} [p.u.]	Q _{1,60,cap} [var]	Q _{1,60,cap} [p.u.]	Q _{expected} [var]	Q _{expected} [p.u.]	Deviation Q _{1,60,cap} - Q _{expected} [var]	Deviation Q _{1,60,cap} - Q _{expected} [p.u.]	Cosphi _{60,cap}	U _{+,60,cap} [V]
100	-24521	-0,98	-20716	-0,83	-21754	-0,87	1038	0,04	-0,76	253,56
90	-21960	-0,88	-23414	-0,94	-24337	-0,97	924	0,04	-0,68	253,56
80	-19682	-0,79	-24695	-0,99	-25000	-1	305	0,01	-0,62	253,86
70	-17206	-0,69	-24522	-0,98	-25000	-1	478	0,02	-0,57	253,59
60	-14724	-0,59	-24544	-0,98	-25000	-1	456	0,02	-0,51	253,59
50	-12195	-0,49	-24577	-0,98	-25000	-1	423	0,02	-0,44	253,59
40	-9897	-0,4	-24510	-0,98	-25000	-1	490	0,02	-0,37	253,59
30	-7284	-0,29	-24570	-0,98	-25000	-1	430	0,02	-0,28	253,59
20	-4857	-0,19	-24562	-0,98	-25000	-1	438	0,02	-0,19	253,59
10	-2310	-0,09	-24571	-0,98	-25000	-1	429	0,02	-0,09	253,6
0---5	-81	0	-24565	-0,98	-25000	-1	435	0,02	0	253,6

Tabelle 18: Gemessen Wirk- und Blindleistung (Überregt) bei Überspannung

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Available power P[% Pn]	U = 110% Un (Underexcited)									
	P _{1,60,cap} [W]	P _{1,60,cap} [p.u.]	Q _{1,60,cap} [var]	Q _{1,60,cap} [p.u.]	Q _{expected} [var]	Q _{expected} [p.u.]	Deviation Q _{1,60,cap} - Q _{expected} [var]	Deviation Q _{1,60,cap} - Q _{expected} [p.u.]	Cosphi 60, cap	U _{1,60,cap} [V]
100	-24248	-0,97	21160	0,85	22059	0,88	-899	-0,04	-0,75	253,37
90	-21655	-0,87	23825	0,95	24608	0,98	-783	-0,03	-0,67	253,34
80	-19297	-0,77	24933	1	25000	1	-67	0	-0,61	253,33
70	-16881	-0,68	24872	0,99	25000	1	-128	-0,01	-0,56	253,31
60	-14395	-0,58	24860	0,99	25000	1	-140	-0,01	-0,5	253,31
50	-11864	-0,47	24863	0,99	25000	1	-137	-0,01	-0,43	253,31
40	-9566	-0,38	24767	0,99	25000	1	-233	-0,01	-0,36	253,3
30	-6953	-0,28	24792	0,99	25000	1	-208	-0,01	-0,27	253,31
20	-4527	-0,18	24751	0,99	25000	1	-249	-0,01	-0,18	253,3
10	-1984	-0,08	24725	0,99	25000	1	-275	-0,01	-0,08	253,29
0---5	242	0,01	24692	0,99	25000	1	-308	-0,01	0,01	253,28

Tabelle 19: Gemessen Wirk- und Blindleistung (Unterregt) bei Überspannung

Figure 13 – Voltage dependent PQ operating points from [14]

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6. Blindleistungsbereitstellung

6.1 Implementierte Regelverfahren

Die Verfahren zur statischen Netzstützung werden vom EZA-Regler als externe Komponente und zertifizierter Software-Baustein umgesetzt.

Folgende Wirk- und Blindleistungssollwertvorgaben sind gemäß VDE AR-N-4110:2018-11 implementiert:

- Blindleistung als Funktion der Netzspannung $Q(U)$
- Blindleistung als Funktion der Wirkleistung $Q(P)$
- Blindleistung als Funktion der Netzspannung mit Begrenzungsfunktion $Q(U_{ab})$
- Fester Verschiebungsfaktor $\cos(\varphi)$
- Feste Blindleistungssollwertvorgabe Q_{soll}
- Wirkleistungssollwertvorgabe P_{soll}
- Wirkleistungsgradient nach Spannungslosigkeit $P(U)$

Diese Funktionen sind nicht Teil des angestrebten Zertifikats. Das Gerät TruConvert AC 3025 ist nur im Zusammenspiel mit einem nach VDE AR-N-4110:2018-11 zertifizierten Regler der die o.g. Funktionen abbildet zu verwenden.

Für den in Kapitel 2.10 definierten EZA-Regler sind die Beschreibungen der implementierten Regelverfahren zu Blindleistungssollwertvorgaben im Kapitel 2.3 der Dokumentation des Herstellers [2], ab Seite 16 definiert.

6.2 Einstellbarer Blindleistungsgradient

Die Änderungsgeschwindigkeit der Blindleistung wird über einen Parameter gesteuert der einer Zeitkonstante entspricht. Es kann zwischen einem Tiefpassfilterverhalten erster Ordnung (PT1-Verhalten) oder einer Rampe ausgewählt werden. Der Parameter und seine Einstellungen sind im Kapitel 2.3 der Dokumentation des Herstellers [2] ab Seite 19 unter den Parameternamen „rSetpointSettling“ definiert. Die im EZA-Regler eingestellte Dynamik / Gradient bei quasistationären Vorgaben wird nicht durch den Wechselrichter verlangsamt.

Figure 14.- Reactive Power Provision Methods from [14]

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3.4. Protection system (on PGU level)



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4.4 PGU disconnection from the grid

Note:

Tests were not conducted. The PGU does not have an integrated protection relay. An external protection relay must be utilized to accomplish PGU disconnection from the grid.

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4.5 Reconnection conditions							
4.5.1 Reconnection without tripping of the decoupling protection							
Undervoltage Test		Overvoltage Test		Underfrequency Test		Overfrequency Test	
Steps [%Un]	Connection yes/no	Steps [%Un]	Connection yes/no	Steps [Hz]	Connection yes/no	Steps [Hz]	Connection yes/no
88	No	112	No				
89	No	111	No	47,4	No	50,3	No
90	No	110	No	47,5	No	50,2	yes
91	Yes	109	yes	47,6	yes	50,1	-----
92	----	108	-----				

General notes for Testing:
 Test dates: See annex 7
 Test environment: See page 7.
 Operation mode of test object: Operation limited by reactive / active power setpoint.
 Adjustable parameters: See annex 8.

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Figure 15 – Results of grid protection from [6]

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3.5. Self-protection

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Die Immunität zu Überspannungen wird maßgeblich durch zwei Faktoren bestimmt:

- Einerseits die für die Hardwarebauteile maximal zulässige Spannung. Diese wird als „Maximal erlaubte Netzspannung“ in der Dokumentation des Wechselrichters [10] definiert und beträgt 528 V_{AC} Leiter-Leiter bzw. 305 V_{AC} Leiter-Neutral. Diese Spannung kann dauerhaft anliegen und kurzzeitig überschritten werden (100ms).
- Andererseits die zum Zeitpunkt der Überspannung anliegende Batterie- bzw. Zwischenkreisspannung.

Die notwendige Batterie bzw. DC-Zwischenkreisspannung in Abhängigkeit der Spannungserhöhung wird in Bild 17 dargestellt.

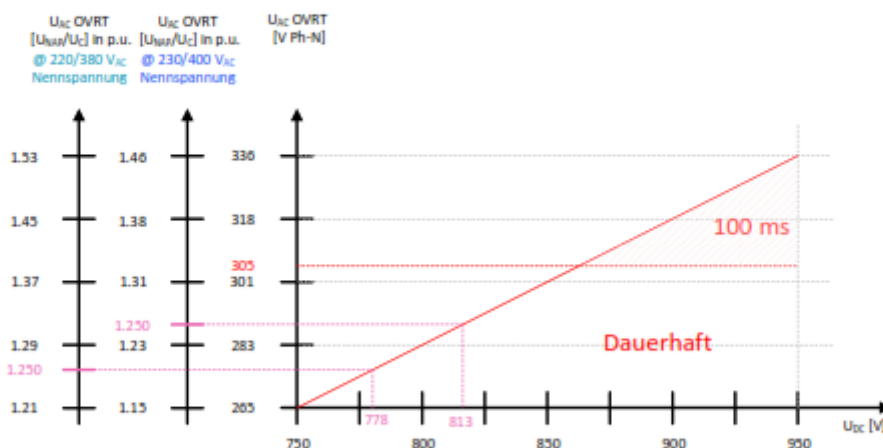


Bild 17: Minimale DC Spannung für Netzseitige Überspannungen (HVRT)

Liegt die Batterie bzw. DC-Zwischenkreisspannung während einer netzseitigen Überspannung unterhalb der geforderten Minimalspannung, so droht ein unkontrollierter Strom vom Netz Richtung Batterie zu fließen. Zum Schutz des Umrichters und der Batterie wird sich in diesem Fall der Umrichter vom Netz trennen.

Um die in VDE-AR-N-4110:2018-11 geforderte Überspannungsfähigkeit von 1.25 p.u. zu garantieren wird die minimale DC Spannung gemäß der gewählten AC-Netzspannung angepasst.
Für eine Nennspannung U_n von 220/380 VAC gilt U_{dc_min} = 778 V.
Für eine Nennspannung U_n von 230/400 VAC gilt U_{dc_min} = 813 V.

Es ist bei der Systemauslegung darauf zu achten, dass die OCV Batteriespannung mindestens die oben definierte U_{dc_min} entspricht, wenn diese Batterie direkt am Zwischenkreis eingebunden wird.

Figure 16. – Self-protection [14]

Apart from this the FRT-capability limits (see 3.7) and overcurrent- and temperature protection settings (see 5) need to be considered

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3.6. Quasi-static operation

Manufacturer's data from [6]

The unit can be continuously operated within the voltage / frequency range of 85% U_n and 115% U_n / 47 Hz and 53 Hz.

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3. Leistungsvermögen

3.1 Darstellung der Arbeitsbereiche der Einheit (U-F Diagramm)

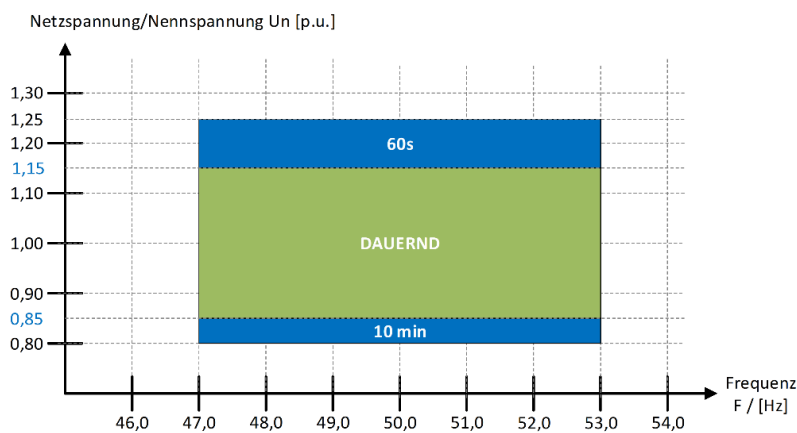


Bild 6: U-F Diagramm

Der TruConvert AC 3025 kann unter folgenden Elektrischen Bedingungen kontinuierlich arbeiten:

Bezeichnung	Bereich	Nominalwert
Spannung U [V L-L]	[340 - 460] V	400 V
Frequenz	[47 - 53] Hz	50 Hz

Bei Betrieb unterhalb von 340 V wird die maximale Leistung nach 10 min reduziert.

3.2 Maximale Gradiente im kontinuierlichen Betrieb

Maximaler Spannungsgradient (in % U_n pro Zeiteinheit)	Der TruConvert AC 3025 ermöglicht einen quasistationären Betrieb bei Spannungsgradienten von 5% U_n / min. Der maximal mögliche Spannungsgradient ist sonst nur durch den FRT Betrieb eingeschränkt.
Maximaler Frequenzgradient (in Hz pro Zeiteinheit, für Zeitfenster)	Der verwendete zertifizierte NA-Schutz erfüllt die ROCOF Anforderungen. Die Werkseinstellung beträgt 2 Hz/s. Der Umrichter selbst (TruConvert AC 3025) hat keine Begrenzung in Bezug auf einen Frequenzgradienten und bleibt solange die folgenden gemittelten Frequenzänderungsgeschwindigkeiten nicht überschritten werden am Netz: <ul style="list-style-type: none"> ± 2,0 Hz/s für ein gleitendes Zeitfenster von 0,5 s oder ± 1,5 Hz/s für ein gleitendes Zeitfenster von 1 s oder ± 1,25 Hz/s für ein gleitendes Zeitfenster von 2 s.

Figure 17. - Display of the operating ranges of the unit (U-F) diagram [14]

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3.7. Fault ride through capability

Within the adjustable parameter ranges of the grid monitoring the PGU can ride through the symmetrical and asymmetrical faults according to the Fault Ride-Through (FRT) limit curve for a Type 2 power generating plant.



