X20(c)CM0985-1

Data sheet
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Translation of the original documentation

Publishing information

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Disclaimer

1 General information

1.1 Other applicable documents

For additional and supplementary information, see the following documents.

Other applicable documents

Document name	Title
MAX20	X20 System user's manual

1.2 Coated modules

Coated modules are X20 modules with a protective coating for the electronics component. This coating protects X20c modules from condensation and corrosive gases.
The modules' electronics are fully compatible with the corresponding X20 modules.

> For simplification purposes, only images and module IDs of uncoated modules are used in this data sheet.

The coating has been certified according to the following standards:

- Condensation: BMW GS 95011-4, 2x 1 cycle
- Corrosive gas: EN 60068-2-60, method 4, exposure 21 days

1.3 Order data

Order number	Short description	Figure
	Other functions	
X20CM0985-1	X20 digital and analog mixed module, multi-measurement transducer / synchronization module, 5 digital outputs, 24 VDC, 0.5 A, source, 1 relay, 1 A, 8 analog inputs, ±480 V / 120 V, 16-bit converter resolution, 3 analog inputs, 5 A / 1 A AC, 16-bit converter resolution, additional software functionalities, order terminal blocks 0TB3102-7011, 0TB3104-7011, 0TB3102-7012, 0TB3104-7012 and 2x X20TB12 separately!	
X20cCM0985-1	X20 digital and analog mixed module, coated, multi-measurement transducer / synchronization module, 5 digital outputs, 24 VDC, 0.5 A, source, 1 relay, 1 A, 8 analog inputs, ±480 V / 120 V, 16-bit converter resolution, 3 analog inputs, 5 A / 1 A AC, 16-bit converter resolution, additional software functionalities, order terminal blocks 0TB3102-7011, 0TB3104-7011, 0TB3102-7012, 0TB3104-7012 and 2x X20TB12 separately!	
	Required accessories	
	Terminal blocks	
0TB3102-7011	Accessory terminal block, 2-pin, A-coded, screw clamp terminal block 6 mm²	
0TB3102-7012	Accessory terminal block, 2-pin, B-coded, screw clamp terminal block 6 mm²	
0TB3104-7011	Accessory terminal block, 4-pin, A-coded, screw clamp terminal block 6 mm²	
0TB3104-7012	Accessory terminal block, 4-pin, B-coded, screw clamp terminal block 6 mm²	
X20TB12	X20 terminal block, 12-pin, 24 VDC keyed	

Table 1: X20CM0985-1, X20cCM0985-1 - Order data

1.4 Module description

The module has a compact size and combines a power measurement module that has special features with a synchronization unit that is able to meet all demands.

The measurement unit's 3 current inputs are suitable for both X: 1 A and X: 5 A current transformers. Overcurrent resistance and the high resolution of the measurement unit round off its features. For the voltage inputs, the value range can be configured between 480 VAC and 120 VAC.

The area of use includes 4-wire AC networks with a phase voltage up to 480 VAC and 3-wire systems, whereas L2 can be grounded (V-connection). The module can also handle Aron measuring circuits.

The resulting measured values include the pure phase current; line-to-line voltage or phase voltage; the effective, reactive and apparent power parts; the mains frequency; the power factor and much more. In addition, peak values and energy meters are stored on the module in nonvolatile memory. Depending on the configuration, it is also possible to use a digital output as a pulse encoder for an external energy meter.

The synchronization unit doesn't just take the phasing and phase voltage into consideration; integrated intelligence also monitors the rate of change and other parameters, allowing them to influence when the synchronization output is switched. It is also possible to monitor a generator using a large number of additional conditions. A total of 4 voltage inputs provide substantial overall flexibility.

Monitoring functions expand the features of the module. Dependent overcurrent monitoring is included, which utilizes the thermal capacity of the motor/generator to allow short overloads while still providing full protection. The dependent, delayed imbalanced load monitoring used to protect three-phase generator and three-phase networks from imbalanced load can be adapted to the characteristics of different generator types using parameters while taking their special thermal time constants into account.

- Energy measurement for 120 to 480 VAC
- Simultaneous measurement of 2 AC mains networks plus 2 additional voltages
- For multifunctional measurement tasks
- Intelligent mains synchronization unit

Functions

- Generator monitoring
- Busbar monitoring
- Synchronization functions
- Measurement functions
- Counter functions

Information:

Section "Safety guidelines" on page 5 must be read before commissioning the module.

1.5 Safety guidelines

General information

Programmable logic controllers, operating/monitoring devices (e.g. industrial PCs, Power Panels, Mobile Panels, etc.) as well as uninterruptible power supplies have all been designed, developed and manufactured by B&R for conventional use or for use with increased safety requirements (safety technology) in industry. They were not designed, developed and manufactured for any use involving serious risks or hazards that could lead to death, injury, serious physical damage or loss of any kind without the implementation of exceptionally stringent safety precautions. In particular, such risks and hazards include the use of these devices to monitor nuclear reactions in nuclear power plants, their use in flight control or flight safety systems as well as in the control of mass transportation systems, medical life support systems or weapons systems.

When using programmable logic controllers or operating/monitoring devices as control systems together with a Soft PLC (e.g. B&R Automation Runtime or comparable product) or Slot PLC (e.g. B&R LS251 comparable product), safety precautions relevant to industrial control systems (e.g. the provision of safety devices such as emergency stop circuits, etc.) must be observed in accordance with applicable national and international regulations. The same applies for all other devices connected to the system, e.g. drives.

All tasks such as the installation, commissioning and servicing of devices are only permitted to be carried out by qualified personnel. Qualified personnel are those familiar with the transport, mounting, installation, commissioning and operation of devices who also have the appropriate qualifications (e.g. IEC 60364-1). National accident prevention regulations must be observed.

The safety notices, connection descriptions (type plate and documentation) and limit values listed in the technical data are to be read carefully before installation and commissioning and must be observed.

The use of these products is restricted to the following persons:

- **Qualified personnel*** who are familiar with relevant safety concepts for automation technology as well as applicable standards and regulations.
- **Qualified personnel*** who plan, develop, install and commission safety equipment in machines and systems.

***Qualified personnel** in the context of this manual's safety guidelines are those who, due to their training, experience and instruction combined with their knowledge of relevant standards, regulations, accident prevention guidelines and operating conditions, are qualified to carry out essential tasks and to recognize and avoid potentially dangerous situations. In this regard, sufficient language skills are also required in order to be able to properly understand this manual.

Intended use

Danger!

Electronic devices are generally not failsafe. If the multi-measurement and synchronization unit fails, the user is responsible for ensuring that the connected motor or generator is brought to a safe state.

Danger !

Les appareils électroniques ne sont généralement pas à l'abri des pannes. En cas de défaillance de l'unité de mesure multiple et de synchronisation, il incombe à l'utilisateur de veiller à ce que le moteur ou le générateur connecté soit sécurisé.

Some errors are detected and prevented in the synchronization unit by the system's internal software monitoring. However, when the device is in operation it is always possible for errors, defective components, software errors or configuration mistakes to occur at any time. B&R emphasizes that the multi-measurement and synchronization unit possesses neither a failsafe function nor a redundancy system. For this reason, independent higher-level safety precautions need to be put in place to ensure that personnel and machines are protected.

Grounding the Mounting Rail

For grounding purposes, a good conductive connection between the mounting rail and the metal back wall is required. The mounting rail is to be connected conductively to the back wall. This is achieved by inserting a contact washer with the fastening screw.

Information:

The control cabinet back wall must be connected with GND

2 Technical description

2.1 Technical data

<table>
<tr><th>Order number</th><th>X20CM0985-1</th><th>X20cCM0985-1</th></tr>
<tr><td colspan="3">Short description</td></tr>
<tr><td>I/O module</td><td colspan="2">X20 energy measurement and synchronization module</td></tr>
<tr><td colspan="3">General information</td></tr>
<tr><td>B&R ID code</td><td>0xB768</td><td>0xE4FF</td></tr>
<tr><td>Status indicators</td><td colspan="2">Channel status, operating state, module status</td></tr>
<tr><td>Diagnostics</td><td colspan="2"></td></tr>
<tr><td>Module run/error</td><td colspan="2">Yes, using LED status indicator and software</td></tr>
<tr><td>Analog inputs</td><td colspan="2">Yes, using LED status indicator (measurement range of analog inputs)</td></tr>
<tr><td>Digital outputs</td><td colspan="2">Yes, using LED status indicator and software</td></tr>
<tr><td>Overvoltage category</td><td colspan="2">II [1)]</td></tr>
<tr><td>Measurable frequency</td><td colspan="2"></td></tr>
<tr><td>Measurement range</td><td colspan="2">15.2 Hz to 2x nominal frequency [2)]</td></tr>
<tr><td>Accuracy</td><td><10 mHz at 400 V ±5% or 100 V ±5% [3)]</td><td><10 mHz at 400 V ±5% or 100 V ±5% [4)]</td></tr>
<tr><td>Power consumption</td><td colspan="2"></td></tr>
<tr><td>Bus</td><td colspan="2">1.05 W</td></tr>
<tr><td>Internal I/O</td><td colspan="2">4 W</td></tr>
<tr><td>Additional power dissipation caused by actuators (resistive) [W]</td><td colspan="2">-</td></tr>
<tr><td>Certifications</td><td colspan="2"></td></tr>
<tr><td>CE</td><td colspan="2">Yes</td></tr>
<tr><td>UKCA</td><td colspan="2">Yes</td></tr>
<tr><td>ATEX</td><td colspan="2">Zone 2, II 3G Ex nA nC IIA T5 Gc
IP20, Ta (see X20 user's manual)
FTZÚ 09 ATEX 0083X</td></tr>
<tr><td>UL</td><td colspan="2">cULus E115267
Industrial control equipment</td></tr>
<tr><td>HazLoc</td><td colspan="2">cCSAus 244665
Process control equipment
for hazardous locations
Class I, Division 2, Groups ABCD, T5</td></tr>
<tr><td>DNV</td><td colspan="2">Temperature: B (0 to 55°C)
Humidity: B (up to 100%)
Vibration: B (4 g)
EMC: B (bridge and open deck)</td></tr>
<tr><td>CCS</td><td>Yes</td><td>-</td></tr>
<tr><td>LR</td><td colspan="2">ENV1</td></tr>
<tr><td>KR</td><td colspan="2">Yes</td></tr>
<tr><td>ABS</td><td colspan="2">Yes</td></tr>
<tr><td>BV</td><td colspan="2">EC33B
Temperature: 5 - 55°C
Vibration: 4 g
EMC: Bridge and open deck</td></tr>
<tr><td>KC</td><td>Yes</td><td>-</td></tr>
<tr><td>UL 6200</td><td>Rev. D0
Hardware upgrade 2.5.0.0</td><td>-</td></tr>
<tr><td colspan="3">Digital outputs</td></tr>
<tr><td>Quantity</td><td colspan="2">5</td></tr>
<tr><td>Variant</td><td colspan="2">Current-sourcing FET</td></tr>
<tr><td>Nominal voltage</td><td colspan="2">24 VDC</td></tr>
<tr><td>Switching voltage</td><td colspan="2">24 VDC -15% / +20%</td></tr>
<tr><td>Nominal output current</td><td colspan="2">0.1 A</td></tr>
<tr><td>Total nominal current</td><td colspan="2">0.5 A</td></tr>
<tr><td>Connection type</td><td colspan="2">1-wire connections</td></tr>
<tr><td>Output circuit</td><td colspan="2">Source</td></tr>
<tr><td>Output protection</td><td colspan="2">Thermal shutdown in the event of overcurrent or short circuit</td></tr>
<tr><td>Diagnostic status</td><td colspan="2">Output monitoring with 10 ms delay</td></tr>
<tr><td>Leakage current when the output is switched off</td><td colspan="2">5 µA</td></tr>
<tr><td>Residual voltage</td><td colspan="2"><0.3 V at 0.1 A nominal current</td></tr>
<tr><td>Peak short-circuit current</td><td colspan="2"><2 A</td></tr>
<tr><td>Switch-on in the event of overload shutdown or short-circuit shutdown</td><td colspan="2">Approx. 10 ms, depends on the module temperature</td></tr>
</table>

Table 2: X20CM0985-1, X20cCM0985-1 - Technical data

Technical description

Order number	X20CM0985-1	X20cCM0985-1
Switching delay		
0 → 1	<300 µs	
1 → 0	<300 µs	
Switching frequency		
Resistive load	Max. 100 Hz	
Insulation voltage between channel and bus	500 V_{eff}	
Relay outputs		
Quantity	1	
Variant	Relay / Changeover contact	
Nominal voltage	30 VDC / 240 VAC	
Rated frequency	DC / 45 to 63 Hz	
Switching capacity		
Min.	10 mA / 5 VDC	
Max.	30 W / 240 VAC	
Nominal output current	1 A at 30 VDC / 1 A at 240 VAC	
Actuator power supply	External	
Switching voltage	Max. 60 VDC / 250 VAC	
Switching delay		
0 → 1	≤10 ms	
1 → 0	≤10 ms	
Service life [5]		
Mechanical	Min. 10 x 10^6 ops.	
Electrical	Min. 60 x 10^3 ops. (NC) at 1 A Min. 30 x 10^3 ops. (NO) at 1 A	
Contact resistance	Max. 100 mΩ	
Protective circuit		
Internal	None	
External	None	
DC	Inverse diode, RC combination or VDR	
AC	RC combination or VDR	
Insulation voltage		
Channel - Channel	1000 VAC / 1 min	
Channel - Bus	4000 VAC / 1 min	
Analog input voltage		
Channels	8	
Input	120 VAC / 480 VAC	
Input type	Single-ended	
Digital converter resolution	±15-bit	
Conversion time		
50 Hz	10 ms	
60 Hz	8.33 ms	
Permissible input signal	Max. 132 VAC / 528 VAC	
Output format [6]		
±120 VAC	1 LSB = 0x0001 = 5.707 mV	
±480 VAC	1 LSB = 0x0001 = 22.787 mV	
Output of digital value during overload		
Overshoot	0x7FFF	
Undershoot	0x8001	
Conversion method	SAR	
Input filter		
Cutoff frequency	10 kHz	
Slope	60 dB	
Maximum gain drift [7]	0.02% per °C	
Maximum offset drift [8]	0.003% per °C	
Crosstalk between channels	-70 dB	
Nonlinearity [8]	≤0.5% at 45 to 65 Hz	
Protection against electric shock	Protective impedance per EN 61131-2	
Test voltage between channel and bus (type test)	3700 V_{eff}	
Output format	INT	
Input impedance in signal range	Approx. 3 MΩ	
Max. error at 25°C		
Gain	0.09% [7]	
Offset	0.03% [8]	
Input protection	Overvoltage protection	
Analog input current		
Channels	3	
Input	1 A / 5 A AC	
Input type	Isolated current transformer according to the compensation principle with a magnetic sensor, for connecting an external transformer	
Digital converter resolution	±15-bit	

Table 2: X20CM0985-1, X20cCM0985-1 - Technical data

Order number	X20CM0985-1	X20cCM0985-1
Conversion time		
50 Hz	10 ms	
60 Hz	8.33 ms	
Permissible input signal	Max. 1.5 A / 7.7 A	
Output format [6]		
±1 A	1 LSB = 0x0001 = 189.903 µA	
±5 A	1 LSB = 0x0001 = 949.513 µA	
Output of digital value during overload		
Overshoot	0x7FFF	
Undershoot	0x8001	
Conversion method	SAR	
Input filter		
Cutoff frequency	10 kHz	
Slope	60 dB	
Maximum gain drift [7]	0.07% per °C	
Maximum offset drift	Measurement range 2 A: 0.0064% per °C, measurement range 10 A: 0.00384% per °C	
Crosstalk between channels	-70 dB	
Nonlinearity [9]	≤0.5% at 45 to 65 Hz	
Insulation voltage between channel and bus	500 V_{eff}	
Output format	INT	
Max. error at 25°C		
Gain	0.2% [7]	
Offset	0.05% [9]	
Thermal overcurrent [10]	15 x I_{Nom} for 0.2 s [11]	
Monitored overcurrent	4 x I_{Nom} [11]	
Input impedance [12]		
Measurement range 1 A	Max. 30 mΩ	
Measurement range 5 A	Max. 10 mΩ	
Electrical properties		
Electrical isolation	Bus isolated from I/O power supply and digital inputs and outputs Digital inputs and outputs isolated from each other	
Operating conditions		
Mounting orientation		
Horizontal	Yes	
Vertical	Yes	
Installation elevation above sea level		
0 to 2000 m	No limitation	
>2000 m	Reduction of ambient temperature by 0.5°C per 100 m	
Degree of protection per EN 60529	IP20	
Ambient conditions		
Temperature		
Operation		
Horizontal mounting orientation	-25 to 60°C	
Vertical mounting orientation	-25 to 50°C	
Derating	See section "Derating".	
Storage	-40 to 85°C	
Transport	-40 to 85°C	
Relative humidity		
Operation	5 to 95%, non-condensing	Up to 100%, condensing
Storage	5 to 95%, non-condensing	
Transport	5 to 95%, non-condensing	
Mechanical properties		
Note	Order 2x terminal block X20TB12 separately. Order 2x screw clamp terminal block TB3102 and 2x screw clamp terminal block TB3104 separately.	
Pitch	$87.5^{+0.2}$ mm	

Table 2: X20CM0985-1, X20cCM0985-1 - Technical data

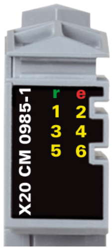
1) EN 61131-2
2) Rated frequency: 48 to 62 Hz. Synchronization is only possible at the nominal frequency.
3) - In the frequency range from 49 to 51 Hz provided that the line-to-line voltages (L1 - L2, L2 - L3, L3 - L1) have a strictly monotone zero crossing.
   - The measurement accuracy of the frequency measurement results from the following:
   a. Internal measurement accuracy of the frequency measurement <5 mHz.
   b. Resolution of frequency value 10 mHz
   c. Rounding
4) - In the frequency range from 49 to 51 Hz provided that the line-to-line voltages (L1 - L2, L2 - L3, L3 - L1) have a strictly monotone zero crossing.
   - The measurement precision of the frequency measurement results from the following:
   a. Internal measurement precision of the frequency measurement <5 mHz.
   b. Resolution of frequency value 10 mHz
   c. Rounding
5) See section "Electrical service life".
6) INT, range of values: 0x8001 to 0x7FFF
7) Based on the current measured value
8) Based on the measurement range 240 VAC / 960 VAC
9) Based on the measurement range 2 A / 10 A

10) This can result in the measurement hysteresis being offset in relation to the overcurrent.
11) Based on the measurement range 1 A / 5 A
12) Including current transformer, circuit path and X20TB12 terminal block (5 mΩ)

2.2 LED status indicators

For a description of the various operating modes, see section "Additional information - Diagnostic LEDs" in the X20 system user's manual.

LED status indicators - Right

Figure	LED	Color	Status	Description
	r	Green	Off	No power to module
			Single flash	RESET mode
			Double flash	BOOT mode (during firmware update)[1]
			Blinking	PREOPERATIONAL mode
			On	RUN mode
	e	Red	Off	No power to module or everything OK
			On	Error or reset status
	e + r	Red on / Green single flash		Invalid firmware
	1 - 6	Orange		Output status of the corresponding digital output

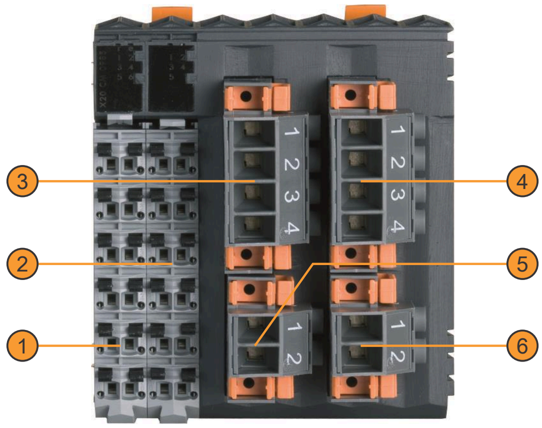
1) Depending on the configuration, a firmware update can take up to several minutes.

Status-LEDs right

Figure	LED[1]	Terminal	Color	Status	Description
	1	X3	Green	On	Measurement range: 120 VAC
			Red	On	Measurement range: 480 VAC
	2	X4	Green	On	Measurement range: 120 VAC
			Red	On	Measurement range: 480 VAC
	3	X5	Green	On	Measurement range: 120 VAC
			Red	On	Measurement range: 480 VAC
	4	X6	Green	On	Measurement range: 120 VAC
			Red	On	Measurement range: 480 VAC
	5	X2	Green	On	Measurement range: 1 A
			Red	On	Measurement range: 5 A

1) LEDs 1 - 5 are green/red dual LEDs.