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8. FRT Verhalten (HVRT & LVRT) und dynamische Netzstützung

8.1 Spannungs-Zeit Kennlinie

Die Immunität zu Unter- und Überspannungen ist in Bild 16 mit der unteren schwarzen Kurve dargestellt. Diese Kurve definiert die Zeit, die der Umrichter TruConvert AC 3025 mindestens am Netz bleiben kann bei definierter Netzspannung, unabhängig vom Betriebsmodi der EZE (Netz-einspeisung oder Bezug). Im Fehler kann bis zum maximalen Scheinstrom eingespeist werden. Die Grenzkurven beziehen sich auf Leiter-Leiter Spannungen.

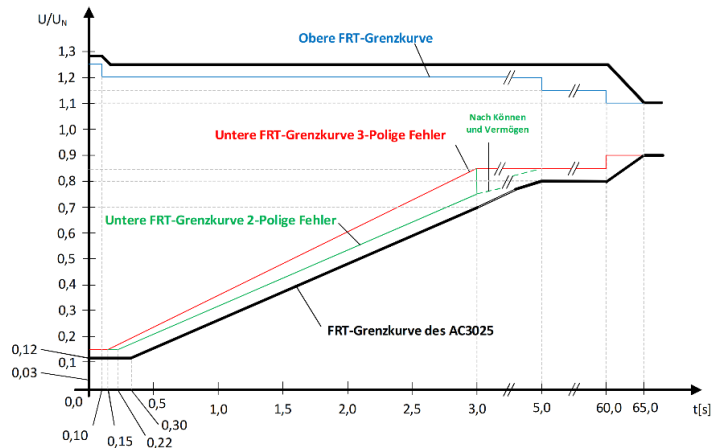


Bild 16: FRT Grenzkurve des Wechselrichters TruConvert AC 3025

Die Stützpunkte der FRT-Grenzkurve werden hier noch tabellarisch verdeutlicht:

Stützpunkt Nr.	Koordinate [Zeit in s , Spannung in p.u.]
1	[0.0 , 0.12]
2	[0.3 , 0.12]
3	[3.0 , 0.7]
4	[5.0 , 0.8]
5	[60 , 0.8]
6	[65 , 0.9]
7	[∞ , 0.9]

Tabelle 26: Stützpunkte der LVRT-Grenzkurve

Anmerkung: Bei Betrieb unterhalb von 340 V wird die maximale Leistung nach 10 min reduziert.

Stützpunkt Nr.	Koordinate [Zeit in s , Spannung in p.u.]
1	[0.0 , 1.28]
2	[0.1 , 1.28]
3	[0.16 , 1.25]
4	[60 , 1.25]
5	[65 , 1.10]
6	[∞ , 1.10]

Tabelle 27: Stützpunkte der HVRT-Grenzkurve

Figure 18. - FRT Limit curve of the TruConvert AC 3025 inverter [14]

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3.8. Short-circuit current contributions

In the following the test results from [6] are summarized:

TruConvert AC3025 (Discharging Mode)

Ergebnis	25.1			25.2			25.3			25.4			
	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	
16	0,278	0,278	0,278	0,251	0,250	0,250	Die EZE ist in der Lage, mehrfach aufeinanderfolgende Spannungseinbrüche durchzufahren. / The PGU is able to ride through several consecutive voltage dips.				0,552	0,998	0,556
17	0,278			0,250							0,638		
22	0,999			0,998							0,999		
23	0,000			0,002							0,001		
28 ²⁾	0,006			0,006							0,003		
32	-0,985			-0,196							-0,985		
51 - 53	87,4	76,5	79,4	94,8	57,7	66,2					96,6	60,4	60,1
54 - 56	0,643	0,989	1,404	0,165	0,495	0,745					0,627	0,607	0,931
57 - 59	1,214	1,204	1,201	1,216	1,205	1,203					1,218	0,610	0,597
60 - 62	1,214	1,205	1,201	1,216	1,205	1,203					1,219	0,610	0,596
63 - 65	1,214	1,205	1,200	1,216	1,205	1,203					1,218	0,611	0,597
66 - 68	1,213	1,206	1,202	1,216	1,205	1,203					1,220	0,609	0,596
69 - 71	0,991	0,985	0,985	0,150	0,148	0,150					1,222	0,608	0,598
74	0,006			0,382							0,003		
Ergebnis	25.5			50.1			50.2			50.3			
	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	
16	0,552	0,998	0,556	0,523	0,522	0,523	0,522	0,522	0,522	0,678	0,998	0,670	
17	0,638			0,523			0,522			0,761			
22	0,998			0,999			0,998			0,999			
23	0,001			0,001			0,001			0,001			
28 ²⁾	-0,005			0,004			-0,004			0,006			
32	-0,196			-0,985			-0,196			-0,985			
51 - 53	96,1	45,8	38,8	77,3	79,7	80,3	60,6	52,2	63,8	76,9	51,1	56,8	
54 - 56	0,205	0,079	0,266	1,038	1,292	1,415	0,200	0,498	0,522	1,100	0,849	1,074	
57 - 59	1,218	0,611	0,597	1,207	1,199	1,197	0,995	0,986	0,982	1,219	0,410	1,179	
60 - 62	1,219	0,609	0,595	1,208	1,198	1,197	0,994	0,987	0,983	1,213	0,405	1,187	
63 - 65	1,218	0,610	0,597	1,207	1,198	1,198	0,995	0,986	0,984	1,214	0,403	1,187	
66 - 68	1,219	0,609	0,596	1,207	1,199	1,197	0,995	0,986	0,983	1,214	0,405	1,186	
69 - 71	1,219	0,605	0,596	1,207	1,199	1,196	0,995	0,986	0,982	1,213	0,404	1,186	
74	0,002			0,004			0,008			0,001			
Ergebnis	50.4			50.5			50.6			75.1			
	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	
16	0,674	0,998	0,674	0,500	0,499	0,500	0,660	0,998	0,661	0,762	0,761	0,762	
17	0,760			0,499			0,749			0,761			
22	0,998			0,999			0,999			0,999			
23	0,001			0,000			0,001			0,000			
28 ²⁾	-0,004			0,006			0,005			0,006			
32	-0,196			-0,985			-0,985			-0,985			
51 - 53	59,8	19,8	33,2	77,2	79,9	80,5	77,0	51,1	56,4	64,5	62,4	66,7	
54 - 56	0,254	0,118	0,288	0,833	0,962	1,260	0,810	0,743	0,843	1,138	1,116	1,175	
57 - 59	0,998	0,337	0,664	0,018	0,016	0,014	0,018	0,027	0,023	1,097	1,087	1,088	
60 - 62	1,002	0,334	0,663	0,018	0,016	0,014	0,018	0,027	0,024	1,097	1,087	1,087	
63 - 65	1,002	0,334	0,662	0,018	0,016	0,014	0,018	0,027	0,024	1,097	1,086	1,087	
66 - 68	1,001	0,334	0,662	0,018	0,016	0,014	0,018	0,027	0,024	1,097	1,087	1,087	
69 - 71	1,001	0,334	0,662	0,018	0,016	0,014	0,018	0,027	0,024	1,097	1,088	1,087	
74	0,002			0,017			0,017			0,000			

3. Annex 3 – Extract from the test report

Ergebnis	75.2			75.3			75.4			75.5		
	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾
16	0,761	0,760	0,761	0,737	0,736	0,737	0,778	0,777	0,777	0,772	0,771	0,772
17	0,761			0,737			0,777			0,771		
22	0,999			0,974			1,021			0,999		
23	0,001			0,001			0,001			0,000		
28 ²⁾	-0,005			1,018			-0,965			0,001		
32	-0,196			-0,183			-0,195			-0,196		
51 - 53	28,4	27,6	33,0	74,7	74,5	74,3	66,8	66,9	66,3	64,9	52,3	63,5
54 - 56	0,332	0,335	0,328	1,137	1,061	0,971	1,271	1,224	1,199	0,496	0,539	0,527
57 - 59	0,534	0,526	0,525	0,554	0,553	0,555	1,226	1,213	1,209	0,964	0,954	0,951
60 - 62	0,533	0,526	0,525	0,554	0,553	0,556	1,226	1,213	1,208	0,965	0,955	0,952
63 - 65	0,533	0,526	0,525	0,554	0,553	0,555	1,225	1,213	1,208	0,965	0,956	0,952
66 - 68	0,534	0,527	0,525	0,554	0,553	0,555	1,226	1,213	1,209	0,965	0,955	0,951
69 - 71	0,534	0,527	0,525	0,553	0,553	0,555	1,226	1,213	1,208	0,964	0,955	0,951
74	0,011			0,007			0,017			0,013		

Ergebnis	75.6			75.7			75.8			80.1		
	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾
16	0,830	1,000	0,826	0,820	0,999	0,817	0,834	1,000	0,835	0,809	0,809	0,809
17	0,881			0,874			0,886			0,809		
22	0,999			0,998			0,999			0,999		
23	0,001			0,002			0,000			0,000		
28 ²⁾	0,003			0,005			0,001			0,006		
32	-0,985			-0,196			-0,196			-0,985		
51 - 53	64,2	51,0	57,6	27,5	10,9	21,0	64,8	20,9	37,2	61,0	61,8	62,8
54 - 56	1,034	0,847	1,115	0,362	0,074	0,330	0,681	0,162	0,493	1,045	1,091	1,137
57 - 59	1,092	0,776	1,187	0,514	0,124	0,416	0,981	0,334	0,645	1,059	1,050	1,050
60 - 62	1,089	0,776	1,189	0,514	0,123	0,417	0,980	0,334	0,644	1,058	1,049	1,050
63 - 65	1,091	0,778	1,188	0,514	0,125	0,416	0,981	0,336	0,643	1,059	1,049	1,051
66 - 68	1,091	0,778	1,188	0,514	0,123	0,417	0,980	0,332	0,646	1,058	1,049	1,050
69 - 71	1,091	0,777	1,187	0,514	0,123	0,418	0,980	0,333	0,644	1,059	1,050	1,050
74	0,000			0,000			0,009			0,000		

Ergebnis	80.2			85.1			110.1			110.2		
	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾
16	0,863	1,000	0,859	0,870	0,869	0,870	1,079	1,000	1,081	1,079	0,999	1,079
17	0,905			0,869			1,053			1,052		
22	0,999			0,998			0,999			0,999		
23	0,000			0,001			0,001			0,001		
28 ²⁾	0,006			-0,004			0,018			-0,002		
32	-0,985			-0,196			-0,985			-0,196		
51 - 53	61,1	51,8	56,5	17,2	17,2	19,8	53,3	55,2	46,5	14,8	15,3	6,7
54 - 56	1,020	0,905	1,083	0,267	0,324	0,304	1,023	1,063	0,894	0,276	0,285	0,108
57 - 59	1,056	0,825	1,152	0,332	0,326	0,325	1,018	1,074	0,891	0,272	0,288	0,110
60 - 62	1,055	0,825	1,153	0,332	0,326	0,325	1,019	1,073	0,891	0,273	0,287	0,110
63 - 65	1,056	0,824	1,153	0,332	0,326	0,325	1,019	1,074	0,891	0,273	0,288	0,110
66 - 68	1,055	0,824	1,154	0,332	0,326	0,325	1,020	1,073	0,890	0,272	0,287	0,111
69 - 71	1,055	0,825	1,154	0,332	0,325	0,326	1,019	1,074	0,891	0,272	0,288	0,110
74	0,000			0,000			0,000			0,000		

3. Annex 3 – Extract from the test report

Ergebnis	110.3			115.1			115.2			-		
	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾
16	1,098	1,097	1,098	1,153	1,152	1,153	1,152	1,151	1,152	-	-	-
17	1,098			1,152			1,152			-		
22	0,999			0,999			0,999			-		
23	0,001			0,000			0,001			-		
28 ²⁾	-0,004			0,006			-0,006			-		
32	-0,196			-0,985			-0,196			-		
51 - 53	16,0	13,6	13,7	53,2	56,5	52,4	23,7	17,0	18,6	-	-	-
54 - 56	0,253	0,200	0,235	1,032	0,940	0,993	0,309	0,252	0,340	-	-	-
57 - 59	0,264	0,264	0,268	1,040	1,035	1,035	0,350	0,349	0,353	-	-	-
60 - 62	0,264	0,264	0,268	1,040	1,035	1,036	0,349	0,351	0,354	-	-	-
63 - 65	0,264	0,265	0,269	1,040	1,034	1,036	0,348	0,350	0,354	-	-	-
66 - 68	0,263	0,264	0,267	1,039	1,034	1,035	0,349	0,349	0,353	-	-	-
69 - 71	0,264	0,264	0,267	1,040	1,036	1,036	0,349	0,350	0,355	-	-	-
74	0,000			0,000			0,015			-		

Note:

Die Ergebnisse in der Tabelle sind anhand der Tabelle 4-70 in FGW TR3 (Rev.25) wie folgt durchnummeriert /
The results in the table are numbered according to Table 4-70 in FGW TR3 (Rev.25) as follows :

¹⁾ A / B / C kennzeichnen die Phase-Phase-Spannungen (L12, L23, L31) oder die Phasenströme (L1, L2, L3). /
A / B / C indicate the phase-phase voltages (L12, L23, L31) or the phase currents (L1, L2, L3).

²⁾ Untererregter / induktiver Blindstrom hat ein negatives Vorzeichen, übererregter / kapazitiver Blindstrom hat ein positives Vorzeichen, das Vorzeichen der Blindleistung ist gleich wie Blindstrom. /
Under-excited / inductive reactive current has a negative sign, over-excited / capacitive reactive current has a positive sign, the sign of the reactive power is the same as the reactive current.

³⁾ Test für Mehrfachfehler zu nachweisen, dass die EZE in der Lage ist, mehrfach aufeinanderfolgende Spannungseinbrüche durchfahren zu können. /
Test for multiple faults to proven the PGU is able to ride through several consecutive voltage dips.

Nr.:	Parameter	Phasenbezug, Bezugszeit, Wert [Einheit] / Phase reference, Reference time, Value [unit]
16	Istwert Spannungseinbruchtiefe / Spannungserhöhung / Measured value of voltage drop / increase (L12, L23, L31)	Phase-Phase, t1 + 100ms ... t2 zu t1 - 60s ... t1) [p.u. U _n]
17	Istwert Spannungseinbruchtiefe / Spannungserhöhung / Measured value of voltage drop / increase	Mitsystem / Pos. seq., Phase-neutral, t1 + 100ms ... t2 zu t1 - 60s ... t1) [p.u. U _n]
22	Spannung / Voltage	Mitsystem / Pos. seq., Phase-neutral, t1 - 60s bis t1) [p.u. U _n]
23	Spannung / Voltage	Gegensystem / Neg. seq., Phase-neutral, t1 - 60s bis t1) [p.u. U _n]
28 ²⁾	Blindstrom / Reactive current	Mitsystem / Neg. seq., t1 - 60s bis t1) [p.u. I _n]
32	Wirkleistung / Active Power	Gesamt / Total, t1 - 10s ... t1 [p.u. P _n]
51 - 53	Kurzschlussströme Scheitelwerte / Short-circuit currents, peak value (L1,L2,L3)	t1 ... t1 + 20ms [A]
54 - 56	Kurzschlussströme 1-Perioden-Effektivwert / Short-circuit currents, 1-period RMS value (L1,L2,L3)	t1 ... t1 + 20ms [p.u. I _n]
57 - 59	Kurzschlussströme 1-Perioden-Effektivwert / Short-circuit currents, 1-period RMS value (L1,L2,L3)	t1 + 80ms ... t1 + 100ms [p.u. I _n]
60 - 62	Kurzschlussströme 1-Perioden-Effektivwert / Short-circuit currents, 1-period RMS value (L1,L2,L3)	t1 + 130ms ... t1 + 150ms [p.u. I _n]
63 - 65	Kurzschlussströme 1-Perioden-Effektivwert / Short-circuit currents, 1-period RMS value (L1,L2,L3)	t1 + 280ms ... t1 + 300ms [p.u. I _n]
66 - 68	Kurzschlussströme 1-Perioden-Effektivwert / Short-circuit currents, 1-period RMS value (L1,L2,L3)	t1 + 480ms ... t1 + 500ms [p.u. I _n]
69 - 71	Kurzschlussströme 1-Perioden-Effektivwert / Short-circuit currents, 1-period RMS value (L1,L2,L3)	t1 + 980ms ... t1 + 1000ms [p.u. I _n]
74	Anschwingzeit Wirkstrom / Response time of active current	Mitsystem / Pos. seq. [s]

3. Annex 3 – Extract from the test report

TruConvert AC3025 (Discharging Mode)

Test 50.4 (Phase 2)

Ergebnis	25.5			50.1			50.2			50.5		
	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾
16	-	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-	-
28 ²⁾	-	-	-	-	-	-	-	-	-	-	-	-
32	-	-	-	-	-	-	-	-	-	-	-	-
51 - 53	-	-	-	-	-	-	-	-	-	-	-	-
54 - 56	-	-	-	-	-	-	-	-	-	-	-	-
57 - 59	-	-	-	-	-	-	-	-	-	-	-	-
60 - 62	-	-	-	-	-	-	-	-	-	-	-	-
63 - 65	-	-	-	-	-	-	-	-	-	-	-	-
66 - 68	-	-	-	-	-	-	-	-	-	-	-	-
69 - 71	-	-	-	-	-	-	-	-	-	-	-	-
74	-	-	-	-	-	-	-	-	-	-	-	-
Ergebnis	50.3			50.4			50.6			75.1		
	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾
16	-	-	-	0,674	0,673	0,999	-	-	-	-	-	-
17	-	-	-	0,761	-	-	-	-	-	-	-	-
22	-	-	-	0,998	-	-	-	-	-	-	-	-
23	-	-	-	0,000	-	-	-	-	-	-	-	-
28 ²⁾	-	-	-	0,007	-	-	-	-	-	-	-	-
32	-	-	-	-0,196	-	-	-	-	-	-	-	-
51 - 53	-	-	-	31,2	52,6	16,1	-	-	-	-	-	-
54 - 56	-	-	-	0,428	0,535	0,168	-	-	-	-	-	-
57 - 59	-	-	-	0,662	0,987	0,315	-	-	-	-	-	-
60 - 62	-	-	-	0,661	0,986	0,316	-	-	-	-	-	-
63 - 65	-	-	-	0,661	0,985	0,315	-	-	-	-	-	-
66 - 68	-	-	-	0,663	0,986	0,316	-	-	-	-	-	-
69 - 71	-	-	-	0,662	0,986	0,316	-	-	-	-	-	-
74	-	-	-	0,008	-	-	-	-	-	-	-	-

3. Annex 3 – Extract from the test report

TruConvert AC3025 (Discharging Mode)

Test 50.4 (Phase 3)

Ergebnis	25.5			50.1			50.2			50.5		
	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾
16	-	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-	-
28 ²⁾	-	-	-	-	-	-	-	-	-	-	-	-
32	-	-	-	-	-	-	-	-	-	-	-	-
51 - 53	-	-	-	-	-	-	-	-	-	-	-	-
54 - 56	-	-	-	-	-	-	-	-	-	-	-	-
57 - 59	-	-	-	-	-	-	-	-	-	-	-	-
60 - 62	-	-	-	-	-	-	-	-	-	-	-	-
63 - 65	-	-	-	-	-	-	-	-	-	-	-	-
66 - 68	-	-	-	-	-	-	-	-	-	-	-	-
69 - 71	-	-	-	-	-	-	-	-	-	-	-	-
74	-	-	-	-	-	-	-	-	-	-	-	-
Ergebnis	50.3			50.4			50.6			75.1		
	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾
16	-	-	-	0,999	0,673	0,674	-	-	-	-	-	-
17	-	-	-	0,760	-	-	-	-	-	-	-	-
22	-	-	-	0,998	-	-	-	-	-	-	-	-
23	-	-	-	0,000	-	-	-	-	-	-	-	-
28 ²⁾	-	-	-	0,007	-	-	-	-	-	-	-	-
32	-	-	-	-0,196	-	-	-	-	-	-	-	-
51 - 53	-	-	-	19,1	29,9	46,9	-	-	-	-	-	-
54 - 56	-	-	-	0,209	0,237	0,422	-	-	-	-	-	-
57 - 59	-	-	-	0,320	0,651	0,979	-	-	-	-	-	-
60 - 62	-	-	-	0,321	0,653	0,979	-	-	-	-	-	-
63 - 65	-	-	-	0,321	0,654	0,979	-	-	-	-	-	-
66 - 68	-	-	-	0,321	0,653	0,979	-	-	-	-	-	-
69 - 71	-	-	-	0,323	0,652	0,980	-	-	-	-	-	-
74	-	-	-	0,008	-	-	-	-	-	-	-	-

3. Annex 3 – Extract from the test report

TruConvert AC3025 (Charging Mode)

Ergebnis	25.1			25.2			25.3			25.4		
	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾
16	-	-	-	0,251	0,250	0,250	Die EZE ist in der Lage, mehrfach aufeinanderfolgende Spannungseinbrüche durchzufahren. / The PGU is able to ride through several consecutive voltage dips.	-	-	-	-	-
17	-	-	-	0,250	-	-		-	-	-	-	-
22	-	-	-	0,998	-	-		-	-	-	-	-
23	-	-	-	0,002	-	-		-	-	-	-	-
28 ²⁾	-	-	-	-0,001	-	-		-	-	-	-	-
32	-	-	-	0,201	-	-		-	-	-	-	-
51 - 53	-	-	-	101,5	57,9	75,5		-	-	-	-	-
54 - 56	-	-	-	0,636	0,215	0,704		-	-	-	-	-
57 - 59	-	-	-	1,216	1,206	1,203		-	-	-	-	-
60 - 62	-	-	-	1,216	1,205	1,203		-	-	-	-	-
63 - 65	-	-	-	1,215	1,207	1,203		-	-	-	-	-
66 - 68	-	-	-	1,216	1,205	1,203		-	-	-	-	-
69 - 71	-	-	-	0,203	0,201	0,200		-	-	-	-	-
74	-	-	-	0,008	-	-		-	-	-	-	-

Ergebnis	25.5			50.1			50.2			50.5		
	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾
16	-	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-	-
28 ²⁾	-	-	-	-	-	-	-	-	-	-	-	-
32	-	-	-	-	-	-	-	-	-	-	-	-
51 - 53	-	-	-	-	-	-	-	-	-	-	-	-
54 - 56	-	-	-	-	-	-	-	-	-	-	-	-
57 - 59	-	-	-	-	-	-	-	-	-	-	-	-
60 - 62	-	-	-	-	-	-	-	-	-	-	-	-
63 - 65	-	-	-	-	-	-	-	-	-	-	-	-
66 - 68	-	-	-	-	-	-	-	-	-	-	-	-
69 - 71	-	-	-	-	-	-	-	-	-	-	-	-
74	-	-	-	-	-	-	-	-	-	-	-	-

Ergebnis	50.3			50.4			50.6			75.1		
	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾
16	-	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-	-
28 ²⁾	-	-	-	-	-	-	-	-	-	-	-	-
32	-	-	-	-	-	-	-	-	-	-	-	-
51 - 53	-	-	-	-	-	-	-	-	-	-	-	-
54 - 56	-	-	-	-	-	-	-	-	-	-	-	-
57 - 59	-	-	-	-	-	-	-	-	-	-	-	-
60 - 62	-	-	-	-	-	-	-	-	-	-	-	-
63 - 65	-	-	-	-	-	-	-	-	-	-	-	-
66 - 68	-	-	-	-	-	-	-	-	-	-	-	-
69 - 71	-	-	-	-	-	-	-	-	-	-	-	-
74	-	-	-	-	-	-	-	-	-	-	-	-

3. Annex 3 – Extract from the test report

Ergebnis	75.2			75.3			75.4			75.5		
	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾
16	-	-	-	0,750	0,748	0,748	-	-	-	-	-	-
17	-	-	-	0,749	-	-	-	-	-	-	-	-
22	-	-	-	0,998	-	-	-	-	-	-	-	-
23	-	-	-	0,002	-	-	-	-	-	-	-	-
28 ²⁾	-	-	-	0,000	-	-	-	-	-	-	-	-
32	-	-	-	0,201	-	-	-	-	-	-	-	-
51 - 53	-	-	-	40,7	27,9	30,8	-	-	-	-	-	-
54 - 56	-	-	-	0,311	0,319	0,360	-	-	-	-	-	-
57 - 59	-	-	-	0,526	0,519	0,516	-	-	-	-	-	-
60 - 62	-	-	-	0,526	0,519	0,516	-	-	-	-	-	-
63 - 65	-	-	-	0,525	0,519	0,516	-	-	-	-	-	-
66 - 68	-	-	-	0,526	0,519	0,516	-	-	-	-	-	-
69 - 71	-	-	-	0,525	0,519	0,516	-	-	-	-	-	-
74	-	-	-	0,011	-	-	-	-	-	-	-	-
Ergebnis	75.6			75.7			75.8			80.1		
	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾
16	-	-	-	0,820	0,999	0,817	-	-	-	-	-	-
17	-	-	-	0,874	-	-	-	-	-	-	-	-
22	-	-	-	0,998	-	-	-	-	-	-	-	-
23	-	-	-	0,002	-	-	-	-	-	-	-	-
28 ²⁾	-	-	-	-0,001	-	-	-	-	-	-	-	-
32	-	-	-	0,201	-	-	-	-	-	-	-	-
51 - 53	-	-	-	43,7	26,6	11,4	-	-	-	-	-	-
54 - 56	-	-	-	0,467	0,374	0,144	-	-	-	-	-	-
57 - 59	-	-	-	0,532	0,424	0,135	-	-	-	-	-	-
60 - 62	-	-	-	0,532	0,424	0,135	-	-	-	-	-	-
63 - 65	-	-	-	0,532	0,425	0,135	-	-	-	-	-	-
66 - 68	-	-	-	0,531	0,424	0,136	-	-	-	-	-	-
69 - 71	-	-	-	0,533	0,425	0,135	-	-	-	-	-	-
74	-	-	-	0,000	-	-	-	-	-	-	-	-
Ergebnis	80.2			85.1			110.1			110.2		
	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾
16	-	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-	-
28 ²⁾	-	-	-	-	-	-	-	-	-	-	-	-
32	-	-	-	-	-	-	-	-	-	-	-	-
51 - 53	-	-	-	-	-	-	-	-	-	-	-	-
54 - 56	-	-	-	-	-	-	-	-	-	-	-	-
57 - 59	-	-	-	-	-	-	-	-	-	-	-	-
60 - 62	-	-	-	-	-	-	-	-	-	-	-	-
63 - 65	-	-	-	-	-	-	-	-	-	-	-	-
66 - 68	-	-	-	-	-	-	-	-	-	-	-	-
69 - 71	-	-	-	-	-	-	-	-	-	-	-	-
74	-	-	-	-	-	-	-	-	-	-	-	-

3. Annex 3 – Extract from the test report

Ergebnis	110.3			115.1			115.2			-		
	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾	A ¹⁾	B ¹⁾	C ¹⁾
16	-	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-	-
28 ²⁾	-	-	-	-	-	-	-	-	-	-	-	-
32	-	-	-	-	-	-	-	-	-	-	-	-
51 - 53	-	-	-	-	-	-	-	-	-	-	-	-
54 - 56	-	-	-	-	-	-	-	-	-	-	-	-
57 - 59	-	-	-	-	-	-	-	-	-	-	-	-
60 - 62	-	-	-	-	-	-	-	-	-	-	-	-
63 - 65	-	-	-	-	-	-	-	-	-	-	-	-
66 - 68	-	-	-	-	-	-	-	-	-	-	-	-
69 - 71	-	-	-	-	-	-	-	-	-	-	-	-
74	-	-	-	-	-	-	-	-	-	-	-	-

Note:

Die Ergebnisse in der Tabelle sind anhand der Tabelle 4-70 in FGW TR3 (Rev.25) wie folgt durchnummeriert /
The results in the table are numbered according to Table 4-70 in FGW TR3 (Rev.25) as follows :

¹⁾ A / B / C kennzeichnen die Phase-Phase-Spannungen (L12, L23, L31) oder die Phasenströme (L1, L2, L3). /
A / B / C indicate the phase-phase voltages (L12, L23, L31) or the phase currents (L1, L2, L3).