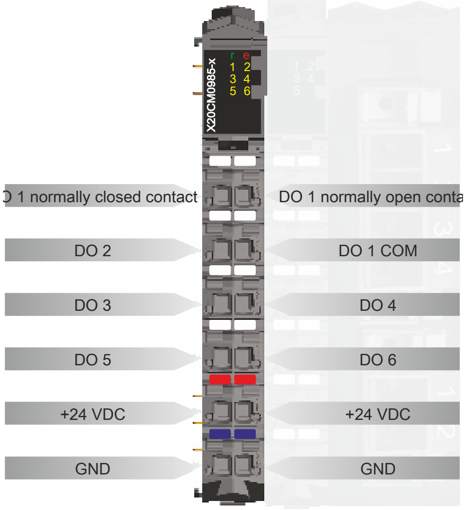
2.3 Connection elements



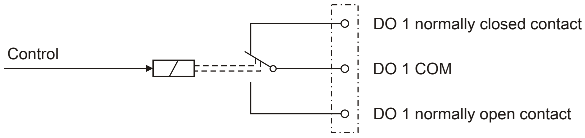
1	Digital outputs X1	2	Analog current inputs X2 (generator network)
3	Analog voltage inputs X3 (generator network)	4	Analog voltage inputs X5 (busbar)
5	Analog voltage inputs X4 (synchronization network 1)	6	Analog voltage inputs X6 (synchronization network 2)

2.4 Digital outputs X1

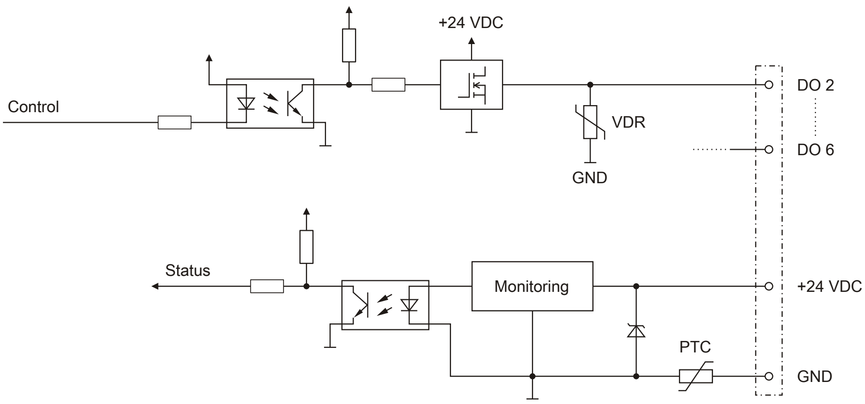
Terminals X1 and X2 can be keyed differently to prevent unintentional incorrect connection on the module.



DO1 - Output circuit diagram



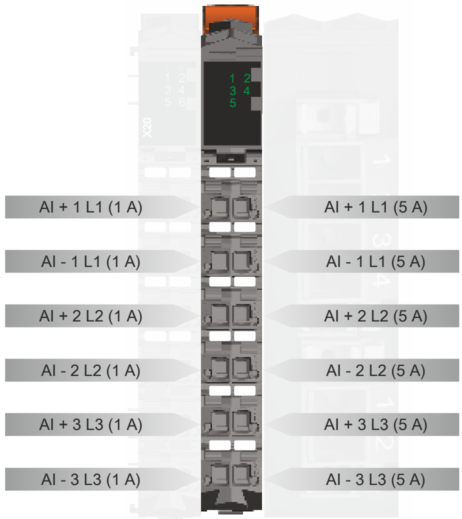
DO2 - DO 6 - Output circuit diagram



2.5 X2 analog current inputs

The X2 terminal measures the three phase currents of the generator mains using an externally connected current transformer. The measurement range of the current inputs can be configured as 1 A or 5 A.

Terminals X1 and X2 can be keyed differently to prevent unintentional incorrect connection on the module.



Danger!

Risk of electric shock!

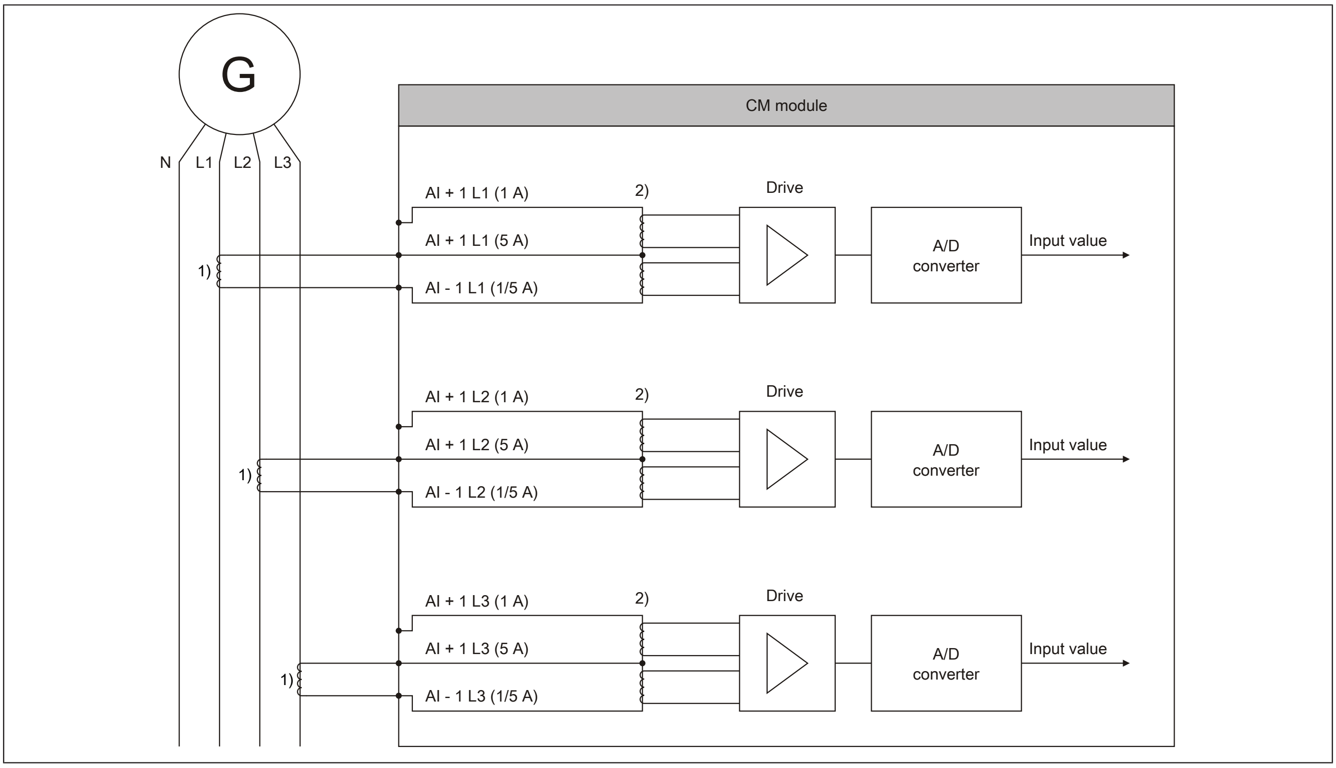
The terminal block is only permitted to conduct voltage while it is connected. It is not permitted to be disconnected or connected while voltage is applied or have voltage applied to it while it is removed under any circumstances!

Danger !

Risque d'électrocution !

Le connecteur ne peut conduire la tension que lorsqu'il est connecté. Il est interdit de le déconnecter ou de le connecter si une tension est appliquée ou si une tension lui est appliquée lors de son retrait dans n'importe quelle circonstance !

Input circuit diagram - Analog current inputs



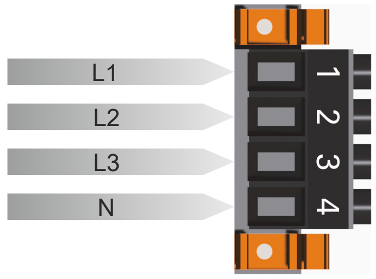
1) External current transformers
2) Internal current transformers

2.6 X3 and X5 analog voltage inputs

The X3 and X5 terminals are used to measure and monitor the line-to-line and phase voltages of the generator mains and bus bar.

- Terminal X3: Generator mains
- Terminal X5: Bus bar

Terminals X3 and X5 are keyed differently to prevent unintentional incorrect connection on the module. Section "Releasing the locking clip for terminals X3 - X6" on page 21 describes how to release the terminal locking clip.



2.7 X4 and X6 analog voltage inputs

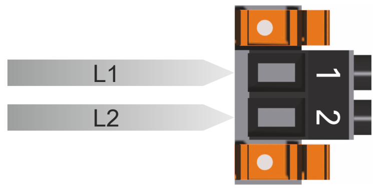
Terminals X4 and X6 are keyed differently to prevent unintentional incorrect connection on the module. Section "Releasing the locking clip for terminals X3 - X6" on page 21 describes how to release the terminal locking clip.

The two terminals are connected differently depending on the selected configuration (see register "ConfigOutput68" on page 53).

Configuration as synchronization network 1 / synchronization network 2

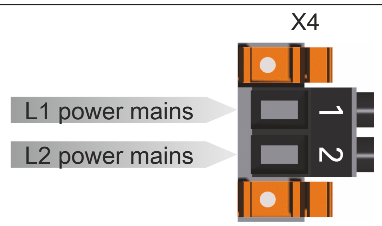
The voltage inputs on the X4 and X6 terminals are used to determine the line-to-line voltages for synchronization between two different mains networks.

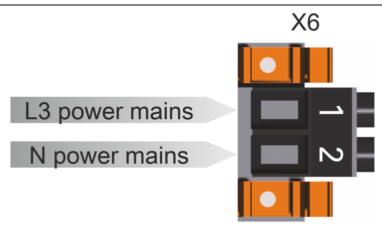
- Terminal X4: Synchronization mains network 1
- Terminal X6: Synchronization mains network 2



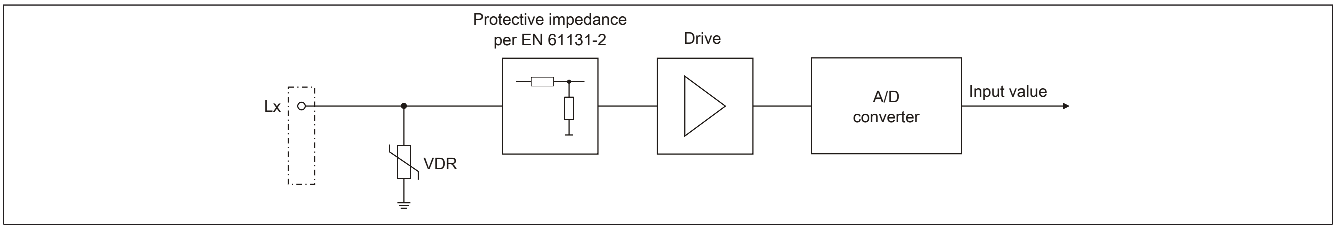
Configuration as 3-phase mains

The terminals X4 and X6 can be combined to form a 3-phase mains. The X4 and X6 terminals are used to measure and monitor the line-to-line voltages and phase voltages of the power mains.



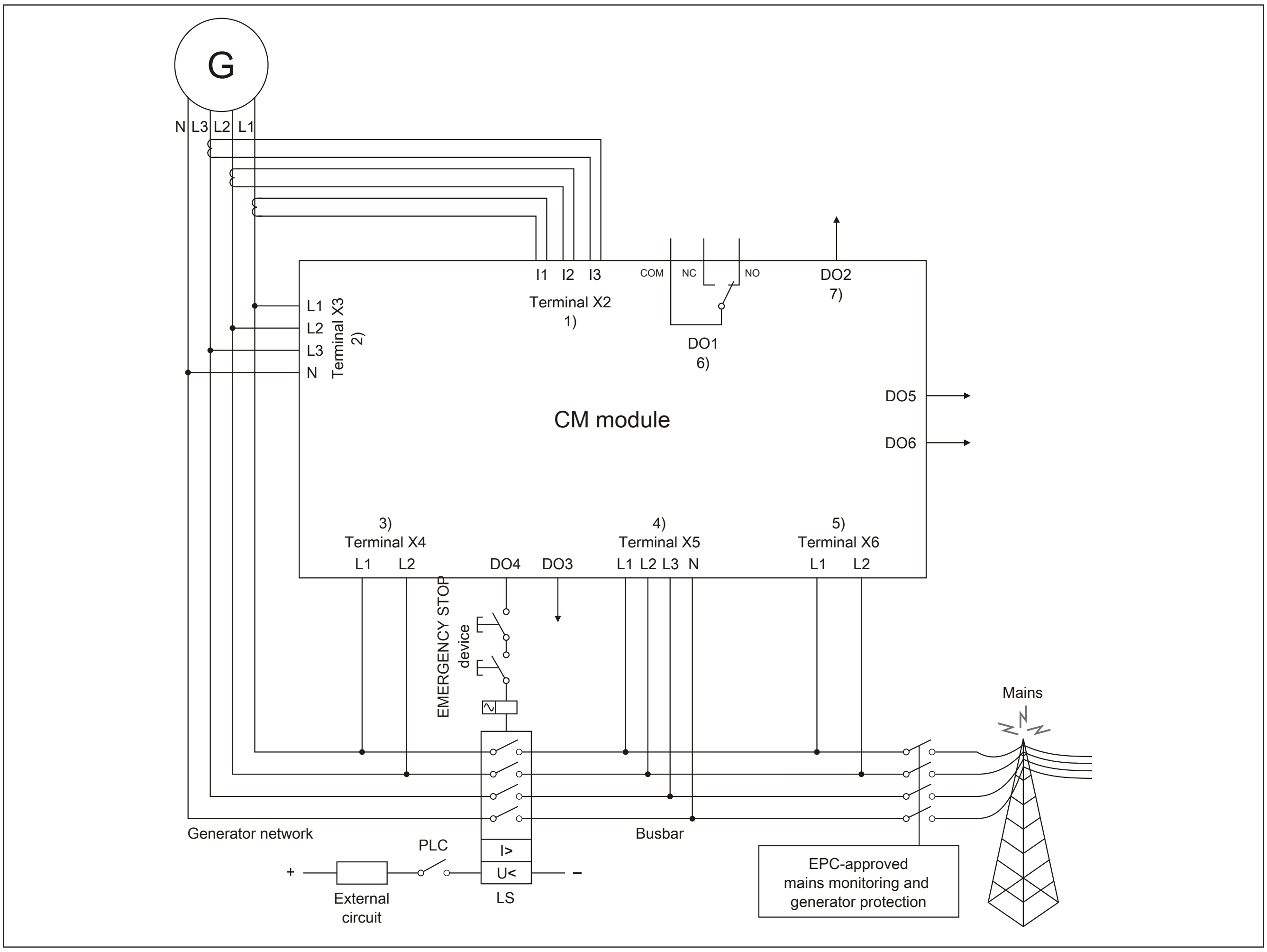


Input circuit diagram, analog voltage inputs



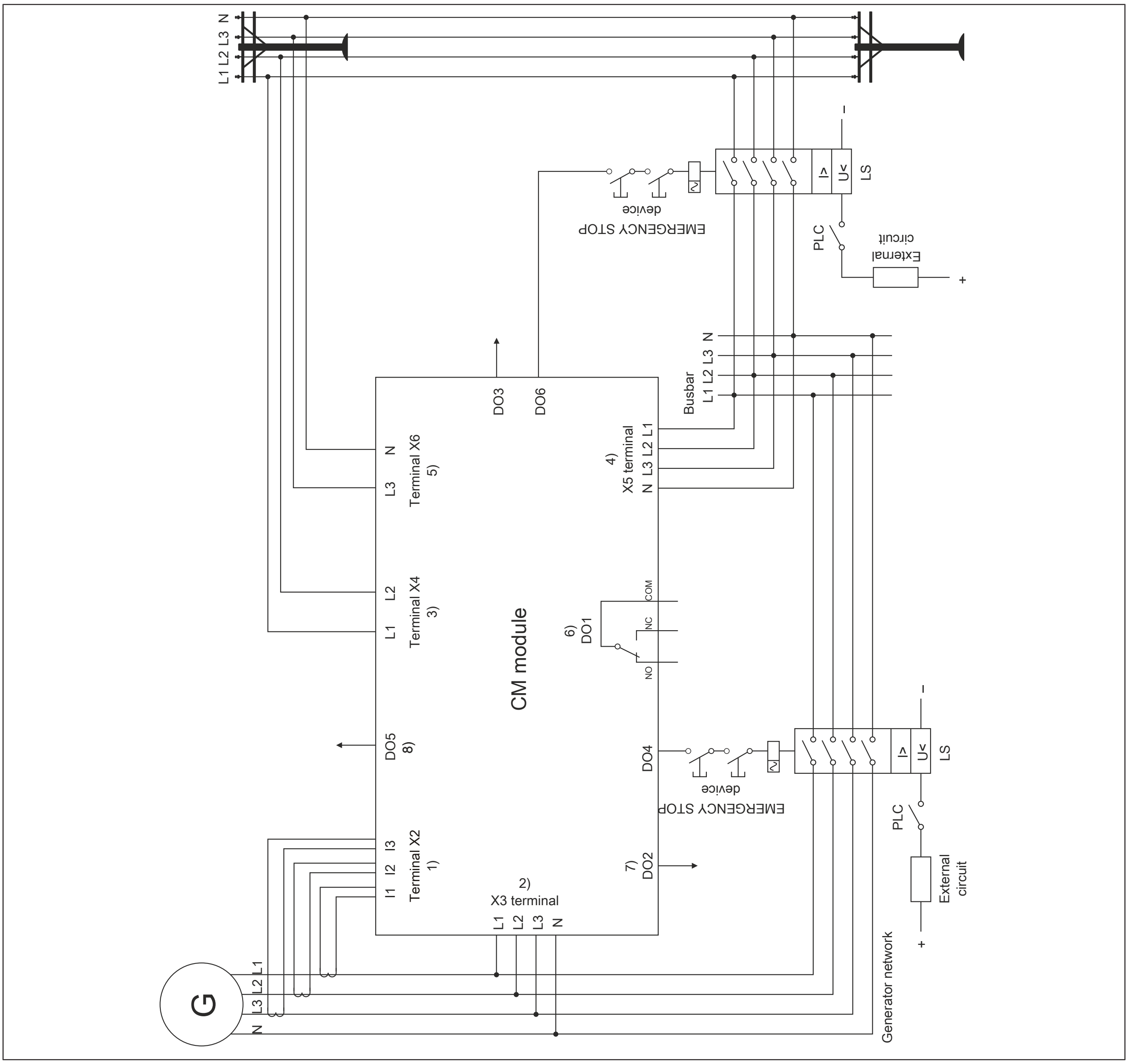
2.8 Circuit diagram

Example for network configuration "Synchronization network 1 / Synchronization network 2"



1) **Terminal X2:** Current inputs for generator network 5 A / 1 A
2) **Terminal X3:** Generator network 480 VAC / 120 VAC
3) **Terminal X4:** Synchronization network 1 480 VAC / 120 VAC
4) **Terminal X5:** Busbar network 480 VAC / 120 VAC
5) **Terminal X6:** Synchronization network 2 480 VAC / 120 VAC
6) **DO1:** Monitoring relay
7) **DO2:** Generator energy, pulse = x * kWh

Example of mains configuration "3-phase mains"

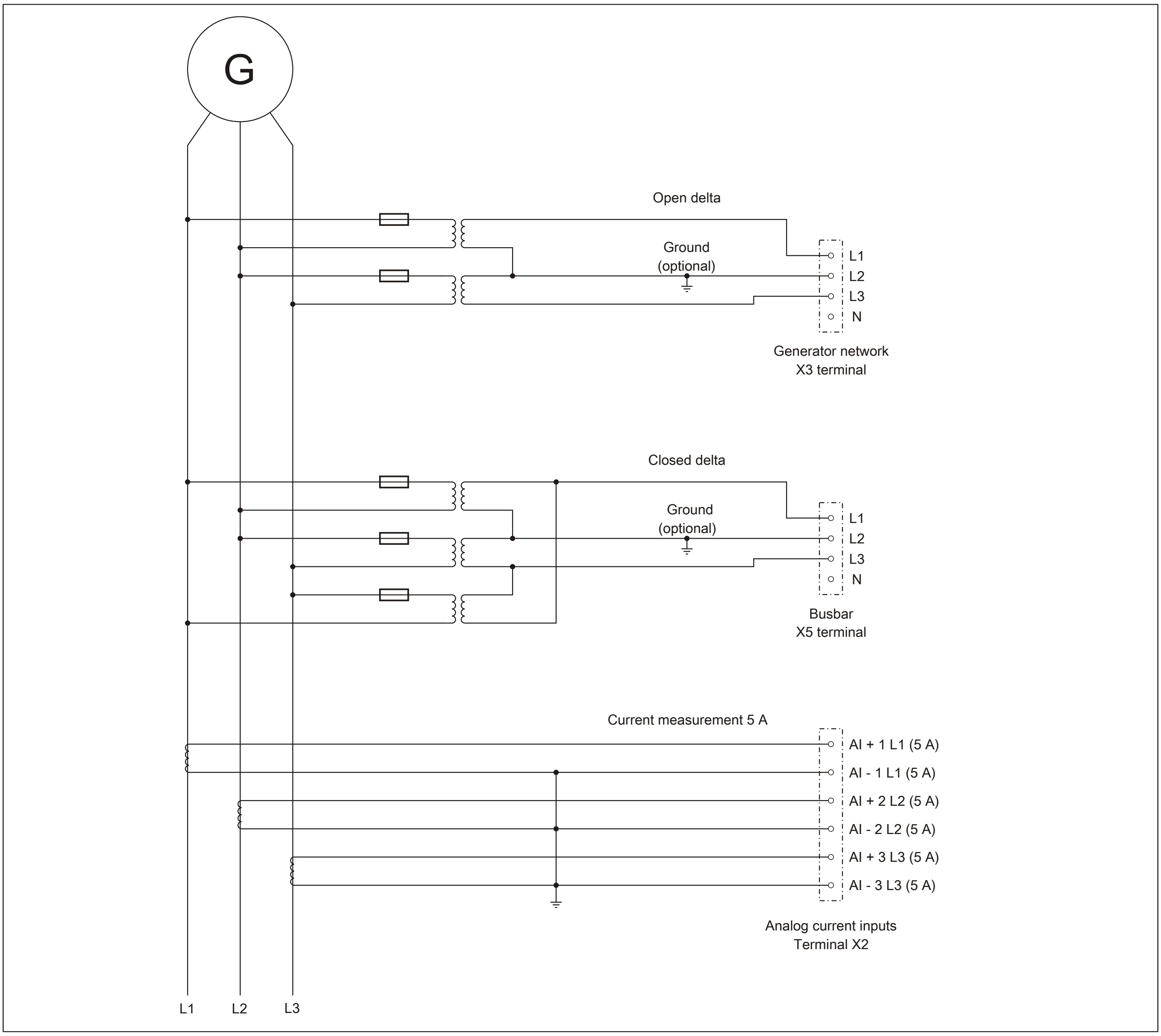


1) **Terminal X2:** Generator inputs for generator network 5 A / 1 A
2) **Terminal X3:** Generator network 480 VAC / 120 VAC
3) **Terminal X4:** Mains 480 VAC / 120 VAC
4) **Terminal X5:** Busbar network 480 VAC / 120 VAC
5) **Terminal X6:** Mains 480 VAC / 120 VAC
6) **DO1:** Generator monitoring
7) **DO2:** Generator energy pulse = x * kWh
8) **DO5:** Network monitoring