²⁾ Untererregter / induktiver Blindstrom hat ein negatives Vorzeichen, übererregter / kapazitiver Blindstrom hat ein positives Vorzeichen, das Vorzeichen der Blindleistung ist gleich wie Blindstrom. /
Under-excited / inductive reactive current has a negative sign, over-excited / capacitive reactive current has a positive sign, the sign of the reactive power is the same as the reactive current.

³⁾ Test für Mehrfachfehler zu nachweisen, dass die EZE in der Lage ist, mehrfach aufeinanderfolgende Spannungseinbrüche durchfahren zu können. /
Test for multiple faults to proven the PGU is able to ride through several consecutive voltage dips.

Nr.:	Parameter	Phasenbezug, Bezugszeit, Wert [Einheit] / Phase reference, Reference time, Value [unit]
16	Istwert Spannungseinbruchtiefe / Spannungserhöhung / Measured value of voltage drop / increase (L12, L23, L31)	Phase-Phase, t1 + 100ms ... t2 zu t1 - 60s ... t1) [p.u. U _n]
17	Istwert Spannungseinbruchtiefe / Spannungserhöhung / Measured value of voltage drop / increase	Mitsystem / Pos. seq., Phase-neutral, t1 + 100ms ... t2 zu t1 - 60s ... t1) [p.u. U _n]
22	Spannung / Voltage	Mitsystem / Pos. seq., Phase-neutral, t1 - 60s bis t1) [p.u. U _n]
23	Spannung / Voltage	Gegensystem / Neg. seq., Phase-neutral, t1 - 60s bis t1) [p.u. U _n]
28 ²⁾	Blindstrom / Reactive current	Mitsystem / Neg. seq., t1 - 60s bis t1) [p.u. I _n]
32	Wirkleistung / Active Power	Gesamt / Total, t1 - 10s ... t1 [p.u. P _n]
51 - 53	Kurzschlussströme Scheitelwerte / Short-circuit currents, peak value (L1,L2,L3)	t1 ... t1 + 20ms [A]
54 - 56	Kurzschlussströme 1-Perioden-Effektivwert / Short-circuit currents, 1-period RMS value (L1,L2,L3)	t1 ... t1 + 20ms [p.u. I _n]
57 - 59	Kurzschlussströme 1-Perioden-Effektivwert / Short-circuit currents, 1-period RMS value (L1,L2,L3)	t1 + 80ms ... t1 + 100ms [p.u. I _n]
60 - 62	Kurzschlussströme 1-Perioden-Effektivwert / Short-circuit currents, 1-period RMS value (L1,L2,L3)	t1 + 130ms ... t1 + 150ms [p.u. I _n]
63 - 65	Kurzschlussströme 1-Perioden-Effektivwert / Short-circuit currents, 1-period RMS value (L1,L2,L3)	t1 + 280ms ... t1 + 300ms [p.u. I _n]
66 - 68	Kurzschlussströme 1-Perioden-Effektivwert / Short-circuit currents, 1-period RMS value (L1,L2,L3)	t1 + 480ms ... t1 + 500ms [p.u. I _n]
69 - 71	Kurzschlussströme 1-Perioden-Effektivwert / Short-circuit currents, 1-period RMS value (L1,L2,L3)	t1 + 980ms ... t1 + 1000ms [p.u. I _n]
74	Anschwingzeit Wirkstrom / Response time of active current	Mitsystem / Pos. seq. [s]

Figure 19 – Summary results of short-circuit current contributions

3. Annex 3 – Extract from the test report

The following reference values are applied for calculation of the p.u. values specified in the table above:

	TruConvert AC3025
Rated active power, P_n [kW]	25
Rated voltage (phase-to-phase), U_n [V]	400
Rated current, I_n [A]	36

3. Annex 3 – Extract from the test report

Parameters necessary for calculating the short-circuit currents as specified in DIN EN 60909-0 (VDE 0102) [5] (Manufacturer's data from [14]):

Hersteller	Trumpf Hüttinger GmbH & Co. KG.		
Typenbezeichnung	TruConvert AC 3025		
Einspeisung (ein- / Dreiphasig)	3/N/PE		
Nennscheinleistung	25,0	kVA	S_{rE}
Nennwirkleistung	25,0	kW	P_{rE}
AC Nennspannung (L-L)	400	V	U_n
AC Nennfrequenz	50	Hz	f_n
Nennstrom	36	A	I_r
Maximal Dauerstrom	43	A	I_{max}
Beitrag zum Anfangskurzschlusswechselstrom 2/3 phasig	45,6	A	I''_k
Stoßkurzschlussstrom 2/3 phasig	410	A	I_{p_max}
Effektivwert des Quellenstroms bei dreipoligen Fehler	43 ^{1) 2)}	A	I_{skPF}
Effektivwert des Quellenstroms bei zweipoligen Fehler	43 ^{1) 2)}	A	$I_{(1)sk2PF}$
Effektivwert des Quellenstroms bei einpoligen Fehler	43 ^{1) 2)}	A	$I_{(1)sk1PF}$
Kurzschlussgegenimpedanz ¹	106 ³⁾	Ohm	$Z_{(2)PF}$
Bemerkung: 1) Bei Kurzschluss direkt an der Wechselrichterklennen 2) Nach Herstellerangabe beträgt der Maximale Dauerstrom 43 A. Dieser Wert wird als für Kurzschlusswechselströme nach DIN EN60909-0 festgelegt 3) Nach DIN EN 60909-0 ist die Mitsystemimpedanz als unendlich anzusetzen.			

Figure 20 – Parameters necessary for calculating the short-circuit currents according to DIN EN 60909-0

4. Annex 4 – Validated simulation model

4.1. General information about the simulation model [7]:

Simulation environment used for creation of the PGU model:	PowerFactory 2021 (x86)
Simulation environment used for conducting simulation/validation:	PowerFactory 2021 SP5 (x64)
Data format of the simulation model:	.pfd: PowerFactory model file .zip: Compressed file archive
Identification number of the validated model of the generating unit:	File name: Trumpf_TR4_Rev_2c.zip MD5 - Checksum: b0ec3920f454d9c1af4312100ddeb727 Archive content: File name: Trumpf_TruConvert_AC3025_rev2c_enc.pfd MD5 - Checksum: 157f2c15d4a6e2d77db75d7609c9bc39
Certification the PGU according to:	<input checked="" type="checkbox"/> VDE-AR-N 4110:2018-11
Available model documentation:	Model Implementation report Trumpf Hüttinger GmbH & Co. KG.TruConvert AC 3025, issued by FGH GmbH, Date: 02.Aug.2022 Trumpf_TruConvertAC3025_Model-Report-rev2c
Model type:	<input type="checkbox"/> EMT model <input checked="" type="checkbox"/> RMS model
The model is suitable for	<input checked="" type="checkbox"/> static simulation <input checked="" type="checkbox"/> dynamic simulation <input checked="" type="checkbox"/> simulation of symmetrical and asymmetrical faults <input type="checkbox"/> only simulation of symmetrical faults
Implemented FRT modes:	<input checked="" type="checkbox"/> Full dynamic grid support <input checked="" type="checkbox"/> Limited dynamic grid support
Is k-factor adjustable?	<input checked="" type="checkbox"/> yes <input type="checkbox"/> no
Further functions implemented in the model:	See 4.3 Model parameters [7]
Is a simulation on a PGS configuration with SCR = 5 possible?	<input checked="" type="checkbox"/> yes <input type="checkbox"/> no, for a stable simulation the SCR has to be limited to: _____

4. Annex 4 – Validated simulation model

4.2. Description of the PGU simulation model [7]:

The simulation model of the TruConvert AC3025 is implemented in DigSILENT PowerFactory Version 2021 (x86). In time-domain the static generator model acts as a current source and is suitable for RMS simulations. It is recommended that the integration step size to be set to 1 ms for the simulations.

Description of the main control circuit (Figure 21, Figure 22 & Figure 23):

The inverter is represented by the built-in PowerFactory element Static Generator. The behaviour of dynamic model is determined by the DSL models connected to the Static Generator as showed in in *Figure 23*. Further details are described in the corresponding model documentation.

Detection of FRT event:

The implementation of the FRT detection is identical to the implementation in the PGU:

- If the minimum (for LVRT) or maximum (for HVRT) value of the three phase-to-phase voltages exceeds the activation threshold (default: $U_n \pm 10\%U_n$), a FRT event will be detected.
- A FRT event will be detected if an abrupt voltage change occurs (the absolute difference between the actual value of phase-to-phase voltages and the 1-min average of the Pre-Fault-Voltage exceeds the activation threshold (default: $5\%U_n$).

4. Annex 4 – Validated simulation model

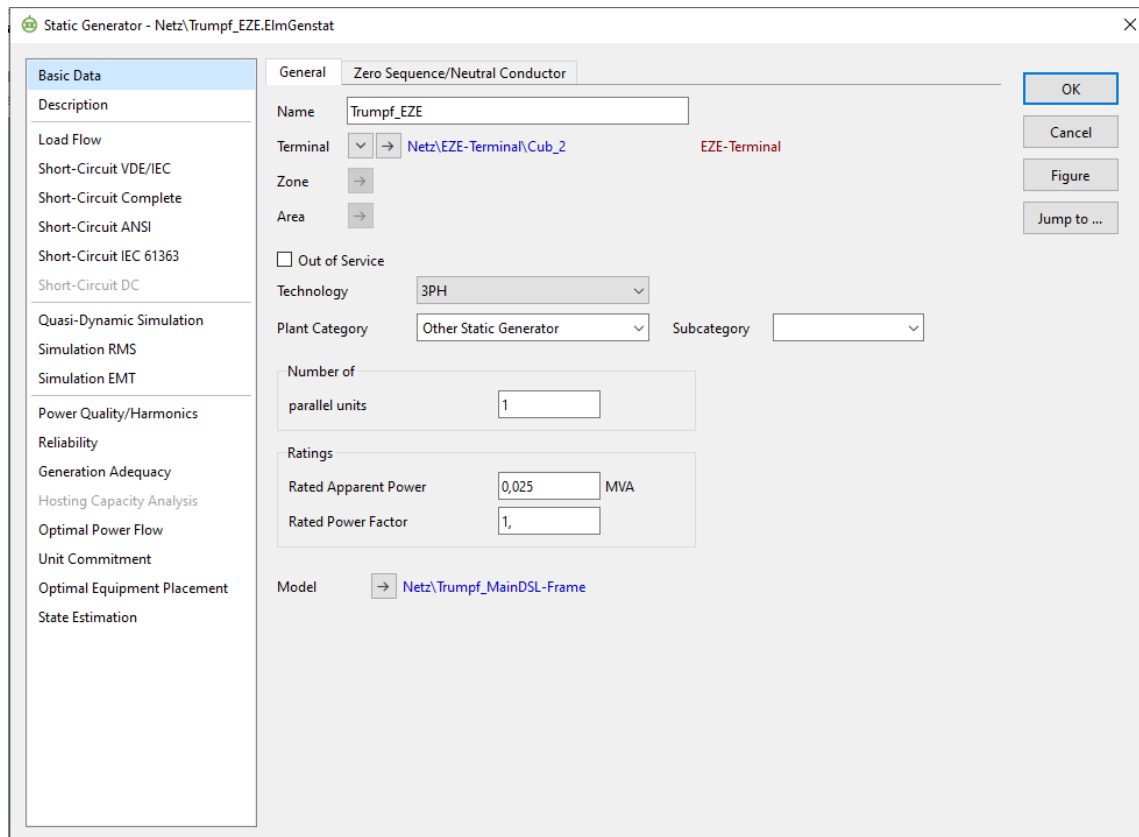


Figure 21 – Static Generator Dialogue window for *Basic Data*

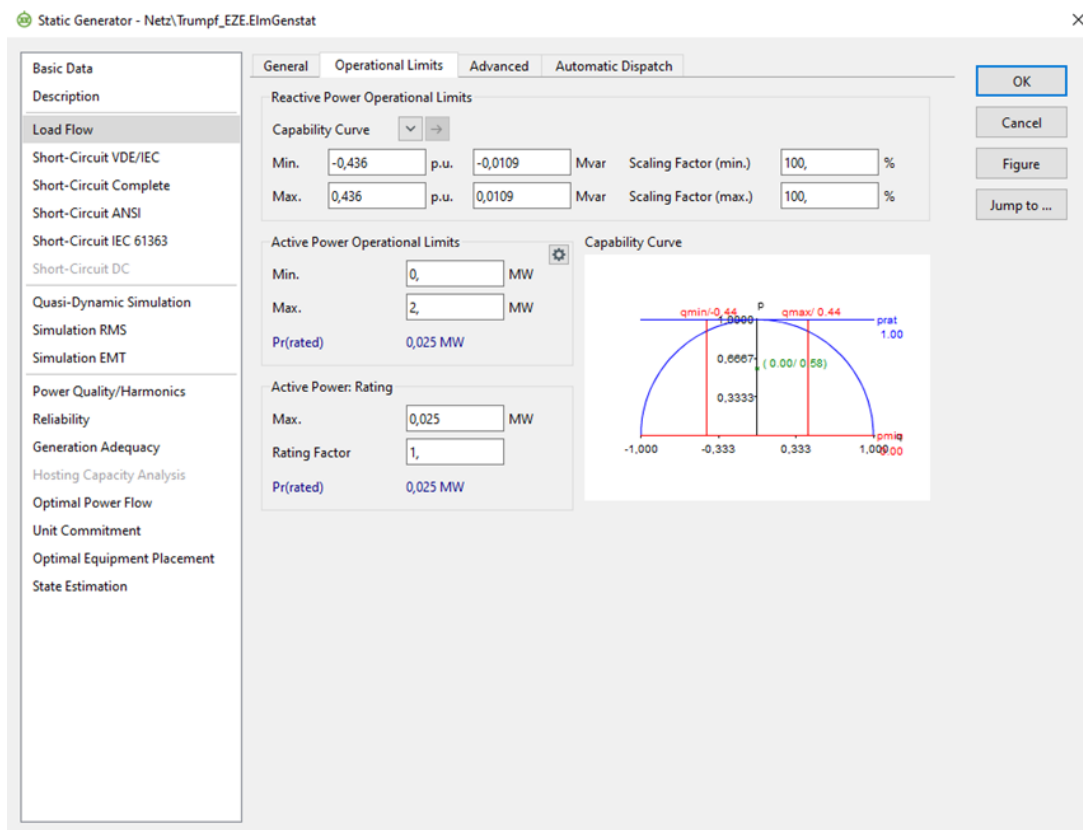


Figure 22 – Static Generator Dialogue window for *Load Flow – Operational Limits*

4. Annex 4 – Validated simulation model

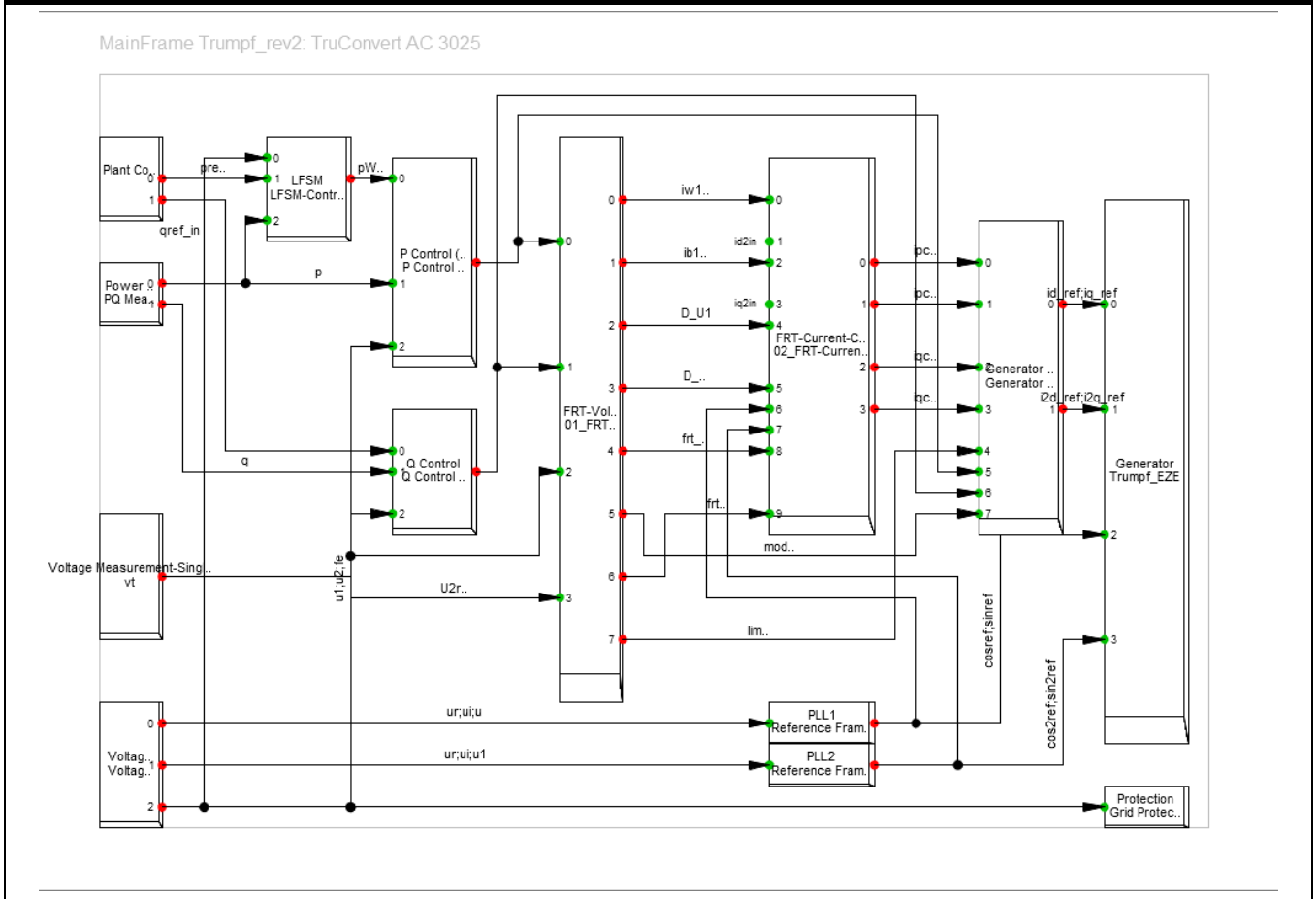


Figure 23 – Control frame of the simulation model

Description of the interface to DC input and AC output (Figure 24):

The unit model is connected to AC mains via the 0,4 kV three phase busbar (which is the measuring point of the voltage measuring element) and also contains the relays of the internal disconnection function.

In time-domain simulations the static generator model acts as a current source, no explicit primary energy conversion is implemented.

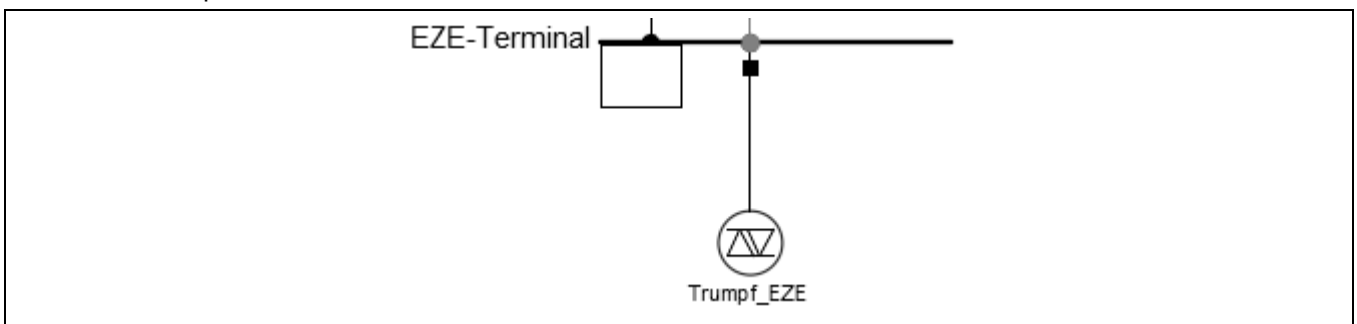


Figure 24 – Interface of the model towards the simulation environment

4. Annex 4 – Validated simulation model

4.3. Model parameters [7]

Description of the accessible parameterization of the model:

The ranges of the following parameters need to be selected in a sensible way: i.e. using the default values or parameter ranges stated in the TG 3 report 19TH0414_TR3_Rev25_0.

Figure 25 shows the composite model *MainFrame Trumpf_rev2* which references to *Control_Frame* shown in Figure 23 and connects to the DSL- and composite models

- *LFSM_Control*;
- *Generator Set Type 4*;
- *P_Control Type 4A*;
- *Q_Control Type 4A*;
- *Grid Protection*
- Reference Frame Rotation (PLL)_pos
- Reference Frame Rotation (PLL)_neg
- 02_FRT-Current-Calc
- 01_FRT-Voltage-Calc.

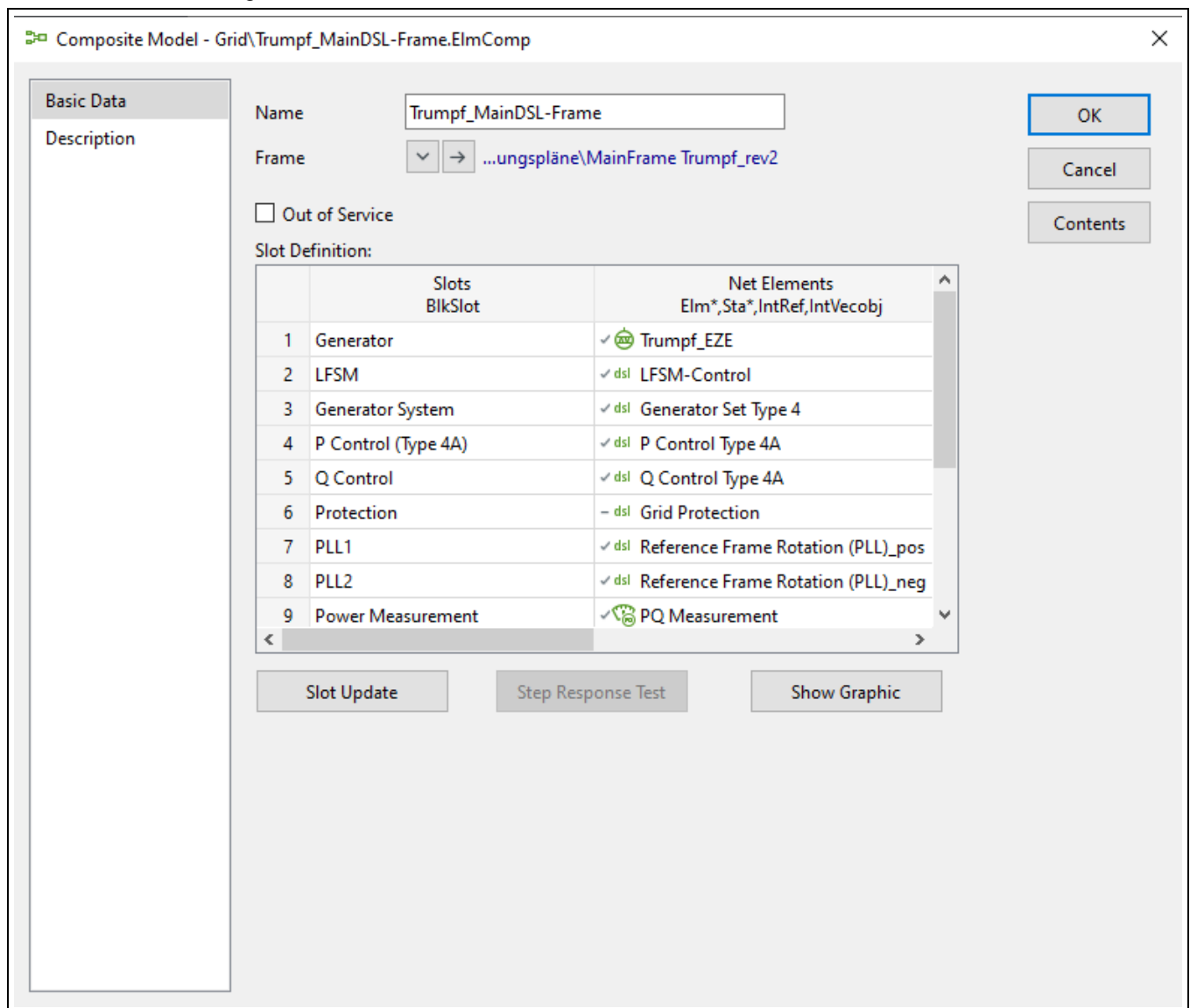
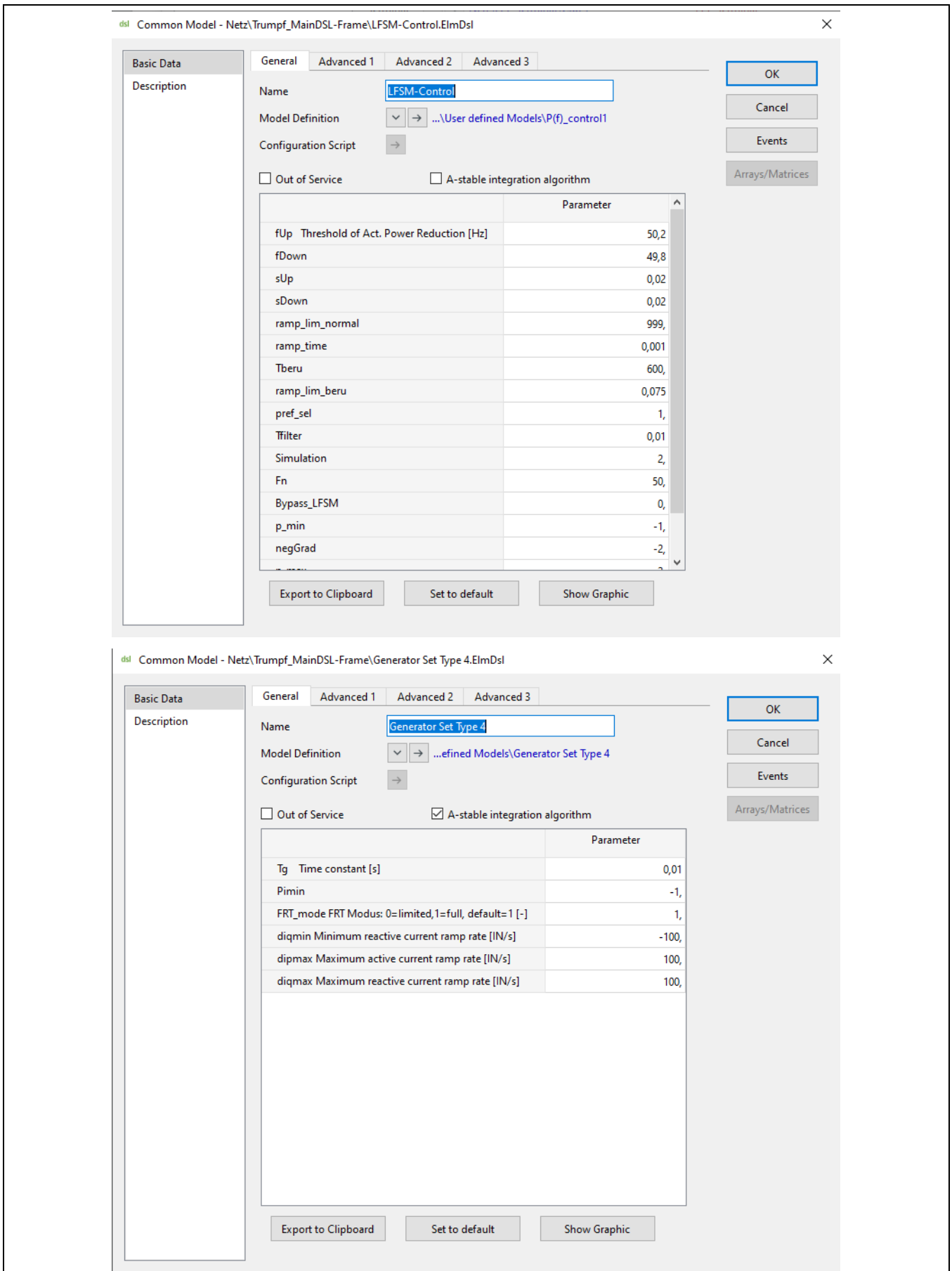