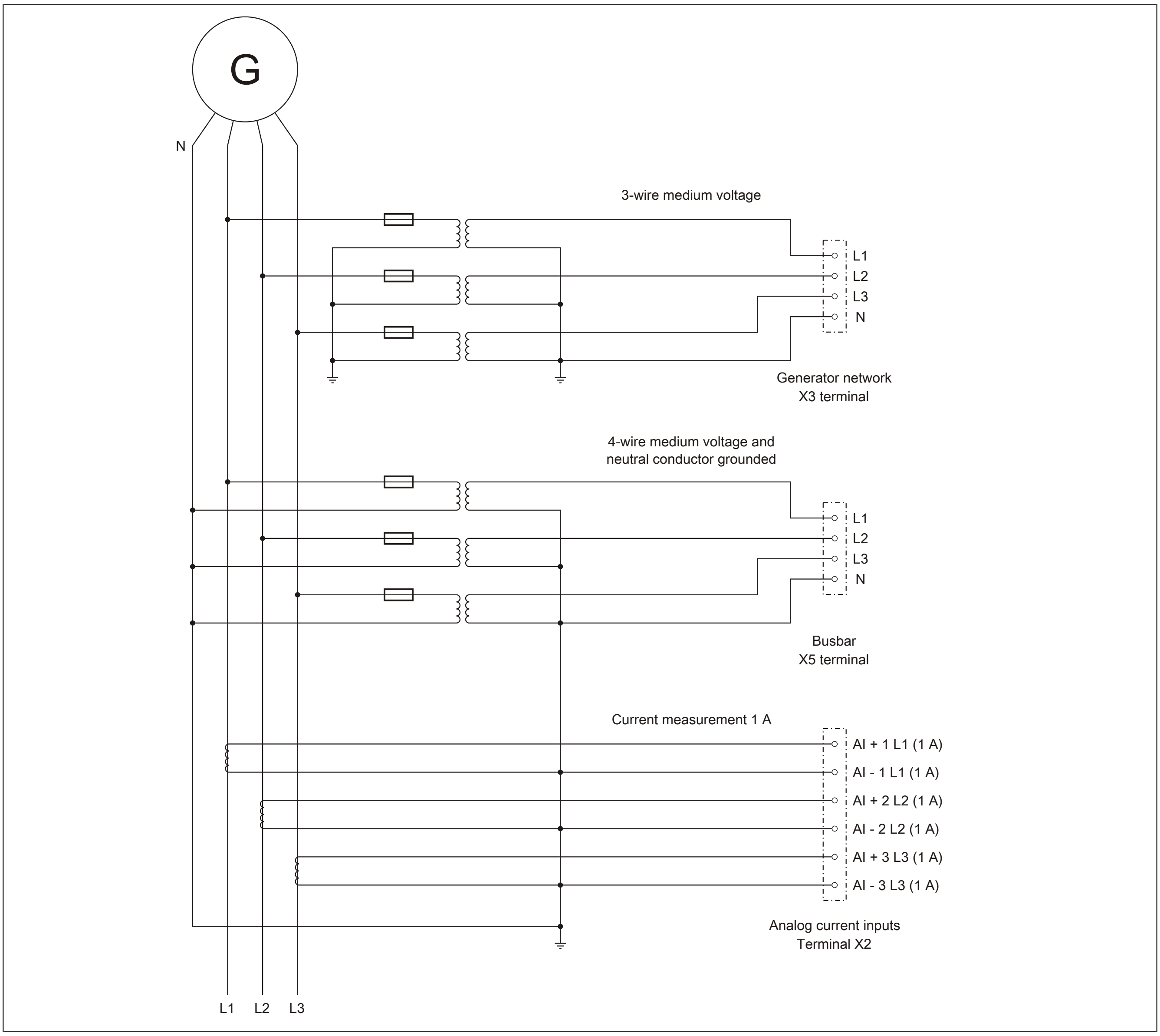
2.9 Typical connection examples for voltage/current measurement

For power measurement, the X3 terminal must always be used in connection with the X2 terminal! For single-phase measurement, always ensure that current input 1 is used for power measurement if voltage input 1 is being used. Otherwise, accurate power measurement is not possible for this phase!

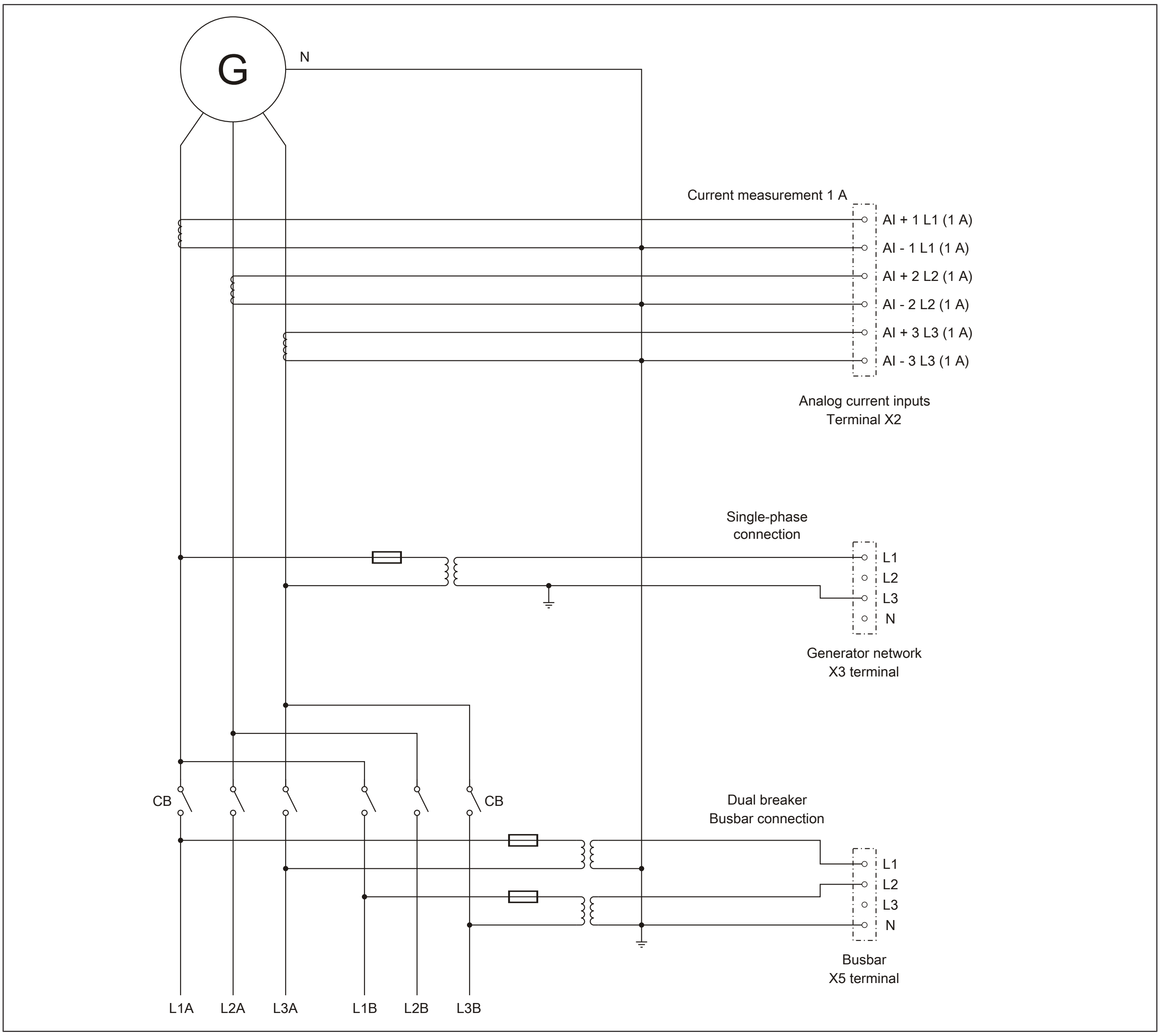
Connection example 1



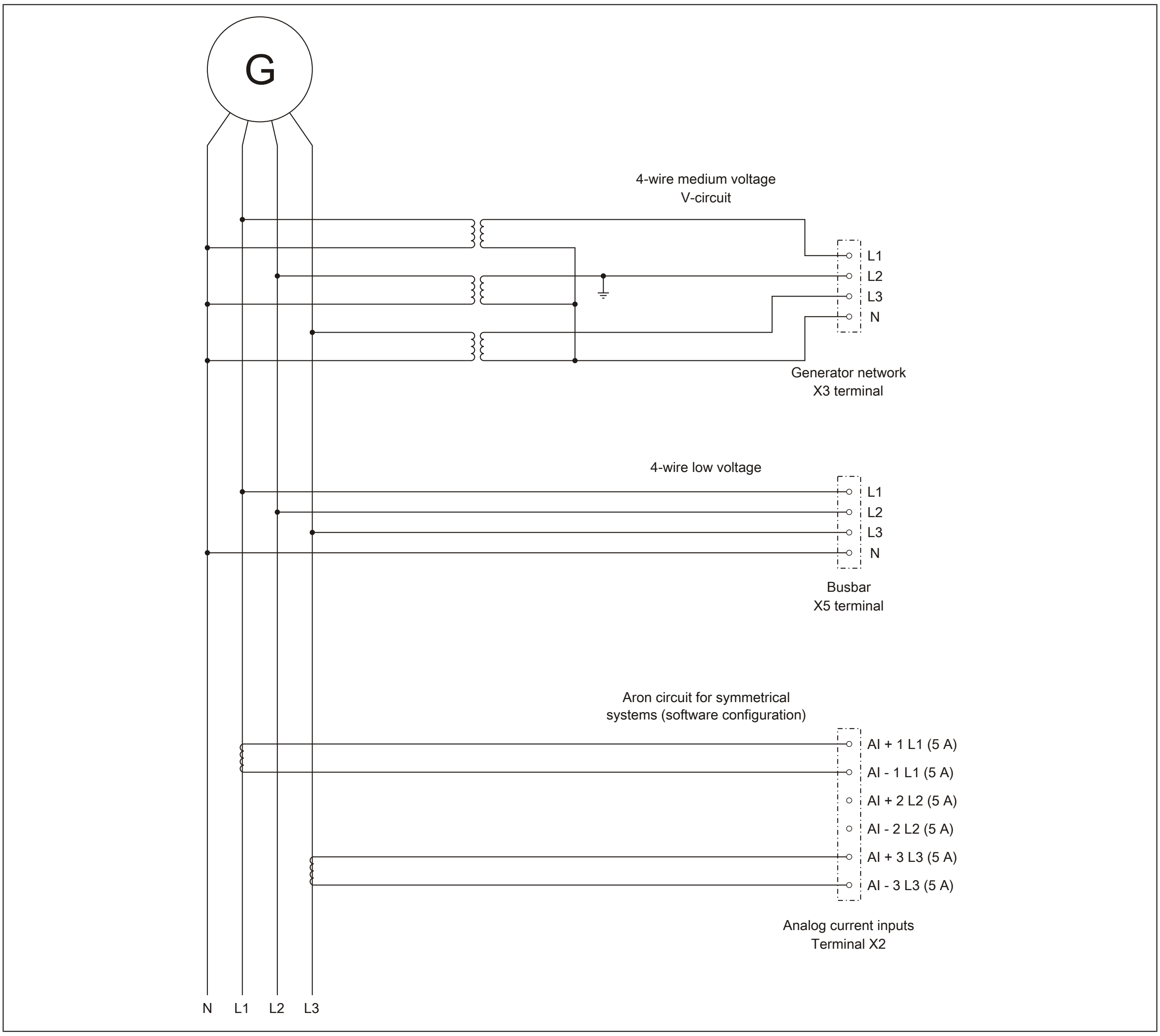
Connection example 2



Connection example 3

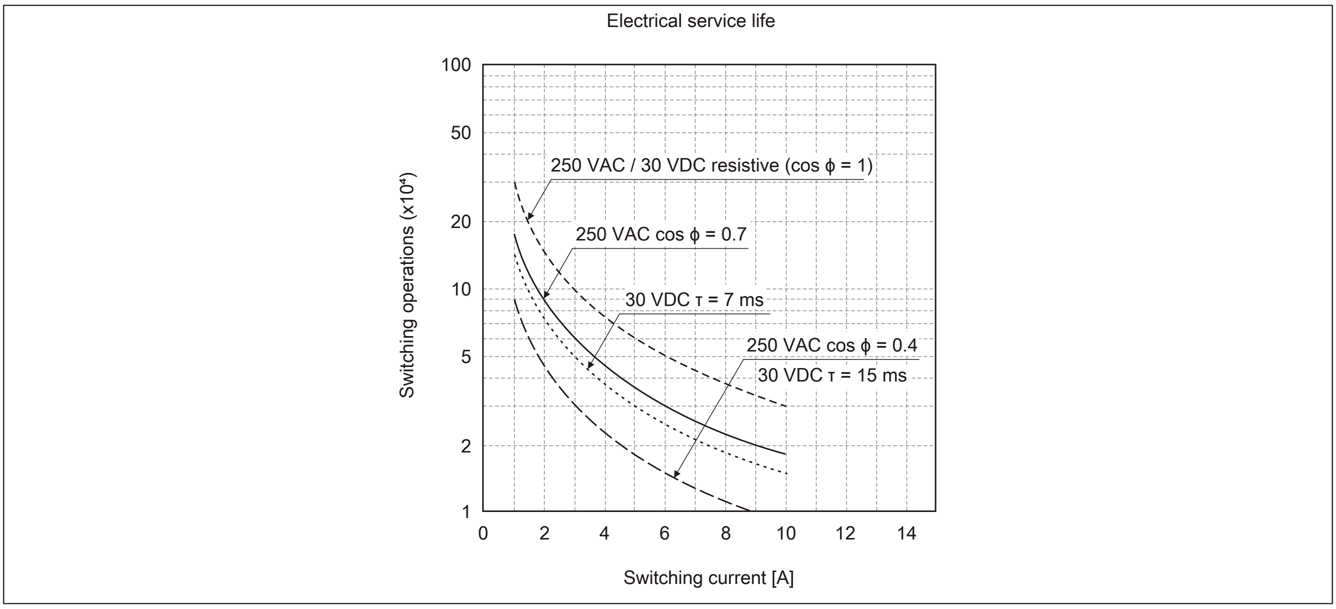


Connection example 4



2.10 Electrical service life

The electrical service life for the DO1 relay output can be seen in the following diagram.



2.11 Releasing the locking clip for terminals X3 - X6

Terminals X3 - X6 are equipped with a terminal locking clip. This clip attaches the terminal block securely to the electronic module. This prevents the terminal from accidentally being disconnected.

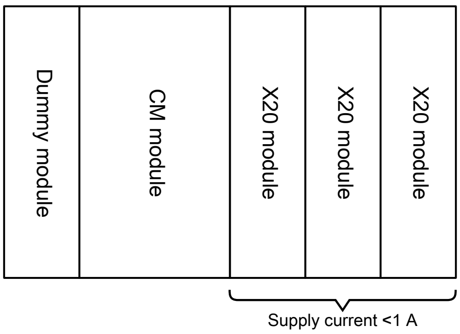
To release the locking clip, press inwards on the corrugated part of the lever with your fingertip (1) and then slide outwards (2). No additional tools are required for removing the terminal.

Terminals X5 and X6 must be removed first before terminals X3 and X4 can be removed.

2.12 Derating

Derating does not need to be taken into account for operation below 55°C.

For operation above 55°C, a dummy module must be connected to the left of the module. A maximum supply current of 1 A is permitted to pass through the module to the modules connected to the right.



3 Function description

3.1 Digital outputs

The module is equipped with 6 digital outputs.

Function description of digital outputs

<table>
<tr><th>Digital output</th><th>Description</th></tr>
<tr><td>DO1</td><td>This digital output is designed as a changeover switch. The monitoring relay is used to optionally monitor the following measured variables of the generator network:
• Overvoltage and undervoltage
• Overfrequency and underfrequency
• Voltage asymmetry
• Current unbalance
• Calculated neutral current (maximum)
• Short-circuit current
• Dependent overcurrent
• Limit value of the capacitive reactive power (exciter failure)
• Generator overload
• Generator feedback</td></tr>
<tr><td>DO2</td><td>DO2 serves as a counter output. The pulses generated can be recorded by an external energy meter (kWh) (see "Pulse value of energy meter output" on page 45).</td></tr>
<tr><td>DO3</td><td>The output is set when the busbar is in a voltage-free state (undershoot of the set parameter). The busbar voltage monitoring is 3-phase.</td></tr>
<tr><td>DO4</td><td>DO4 serves as a synchronization pulse. The circuit breaker is switched on by setting this output. After the configured time has elapsed, the output drops out again (exception: operating mode "Synchro check" on page 42).</td></tr>
<tr><td>DO5</td><td>This output is configurable as a digital output or monitoring output (see register "ConfigOutput24" on page 54). The monitoring function is only available with the "3-phase network" network configuration. When configured as a monitoring output, the following measured quantities of the network can be monitored:
• Overvoltage and undervoltage
• Overfrequency and underfrequency
• Voltage asymmetry
• Phase shift
• Frequency change
The monitoring status can be output either normally or inverted. The corresponding configuration takes place with register "DigitalOutput" on page 75. This setting is disabled again during switch off, reset, warm restart, cold restart, etc.</td></tr>
<tr><td>DO6</td><td>Can be configured either as a digital output or as a synchronization output (see register "ConfigOutput24" on page 54).
When configured as a synchronization output:
DO6 serves as a synchronization pulse. The circuit breaker is switched on by setting this output. After the configured time has elapsed, the output drops out again (exception: operating mode "Synchro check" on page 42).</td></tr>
</table>

3.2 Generator monitoring

A range of monitoring functions are available for generators. The following applies:

- Each monitoring function can be enabled or disabled individually.
- The registers are duplicated for overvoltage/undervoltage and overfrequency/underfrequency.
- Each register can be read back.

Behavior in the event of error

- For the error message to be triggered, the response value of the respective monitoring function must be overshot or undershot for at least as long as specified in the corresponding configuration register.
- The error messages are displayed in status registers StatusInputPacked01 and StatusInputPacked05. The bits of register StatusInputPacked05 are only displayed in the I/O mapping of Automation Studio if the respective status information is enabled in the I/O configuration (menu "Network configuration - Additional status information").
- **Function DO1**
  Digital output 1 can be linked to any error message and set in the event of an error. The mapping is performed via registers "ConfigOutput57" on page 61 and "ConfigOutput97" on page 62.
  The monitoring variables can be assigned to this input either individually or with additional monitoring variables using an OR operator. This makes it possible to set the relay when there are multiple monitoring variables.

> **Information:**
>
> **The minimum pulse duration when a monitoring function responds to both the error bit via X2X as well as the relay is 500 ms.**

Timestamp for generator voltages and currents

These timestamps indicate the time of the last positive zero crossing of the generator voltages (L1-N, L2-N, L3-N) and the generator currents (I1, I2, I3). All required phase ratios can be calculated using these timestamps.