Figure 25 – Composite model *DynamicModel* references to *Control_Frame*

4. Annex 4 – Validated simulation model

Via the common models the parameters of the controllers are accessible and can be set:



The image shows two screenshots of a software configuration interface. The top window is titled 'Common Model - Netz\Trumpf_MainDSL-Frame\LFSM-Control.ElmDsl'. It has tabs for 'General', 'Advanced 1', 'Advanced 2', and 'Advanced 3'. The 'General' tab is active, showing the name 'LFSM-Control' and a model definition path. Below are checkboxes for 'Out of Service' and 'A-stable integration algorithm'. A table lists various parameters and their values:

Parameter	Value
fUp Threshold of Act. Power Reduction [Hz]	50,2
fDown	49,8
sUp	0,02
sDown	0,02
ramp_lim_normal	999,
ramp_time	0,001
Tberu	600,
ramp_lim_beru	0,075
pref_sel	1,
Tfilter	0,01
Simulation	2,
Fn	50,
Bypass_LFSM	0,
p_min	-1,
negGrad	-2,

The bottom window is titled 'Common Model - Netz\Trumpf_MainDSL-Frame\Generator Set Type 4.ElmDsl'. It also has tabs for 'General', 'Advanced 1', 'Advanced 2', and 'Advanced 3'. The 'General' tab is active, showing the name 'Generator Set Type 4' and a model definition path. Below are checkboxes for 'Out of Service' and 'A-stable integration algorithm' (which is checked). A table lists various parameters and their values:

Parameter	Value
Tg Time constant [s]	0,01
Pimin	-1,
FRT_mode FRT Modus: 0=limited,1=full, default=1 [-]	1,
diqmin Minimum reactive current ramp rate [IN/s]	-100,
dipmax Maximum active current ramp rate [IN/s]	100,
diqmax Maximum reactive current ramp rate [IN/s]	100,

4. Annex 4 – Validated simulation model

dsi Common Model - Netz\Trumpf_MainDSL-Frame\P Control Type 4A.ElmDsl

Basic Data

Description

General Advanced 1 Advanced 2 Advanced 3

Name

Model Definition ...r defined Models\P Control Type 4A

Configuration Script

Out of Service A-stable integration algorithm

	Parameter
Tpordp4A Time constant in power order lag [s]	0,01
Pimin	-1,
Tufiltp4A Voltage measurement filter time constant [s]	0,01
dpmxp4A Maximum wind turbine power ramp rate [Pn/s]	999,

dsi Common Model - Netz\Trumpf_MainDSL-Frame\Q Control Type 4A.ElmDsl

Basic Data

Description

General Advanced 1 Advanced 2 Advanced 3

Name

Model Definition ...ned Models\Q Control Type 4A_new

Configuration Script

Out of Service A-stable integration algorithm

	Parameter
Tpordp4A Time constant in power order lag [s]	0,01
Tufiltp4A Voltage measurement filter time constant [s]	0,01
dpmxp4A Maximum wind turbine power ramp rate [Pn/s]	999,

4. Annex 4 – Validated simulation model

dsi Common Model - Netz\Trumpf_MainDSL-Frame\Grid Protection.Elmdsl

Basic Data

Description

General | Advanced 1 | Advanced 2 | Advanced 3

Name:

Model Definition: ...ek\User defined Models\Protection

Configuration Script:

Out of Service A-stable integration algorithm

	Parameter
TfMA Time interval of moving average window [s]	0,9
uover WT over voltage protection activation threshold [Un]	1,2
fover WT over frequency protection activation threshold ...	1,02
uunder WT under voltage protection activation threshold...	0,85
funder WT under frequency protection activation thresho...	0,98
Mzc Zero crossing measurement mode (true = 1 if the ...	0,
dPhimax Maximum rate of change of frequency [fn/s]	5,

Figure 26 – Common models from [7]

4. Annex 4 – Validated simulation model



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A4. Model parameters			
Parameter name	Parameter description	Unit	Default
<i>Common Model – Grid\DynamicModel\Generator Set Type 4.ElmDsl</i>			
Tg	Time constant	[s]	0,01
Pimin			-1
FRT_mode	FRT Modus: 0=limited,1=full, default=1	[-]	1
diquin	Minimum reactive current ramp rate	[IN/s]	-100
dipmax	Maximum active current ramp rate	[IN/s]	100.
diqumax	Maximum reactive current ramp rate	[IN/s]	100
<i>Common Model – Grid\DynamicModel\LFSSM_Control.ElmDsl</i>			
fUp	Threshold of Act. Power Reduction	[Hz]	50,2
fDown	Threshold of Act. Power Increase	[Hz]	49,8
sUp	Static of Act. Power Reduction	[p.u.]	0,02
sDown	Static of Act. Power Increase	[p.u.]	0,02
ramp_lim_normal	Gradient limiter for default active power setpoint events on pref_in (if LFSSM Block is active)	[p.u.]	999
ramp_time	Internal Time for computation	[s]	0,001
Tberu	Time for transition (End of critical network state and return to normal operation) to use the slow gradient (default 10min)	[s]	600
ramp_lim_beru	Gradient limiter for active power setpoint events on pref_in after Frequency event in case transition (Tberu) is active	[p.u.]	0,075
pref_sel	switch for selecting active power reference (true = 1 if the available active power (Pmom) should be used - otherwise false = 0 if the total active power (Pn) should be used)	[[1,0]]	1
Tfilter	PT1-Filter Time Constant	[s]	0,01
Simulation	Simulation [1], Measured [2]	[[1,2]]	2
Fn	Nominal Frequency	[Hz]	50
Bypass_LFSSM	internal Minimal active power	[[1,0]]	0
p_min	Maximum power factor	[p.u.]	-1
negGrad	Neg Gradient for Power Change	[pu/s]	-2
p_max	internal Maximmal active power	[p.u.]	2
posGrad	Pos Gradient for Power Change	[pu/s]	2
<i>Common Model – Grid\DynamicModel\P_Control Type 4A.ElmDsl</i>			
Tporpd4A	Time constant in power order lag	[s]	0,01
Pimin			-1
Tufilt4A	Voltage measurement filter time constant	[s]	0,01
dpmxp4A	Maximum wind turbine power ramp rate	[Pn/s]	999

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4. Annex 4 – Validated simulation model



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A4. Model parameters			
Parameter name	Parameter description	Unit	Default
<i>Common Model – GridDynamicModel\ Q_Control Type 4A.ElmDsl</i>			
Tpordp4A	Time constant in power order lag	[s]	0,01
Tuflt4A	Voltage measurement filter time constant	[s]	0,01
dpmaxp4A	Maximum wind turbine power ramp rate	[Pn/s]	999
<i>Common Model – GridDynamicModel\ Reference Frame Rotation (PLL)_neg.ElmDsl</i>			
TPLL	Time constant for PLL first order filter model	[s]	0,05
uPLL1	Voltage below which the angle of the voltage is filtered and possibly also frozen	[p.u.]	0,05
uPLL2	Voltage below which the angle of the voltage is frozen if $u_{PLL2} \leq u_{PLL1}$	[p.u.]	0,01
<i>Common Model – GridDynamicModel\ Reference Frame Rotation (PLL)_pos.ElmDsl</i>			
TPLL	Time constant for PLL first order filter model	[s]	0,05
uPLL1	Voltage below which the angle of the voltage is filtered and possibly also frozen	[p.u.]	0,05
uPLL2	Voltage below which the angle of the voltage is frozen if $u_{PLL2} \leq u_{PLL1}$	[p.u.]	0,01
<i>Common Model – GridDynamicModel\ 01_FRT-Voltage-Calc\ 01_FRT-Detection\ 02_Error_condition_2.ElmDsl</i>			
en_5pc_detect			1
gcm_FRT_5pc_limL			0,955
gcm_FRT_5pc_limH			1,045
TS			0,001
hyst			0,0001
<i>Common Model – GridDynamicModel\ 01_FRT-Voltage-Calc\ 01_FRT-Detection\ 02_Error_condition_1.ElmDsl</i>			
hyst			0,005
gcm_FRT_10pc_limL			0,9
gcm_FRT_10pc_limH			1,1
<i>Common Model – GridDynamicModel\ 01_FRT-Voltage-Calc\ Delay.ElmDsl</i>			
Ts			0,001
gcm_LP_a_1min			0,99
<i>Common Model – GridDynamicModel\ 01_FRT-Voltage-Calc\ Delta.ElmDsl</i>			
T			0,2
<i>Common Model – GridDynamicModel\ 01_FRT-Voltage-Calc\ Limited-FRT-Calc.ElmDsl</i>			
hyst	Hysteresis for limited threshold Voltage		0,05
mode0_lim	limited dynamic Grid Support threshold Voltage		0,7

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4. Annex 4 – Validated simulation model

A4. Model parameters			
Parameter name	Parameter description	Unit	Default
<i>Common Model – GridDynamicModel\ 01_FRT-Voltage-Calc\ VoltagePreCalc.ElmDsl</i>			
gcm_VN			230
<i>Common Model – GridDynamicModel\ 02_FRT-Current-Calc\ 01_Delta_I_calcLim\ 01_Pre_logic.ElmDsl</i>			
gcm_GN			36,2319
<i>Common Model – GridDynamicModel\ 02_FRT-Current-Calc\ 01_Delta_I_calcLim\ 02_k_Calc_abc.ElmDsl</i>			
gcm_I_lim			42.62575
gcm_GN			36,2319
gcm_epsilon			0,1
y_max1			99999999
<i>Common Model – GridDynamicModel\ 02_FRT-Current-Calc\ 01_Delta_I_calcLim\ 03_k_faktor_lim.ElmDsl</i>			
gcm_FRT_fact	K-Faktor for dynmic grid support		2
<i>Common Model – GridDynamicModel\ 02_FRT-Current-Calc\ 02_IwpreLim.ElmDsl</i>			
gcm_I_lim			1,1765
gcm_GN			1
FRT_Faktor_k	K-Faktor for dynmic grid support		2
y_min1			0
y_max2			99999999
<i>Common Model – GridDynamicModel\ Grid Protection.ElmDsl</i>			
TfMA	Time interval of moving average window	[s]	0,9
uover	WT over voltage protection activation threshold	[Un]	1,2
fover	WT over frequency protection activation threshold	[fn]	1,02
uunder	WT under voltage protection activation threshold	[Un]	0,85
funder	WT under frequency protection activation threshold	[fn]	0,98
Mzc	Zero crossing measurement mode (true = 1 if the WT protection system uses zero crossings to detect frequency - otherwise false = 0)	[0/1]	0
dPhimax	Maximum rate of change of frequency	[fn/s]	5
TfoverWT			
TfunderWT			
TuoveruWT			
TuunderuWT			

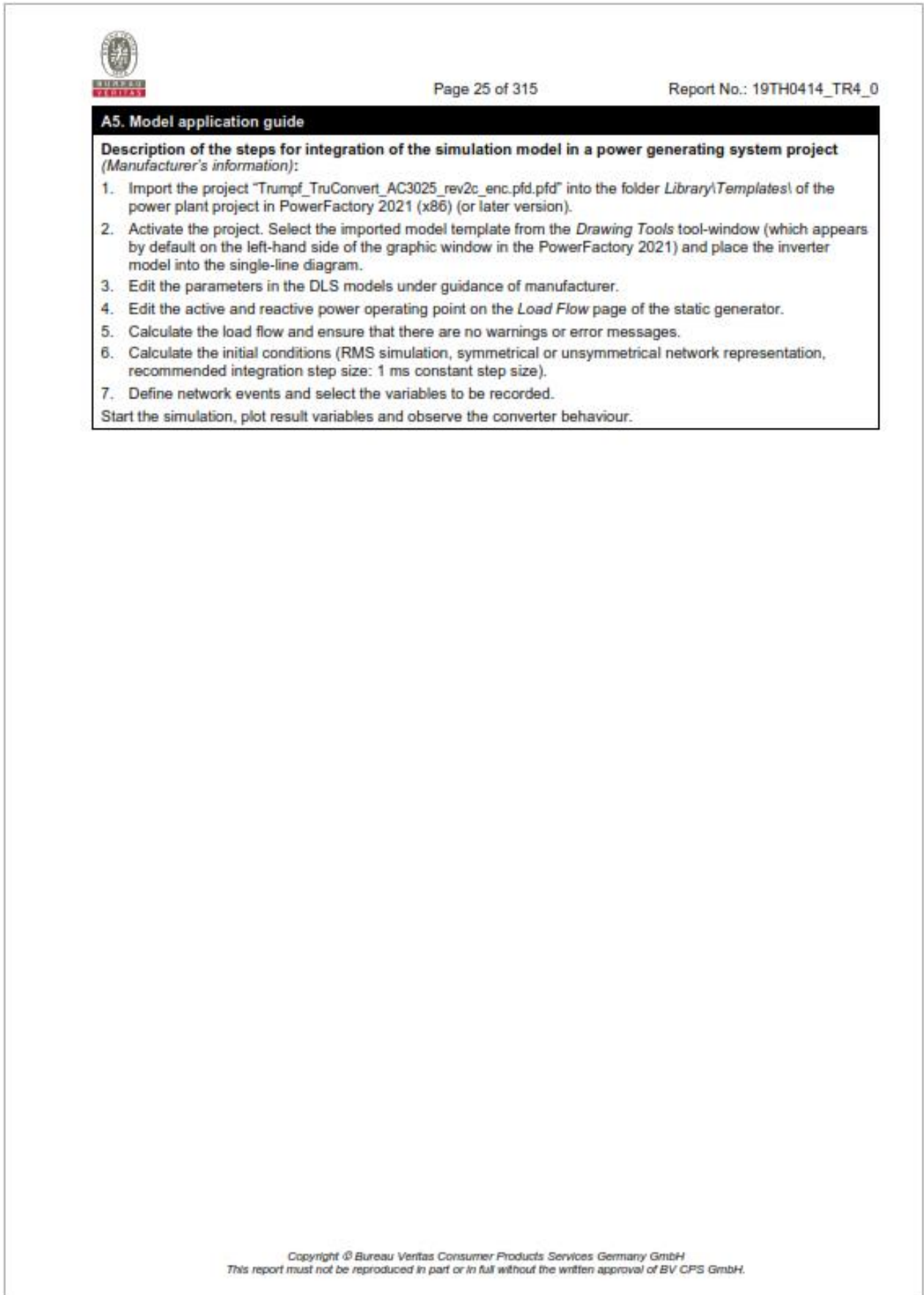
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Figure 27 – Accessible parameters of the model from [7]


4. Annex 4 – Validated simulation model

4.4. Model application guide [7]

Description of the steps for integration of the simulation model in a power generating system project (Manufacturer's information) [7]



The screenshot shows a document page with the following content:

-  Page 25 of 315 Report No.: 19TH0414_TR4_0
- A5. Model application guide**
- Description of the steps for integration of the simulation model in a power generating system project (Manufacturer's information):**
- 1. Import the project "Trumpf_TruConvert_AC3025_rev2c_enc.pfd.pfd" into the folder *Library\Templates* of the power plant project in PowerFactory 2021 (x86) (or later version).
- 2. Activate the project. Select the imported model template from the *Drawing Tools* tool-window (which appears by default on the left-hand side of the graphic window in the PowerFactory 2021) and place the inverter model into the single-line diagram.
- 3. Edit the parameters in the DLS models under guidance of manufacturer.
- 4. Edit the active and reactive power operating point on the *Load Flow* page of the static generator.
- 5. Calculate the load flow and ensure that there are no warnings or error messages.
- 6. Calculate the initial conditions (RMS simulation, symmetrical or unsymmetrical network representation, recommended integration step size: 1 ms constant step size).
- 7. Define network events and select the variables to be recorded.

Start the simulation, plot result variables and observe the converter behaviour.

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4. Annex 4 – Validated simulation model

4.5. Scope of the validation and plausibility tests [7]

The simulation model was checked for validity and plausibility according to TG 4 for following test scenarios:

- Validating P setpoint control according to TG3 Chapters, 4.1.2 (chapter 3.1.2 and 5.5.4.1 in [3])
- Validating over- and underfrequency response according to TG3 Chapter 4.1.3 (chapter 3.1.3, 3.1.4 and 5.5.4.1 in [3])
- Validating the P-Q diagram measured according to TG3 Chapters 4.2.2 and 4.2.3 (chapter 3.2.1 respectively 5.5.2.1 in [3])
- Validating all TG3 FRT tests (chapter 5.3.1 in [3])
- Plausibility tests on single model for different
 - fault types;
 - voltage depth;
 - pre-fault voltages
 - pre-fault active powers
 - pre-fault reactive powers
 - k-factors(chapter 5.5.2 in [3])
- Plausibility checks of the steady-state operation (chapter 5.5.2.2 in [3])
- Plausibility tests for typical PGS configuration for different
 - fault types;
 - voltage depth;
 - pre-fault voltages
 - pre-fault active powers
 - pre-fault reactive powers
 - k-factors(chapter 5.5.3.1 in [3])
- Simulating of unsuccessful automatic reconnection for typical PGS configuration (chapter 5.5.3.2 in [3])

For all the test scenarios the simulation ran stably without any error messages and showed satisfying behaviour.

Note:

The unit provides setting of the reactive power by:

- Q fixed Q reference (tested for both setpoint accuracy and dynamic behaviour)
- power factor control (tested for setpoint accuracy) *
- $\cos\phi(P)$ control function (not implemented / tested)
- Q(U) control function (not implemented / tested)

For all reactive power control functions implemented in the model does NOT provide PT1 filtering effect.

4. Annex 4 – Validated simulation model

4.6. Results of Validating simulation models (PGU) [7]

Summary of validation results - TruConvert AC3025

4. Annex 4 – Validated simulation model

Test label according to T63, chapter 4.8 – Behavior during grid disturbance - Table 4-8b and 4-8c	Positive Sequence						Negative Sequence											
	P		Q		I, V		P		Q		I, V							
	ME	MAE	ME	MAE	ME	MAE	ME	MAE	ME	MAE	ME	MAE						
	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05						
U _{rest} < 0,05	Pre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.1 according to IEC	Fault	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.2 according to IEC	Pre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.3 according to IEC	Fault	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.4 according to IEC	Pre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.5 according to IEC	Fault	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Post	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.6 according to IEC	Pre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.7 according to IEC	Fault	0.15	0.05	0.05	0.05	0.05	0.05	0.14	0.02	0.03	0.06	0.06	0.05	0.06	0.06	0.06	0.06	0.04
Post	0.15	0.05	0.05	0.05	0.05	0.05	0.05	0.14	0.02	0.03	0.06	0.06	0.05	0.06	0.06	0.06	0.06	0.04
0.8 according to IEC	Pre	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
0.9 according to IEC	Fault	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Post	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
1.0 according to IEC	Pre	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
1.1 according to IEC	Fault	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
1.2 according to IEC	Post	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
1.3 according to IEC	Pre	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
1.4 according to IEC	Fault	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
1.5 according to IEC	Post	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

4. Annex 4 – Validated simulation model

Test label according to IEC, chapter 4.6 - Behavior during grid disturbance - Table 4-4B and 4-4C	Positive Sequence						Negative Sequence									
	P		L		B		P		L		B					
	MAE	MRE	MAE	MRE	MAE	MRE	MAE	MRE	MAE	MRE	MAE	MRE				
0, 70 ≤ U _{rest} ≤ 0, 80 Pre 75.2 according to IEC Job / Partial Load / Kp = 2, Krv=2	0.004	0.004	0.004	0.004	0.003	0.003	-0.005	0.005	0.000	0.000	0.000	0.000	-0.002	0.002	-0.002	0.002
0, 70 ≤ U _{rest} ≤ 0, 80 Post 75.3 according to IEC Job / Partial Load / Kp = 2, Krv=2	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
0, 70 ≤ U _{rest} ≤ 0, 80 Pre 75.4 according to IEC Job / Partial Load / Kp = 2, Krv=2	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
0, 70 ≤ U _{rest} ≤ 0, 80 Post 75.5 according to IEC Job / Partial Load / Kp = 2, Krv=2	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
0, 70 ≤ U _{rest} ≤ 0, 80 Pre 75.6 according to IEC Job / Full Load / Kp = 2, Krv=2	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
0, 70 ≤ U _{rest} ≤ 0, 80 Post 75.7 according to IEC Job / Partial Load / Kp = 2, Krv=2	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
0, 70 ≤ U _{rest} ≤ 0, 80 Pre 75.8 according to IEC Job / Partial Load / Kp = 2, Krv=2	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
0, 70 ≤ U _{rest} ≤ 0, 80 Post 80.1 Job / Full Load / Kp = 2, Krv=2, Limited Mode	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
0, 70 ≤ U _{rest} ≤ 0, 80 Pre 80.2 Job / Full Load / Kp = 2, Krv=2, Limited Mode	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
0, 85 ≤ U _{rest} ≤ 0, 90 Pre 85.1 according to IEC Job / Partial Load / Kp = 2, Krv=2	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
0, 85 ≤ U _{rest} ≤ 0, 90 Post 110.1 according to IEC Job / Full Load / Kp = 2, Krv=2	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
0, 85 ≤ U _{rest} ≤ 0, 90 Pre 110.2 according to IEC Job / Full Load / Kp = 2, Krv=2	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
0, 85 ≤ U _{rest} ≤ 0, 90 Post 110.3 according to IEC Job / Full Load / Kp = 2, Krv=2	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
0, 85 ≤ U _{rest} ≤ 0, 90 Pre 110.4 according to IEC Job / Full Load / Kp = 2, Krv=2	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
0, 85 ≤ U _{rest} ≤ 0, 90 Post 110.5 according to IEC Job / Full Load / Kp = 2, Krv=2	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
0, 85 ≤ U _{rest} ≤ 0, 90 Pre 110.6 according to IEC Job / Full Load / Kp = 2, Krv=2	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
0, 85 ≤ U _{rest} ≤ 0, 90 Post 110.7 according to IEC Job / Full Load / Kp = 2, Krv=2	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004

5. Annex 5 – Certification-relevant parameters

Parameter list from [13]:

	Firma / Company:	TRUMPF Hüttinger GmbH + Co. KG	Projekt-Nr. / Project-no.:	19TH0414
	Ansprechpartner / Customer Contact:	Tel.: +49 761 8971-5322 Email: florian.ackermann@trumpf.com	BV-Kontakt / BV Contact:	Josef HIRSCHIEDER Tel: +49 40 74041 - 2087 josef.hirscheider@bureauveritas.com

Parameter list of PGU/storage system or series
1. General information regarding the Parameter list

Manufacturer:	Trumpf Hüttinger GmbH & Co. KG.
Created by:	Florian Ackermann
Created on:	26.10.2021
Revised on:	

2. Information regarding the power generating unit

Type designation (clear identification of the type)	Rated power [kW]	Rated active current [A] (with statement of displacement factor at which the current is valid)
TruConvert AC3025	25	36 A @ $\cos(\varphi) = 1$

3. Parameter set during the measurement

File name:	TruConvert_IL14_B008.zip (Software Package)
Clear identification (inverter): (e.g. MD5 checksum)	754a4460ccffcb54e9cf04d25e884ec8 (MD5 Checksum)

 No adaptations to the standard parameter set were carried out during the measurement.