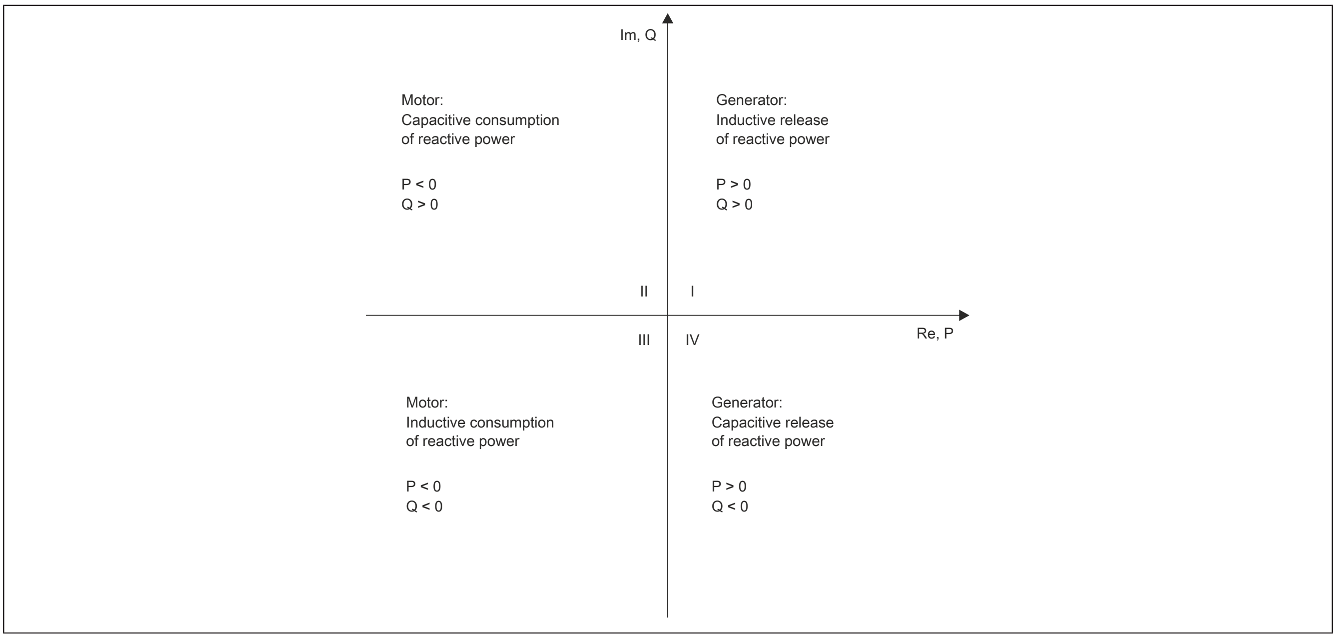
The calculation of the phase ratios and error handling for the calculation must be implemented by the user (e.g. period duration monitoring or checking whether voltages are high enough).

These timestamps are only displayed in the I/O mapping of Automation Studio if the display is enabled in the I/O configuration (menu "Enable timestamps for generator voltage and current").

> **Information:**
>
> **The registers are described in "Generator monitoring" on page 56.**

3.2.1 Generator operating modes

The operating modes possible for the generator are illustrated in this 4 quadrant diagram.

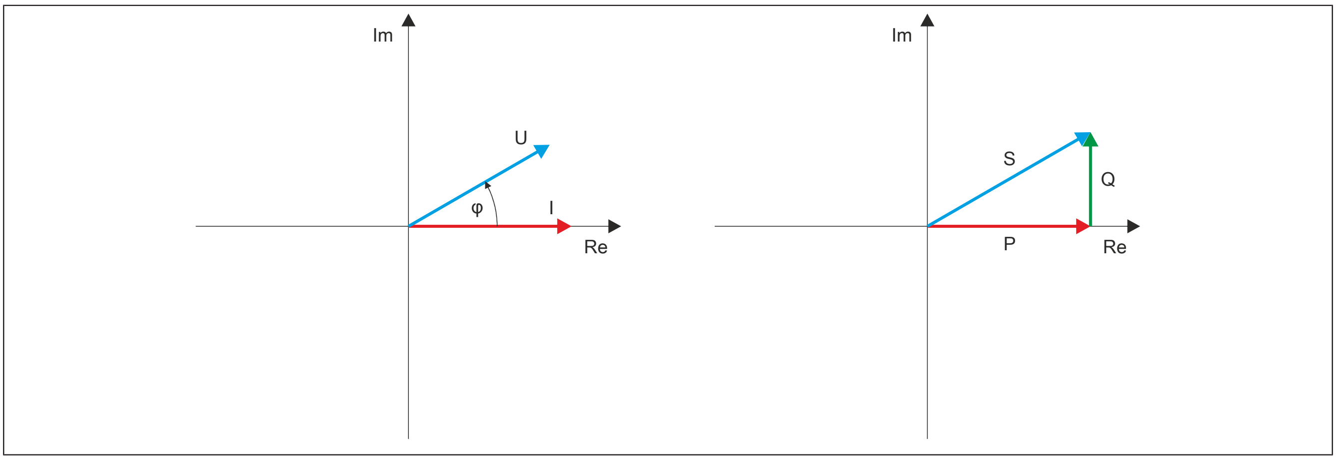


Quadrant I

Generator operation, inductive release of reactive power:

- The active power P and the reactive power Q are greater than 0.
- The phase angle ϕ is between 0 and 90°. This means that U keeps ahead of I.

Example: ϕ = 30°

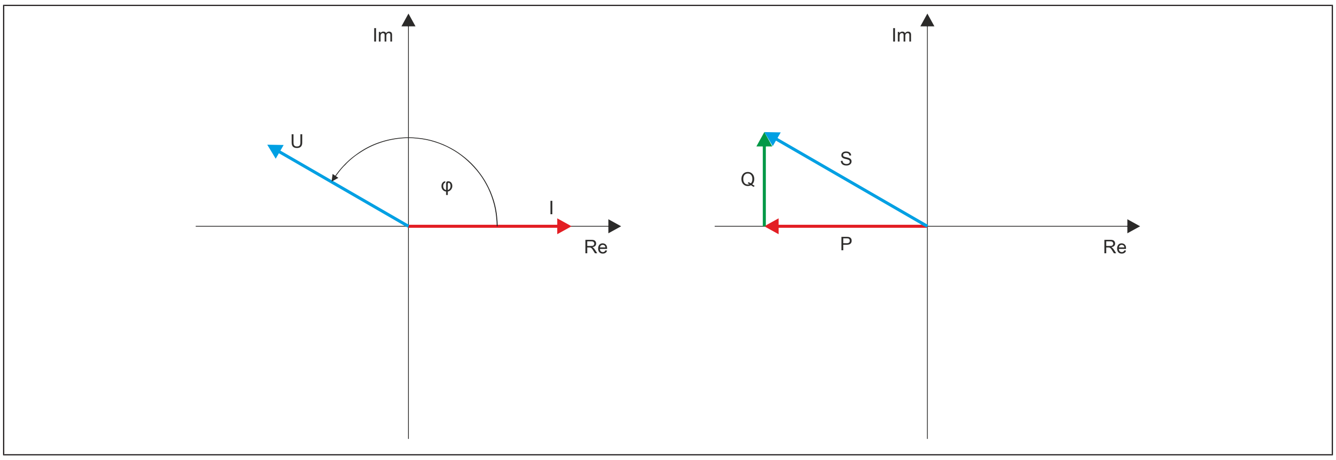


Quadrant II

Motor operation, capacitive reactive power consumption:

- The active power P is less than 0 while the reactive power Q is greater than 0.
- The phase angle ϕ is between 90 and 180°. This means that U keeps ahead of I.

Example: ϕ = 150°

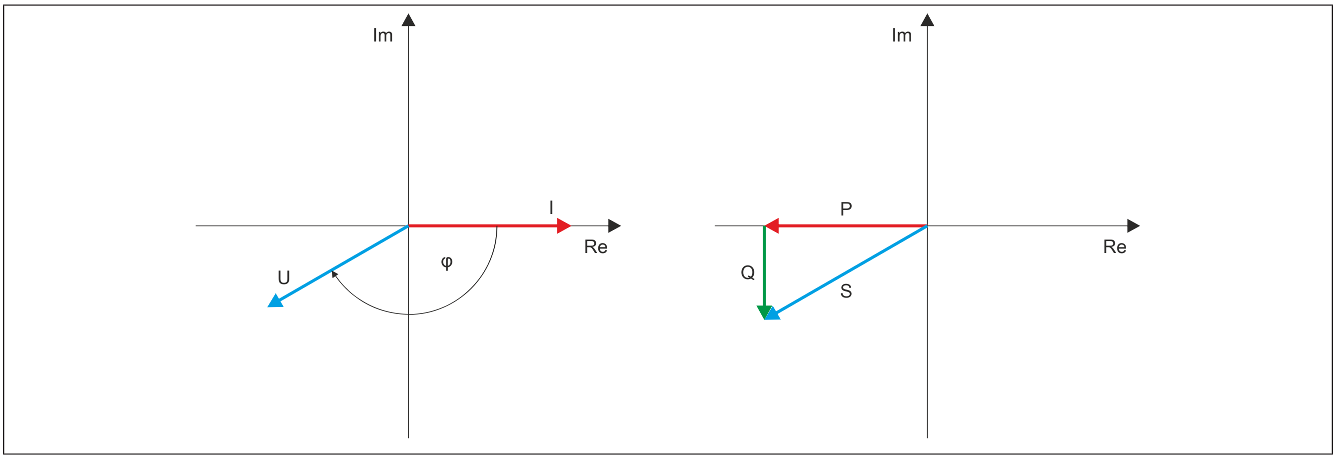


Quadrant III

Motor operation, inductive reactive power consumption:

- The active power P and the reactive power Q are less than 0.
- The phase angle ϕ is between -90 and -180°. This means that U lags behind I.

Example: ϕ = -150°

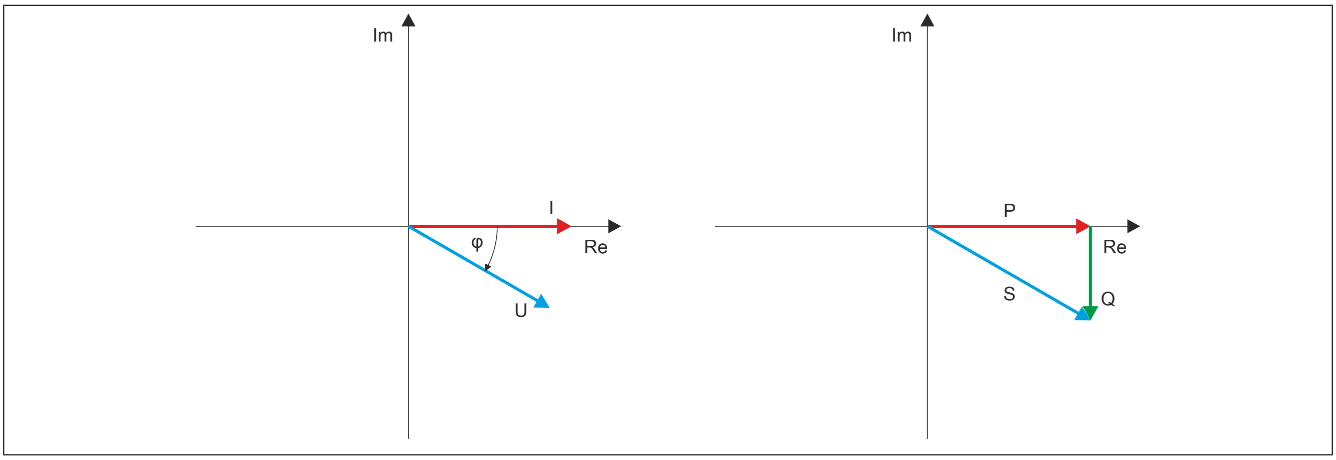


Quadrant IV

Generator operation, capacitive release of reactive power:

- The active power P is greater than 0 while the reactive power Q is less than 0.
- The phase angle ϕ is between 0 and -90°. This means that U lags behind I.

Example: ϕ = -30°



Power factor of the generator

The power factor is a product of the ratio between the active power P and apparent power S. With sinusoidal values, this corresponds to the cosine of the phase shift angle ϕ.

$$|Power\ factor| = \left|\frac{P}{S}\right|$$

The module derives the sign used for the power factor from the signs used with the P and Q values. In this way, it depends on the generator's operating mode:

Sign	Description
Positive	• Quadrant I or III, P and Q positive or P and Q negative • Inductive release of reactive power or inductive reactive power consumption
Negative	• Quadrant II or IV, P negative and Q positive or P positive and Q negative • Capacitive release of reactive power or capacitive reactive power consumption

3.2.2 Enabling/Disabling generator network functions

Power measurement mode

In real transmission grids, both the voltages and currents are not strictly sinusoidal. This means that harmonics or varying intensity are usually superimposed on the fundamental frequency.

In the default setting, the module always takes the contributions of both the fundamental frequency and harmonics into account. In addition to voltage and current measurements, this also applies to all power measurements.

If applications require reactive power control, the reactive power components originating from harmonics (distortion reactive power) can have a disruptive effect. Only the displacement reactive power should be controlled; this is the reactive power component of the fundamental frequency. In particular, controlling to displacement reactive power = 0 (cos φ = 1) may become impossible as a result.

For this reason, the module provides the option to take only the fundamental frequency (1st harmonic) for the power measurements into account if desired. The primary aim is to filter out the distortion reactive power. However, all other measured values based on the power measurement and the associated generator protection functions are also affected by a reconfiguration of the power measurement to the fundamental frequency.

However, the voltage and current measurement values of the generator network are **not** affected, but continue to include the contributions from harmonics (as with the other voltage networks) regardless of the power measurement mode.

Measured value / Function	Associated data point	Associated output	Notes/Details
Active power	AnalogInput19		P → P_H1
Reactive power	AnalogInput20		Q → Q_H1
Apparent power	AnalogInput21		S → S_H1
Power factor	AnalogInput23		Power factor → cos φ |cos φ| = Cos(arctan(Q_H1/P_H1)) The signs of cos φ are described in section "Generator operating modes" on page 24. "I" and "U" should be replaced by the respective 1st harmonic "I_H1" and "U_H1".
Maximum total active power	ConfigOutput52		A change to parameter "Power measurement mode" at runtime has no direct effect on one of these registers or the internal energy meters (e.g. in the form of a meter reset), but only determines the summand or comparison value that is immediately valid (total power/resonant power).
Active energy meter for supply	ConfigOutput54		
Reactive energy meter for supply	ConfigOutput55		
Active energy meter for reference	ConfigOutput71		
Reactive energy meter for reference	ConfigOutput72		
Energy counter output		DO 2	
Generator monitoring function: Capacitive reactive power	StatusInput10	DO 1	
Generator monitoring function: Generator overload	StatusInput31	DO 1	
Generator monitoring function: Generator feedback	StatusInput32	DO 1	

Disabling evaluation of current zero crossings in the event of voltage loss

If this setting is off, the current zero crossings are used for the internal calculations of the generator values instead of the voltage zero crossings in the event of voltage loss on the generator input.

If this setting is enabled, the current zero crossings are ignored in the event of voltage loss on the generator input. This means that in the event of voltage loss (e.g. if no generator is connected), generator values are no longer calculated due to possible noise on the current inputs.

3.2.3 Direction of rotation detection

Direction of rotation detection is used to detect incorrectly wired voltage and current inputs or an incorrect direction of rotation of the generator (for configuration, see register "ConfigOutput24" on page 54).

Phase sequence L1, L2 and L3 is monitored here. If it is not correct, an error message is output (see register "StatusDigitalOutput" on page 75) and synchronization is not possible.

3.2.4 Filtering

Low-pass filter for total power ratings

The total power of P, Q and S or P_H1, Q_H1 and S_H1 (see "Power measurement mode" on page 27) are low-pass filtered. Regardless of this, the maximum values of the total power are recorded unfiltered.

The attenuation behavior of the low-pass filter behaves according to the configurable time constant of a fading e-function. The adjustable parameter serves as a delay element so that current or voltage fluctuations have less of an effect on the display of the calculated power values.

3.2.5 Overvoltage/Undervoltage

If the measured value overshoots or undershoots the defined limit value, error message "Overvoltage/Undervoltage(2)" is indicated after the time delay has elapsed. A response time of up to 80 s can be configured. Depending on the "configuration" on page 55, the 3 phase conductor and/or phase voltages are monitored.

Error registers: "StatusInputPacked01" on page 76 and "StatusInputPacked05" on page 79.

3.2.6 Overfrequency/Underfrequency

If the measured value of the generator frequency overshoots or undershoots the defined percentage value in relation to the nominal frequency, error message "Overfrequency/Underfrequency(2)" is indicated after the time delay has elapsed.

Error registers: "StatusInputPacked01" on page 76 and "StatusInputPacked05" on page 79.

3.2.7 Voltage asymmetry

The tripping value, which can be set as a percentage, is based on the nominal voltage of the generator. If the 3 phase-to-phase voltages of the generator network differ from each other by more than the defined limit value, error message "Voltage unbalance" is indicated after the time delay has elapsed.

It is enough for one of these voltage differences to overshoot or undershoot the limit value.

Error register: "StatusInputPacked01" on page 76.

3.2.8 Unbalanced load monitoring

Unbalanced load monitoring is used to protect three-phase generators and three-phase power systems against unbalanced loads. The tripping characteristic can be adapted to different generator types via adjustable parameters, taking into account its special thermal time constants. These include:

- Load time constant K1
- Unbalanced load constant K2
- Nominal current of the generator

An unbalanced load can be caused by uneven current distribution in the network due to uneven loading, asymmetrical conductor short circuits, conductor interruptions and also switching operations. An unbalanced load causes negative sequence currents in the stator, which produces harmonics of odd order in the stator winding and harmonics of even order in the rotor winding. The rotor is particularly at risk here because the harmonics place additional stress on the rotor winding and induce eddy currents in the solid iron of the rotor, which can even cause melting of the metal or irreparable damage of the metal structure.

Within certain limits and taking the thermal limit load of the generator into account, however, an unbalanced load is permissible. To avoid premature failure of the generator under an unbalanced load, the tripping characteristic of the unbalanced load protection should be adapted to the thermal characteristics of the generator. The unbalanced load protection can also respond to external errors in the network caused by asymmetrical short circuits.

Unbalanced load monitoring constantly monitors the AC currents supplied by the main current transformers and calculates the current unbalanced load current. This is compared with the threshold value, which is calculated using the load time constants. If this threshold value is overshot, error message "Current unbalance" is indicated.

Error register: "StatusInputPacked01" on page 76.

Calculating the tripping time

The tripping time of the unbalanced load protection can be calculated using the following formulas:

Operating mode	Formula
Short-term operation	$t = \frac{K1}{\left(\frac{I_2}{I_{Nom}}\right)^2 - K2^2}$
Continuous operation	$\frac{I_2}{I_{Nom}} \leq K2 \rightarrow t = \infty$
Legend	
t	Calculated tripping time
K1	Permissible load time constant of the generator [s]
K2	Unbalanced load constant (limit between short and continuous operation)
I_2	Calculated inverse current / Unbalanced load current [A]
I_{Name}	Nominal generator current [A]

To calculate the tripping instant, the sampling duration of the measuring system (i.e. 20 ms at 50 Hz voltage) is divided by the calculated tripping time and the results are continuously added together. The value of the summand increases during short-term operation and decreases during continuous operation. If the summand reaches the value 1 (100%), then the maximum permissible value has been reached. The summand is limited between 0 and 1.

The limit between continuous operation and short-term operation is defined by unbalanced load constant K2.

Information:

The summand is neither reset nor does it reduce its value during generator standstill.

Limiting unbalanced load currents >360% I_{Nom}

This limiting is performed starting with upgrade 2.2.0.0 (firmware version 1.10).

For unbalanced load currents of $I_2/I_{Nom} \leq 3.6$, the tripping instant is calculated normally.

For unbalanced load currents of $I_2/I_{Nom} > 3.6$, a ratio of $I_2/I_{Nom} = 3.6$ is used to calculate the tripping instant.

3.2.9 Neutral current

Configurable limit value for the neutral current. If the value is overshot, the error message "Neutral current maximum" is indicated after the defined time delay has elapsed.

Error register: "StatusInputPacked01" on page 76.

3.2.10 Short-circuit current

If the value of the generator current rises above the defined percentage value in relation to the nominal transformer current, error message "Short-circuit current" is indicated after the set time delay has elapsed.

Error register: "StatusInputPacked01" on page 76.

3.2.11 Overcurrent

The response value percentage is based on the nominal current of the generator. If the response value is overshot, error message "Dependent overcurrent" is indicated.

Error register: "StatusInputPacked01" on page 76.

Dependent overcurrent monitoring

Dependent overcurrent monitoring meets the requirements of EN 60255-151.

A generator operated at its nominal current I_{Nom} normally reaches about half of its maximum thermal load capacity. Operating states above the nominal current I_{Nom} result in further heating, which is still permissible until the maximum temperature is reached. The maximum permissible continuous temperature is specified by the insulation class of the respective generator.

Based on the setting and the current measurement, the device forms an internal model based on an I^2t characteristic of the generator temperature. This means that the heat capacity of the generator can be fully utilized for short overloads, while at the same time ensuring full protection. The adjustable parameter for defining the machine model is the nominal current I_{Nom} of the generator and the time multiplier.

3.2.11.1 Tripping characteristic for dependent overcurrent

To calculate the tripping instant, the sampling duration of the measurement system is divided by the calculated tripping time (t). The results are continually added up. If the summand reaches the value 1 (100%), then the maximum permissible value has been reached. The summand is limited between 0 and 1.

Depending on the setting, the tripping characteristic is calculated for a constant overcurrent according to the corresponding formula:

Normally inverse

$$t = \frac{0.14}{\left(\frac{I}{I_N}\right)^{0.02} - 1} * iths$$

Very inverse

$$t = \frac{13.5}{\left(\frac{I}{I_N}\right) - 1} * iths$$

Extremely inverse

$$t = \frac{80}{\left(\frac{I}{I_N}\right)^{2} - 1} * iths$$

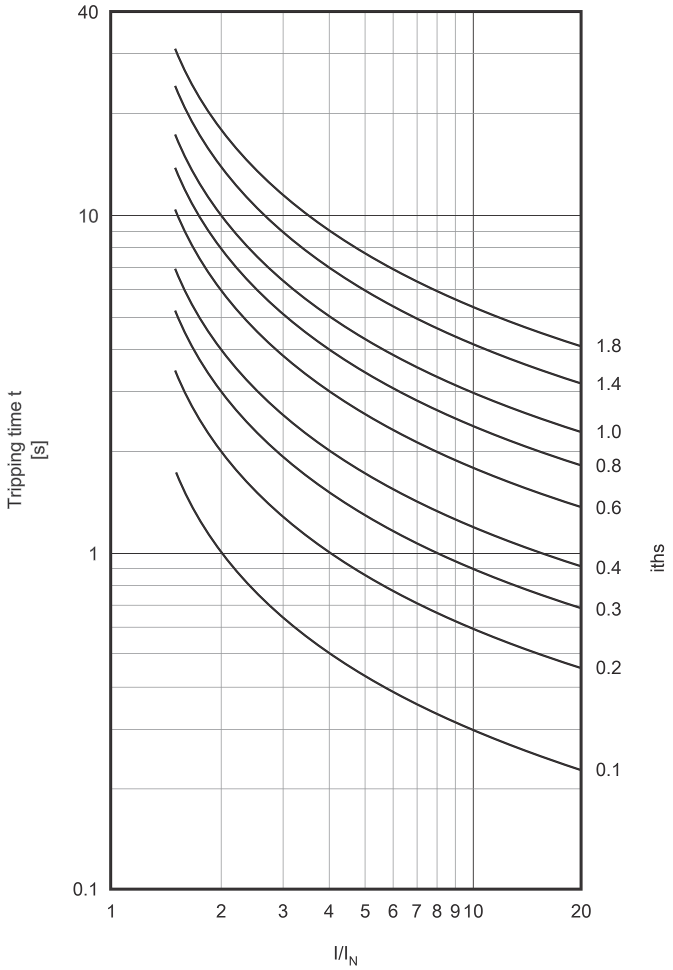
Legend:

t	Tripping time [s]
I	The highest value of the 3 phase currents [A]
I_N	Setpoint [A]
iths	Time factor setting

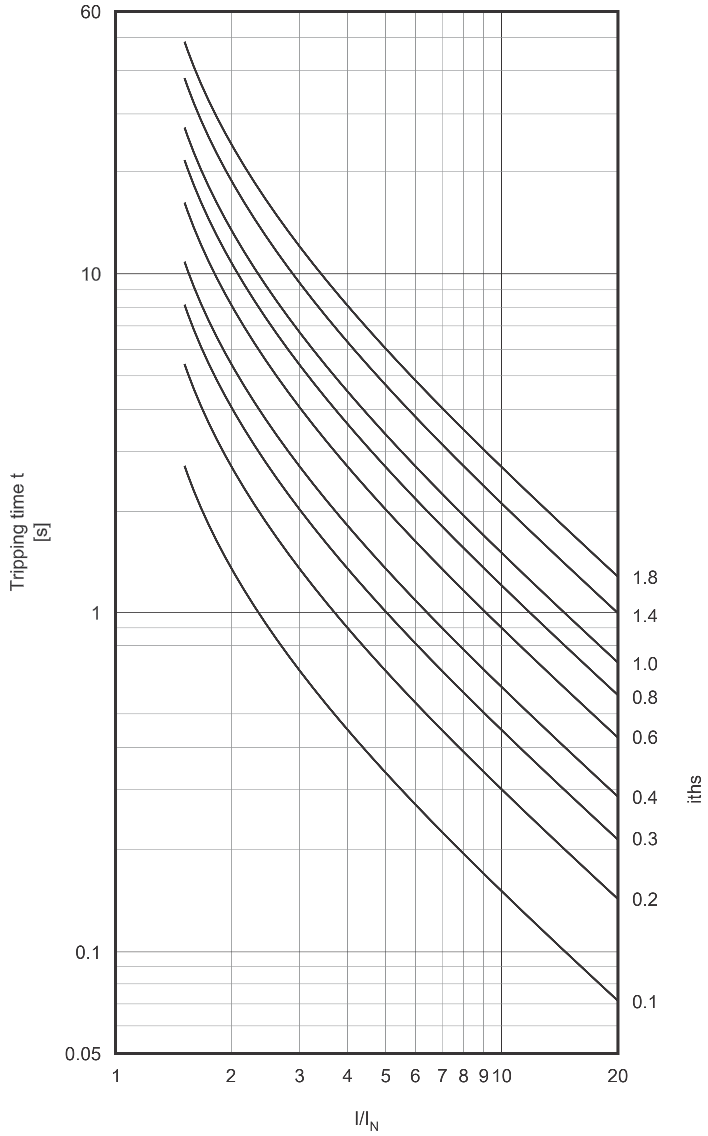
Time factor setting iths can be set via register "ConfigOutput43" on page 59.

The monitor function can be reset by restarting the module or by undershooting the overcurrent value so that the results of the continuous addition decrease again according to the formula.

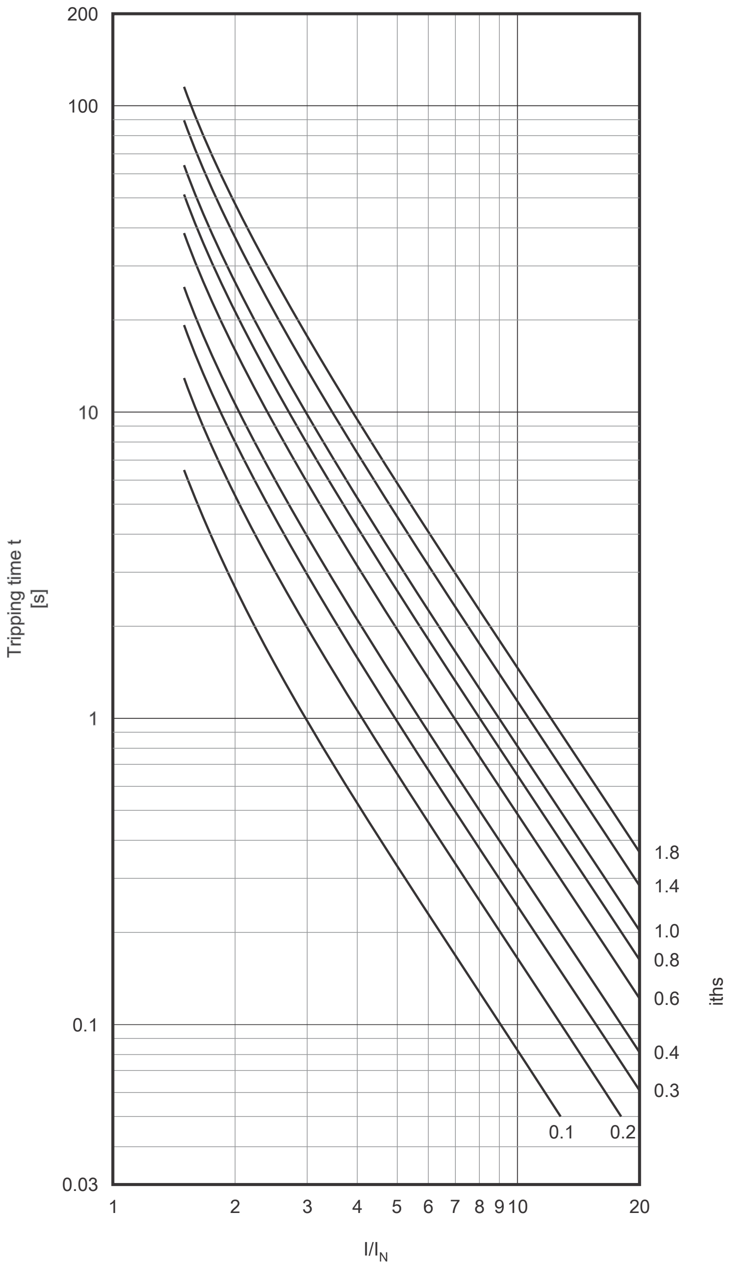
Tripping characteristic per EN 60255-151:2009 section 4.4.1.3 (normally inverse)



Tripping characteristic per EN 60255-151:2009 section 4.4.1.3 (very inverse)



Tripping characteristic per EN 60255-151:2009 section 4.4.1.3 (extremely inverse)



3.2.12 Reactive power / Exciter failure

The reactive power is capacitively monitored for undershooting the defined response value. Monitoring of the capacitive reactive power can be used as exciter failure detection. If the response value is undershot, error message "Capacitive reactive power" is indicated after the set time delay has elapsed.

Error register: "StatusInputPacked01" on page 76.

Depending on the setting of parameter "Power measurement mode" in register "ConfigOutput21" on page 34, either the total reactive power or the fundamental reactive power (displacement reactive power) is compared with the response value.

3.2.13 Generator overload / Generator feedback

If the value of the generator active power overshoots or undershoots the defined percentage value in relation to the nominal power of the generator, error message "Generator overload" or "Generator feedback" is indicated after the time delay has elapsed.

Error register: "StatusInputPacked01" on page 76.

Depending on the setting of parameter "Power measurement mode" in register "ConfigOutput21" on page 55, either the total active power or the fundamental frequency active power is compared with the response value.

The nominal power is calculated as follows:

$P_{NomGen} = U_{NomGen} * I_{NomGen} * \sqrt{3}$

3.3 Network monitoring

The following mains monitoring functions are available if the mains configuration is set to 3-phase mains. The following applies:

- Each monitoring function can be enabled or disabled individually.
- The registers are duplicated for overvoltage/undervoltage and overfrequency/underfrequency.
- Each register can be read back.
- Undervoltage limit values and response times can be configured for 2-point or 6-point monitoring.

Behavior in the event of error

- For triggering, the response value of the respective monitoring function must be continuously overshot or undershot for at least as long as specified in the corresponding configuration register.
- The error messages are displayed in status registers "StatusInputPacked02" on page 77 and "StatusInputPacked04" on page 78
  .
  The bits of register StatusInputPacked04 are only displayed in the I/O mapping of Automation Studio if the respective status information is enabled in the I/O configuration ("Network configuration - Menu Additional status information").
- **Function DO5**
  This digital output can be set after the defined response time has elapsed depending on the assignment of the mains' monitoring variables. The assignments are made via register "ConfigOutput81" on page 69.
  The monitoring variables can be assigned to this input either individually or with additional monitoring variables using an OR operator. This makes it possible to set the relay when there are multiple monitoring variables.

  > **Information:**
  >
  > **The minimum pulse duration when a monitoring function responds to both the fault bit via X2X as well as on the output is 500 ms.**

> **Information:**
>
> **The registers are described in "Mains voltage monitoring" on page 64.**

3.3.1 Network settings

Networks without neutral conductor

When configuring a "3-phase system without a neutral conductor", the potential of the neutral conductor is calculated from the 3 phases ("virtual start point").

The phase voltages are now measured in relation to this "virtual star point".

Mains with grounding

If one of the phases of a network is grounded, it must also be configured as "grounded". If this is not the case, the module may falsely report a phase failure, which blocks the network synchronization function.

Disabling monitoring functions:

- No phase failure monitoring is performed for the phase that is configured as "grounded"
- For 2-phase networks that are "grounded", the direction of rotation is not monitored.

Network configuration

The network can be used either as two 2-phase synchronization networks or combined to form a 3-phase network.

If the network configuration is set to "3-phase network", the monitoring functions of this combined network are enabled.

3.3.2 Overvoltage

If the value of one of the mains voltages configured in register "ConfigOutput22" on page 63 overshoots the defined value, error message "Overvoltage" is indicated after the time delay has elapsed.

Error registers: "StatusInputPacked02" on page 77 and "StatusInputPacked04" on page 78.

3.3.3 Overfrequency

If the value of the mains frequency overshoots the defined percentage value in relation to the nominal frequency, error message "Overfrequency(2)" is indicated after the time delay has elapsed.

Error registers: "StatusInputPacked02" on page 77 and "StatusInputPacked04" on page 78.

3.3.4 Underfrequency

If the value of the mains frequency undershoots the defined percentage value in relation to the nominal frequency, error message "Underfrequency(2)" is indicated after the time delay has elapsed.

Error registers: "StatusInputPacked02" on page 77 and "StatusInputPacked04" on page 78.

3.3.5 Voltage asymmetry

The tripping value, which can be set as a percentage, is based on the nominal voltage of the mains. If the 3 line-to-line voltages of the network differ from one another by more than the defined limit value, error message "Voltage unbalance" is indicated after the time delay has elapsed.

It is enough for one of these voltage differences to overshoot or undershoot the limit value.

Error register: "StatusInputPacked02" on page 77

3.3.6 Undervoltage monitoring in 2-point mode

2 independent limit values and response times can be defined for undervoltage monitoring.

3.3.6.1 Mains undervoltage

If the measured value of one of the mains voltages configured in register "ConfigOutput22" on page 63 or the concatenated mains voltages undershoots the set limit value, error message "Undervoltage" is indicated after the time delay has elapsed.

Error register: "StatusInputPacked02" on page 77

3.3.7 Undervoltage monitoring in 6-point mode

It is possible to define up to 6 limit values and response times for undervoltage monitoring. If not all 6 points are required, the unused limit values and response times must be set to 0.
It is important to note that the specified limit value and response time for each point must be greater than or equal to the previous point (P1 ≤ P2 ≤ P3, etc.).

The defined points are used to create a limit value curve. If the voltage drops below the curve and a response time has expired, the error message "Undervoltage" is signaled ("StatusInputPacked02" on page 77 register). If configured, the D05 monitoring relay is also switched.

A faulty undervoltage monitoring configuration also triggers the "Undervoltage" error message, and monitor relay DO5 is switched if configured to do so (e.g. P1 > P2 and P2 not equal to (0% / 0 ms)).

The types of voltages to be monitored are specified in the mains configuration ("ConfigOutput22" on page 63 register):

- Line-to-line voltages
- Phase voltages
- Line-to-line and phase voltages

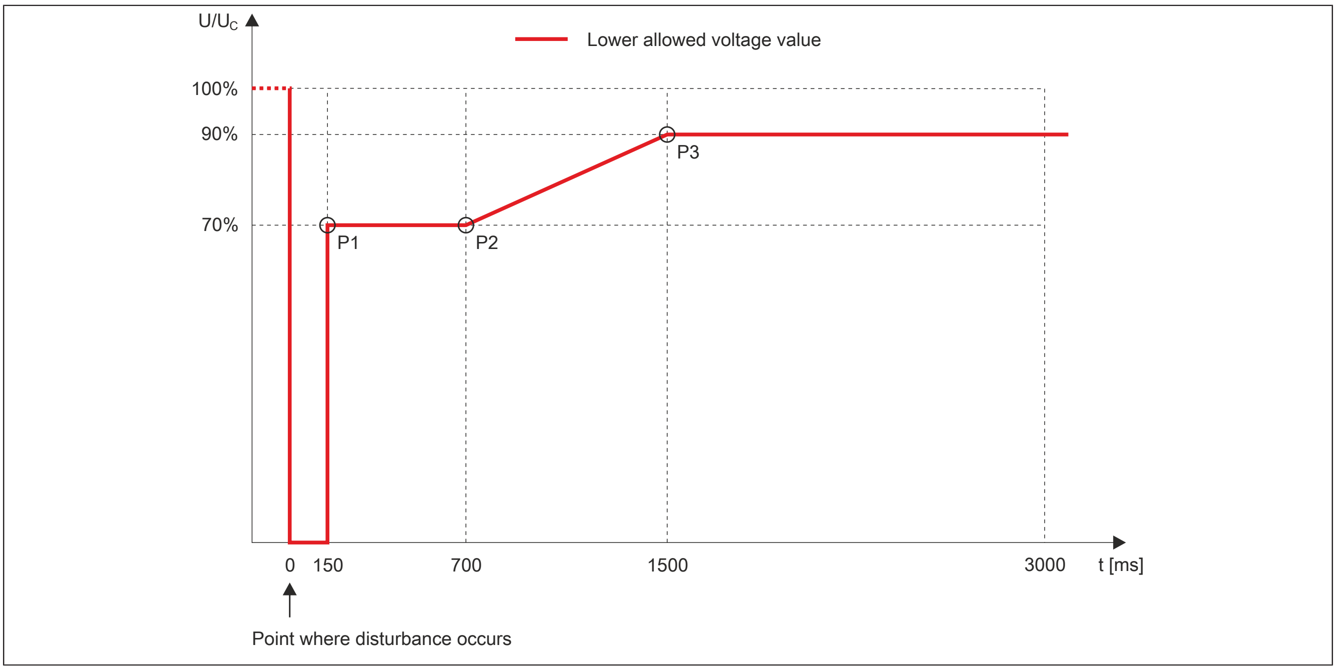
As soon as one of the monitored voltages drops below the limit curve, the corresponding time counter begins counting. The time counter is reset when all voltages are once again equal to or higher than the defined value.

The "Undervoltage" error message is generated when one of the time counters crosses over the limit curve.

3.3.7.1 Example 1 with 3 points:

In this example, 3 limit values are defined, along with the corresponding response times:

- P1 (70% / 150 ms)
- P2 (70% / 700 ms)
- P3 (90% / 1500 ms)
- P4 (0% / 0 ms)
- P5 (0% / 0 ms)
- P6 (0% / 0 ms)



Notes regarding limit curve

- The red line marks the lowest permitted value for monitored voltages.
- If 2 consecutive points have the same limit value, then the response time of the first point is applied. In the example above, this situation is shown with points 1 and 2.
- Between points 2 and 3 the curve has a positive linear slope. If one of the monitored voltages drops in this area, the module calculates the appropriate response time.

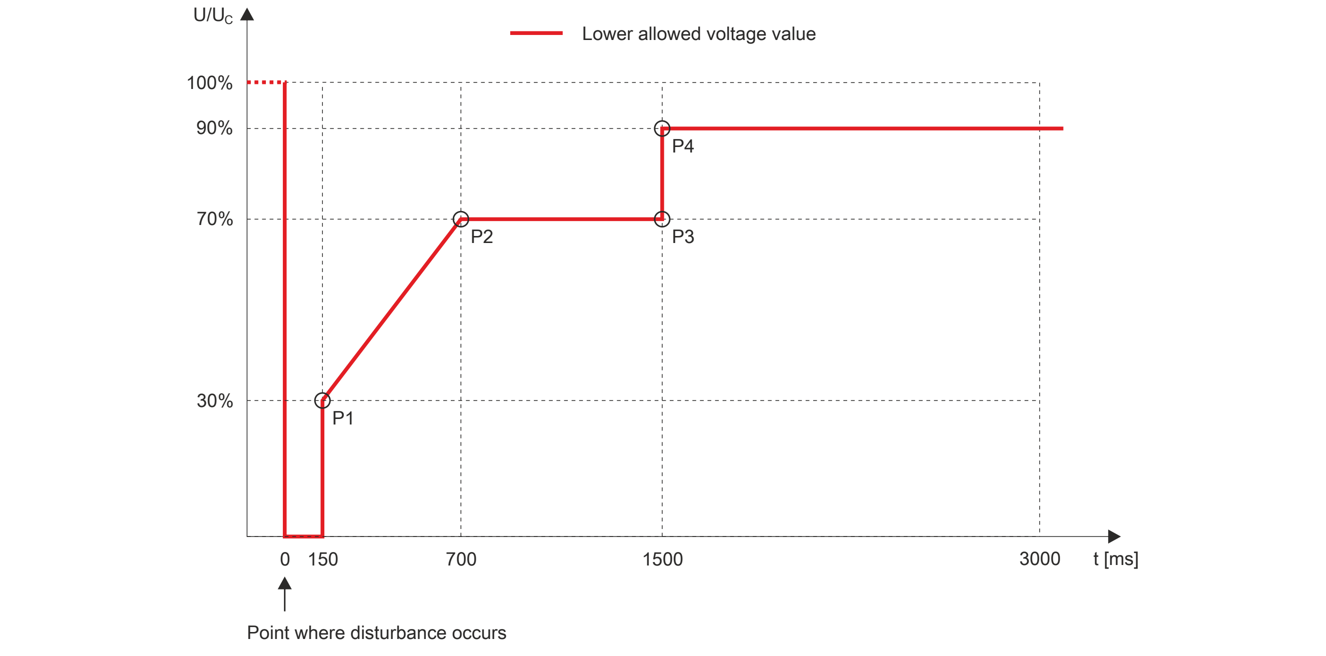
Determining the response time

1) Find voltage value on Y axis
2) Locate intersection on curve
3) Read the response time on the X axis

3.3.7.2 Example 2 with 4 points:

In this example, 4 limit values are defined, along with the corresponding response times:

- P1 (30% / 150 ms)
- P2 (70% / 700 ms)
- P3 (70% / 1500 ms)
- P4 (90% / 1500 ms)
- P5 (0% / 0 ms)
- P6 (0% / 0 ms)



Notes regarding limit curve

- The red line marks the lowest permitted value for monitored voltages.
- Between points 1 and 2 the curve has a positive linear slope. If one of the monitored voltages drops in this area, the module calculates the appropriate response time.
- If 2 consecutive points have the same limit value, then the response time of the first point is applied. In the example, this situation is shown with points 2 and 3.
- Points 1 and 2 are connected directly by a line with a positive slope. To avoid a direct connection between points 2 and 4, one would have to define another point between them with the same limit as point 2 and the same response time as point 4. In this case, that is point 3.