 The following adaptations were made to the standard parameter set during the measurement:

Parameter (clear identification)	No. in 0	Change	Justification as to why the change does not have an influence on the previous measurement results and these can be used as the result for the certification

4. Main Components of the regulating system

Main components of the control system with firmware and software	
Main component(s) of the control system (Hardware on which the control software is operated)	PCB Control AC Sunny
Firmware version (clear identification of the firmware)	V01.27.03 (Inverter)
Software version (clear identification of the software)	V04.25.01 (System Control)
Parameter set (clear identification of the parameter set)	REV94643

5. Annex 5 – Certification-relevant parameters

	Firma / Company:	TRUMPF Hüttinger GmbH + Co. KG	Projekt-Nr. / Project-no.:	19TH0414
	Ansprechpartner / Customer Contact:	Tel.: +49 761 8971-5322 Email: florian.ackermann@trumpf.com	BV-Kontakt / BV Contact:	Josef HIRSCHIEDER Tel: +49 40 74041 - 2087 josef.hirscheider@bureauveritas.com

5. Relevant parameters for the electrical behaviour

General parameter settings (rated values or reference values)						
Parameter set for the default values						
No.	Name	Description	Unit	Setting range		Default value (acc. to parameter set)
				Min.	Max.	
	PowerSetpointP	Active power setpoint	kW	-37,5	37,5	0
	PowerSetpointQ	Reactive power setpoint	kVA	-37,5	37,5	0
	PowerSetpointAC	Apparent power setpoint	kVA	0	37,5	0
	SetpointCosPhi	Cos phi setpoint	-	-1	1	1
	PhasesAreCapacitive	Inductive / Capacitive flag	-	0	1	1
	AcDcActNominalPower	Rated apparent power	VA			25000
	AcDcNominalGridVoltage	Rated voltage	V			400
	NominalGridFrequency	Rated frequency	Hz			50
	AcDcMinDcLinkVoltage	Minimum DC-Link Voltage	V	600	950	830
Active power peaks						
	MaxPowerSetpointAC	max software limit AC power	kVA	0	37,5	37,5
Operating power limited by grid operator						
	Siehe EZA Regler und Herstellererklärung	Funktionen sind im EZA-Regler, nicht im Gerät implementiert				

5. Annex 5 – Certification-relevant parameters

	Firma / Company:	TRUMPF Hüttinger GmbH + Co. KG	Projekt-Nr. / Project-no.:	19TH0414
	Ansprechpartner / Customer Contact:	Tel.: +49 761 8971-5322 Email: florian.ackermann@trumpf.com	BV-Kontakt / BV Contact:	Josef HIRSCHIEDER Tel: +49 40 74041 - 2087 josef.hirscheider@bureauveritas.com

Active power feed-in as a function of grid frequency

ARN4110_AcDcGcA ctivatePffModeRef	Enable/disable the P(f) function	-	0 = inactive	1 = active	1
ARN4110_AcDcGcPf FstartHighf	Start frequency P(f) (Start of frequency regulation - power reduction)	Hz	50,20	50,50	50,20
ARN4110_AcDcGcPf FstartLowf	Start frequency P(f) (Start of frequency regulation - power increase)	Hz	49,50	49,80	49,80
ARN4110_AcDcGcPf PrefHighf	Reference for the calculation of power reduction at overfrequency	-	0 = P _{b_inst}	1 = P _{mom}	0
ARN4110_AcDcGcPf PrefLowf	Reference for the calculation of power increase at underfrequency	-	0 = P _{b_inst}	1 = P _{mom}	0
ARN4110_AcDcGcPf SHighf	Active power gradient at overfrequency	%	2	12	2
ARN4110_AcDcGcPf SLOWf	Active power gradient at underfrequency	%	2	12	2
ARN4110_AcDCGcP fSlopeAlarmMode	Active power gradient at the end of critical state	% P _{binst} /min	0	10	8
ARN4110_AcDCGcP fDurationAlarmMode	Time delay after return in the tolerance band until reset of the critical network state	s	0	3600	600
ARN4110_AcDcGcPf ChargeDischargeSwitch	If ON, it is allowed to switch from charge to discharge modes and vice versa. If OFF then Stop @ P = 0	-	OFF	ON	ON

Active power gradient following disconnection from the grid

Siehe EZA Regler und Herstellererklärung	Funktionen sind im EZA-Regler, nicht im Gerät implementiert				
--	---	--	--	--	--

Reconnection time following disconnection from the grid

Siehe NA-Schutz und Herstellererklärung	Time until reconnection	s	0	1800	60
---	-------------------------	---	---	------	----

Reactive power provision

Siehe EZA Regler und Herstellererklärung	Funktionen sind im EZA-Regler, nicht im Gerät implementiert				
--	---	--	--	--	--

System perturbations

PGU disconnection from the grid

--	--	--	--	--	--

5. Annex 5 – Certification-relevant parameters

	Firma / Company:	TRUMPF Hüttinger GmbH + Co. KG	Projekt-Nr. / Project-no.:	19TH0414
	Ansprechpartner / Customer Contact:	Tel.: +49 761 8971-5322 Email: florian.ackermann@trumpf.com	BV-Kontakt / BV Contact:	Josef HIRSCHIEDER Tel: +49 40 74041 - 2087 josef.hirscheider@bureauveritas.com

Siehe NA-Schutz und Herstellererklärung	Funktionen sind im externen NA-Schutz implementiert, nicht im Gerät				
Siehe NA-Schutz und Herstellererklärung	U>> protection	V			287
Siehe NA-Schutz und Herstellererklärung	t _u >> protection	ms			100
Siehe NA-Schutz und Herstellererklärung	Reset time U>>	s			60
Siehe NA-Schutz und Herstellererklärung	U> protection	V			249
Siehe NA-Schutz und Herstellererklärung	t _u > protection	s			60
Siehe NA-Schutz und Herstellererklärung	Reset time U>	s			60
Siehe NA-Schutz und Herstellererklärung	U< protection	V			184
Siehe NA-Schutz und Herstellererklärung	t _u < protection	s			1
Siehe NA-Schutz und Herstellererklärung	Reset time U<	s			60
Siehe NA-Schutz und Herstellererklärung	U<< protection	V			104
Siehe NA-Schutz und Herstellererklärung	t _u << protection	ms			300
Siehe NA-Schutz und Herstellererklärung	Reset time U<<	s			60
Siehe NA-Schutz und Herstellererklärung	f>>frequency	Hz			52,5
Siehe NA-Schutz und Herstellererklärung	t _r >> frequency	ms			100
Siehe NA-Schutz und Herstellererklärung	f>frequency	Hz			51,5
Siehe NA-Schutz und Herstellererklärung	t _r > frequency	s			5,0
Siehe NA-Schutz und Herstellererklärung	f<frequency	Hz			47,5
Siehe NA-Schutz und Herstellererklärung	t _r < frequency	ms			100
Siehe NA-Schutz und Herstellererklärung	F<<frequency	Hz			47,5
Siehe NA-Schutz und Herstellererklärung	t _r << frequency	ms			100

Connection conditions

5. Annex 5 – Certification-relevant parameters


	Firma / Company:	TRUMPF Hüttinger GmbH + Co. KG	Projekt-Nr. / Project-no.:	19TH0414
	Ansprechpartner / Customer Contact:	Tel.: +49 761 8971-5322 Email: florian.ackermann@trumpf.com	BV-Kontakt / BV Contact:	Josef HIRSCHIEDER Tel: +49 40 74041 - 2087 josef.hirscheider@bureauveritas.com

ARN4110_GcActivateSwitchOnCriteria	Enable/disable the Switch On function	-	0 = disable	1 = enable	1
ARN4110_AcDcGcSwOnVoltageMax	Limit value connection U>	p.u.	1,01	1,15	1,10
ARN4110_GcSwOnVoltageMin	Limit value connection U<	p.u.	0,80	0,99	0,90
ARN4110_AcDcGcSwOnVoltageMax	Limit value connection f>	Hz	50,1	56,0	50,2
ARN4110_AcDcGcSwOnFrequencyMin	Limit value connection f<	Hz	44,0	49,9	47,5
ARN4110_AcDcGcSwOnTime	Switch-On Delay	s	0	300	0

Response during grid faults (FRT Switch-OFF Limits)

Fixed	UVRT curve node 1 U	p.u.			0,12
Fixed	UVRT curve node 1 t	s			0
Fixed	UVRT curve node 2 U	p.u.			0,12
Fixed	UVRT curve node 2 t	s			0,3
Fixed	UVRT curve node 3 U	p.u.			0,7
Fixed	UVRT curve node 3 t	s			3,0
Fixed	UVRT curve node 4 U	p.u.			0,8
Fixed	UVRT curve node 4 t	s			5,0
Fixed	UVRT curve node 5 U	p.u.			0,8
Fixed	UVRT curve node 5 t	s			60,0
Fixed	UVRT curve node 6 U	p.u.			0,9
Fixed	UVRT curve node 6 t	s			65,0
Fixed	UVRT curve node 7 U	p.u.			0,9
Fixed	UVRT curve node 7 t	s			∞
Fixed	OVRT curve node 1 U	p.u.			1,28
Fixed	OVRT curve node 1 t	s			0
Fixed	OVRT curve node 2 U	p.u.			1,28
Fixed	OVRT curve node 2 t	s			0,1
Fixed	OVRT curve node 3 U	p.u.			1,25
Fixed	OVRT curve node 3 t	s			0,16
Fixed	OVRT curve node 4 U	p.u.			1,25
Fixed	OVRT curve node 4 t	s			60,0
Fixed	OVRT curve node 5 U	p.u.			1,10
Fixed	OVRT curve node 5 t	s			65
Fixed	OVRT curve node 6 U	p.u.			1,10
Fixed	OVRT curve node 6 t	s			∞

5. Annex 5 – Certification-relevant parameters

	Firma / Company:	TRUMPF Hüttinger GmbH + Co. KG	Projekt-Nr. / Project-no.:	19TH0414
	Ansprechpartner / Customer Contact:	Tel.: +49 761 8971-5322 Email: florian.ackermann@trumpf.com	BV-Kontakt / BV Contact:	Josef HIRSCHIEDER Tel: +49 40 74041 - 2087 josef.hirscheider@bureauveritas.com

		...				
		...				

Dynamic response for fault ride-through (FRT) in the case of under/overvoltage

ARN4110_AcDcGcActivateRTVoltageModeRef	Activate FRT Capability	-	0 = deactivate	1 = activate	1
ARN4110_AcDcGcRtCalculationMode	Select full or limited Dynamic grid Support	-	1 = full	2 = limited	1
ARN4110_AcDcGcRtKFactor	k factor acc. to 4110	-	0	6	2
ARN4110_AcDcGcRtUvTh	Threshold for limited grid support	p.u.	0	0,8	0,7
ARN4110_AcDcGcRtMinSupTime	FRT - Grid support time	s	1	60	5

Self-protection

AcDcMaxIcoilErrThresh	Upper overcurrent limit (Instantaneous)	A	0	150	150
AcDcMaxTempErrThresh	Temperature protection	°C	10	100	95

6. Relevant parameters for the electrical behaviour

Reading out the parameters

- The parameters can be read out using the following software.

Name:	
Version:	

- The parameters can be read out using the display in the control system.

7. Interfaces

7.1. Active power specification

Interfaces for the active power reduction by defined setpoint	
Analogue interfaces for active power specification (e.g. 0 V – 10 V, 4 mA – 20 mA)	None- implemented in external EZA-Controller
Digital interfaces for active power specification (e.g. potential-free inputs, protocol IEC 60870-5-104)	None- implemented in external EZA-Controller
Measured interface(s)	None- implemented in external EZA-Controller

7.2. Reactive power specification

Interfaces for the provision of reactive power	
Analogue interfaces for the specification of reactive power (z.B. 0 – 20 mA, 4 - 20 mA, 0 – 10 V or -10 - 10 V, Q or cosφ)	None- implemented in external EZA-Controller

5. Annex 5 – Certification-relevant parameters


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Digital interfaces for reactive power specification (e.g. protocol IEC 60870-5-104)		None- implemented in external EZA-Controller		
Permanently adjustable, not variable via external setpoints (e.g. $\cos\phi$ fixed value and Q fixed value, Q(U) characteristic, $\cos\phi(P)$ characteristic)		None- implemented in external EZA-Controller		
Types of reactive power specification (e.g. $\cos\phi$ and Q, Q(U) characteristic, $\cos\phi(P)$ characteristic)		None- implemented in external EZA-Controller		
Measured interface(s) and type of reactive power specification		None- implemented in external EZA-Controller		
External actual value capture possible? (for example for control at the PCC)		None- implemented in external EZA-Controller		
Measured interface(s)		None- implemented in external EZA-Controller		

Figure 28 – Parameter list from [13]