Determining the response time

1) Find voltage value on Y axis
2) Locate intersection on curve
3) Read the response time on the X axis

3.3.8 Microgrid monitoring

A microgrid is a small mains power grid that only supplies a limited area and generally is not connected to other mains grids, which means it can function autonomously. This is in contrast to a synchronous grid, in which multiple smaller mains grids are connected together and synchronized.

With microgrid monitoring, the mains is monitored for over/undervoltage. After a defined response time elapses, a corresponding error message is generated. Microgrid monitoring always checks the line-to-line voltages independently of the configuration in the "ConfigOutput22" on page 63 register.

3.3.8.1 Overvoltage/Undervoltage

If the value of one of the concatenated mains voltages overshoots or undershoots the set value, error message "Standalone mains monitoring" is indicated after the time delay has elapsed.

Error register: "StatusInputPacked04" on page 78

3.3.9 Phase shift monitoring

A phase shift is an abrupt change to the voltage curve that can be caused by a significant change to the load.

In this case, the device recognizes a single change to the period duration. This changed period duration is compared with the calculated average value from past measurements. Monitoring takes place for three phases and if desired also for a single phase. The phase shift monitoring function is only active if the mains voltage is higher than the set percentage value based on the nominal voltage for the converter.

If the response value is overshot, error message "Phase jump" is indicated (register "StatusInputPacked02" on page 77) and, if configured, monitoring relay DO5 is switched.

3.3.9.1 Phase shift monitoring response time

A phase shift is indicated on output DO5 within 2 ms after detection of the phase shift (i.e. after zero crossing of the extended/shortened period), as long as this is configured accordingly.

3.3.9.2 Phase shift detection

Phase shift detection is configured in the "ConfigOutput22" on page 63 register.

Type of monitoring	Description
Only three-phase monitoring	Triggering takes place if the limit value for three-phase monitoring was exceeded on all 3 phases within 2 periods.
Single-phase or three-phase monitoring	Triggering takes place: • If the limit value for single-phase monitoring is exceeded on at least one of the 3 phases • If the limit value for three-phase monitoring was exceeded on all 3 phases within 2 periods.

Phase shift monitoring detects an abrupt change to the period duration of the mains voltage.

The period duration of the current period is compared with the average value for the period duration over the past 4 periods. If the difference exceeds the set limit value, then triggering takes place immediately.

Limit value

The limit value is set in 0.1° increments. The internal limit value in µs is calculated as follows:

$t_{hres}[\mu s] = t_{hres}[0.1°]$ * Period duration / 3600

When do this, the period duration for the set nominal frequency is used.

Example

Calculating t_{hres} [µs] at 50 Hz (period duration = 20000 µs) and limit value 7°:

$t_{hres}[\mu s]$ = 70 * 20000 µs / 3600 = 388.88 µs (rounded to 389 µs)

If the period duration thus changes abruptly by more than +389 µs, triggering takes place.

3.3.10 Network frequency change

Response value

For df/dt monitoring, the change in frequency is determined in each period compared to the previous period. If this value overshoots the set limit value for the specified number of periods in each of the periods and if the sign of the frequency change is always the same, error message "Df/dt (mains frequency change)" is indicated (register "StatusInputPacked02" on page 77) and, if configured, monitoring relay DO5 is switched.

Number of periods

The number of periods for monitoring the mains frequency change can be set. For triggering, the response value must be continuously overshot for at least the set number of periods. The error message is displayed on output DO5 max. 2 ms after internal detection.

Example

With a number of periods of 4 and a mains frequency of 50 Hz, the maximum tripping time is calculated as follows:

Max. tripping time = 4 x 20 ms + 2 ms = 82 ms

The change in period duration introduced by the frequency gradient must still be taken into account.

3.4 Busbar monitoring

A range of configuration options are available for the busbar. The following applies:

- Each register can be read back.

Behavior in the event of error

- Output DO3 is set when the busbar (terminal X5) is in a voltage-free state (busbar voltage undershoots set limit value minimum U_{Bmin}).

Voltage measurement and zero voltage monitoring

The busbar voltage monitoring is 3-phase. The measured values are displayed with linked, as well as phase values. This monitoring can be used to draw conclusions about the synchronization function to be used.

Synchronization function	Busbar voltage measurement
Dead bus	The busbar is in a voltage-free state or the value has undershot the set parameter. Output DO3 is set.
Synchronize with slip	The measured voltage on the busbar is above the set parameter value. Output DO3 is not set.

Monitoring functions

3 parameters are available for monitoring the measured busbar voltage and calculating am error event.

- **Rated busbar voltage**
  This parameter in volts is required to convert the percentages related to this nominal value into physical units.
- **Multiplier ref.**
  Used to convert the measured value into the physical quantity. The multiplier is applied to the respective input value. The resolution is specified in 1/100, i.e. the value 100 means multiplication factor 1 (measured value is not changed).
- **Minimum busbar voltage**
  Configurable threshold in 1/10% increments for zero voltage monitoring of the busbar based on the nominal voltage of the busbar. DO3 is set when the configured threshold is undershot.

Information:

The registers are described in "Busbar" on page 69.

3.5 Synchronization functions

4 voltage inputs (X3 to X6) can be used for synchronization:

- X4 - X6: Synchronization network 1 - Synchronization network 2

> **Information:**
>
> **Configuration X4 - X6 is only possible if configured for network configuration "Synchronization network 1 / Synchronization network 2" in register "ConfigOutput68" on page 53.**

- X4 - X5: Synchronization network 1 - Busbar
- X4 - X3: Synchronization network 1 - Generator
- X5 - X3: Busbar - generator

> **Information:**
>
> **The registers are described in "Synchronization" on page 70.**

3.5.1 Differential frequency

The prerequisite for issuing a switch-on command on DO4 is that the set differential frequency is overshot or undershot. The following applies:

- Positive value (upper frequency) corresponds to positive slip → Generator frequency greater than busbar frequency during synchronization
- Negative value (lower frequency) corresponds to negative slip → Generator frequency lower than busbar frequency during synchronization

3.5.2 Differential voltage

The prerequisite for issuing a switch-on command on DO4 is that the differential voltage set as a percentage is overshot in relation to the nominal voltage of the synchronization network.

3.5.3 Differential angle

The prerequisite for issuing a switch-on command on DO4 is that the difference angle between the two synchronization networks is undershot.

3.5.4 Phase rotation

This parameter is used to correct any phase shifts of upstream transformer switching groups before the networks to synchronize. The parameter specifies by how many degrees the synchronization network leads the network to synchronize.

3.5.5 Synchronization outputs

Digital outputs 4 and 6 can be used as synchronization outputs. Both outputs can be configured independently of each other.

- The duration of the switch-on pulse can be adjusted for the following switching units. After the configured time has elapsed, the output drops out again
- The trigger time of the generator circuit breaker corresponds to the lead time of the closing command. The switch-on command occurs before the synchronization point at the configured time.

3.5.6 Synchronization modes

The following synchronization modes are available on the module:

3.5.6.1 Synchronize with slip

The following applies to synchronization network 1 and synchronization network 2:

- 50% < U < 125% of the nominal voltage U_N
- 80% < f < 110% of the nominal frequency f_N

The generator voltage is adjusted to the synchronizing voltage in amplitude and frequency. The switch-on command is calculated taking the configured phase angle (Δα), a set transformer switching group and the switch's own time into account and is sent in advance so that the main contacts of the circuit breaker are closed at the synchronous point.

Synchronization takes place under the following conditions:

- Synchronization mode "Slip" is set in the software.
- The device is ready for operation.
- The directions of rotation of the network to synchronize are OK (direction of rotation detection)
- The configured limit for voltage difference is observed (ΔU_{max}).
- The configured limits for frequency difference are observed (Δf_{max} and Δf_{min}).
- The configured limit for the phase angle (including transformer switching group Δα) is observed (ϕ_{max}).

After setting synchronization mode "Slip", synchronization is only enabled when the absolute value of the difference angle between the two networks to synchronize is >5° for at least 100 ms.

This means that if the phase difference happens to be within ±5° when the request is set, synchronization is only enabled after 100 ms if the phase difference is greater.

Resetting mode "Synchronization with slip" cancels the synchronization.

In order to receive a synchronization pulse, the synchronization window must be entered from any phase direction after the synchronization command has been enabled while complying with all the synchronization conditions specified above.
The switch is not engaged immediately after the phase window is reached. The switch is not engaged until synchronization to the synchronization point is possible, taking the switch lead time into account.

With very small frequency differences or frequency equality, and in compliance with the conditions described above, synchronization also occurs at a phase angle = 0°.

If all conditions are met, the synchronization output changes its state from low to high. After the configured pulse duration has elapsed, it switches from high to low again.

3.5.6.2 Synchro check

In this operating mode, the device can be used as a synchronization control. Output DO4 remains set as long as the following conditions are met:

- Command "-Check" is set by the software.
- The device is ready for operation.
- The directions of rotation of the network to synchronize are OK (direction of rotation detection)
- The configured limit for voltage difference is observed (ΔU_{max}).
- The configured limits for frequency difference are observed (Δf_{max} and Δf_{min}).
- The configured limit for the phase angle is observed (ϕ_{max})

As long as all conditions are met, DO4 remains high.

3.5.6.3 Switching to voltage-free "Dead bus"

Output of the switch on command for the circuit breaker without synchronization if the following conditions are met:

- Command "Dead bus" is set in the software.
- The device is ready for operation.
- The busbar is voltage-free: $U_B < U_{BminSync}$ as a percentage of U_{NomBus}.

U_B ...	Busbar phase voltage
$U_{BminSync}$ ...	Dead bus voltage
U_{NomBus} ...	Nominal busbar voltage

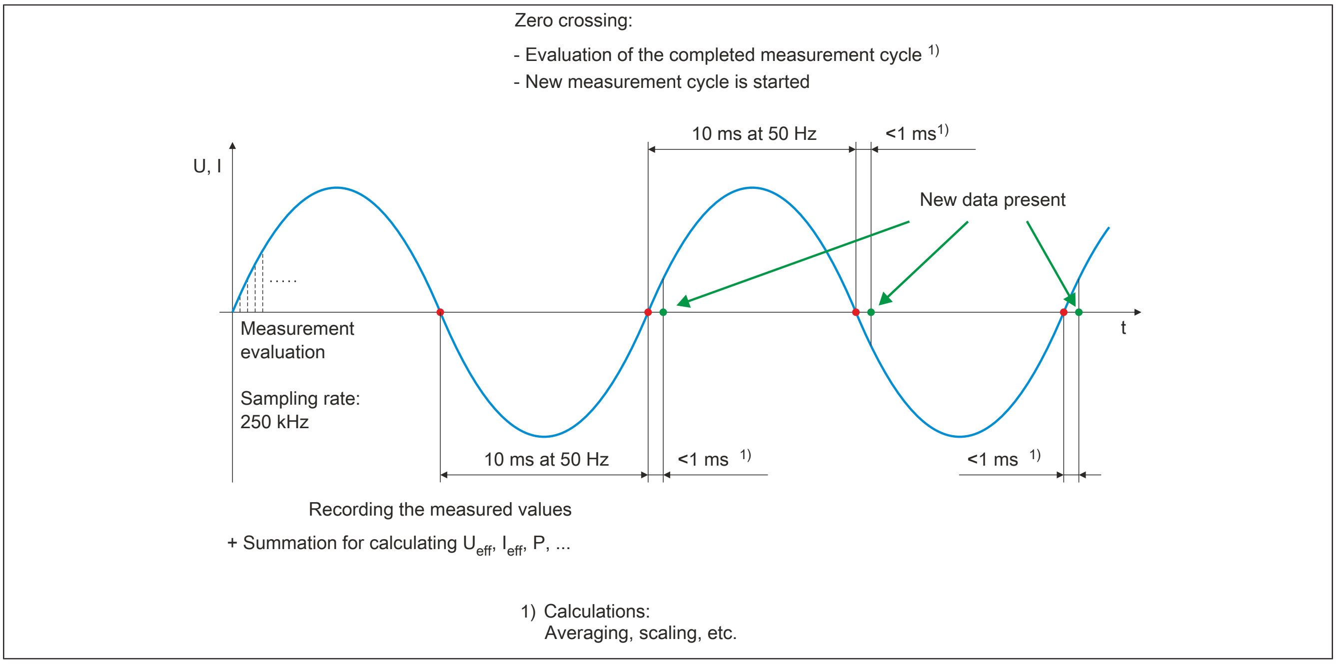
If all conditions are met, DO4 changes its state from low to high. After the configured pulse duration has elapsed, it switches from high to low again.

3.5.7 Synchronization for commissioning tests

> **Information:**
>
> **2-phase synchronization are only permitted to be set for commissioning tests with a 2-phase simulation setup.**
>
> **If only 2 phases are connected, the respective network must be configured with a neutral conductor since a network with a "virtual neutral point" with 2 phases is not possible (see tab "ConfigOutput68" on page 53).**

3.6 Measurement functions

Timing diagram



Measured parameters for generator mains (X3)

- Phase currents
- Mean current value
- Dynamic mean current value
  The dynamic mean value is the amount of change (I_{m_diff}) in the mean current value (sampling time: 10 ms).
  The value decays in an e-function.
  $I_{m\_diff} > I_{m\_dyn} \rightarrow I_{m\_dyn} = I_{m\_diff}$
  $I_{m\_diff} \leq I_{m\_dyn} \rightarrow I_{m\_dyn} = I_{m\_dyn} * 0.98$
- Neutral current
- Line-to-line voltage
- Phase voltages
- Nominal voltage value
- Total apparent performance
- Total reactive power
- Total effective power
- Active power factor
- Frequency

Measured parameters for generator monitoring

- Unbalanced load meter
  Shows the current status of the unbalanced load meter (see "Unbalanced load monitoring" on page 29).
  The unbalanced load counter can be reset with an acyclic trigger bit (see register "ConfigOutput23" on page 54).
- Unbalanced load current

Measured parameters between synchronization networks

- Differential angle
  Specifies by how many degrees the synchronization network is ahead of the network to be synchronized.
- Differential voltage
  Differential voltage between the networks being synchronized.

Measured parameters for busbar, synchronization networks and mains

- Line-to-line voltage
- Phase voltage (not for synchronization network)
- Frequency

3.7 Counter functions

Power measurement mode

Depending on the setting of parameter "Power measurement mode" in register "ConfigOutput21" on page 55, either the total active power or the fundamental active power is added up. Changing parameter "Power measurement mode" during runtime does not restart the internal energy meter.

Pulse value of energy meter output

Output DO2 emits pulses whose frequency is proportional to the measured energy. The measurement is performed according to Power measurement mode. The frequency of the pulses can be adjusted. The length of the pulse is 400 ms. The pulse frequency must be set so that even at the highest possible power, the interval between two pulses is not less than 400 ms. After a restart, the internal counter of the pulse output starts at 0 kWh.

Maximum value and counter memory

Maximum values and counter values are saved:

- Maximum phase current
- Maximum neutral current
- Maximum total power, corresponds to Power measurement mode.
- Active energy meter, corresponds to Power measurement mode.
- Reactive energy meter, corresponds to Power measurement mode.

The maximum values are recorded from the effective measurements before the configurable filter. The maximum values are readable and writable as acyclic registers.

After a restart, the saved maximum values and counter values are reloaded into their registers and the module-internal work counters are reset. It is also possible to reset or write to the saved maximum values and counter values through an acyclic register.

Information:

The registers are described in "Maximum value buffer and power meter" on page 72.

4 Commissioning

4.1 Using the module on the bus controller

Function model 254 "Bus controller" is used by default only by non-configurable bus controllers. All other bus controllers can use other registers and functions depending on the fieldbus used.

For detailed information, see section "Additional information - Using I/O modules on the bus controller" in the X20 user's manual (version 3.50 or later).

5 Register description

5.1 General data points

In addition to the registers described in the register description, the module has additional general data points. These are not module-specific but contain general information such as serial number and hardware variant.

General data points are described in section "Additional information - General data points" in the X20 System user's manual.

5.2 Function model 0 - Standard

Register	Description	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
General registers - Configuration						
2762	ConfigOutput68 (Read) Network settings	UINT		(•)[1]		•
2561	ConfigOutput20 (Read) Nominal voltage range, nominal current range and Aron circuit	USINT		(•)[1]		•
2614	ConfigOutput10 (Read) Nominal frequency (f_{Nom})	UINT		(•)[1]		•
2569	ConfigOutput24 (Read) General configuration register	USINT		(•)[1]		•
2567	ConfigOutput23 (Read) Trigger bits	USINT		(•)[1]		•
Generator network - Configuration						
2582	ConfigOutput02 (Read) Nominal voltage of the generator network ($_{UNomGen}$)	UINT		(•)[1]		•
2598	ConfigOutput06 (Read) Multiplier for the generator network	UINT		(•)[1]		•
2590	ConfigOutput04 (Read) Nominal current of the generator network ($_{INom}$)	UINT		(•)[1]		•
2610	ConfigOutput09 (Read) Multiplier for current transformer	UINT		(•)[1]		•
2563	ConfigOutput21 (Read) Enables/Disables generator network functions	UINT		(•)[1]		•
2746	ConfigOutput41 (Read) Low-pass filter for total power ratings	UINT		(•)[1]		•
Generator monitoring functions - Configuration						
2658	ConfigOutput16 (Read) Overvoltage limit value 1 of the generator network (U_{maxGen})	UINT		(•)[1]		•
2938	ConfigOutput118 (Read) Overvoltage limit value 2 of the generator network (U_{maxGen})	UINT		(•)[1]		•
2706	ConfigOutput26 (Read) Response time 1 for generator overvoltage (U_{maxGen})	UINT		(•)[1]		•
2942	ConfigOutput119 (Read) Response time 2 for generator overvoltage (U_{maxGen})	UINT		(•)[1]		•
2662	ConfigOutput27 (Read) Undervoltage limit value of generator network 1 ($U_{min1Gen}$)	UINT		(•)[1]		•
2702	ConfigOutput59 (Read) Undervoltage limit value of generator network 2 ($U_{min2Gen}$)	UINT		(•)[1]		•
2710	ConfigOutput28 (Read) Response time for generator undervoltage 1 ($U_{min1Gen}$)	UINT		(•)[1]		•
2734	ConfigOutput65 (Read) Response time for generator undervoltage 2 ($U_{min2Gen}$)	UINT		(•)[1]		•
2666	ConfigOutput29 (Read) Generator overfrequency 1 (f_{maxGen})	UINT		(•)[1]		•
2954	ConfigOutput122 (Read) Generator overfrequency 2 (f_{maxGen})	UINT		(•)[1]		•
2714	ConfigOutput30 (Read) Response time 1 for generator overfrequency (f_{maxGen})	UINT		(•)[1]		•
2958	ConfigOutput123 (Read) Response time 2 for generator overfrequency (f_{maxGen})	UINT		(•)[1]		•
2670	ConfigOutput31 (Read) Generator underfrequency 1 (f_{minGen})	UINT		(•)[1]		•
2946	ConfigOutput120 (Read) Generator underfrequency 2 (f_{minGen})	UINT		(•)[1]		•
2718	ConfigOutput32 (Read) Response time 1 for generator underfrequency (f_{minGen})	UINT		(•)[1]		•

Register description

Register	Description	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
2950	ConfigOutput121 (Read) Response time 2 for generator underfrequency (f_{minGen})	UINT		(•)[1)]		•
2674	ConfigOutput33 (Read) Generator voltage unbalance (U_{asGen})	UINT		(•)[1)]		•
2722	ConfigOutput34 (Read) Response time for the generator voltage unbalance (U_{asGen})	UINT		(•)[1)]		•
2742	ConfigOutput35 (Read) Load time constant for current unbalance	UINT		(•)[1)]		•
2902	ConfigOutput109 (Read) Unbalanced load constant	UINT		(•)[1)]		•
2962	ConfigOutput124 (Read) Nominal current of the generator network for unbalanced load protection	UINT		(•)[1)]		•
2678	ConfigOutput36 (Read) Maximum limit value of neutral current	UINT		(•)[1)]		•
2726	ConfigOutput37 (Read) Response time for neutral current monitoring	UINT		(•)[1)]		•
2682	ConfigOutput38 (Read) Short-circuit current	UINT		(•)[1)]		•
2730	ConfigOutput39 (Read) Response time for short-circuit current	UINT		(•)[1)]		•
2686	ConfigOutput42 (Read) Dependent overcurrent	UINT		(•)[1)]		•
2690	ConfigOutput43 (Read) Time factor setting (iths) for dependent overcurrent	UINT		(•)[1)]		•
2694	ConfigOutput44 (Read) Capacitive reactive power	UINT		(•)[1)]		•
2738	ConfigOutput45 (Read) Response time for reactive power monitoring	UINT		(•)[1)]		•
2830	ConfigOutput89 (Read) Generator overload	UINT		(•)[1)]		•
2834	ConfigOutput90 (Read) Response time for generator overload	UINT		(•)[1)]		•
2838	ConfigOutput91 (Read) Generator feedback	UINT		(•)[1)]		•
2842	ConfigOutput92 (Read) Response time for generator feedback	UINT		(•)[1)]		•
3026	ConfigOutput136 (Read) Tripping characteristic for dependent overcurrent	UINT		(•)[1)]		•
	Function DO1					
2698	ConfigOutput57 (Read) Monitoring functions - 1	UINT		(•)[1)]		•
2854	ConfigOutput97 (Read) Monitoring functions - 2	UINT		(•)[1)]		•
Synchronization networks (for network configuration "Synchronization network 1 / Synchronization network 2") - Configuration						
2578	ConfigOutput01 (Read) Nominal voltage of the synchronization networks (${}_{UNomSyn}$)	UINT		(•)[1)]		•
2602	ConfigOutput07 (Read) Multiplier for synchronization network 1	UINT		(•)[1)]		•
2606	ConfigOutput08 (Read) Multiplier for synchronization network 2	UINT		(•)[1)]		•
Network (for network configuration "3-phase network") - Configuration						
2578	ConfigOutput01 (Read) Nominal voltage of the network (U_{NomNet})	UINT		(•)[1)]		•
2602	ConfigOutput07 (Read) Multiplier for the network	UINT		(•)[1)]		•
2565	ConfigOutput22 (Read) Enables/Disables network functions	UINT		(•)[1)]		•
Network monitoring functions (for network configuration "3-phase network") - Configuration						
	Network voltage monitoring					
2766	ConfigOutput73 (Read) Overvoltage limit value 1 of the network (U_{maxNet})	UINT		(•)[1)]		•
2858	ConfigOutput98 (Read) Overvoltage limit value 2 of the network (U_{maxNet})	UINT		(•)[1)]		•
2802	ConfigOutput82 (Read) Response time 1 for network overvoltage (U_{maxNet})	UINT		(•)[1)]		•
2862	ConfigOutput99 (Read) Response time 2 for network overvoltage (U_{maxNet})	UINT		(•)[1)]		•
2774	ConfigOutput75 (Read) Network overfrequency 1 (f_{maxNet})	UINT		(•)[1)]		•
2874	ConfigOutput102 (Read) Network overfrequency 2 (f_{maxNet})	UINT		(•)[1)]		•
2810	ConfigOutput84 (Read) Response time 1 for network overfrequency (f_{maxNet})	UINT		(•)[1)]		•
2878	ConfigOutput103 (Read) Response time 2 for network overfrequency (f_{maxNet})	UINT		(•)[1)]		•
2778	ConfigOutput76 (Read) Network underfrequency 1 (f_{minNet})	UINT		(•)[1)]		•

Register	Description	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
2882	ConfigOutput104 (Read) Network underfrequency 2 (f_{minNet})	UINT		(•)[1]		•
2814	ConfigOutput85 (Read) Response time 1 for network underfrequency (f_{minNet})	UINT		(•)[1]		•
2886	ConfigOutput105 (Read) Response time 2 for network underfrequency (f_{minNet})	UINT		(•)[1]		•
2782	ConfigOutput77 (Read) Network voltage unbalance (U_{asNet})			(•)[1]		•
2818	ConfigOutput86 (Read) Response time for network voltage unbalance (U_{asNet})			(•)[1]		•
	Undervoltage monitoring in 2-point mode					
2770	ConfigOutput74 (Read) Undervoltage limit value 1 of the network (U_{minNet})			(•)[1]		•
2866	ConfigOutput100 (Read) Undervoltage limit value 2 of the network (U_{minNet})			(•)[1]		•
2806	ConfigOutput83 (Read) Response time 1 for network undervoltage (U_{minNet})			(•)[1]		•
2870	ConfigOutput101 (Read) Response time 2 for network undervoltage (U_{minNet})			(•)[1]		•
	Undervoltage monitoring in 6-point mode					
2770	ConfigOutput74 (Read) Undervoltage limit value (U_{minNet}) (1st network)			(•)[1]		•
2866	ConfigOutput100 (Read) Undervoltage limit value (U_{minNet}) (2nd network)			(•)[1]		•
2906	ConfigOutput110 (Read) Undervoltage limit value (U_{minNet}) (3rd network)			(•)[1]		•
2914	ConfigOutput112 (Read) Undervoltage limit value (U_{minNet}) (4th network)			(•)[1]		•
2922	ConfigOutput114 (Read) Undervoltage limit value (U_{minNet}) (5th network)			(•)[1]		•
2930	ConfigOutput116 (Read) Undervoltage limit value (U_{minNet}) (6th network)			(•)[1]		•
2806	ConfigOutput83 (Read) Response time for network undervoltage (U_{minNet}) (1st network)			(•)[1]		•
2870	ConfigOutput101 (Read) Response time for network undervoltage (U_{minNet}) (2nd network)			(•)[1]		•
2910	ConfigOutput111 (Read) Response time for network undervoltage (U_{minNet}) (3rd network)			(•)[1]		•
2918	ConfigOutput113 (Read) Response time for network undervoltage (U_{minNet}) (4th network)			(•)[1]		•
2926	ConfigOutput115 (Read) Response time for network undervoltage (U_{minNet}) (5th network)			(•)[1]		•
2934	ConfigOutput117 (Read) Response time for network undervoltage (U_{minNet}) (6th network)			(•)[1]		•
	Microgrid monitoring					
2890	ConfigOutput106 (Read) Overvoltage limit value of the microgrid (U_{maxNet})	UINT		(•)[1]		•
2894	ConfigOutput107 (Read) Undervoltage limit value of the microgrid (U_{minNet})	UINT		(•)[1]		•
2898	ConfigOutput108 (Read) Response time for the microgrid limit value	UINT		(•)[1]		•
	Phase shift monitoring					
2786	ConfigOutput78 (Read) Maximum phase difference for a single phase	UINT		(•)[1]		•
2790	ConfigOutput79 (Read) Maximum phase difference for three phases	UINT		(•)[1]		•
2826	ConfigOutput88 (Read) Minimum voltage for phase shift monitoring	UINT		(•)[1]		•
	Network frequency change					
2794	ConfigOutput80 (Read) Response value for network frequency change (df/dt)	UINT		(•)[1]		•
2822	ConfigOutput87 (Read) Number of periods for network frequency change (df/dt)	UINT		(•)[1]		•
	Function DO5					
2798	ConfigOutput81 (Read) Monitoring functions	UINT		(•)[1]		•
Busbar - Configuration						
2586	ConfigOutput03 (Read) Nominal voltage of busbar (U_{NomBus})	UINT		(•)[1]		•
2594	ConfigOutput05 (Read) Multiplier for busbar	UINT		(•)[1]		•
2650	ConfigOutput40 (Read) Minimum busbar voltage (U_{Bmin})	UINT		(•)[1]		•

Register description

Register	Description	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
Synchronization - Configuration						
3	ConfigOutputPacked01 Synchronization mode	USINT			•	
2654	ConfigOutput56 (Read) Synchronization configuration	UINT		(•)[1]		•
2626	ConfigOutput11 (Read) Maximum permissible differential frequency (df_{max})	UINT		(•)[1]		•
2630	ConfigOutput12 (Read) Minimum permissible differential frequency (df_{min})	UINT		(•)[1]		•
2634	ConfigOutput13 (Read) Maximum permissible differential voltage (dU_{max})	UINT		(•)[1]		•
2638	ConfigOutput14 (Read) Maximum permissible differential angle (ϕ_{Max})	UINT		(•)[1]		•
2618	ConfigOutput15 (Read) Phase rotation of synchronization network 1 ($d\alpha$)	UINT		(•)[1]		•
2754	ConfigOutput47 (Read) Pulse duration of switch-on relay on DO4	UINT		(•)[1]		•
2758	ConfigOutput48 (Read) Circuit breaker response time on DO4	UINT		(•)[1]		•
2642	ConfigOutput95 (Read) Pulse duration of switch-on relay on DO6	UINT		(•)[1]		•
2646	ConfigOutput96 (Read) Circuit breaker response time on DO6	UINT		(•)[1]		•
2622	ConfigOutput58 (Read) Dead bus voltage ($U_{BminSync}$)	UINT		(•)[1]		•
2846	ConfigOutput93 (Read) 2-phase synchronization for commissioning tests	UINT		(•)[1]		•
Maximum value storage and power meter - Configuration						
2750	ConfigOutput46 (Read) Pulse value of energy meter output	UINT		(•)[1]		•
2850	ConfigOutput94 (Read) Count value for active energy meter and reactive energy meter	UINT		(•)[1]		•
3074	ConfigOutput49 Maximum phase current of generator I1	INT		•		
	ConfigOutput60 Reset maximum phase current I1	INT				•
3078	ConfigOutput50 Maximum phase current I2	INT		•		
	ConfigOutput61 Reset maximum phase current I2	INT				•
3082	ConfigOutput51 Maximum phase current I3	INT		•		
	ConfigOutput62 Resets maximum phase current I3	INT				•
3086	ConfigOutput52 Maximum total active power	INT		•		
	ConfigOutput63 Resets maximum total active power	INT				•
3090	ConfigOutput53 Maximum neutral current	INT		•		
	ConfigOutput64 Resets maximum neutral current	INT				•
3108	ConfigOutput54 Active energy meter for supply	DINT		•		
	ConfigOutput66 Writes to active energy meter for supply	DINT				•
3124	ConfigOutput55 Reactive energy meter for supply	DINT		•		
	ConfigOutput67 Writes to reactive energy meter for supply	DINT				•
3116	ConfigOutput71 Active energy meter for reference	DINT		•		
	ConfigOutput69 Writes to active energy meter for reference	DINT				•
3132	ConfigOutput72 Reactive energy meter for reference	DINT		•		
	ConfigOutput70 Writes to reactive energy meter for reference	DINT				•
General registers - Communication						
1	DigitalOutputPacked01 Digital outputs 05 - 06 and various control bits	USINT			•	
	DigitalOutput05	Bit 0				
	DigitalOutput06	Bit 1				
	ResetGeneratorErrors	Bit 2				
	ResetMainsErrors	Bit 3				
	InvertDO5	Bit 4				

Register	Description	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
165	StatusDigitalOutputPacked01 Status of digital outputs	USINT	•			
	StatusDigitalOutput01	Bit 0				
	...	...				
	StatusDigitalOutput06	Bit 5				
	StatusInput17	Bit 6				
	StatusInput16	Bit 7				
162	StatusInputPacked01 Generator network error register	UINT	•			
	StatusInput01	Bit 0				
	...	...				
	StatusInput11	Bit 10				
	StatusInput31	Bit 11				
	StatusInput32	Bit 12				
	StatusInput18	Bit 15				
167	StatusInputPacked02 Network error register	USINT	•			
	StatusInput24	Bit 0				
	...	...				
	StatusInput30	Bit 6				
	StatusInput33	Bit 7				
186	StatusInputPacked03 General error register	UINT	•			
	StatusInput12	Bit 0				
	...	...				
	StatusInput15	Bit 3				
	StatusInput19	Bit 4				
	...	...				
	StatusInput23	Bit 7				
190	StatusInputPacked04 Network error register (continued)	UINT	•			
	StatusInput34	Bit 0				
	...	...				
	StatusInput37	Bit 4				
194	StatusInputPacked05 Generator network error register (continued)	UINT	•			
	StatusInput38	Bit 0				
	...	...				
	StatusInput40	Bit 2				
Measured values for generator network - Communication						
30	AnalogInput01 Phase current I1	INT	•			
34	AnalogInput02 Phase current I2	INT	•			
38	AnalogInput03 Phase current I3	INT	•			
42	AnalogInput04 Current average I1, I2, I3	INT	•			
46	AnalogInput05 Neutral current In	INT	•			
170	AnalogInput06 Current average, dynamic (Im_dyn)	UINT	•			
2	AnalogInput07 Line-to-line voltage UG12	INT	•			
6	AnalogInput08 Line-to-line voltage UG23	INT	•			
10	AnalogInput09 Line-to-line voltage UG31	INT	•			
18	AnalogInput10 Phase voltage UG1	INT	•			
22	AnalogInput11 Phase voltage UG2	INT	•			
26	AnalogInput12 Phase voltage UG3	INT	•			
14	AnalogInput22 Voltage average UG12, UG23, UG31	INT	•			
174	AnalogInput19 Total active power filtered P/P_H1	INT	•			
178	AnalogInput20 Total reactive power filtered Q/Q_H1	INT	•			
182	AnalogInput21 Total apparent power filtered Q/S_H1	INT	•			
54	AnalogInput23 Power factor of generator/cos ϕ	INT	•			
50	AnalogInput24 Frequency of the generator network	UINT	•			
	Timestamp for generator voltages and currents					

Register description

Register	Description	Data type	Read		Write	
			Cyclic	Acyclic	Cyclic	Acyclic
772	AnalogInput38 Timestamp of positive zero crossing of phase voltage UG1	DINT	•			
780	AnalogInput39 Timestamp of positive zero crossing of phase voltage UG2	DINT	•			
788	AnalogInput40 Timestamp of positive zero crossing of phase voltage UG3	DINT	•			
796	AnalogInput41 Timestamp of positive zero crossing of phase current I1	DINT	•			
804	AnalogInput42 Timestamp of positive zero crossing of phase current I2	DINT	•			
812	AnalogInput43 Timestamp of positive zero crossing of phase current I3	DINT	•			
Generator monitoring functions - Communication						
3330	AnalogInput36 Reads the unbalanced load meter	UINT		•		
3334	AnalogInput37 Reads unbalanced load current I2	INT		•		
Measured values for busbar - Communication						
82	AnalogInput13 Line-to-line voltage of busbar UB12	INT	•			
86	AnalogInput14 Line-to-line voltage of busbar UB23	INT	•			
90	AnalogInput15 Line-to-line voltage of busbar UB31	INT	•			
94	AnalogInput16 Phase voltage of bus bar UB1	INT	•			
98	AnalogInput17 Phase voltage of bus bar UB2	INT	•			
102	AnalogInput18 Phase voltage of bus bar UB3	INT	•			
106	AnalogInput35 Frequency of busbar	UINT	•			
Measured values for synchronization networks (for network configuration "Synchronization network 1 / Synchronization network 2") - Communication						
114	AnalogInput25 Line-to-line voltage of synchronization network 1 US1	INT	•			
134	AnalogInput26 Line-to-line voltage of synchronization network 2 US2	INT	•			
138	AnalogInput27 Frequency of synchronization network 1	UINT	•			
142	AnalogInput28 Frequency of synchronization network 2	UINT	•			
Measured values for network (for network configuration "3-phase network") - Communication						
114	AnalogInput25 Line-to-line voltage of network UN12	INT	•			
118	AnalogInput31 Line-to-line voltage of network UN23	INT	•			
122	AnalogInput32 Line-to-line voltage of network UN31	INT	•			
126	AnalogInput33 Phase voltage of network UN1	INT	•			
130	AnalogInput34 Phase voltage of network UN2	INT	•			
134	AnalogInput26 Phase voltage of network UN3	INT	•			
138	AnalogInput27 Network frequency	UINT	•			
Synchronization - Communication						
146	AnalogInput29 Differential angle between synchronization networks	INT	•			
150	AnalogInput30 Differential voltage between synchronization networks	INT	•			

1) This configuration register has a dual design. The register with "Read" in the name allows the configured value to be read back.

5.3 Configuration registers

5.3.1 General registers

5.3.1.1 Mains settings

Name:
ConfigOutput68
ConfigOutput68Read

This register is used to configure the module according to the connected network. For details, see "Network settings" on page 35.

Data type	Values
UINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0 - 1	Generator mains configuration	00	3-phase network with neutral conductor
		01	3-phase mains without neutral conductor
		10 to 11	Reserved
2 - 3	Busbar configuration	00	3-phase network with neutral conductor
		01	3-phase mains without neutral conductor
		10 to 11	Reserved
4 - 5	Mains configuration	00	3-phase network with neutral conductor
		01	3-phase mains without neutral conductor
		10	Synchronization network 1 / Synchronization network 2
		11	Reserved
6 - 7	Reserved	0	
8 - 9	Generator mains ground	00	No phases grounded
		01	L1 grounded
		10	L2 grounded
		11	L3 grounded
10 - 11	Busbar ground	00	No phases grounded
		01	L1 grounded
		10	L2 grounded
		11	L3 grounded
12 - 13	Grounding of synchronization network 1	00	No phases grounded
		01	L1 grounded
		10	L2 grounded
		11	L3 grounded
14 - 15	Grounding of synchronization network 2	00	No phases grounded
		01	L1 grounded
		10	L2 grounded
		11	L3 grounded

5.3.1.2 Nominal voltage range, nominal current range and Aron circuit

Name:
ConfigOutput20
ConfigOutput20Read

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	Nominal voltage range of generator mains	0	Voltage 100 V
		1	Voltage 400 V
1	Nominal voltage range of busbar	0	Voltage 100 V
		1	Voltage 400 V
2	Nominal voltage range of synchronization network 1	0	Voltage 100 V
		1	Voltage 400 V
3	Nominal voltage range of synchronization network 2	0	Voltage 100 V
		1	Voltage 400 V
4	Nominal current range of the generator mains	0	Current range 1 A
		1	Current range 5 A
5	Switch to power measurement principle of Aron circuit	0	Aron circuit disabled: Three-phase supply with neutral line
		1	Aron circuit enabled: Three-phase supply without neutral line
6 - 7	Reserved	0	

5.3.1.3 Nominal frequency (f_{Nom})

Name:
ConfigOutput10
ConfigOutput10Read

This is needed for converting the percentages based on this nominal value into physical units.

Data type	Value	Information	Resolution
UINT	4800 to 6200	corresponds to 48 to 62 Hz.	0.01 Hz

5.3.1.4 General configuration register

Name:
ConfigOutput24
ConfigOutput24Read

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0 - 1	DO5 function	00	DO5 is freely available to the user
		01	Monitoring output of the mains
		10	DO5 is freely available to the user or can be used as a mains monitoring output (the two signals are linked with an OR)
		11	Reserved
2 - 3	DO6 function	00	DO6 is freely available to the user
		01	Synchronization output (control of power switch)
		10 to 11	Reserved
4	Definition of rotational direction monitoring of all mains	0	Right rotating field
		1	Left rotating field
5 - 7	Reserved	0	

5.3.1.5 Trigger bits

Name:
ConfigOutput23
ConfigOutput23Read

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	Reset unbalanced load meter	0	Unbalanced load meter not set to 0
		1	On rising edge: Unbalanced load meter set to 0
1 - 7	Reserved	0	

5.3.2 Generator mains

5.3.2.1 Nominal voltage of generator mains (U_{NomGen})

Name:
ConfigOutput02
ConfigOutput02Read

This is needed for converting the percentages based on this nominal value into physical units.

Data type	Value	Information	Resolution
UINT	70 to 65000	Corresponds to 70 to 65000 V	1 V

5.3.2.2 Multiplier for generator mains

Name:
ConfigOutput06
ConfigOutput06Read

Used to convert the measured value into the physical quantity. The multiplier is applied to the respective input value.

The value 100 corresponds to a multiplication factor of 1 (measured value not changed).

Data type	Value	Information	Resolution
UINT	1 to 65535	Corresponds to 0.01 to 655.35	0.01

5.3.2.3 Nominal current of generator mains (I_{Nom})

Name:
ConfigOutput04
ConfigOutput04Read

This is needed for converting the percentages based on this nominal value into physical units.

Data type	Value	Information	Resolution
UINT	0 to 65000	Corresponds to 0 to 65000 A	1 A

5.3.2.4 Multiplier for current transformer

Name:
ConfigOutput09
ConfigOutput09Read

Used to convert the measured value into the physical quantity. The multiplier is applied to the respective input value.

Data type	Value	Information	Resolution
UINT	1 to 65535	Corresponds to 1 to 65535	1

5.3.2.5 Turns generator mains functions on/off

Name:
ConfigOutput21
ConfigOutput21Read

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	Error acknowledgment mode	0	Error bits are reset by the module
		1	Error bits are reset by the user
2 - 3	Check all overvoltages and undervoltages[1]	00	3 phase voltages
		01	3 line-to-line voltages
		10	3 line-to-line and 3 phase voltages
		11	Reserved
4	Reserved	0	
5	Enables extended range for Unbalanced load constant (K2)[2]	0	Range 0.08 to 0.15
		1	Range 0.08 to 0.35
6	Power measurement mode[3]	0	Total output - Including the harmonic component
		1	Fundamental power - 1st harmonic only
7	Disabling evaluation of current zero crossings in the event of voltage loss[4]	0	Current zero crossings are evaluated in the event of voltage loss (default).
		1	Current zero crossings are ignored in the event of voltage loss.

1) This parameter is supported starting with upgrade 1.6.0.0 (firmware version 1.02). For the configuration of limit values, see "Generator monitoring" on page 56.
2) This parameter is supported starting with upgrade 2.3.1.0 (firmware version 1.11).
3) This parameter is supported starting with upgrade 1.5.0.0 (firmware version 1.01).
4) This parameter is supported starting with upgrade 2.2.0.0 (firmware version 1.10).

5.3.2.6 Low-pass filter for total power ratings

Name:
ConfigOutput41
ConfigOutput41Read

Parameter for the low-pass filter delay time of the total power P, Q and S or P_H1, Q_H1 and S_H1 (see "Power measurement mode" on page 27).

Data type	Value	Information	Resolution
UINT	0 to 300	Corresponds to 0 to 300 ms	1 ms

5.3.3 Generator monitoring

5.3.3.1 Overvoltage limit of generator mains (Umax)

Name:
ConfigOutput16 (1st value)
ConfigOutput118 (2nd value)
ConfigOutput16Read (1st value)
ConfigOutput118Read (2nd value)

If one of the generator voltages configured in register "ConfigOutput21" on page 55 overshoots the value set here, error message "Overvoltage" or "Overvoltage2" is indicated after the time delay has elapsed.

Data type	Value	Information	Resolution
UINT	0 to 2000	Corresponds to 0 to 200% of U_{NomGen}	0.1%

5.3.3.2
Generator overvoltage response time (U_{max})

Name:
ConfigOutput26 (1st time)
ConfigOutput119 (2nd time)
ConfigOutput26Read (1st time)
ConfigOutput119Read (2nd time)

For triggering, the response value must be continuously overshot for at least as long as specified in this register.

Data type	Value	Information	Resolution
UINT	5 to 100	Corresponds to 0.5 to 10 s	0.1 s

5.3.3.3 Undervoltage limit of generator mains (U_{min})

Name:
ConfigOutput27 (1st value)
ConfigOutput59 (2nd value)
ConfigOutput27Read (1st value)
ConfigOutput59Read (2nd value)

If one of the generator voltages configured in register "ConfigOutput21" on page 55 undershoots the value set here, error message "Undervoltage" or "Undervoltage2" is indicated after the time delay has elapsed.

Data type	Value	Information	Resolution
UINT	0 to 2000	Corresponds to 0 to 200% of U_{NomGen}	0.1%

5.3.3.4 Response time for generator undervoltage (U_{min})

Name:
ConfigOutput28 (1st time)
ConfigOutput65 (2nd time)
ConfigOutput28Read (1st time)
ConfigOutput65Read (2nd time)

For triggering, the response value must be continuously undershot for at least as long as specified in this register.

Data type	Value	Information	Resolution
UINT	5 to 100	Corresponds to 0.5 to 10 s	0.1 s

5.3.3.5 Generator over-frequency (f_{max})

Name:
ConfigOutput29 (1st frequency)
ConfigOutput122 (2nd frequency)
ConfigOutput29Read (1st frequency)
ConfigOutput122Read (2nd frequency)

If the generator frequency overshoots the percentage value set here in relation to the nominal frequency, error message "Overfrequency" or "Overfrequency 2" is indicated after the time delay has elapsed.

Data type	Value	Information	Resolution
UINT	0 to 2000	For 0 to 200% of f_{Nom}	0.1%

5.3.3.6 Response time for generator over-frequency (f_{max})

Name:
ConfigOutput30 (1st time)
ConfigOutput123 (2nd time)
ConfigOutput30Read (1st time)
ConfigOutput123Read (2nd time)

The error is only triggered if the response value is exceeded in the positive direction without interruption for as long as is specified in this register.

Data type	Value	Information	Resolution
UINT	5 to 100	For 0.5 for 10 s	0.1 s

5.3.3.7 Generator under-frequency (f_{min})

Name:
ConfigOutput31 (1st frequency)
ConfigOutput120 (2nd frequency)
ConfigOutput31Read (1st frequency)
ConfigOutput120Read (2nd frequency)

If the generator frequency undershoots the percentage value set here in relation to the nominal frequency, error message "Underfrequency" or "Underfrequency 2" is indicated after the time delay has elapsed.

Data type	Value	Information	Resolution
UINT	0 to 2000	For 0 to 200% of f_{Nom}	0.1%

5.3.3.8 Response time for generator under-frequency (f_{min})

Name:
ConfigOutput32 (1st time)
ConfigOutput121 (2nd time)
ConfigOutput32Read (1st time)
ConfigOutput121Read (2nd time)

The error is only triggered if the response value is exceeded in the negative direction without interruption for as long as is specified in this register.

Data type	Value	Information	Resolution
UINT	5 to 100	For 0.5 to 10 s	0.1 s

5.3.3.9 Generator voltage asymmetry (U_{as})

Name:
ConfigOutput33
ConfigOutput33Read

If one or more line-to-line voltages of the generator network differ from each other by more than the set limit value, error message "Voltage unbalance" is indicated after the time delay has elapsed.

Data type	Value	Information	Resolution
UINT	0 to 300	For 0 to 30% of U_{NomGen}	0.1%

5.3.3.10 Response time for generator voltage asymmetry (U_{as})

Name:
ConfigOutput34
ConfigOutput34Read

This error is triggered only if the response value is exceeded without interruption (in either the positive or negative direction) for as long as is specified in this register.

Data type	Value	Information	Resolution
UINT	5 to 100	For 0.5 to 10 s	0.1 s

5.3.3.11 Load time constant for current asymmetry (K1)

Name:
ConfigOutput35
ConfigOutput35Read

The dependent delayed unbalanced load monitoring (see "Unbalanced load monitoring" on page 29) constantly monitors the AC currents applied by the main current transformers and continuously calculates the current unbalanced load current. This is compared with the threshold value, which is calculated using the load time constants. If this threshold value is overshot, error message "Current unbalance" is indicated.

Data type	Value	Information	Resolution
UINT	1 to 65535	For 0.1 to 6553.5 s	0.1 s

5.3.3.12 Unbalanced load constant (K2)

Name:
ConfigOutput109
ConfigOutput109Read

The limit between continuous operation and short-term operation is defined by the unbalanced load constant K2 (see "Unbalanced load monitoring" on page 29).

Data type	Value	Information	Resolution
UINT	8 to 15 8 to 35	For 0.08 to 0.15 For 0.08 to 0.35[1)]	0.01

1) The extended range is supported starting with upgrade 2.3.1.0 (firmware version 1.11).
For range switching, see register "Turns generator mains functions on/off" on page 55.

5.3.3.13 Nominal current on generator mains for unbalanced load protection

Name:
ConfigOutput124
ConfigOutput124Read

The nominal current for unbalanced load protection can be set separately. If the value is set to 0, the normal nominal current is used for calculations.

Data type	Value	Information	Resolution
UINT	0 to 65000	For 0 to 65000 A	1 A

5.3.3.14 Maximum limit of neutral conductor current

Name:
ConfigOutput36
ConfigOutput36Read

Configurable limit value for the neutral current. If the value is overshot, the error message "Neutral current maximum" is indicated after the defined time delay has elapsed.

Data type	Value	Information	Resolution
UINT	0 to 1000	For 0 to 100% of I_{Nom}	0.1%

5.3.3.15 Response time for neutral conductor current monitor

Name:
ConfigOutput37
ConfigOutput37Read

The error is only triggered if the response value is exceeded in the positive direction without interruption for as long as is specified in this register.

Data type	Value	Information	Resolution
UINT	5 to 100	For 0.5 to 10 s	0.1 s

5.3.3.16 Short circuit current

Name:
ConfigOutput38
ConfigOutput38Read

If the value of the generator current rises above the defined percentage value in relation to the rated transformer current, error message "Short-circuit current" is indicated after the defined time delay has elapsed.

Data type	Value	Information	Resolution
UINT	1000 to 5000	For 100 to 500% of I_{Nom}	0.1%

5.3.3.17 Response time for short circuit current

Name:
ConfigOutput39
ConfigOutput39Read

The error is only triggered if the response value is exceeded in the positive direction without interruption for as long as is specified in this register.

Data type	Value	Information	Resolution
UINT	4 to 500	For 0.04 to 5 s	0.01 s

5.3.3.18 Dependent overcurrent

Name:
ConfigOutput42
ConfigOutput42Read

The response value percentage is based on the nominal current of the generator. If the response value is overshot, error message "Dependent overcurrent" is indicated.

Data type	Value	Information	Resolution
UINT	1000 to 2000	For 100 to 200% of I_{Nom}	0.1%

5.3.3.19 Time factor setting (iths) for dependent overcurrent

Name:
ConfigOutput43
ConfigOutput43Read

Time factor setting iths is needed to calculate the "Tripping characteristic for dependent overcurrent" on page 61.

Data type	Value	Information	Resolution
UINT	1 to 20	For 0.1 to 2	0.1

5.3.3.20 Capacitive reactive power

Name:
ConfigOutput44
ConfigOutput44Read

The reactive power is capacitively monitored for undershooting the defined response value. The monitoring of the capacitive reactive power can be used as exciter failure detection. If the value undershoots the response value, error message "Capacitive reactive power" is indicated after the set time delay has elapsed.

Data type	Value	Information	Resolution
INT	-32768 to 32767	For -32768 to 32767 kvar	1 kvar

5.3.3.21 Response time for reactive power monitoring

Name:
ConfigOutput45
ConfigOutput45Read

The error is only triggered if the response value is exceeded in the positive direction without interruption for as long as is specified in this register.

Data type	Value	Information	Resolution
UINT	5 to 100	For 0.5 to 10 s	0.1 s

5.3.3.22 Generator overload

Name:
ConfigOutput89
ConfigOutput89Read

If the generator active power overshoots the percentage value set here in relation to the nominal power of the generator, error message "Generator overload" is indicated after the time delay has elapsed.

Depending on how the "Power measurement mode" parameter is set in the "ConfigOutput21" on page 55 register, either the total active power or the fundamental frequency active power is compared with the response value.

The nominal power is calculated as follows:

$P_{NomGen} = U_{NomGen} * I_{NomGen} * \sqrt{3}$

Data type	Value	Information	Resolution
UINT	0 to 2000	For 0 to 200% of P_{NomGen}	0.1%

5.3.3.23 Response time for generator overload

Name:
ConfigOutput90
ConfigOutput90Read

The error is only triggered if the response value is exceeded in the positive direction without interruption for as long as is specified in this register.

Data type	Value	Information	Resolution
UINT	5 to 100	For 0.5 to 10 s	0.1 s

5.3.3.24 Generator feedback

Name:
ConfigOutput91
ConfigOutput91Read

If the negative generator active power undershoots the percentage value set here in relation to the nominal power of the generator, error message "Generator feedback" is indicated after the time delay has elapsed.

Depending on how the "Power measurement mode" parameter is set in the "ConfigOutput21" on page 55 register, either the total active power or the fundamental frequency active power is compared with the response value.

The nominal power is calculated as follows:

$P_{NomGen} = U_{NomGen} * I_{NomGen *} \sqrt{3}$

Data type	Value	Information	Resolution
UINT	0 to 2000	0 to 200% of P_{NomGen}	0.1%

5.3.3.25 Response time for generator feedback

Name:
ConfigOutput92
ConfigOutput92Read

The error is only triggered if the response value is exceeded in the negative direction without interruption for as long as is specified in this register.

Data type	Value	Information	Resolution
UINT	5 to 100	For 0.5 to 10 s	0.1 s

5.3.3.26 Tripping characteristic for dependent overcurrent

Name:
ConfigOutput136
ConfigOutput136Read

To calculate the tripping instant, the sampling duration of the measurement system is divided by the calculated tripping time (t). The results are continually added up. If the summand reaches the value 1 (100%), then the maximum permissible value has been reached. The summand is limited between 0 and 1.

Data type	Values	Information
UINT	0	Normally inverse (default)
	1	Very inverse
	2	Extremely inverse

5.3.3.27 Function DO1

5.3.3.27.1 Assigning monitoring functions - 1

Name:
ConfigOutput57
ConfigOutput57Read

The following monitoring functions can be assigned to the monitoring relay using this register:

Data type	Values
UINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	Overvoltage (of a phase)	0	Do not assign function
		1	Assign function
1	Undervoltage (of a phase)	0	Do not assign function
		1	Assign function
2	Overfrequency	0	Do not assign function
		1	Assign function
3	Underfrequency	0	Do not assign function
		1	Assign function
4	Voltage asymmetry	0	Do not assign function
		1	Assign function
5	Current asymmetry (unbalanced load)	0	Do not assign function
		1	Assign function
6	Neutral conductor current, maximum	0	Do not assign function
		1	Assign function
7	Short circuit current	0	Do not assign function
		1	Assign function
8	Dependent overcurrent	0	Do not assign function
		1	Assign function
9	Capacitive reactive power (exciter failure)	0	Do not assign function
		1	Assign function
10	Ready	0	Do not assign function
		1	Assign function
11	Generator overload	0	Do not assign function
		1	Assign function
12	Generator feedback	0	Do not assign function
		1	Assign function
13 - 14	Reserved	0	
15	Undervoltage 2 (one phase)	0	Do not assign function
		1	Assign function

5.3.3.27.2 Assigning monitoring functions - 2

Name:
ConfigOutput97
ConfigOutput97Read

The following additional monitoring functions can be assigned to the monitoring relay using this register:

Data type	Values
UINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	Overvoltage 2 (one phase)	0	Do not assign function
		1	Assign function
1	Underfrequency 2	0	Do not assign function
		1	Assign function
2	Overfrequency 2	0	Do not assign function
		1	Assign function
3 - 15	Reserved	0	

5.3.4 Synchronization mains

(for network configuration "Synchronization network 1 / Synchronization network 2")

5.3.4.1 Nominal voltage of synchronization mains (U_{NomSyn})

Name:
ConfigOutput01
ConfigOutput01Read

This is needed for converting the percentages based on this nominal value into physical units.

Data type	Value	Information	Resolution
UINT	70 to 65000	For 70 to 65000 V	1 V

5.3.4.2 Multiplier for synchronization mains

Name:
ConfigOutput07 (mains 1)
ConfigOutput08 (mains 2)
ConfigOutput07Read (mains 1)
ConfigOutput08Read (mains 2)

Used to convert the measured value into the physical quantity. The multiplier is applied to the respective input value.

100 means a multiplier factor of 1 (measured value not changed).

Data type	Value	Information	Resolution
UINT	1 to 65535	For 0.01 to 655.35	0.01

5.3.5 Mains

Mains (for mains configuration "3-phase mains")

5.3.5.1 Nominal voltage of mains ($U_{NomMains}$)

Name:
ConfigOutput01
ConfigOutput01Read

This is needed for converting the percentages based on this nominal value into physical units.

Data type	Value	Information	Resolution
UINT	70 to 65000	For 70 to 65000 V	1 V

5.3.5.2 Multiplier for mains

Name:
ConfigOutput07
ConfigOutput07Read

Used to convert the measured value into the physical quantity. The multiplier is applied to the respective input value.

100 means a multiplier factor of 1 (measured value not changed).

Data type	Value	Information	Resolution
UINT	1 to 65535	For 0.01 to 655.35	0.01

5.3.5.3 Enable/disable mains functions

Name:
ConfigOutput22
ConfigOutput22Read

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	Error acknowledgment mode	0	Mains error bits are reset by the module
		1	Mains error bits are reset by the user
1	Phase shift measurement	0	Three-phase only
		1	Single- or three-phase
2 - 3	Check all overvoltages and undervoltages[1)]	00	3 phase voltages
		01	3 line-to-line voltages
		10	3 line-to-line and 3 phase voltages
		11	Reserved
4	Configuration of undervoltage monitoring	0	2-point mode
		1	6-point mode
5 - 7	Reserved	0	

1) This parameter is supported starting with upgrade 1.6.0.0 (firmware version 102). For information about configuring limit values, see "Mains voltage monitoring" on page 64.

5.3.6 Mains monitoring functions

(for "3-phase mains" configuration)

The following mains monitoring functions are available if the network configuration is set to a 3-phase mains (see register "Mains settings" on page 53).

5.3.6.1 Mains voltage monitoring

5.3.6.1.1 Overvoltage limit of the mains ($U_{maxMains}$)

Name:
ConfigOutput73 (1st value)
ConfigOutput98 (2nd value)
ConfigOutput73Read (1st value)
ConfigOutput98Read (2nd value)

If one of the mains voltages configured in register "ConfigOutput22" on page 63 overshoots the value set here, error message "Overvoltage" or "Overvoltage 2" is indicated after the time delay has elapsed.

Data type	Value	Information	Resolution
UINT	0 to 2000	For 0 to 200% of $U_{NomMains}$	0.1%

5.3.6.1.2 Response time for mains overvoltage ($U_{MaxMains}$)

Name:
ConfigOutput82 (1st time)
ConfigOutput99 (2nd time)
ConfigOutput82Read (1st time)
ConfigOutput99Read (2nd time)

The error is only triggered if the response value is exceeded in the positive direction without interruption for as long as is specified in this register.

Data type	Value	Information	Resolution
UINT	5 to 60000	For 0.005 to 60 s	0.001 s

5.3.6.1.3 Mains over-frequency ($f_{maxMains}$)

Name:
ConfigOutput75 (1st frequency)
ConfigOutput102 (2nd frequency)
ConfigOutput75Read (1st frequency)
ConfigOutput102Read (2nd frequency)

If the mains frequency overshoots the percentage value set here in relation to the nominal frequency, error message "Overfrequency" or "Overfrequency 2" is indicated after the time delay has elapsed.

Data type	Value	Information	Resolution
UINT	0 to 2000	For 0 to 200% of f_{Nom}	0.1%

5.3.6.1.4 Response time for mains over-frequency ($f_{maxMains}$)

Name:
ConfigOutput84 (1st time)
ConfigOutput103 (2nd time)
ConfigOutput84Read (1st time)
ConfigOutput103Read (2nd time)

The error is only triggered if the response value is exceeded in the positive direction without interruption for as long as is specified in this register.

Data type	Value	Information	Resolution
UINT	5 to 60000	For 0.005 to 60 s	0.001 s

5.3.6.1.5 Mains under-frequency ($f_{minMains}$)

Name:
ConfigOutput76 (1st frequency)
ConfigOutput104 (2nd frequency)
ConfigOutput76Read (1st frequency)
ConfigOutput104Read (2nd frequency)

If the mains frequency undershoots the percentage value set here in relation to the nominal frequency, error message "Underfrequency" or "Underfrequency 2" is indicated after the time delay has elapsed.

Data type	Value	Information	Resolution
UINT	0 to 2000	For 0 to 200% of f_{Nom}	0.1%

5.3.6.1.6 Response time for mains under-frequency ($f_{minMains}$)

Name:
ConfigOutput85 (1st time)
ConfigOutput105 (2nd time)
ConfigOutput85Read (1st time)
ConfigOutput105Read (2nd time)

The error is only triggered if the response value is exceeded in the negative direction without interruption for as long as is specified in this register.

Data type	Value	Information	Resolution
UINT	5 to 60000	For 0.005 to 60 s	0.001 s

5.3.6.1.7 Mains voltage asymmetry ($U_{asMains}$)

Name:
ConfigOutput77
ConfigOutput77Read

The tripping value, which can be set as a percentage, is based on the nominal voltage of the mains. If the 3 line-to-line voltages of the network differ from one another by more than the defined limit value, error message "Voltage unbalance" is indicated after the time delay has elapsed.

Data type	Value	Information	Resolution
UINT	0 to 300	For 0 to 30% of $U_{NomMains}$	0.1%

5.3.6.1.8 Response time for the mains voltage asymmetry ($U_{asMains}$)

Name:
ConfigOutput86
ConfigOutput86Read

This error is triggered only if the response value is exceeded without interruption (in either the positive or negative direction) for as long as is specified in this register.

Data type	Value	Information	Resolution
UINT	5 to 100	For 0.005 to 0.1 s	0.001 s

5.3.6.2 Undervoltage monitoring in 2-point mode

2 independent limit values and response times can be defined for undervoltage monitoring.

5.3.6.2.1 Undervoltage limit 1 of the network (U_{minNet})

Name:
ConfigOutput74
ConfigOutput74Read

If one of the mains voltages configured in register "ConfigOutput22" on page 63 undershoots the value set here, error message "Undervoltage" is indicated after the time delay has elapsed.

Data type	Value	Information	Resolution
UINT	0 to 2000	For 0 to 200% of $U_{NomMains}$	0.1%

5.3.6.2.2 Undervoltage limit 2 of the mains ($U_{minMains}$)

Name:
ConfigOutput100
ConfigOutput100Read

If one of the concatenated mains voltages undershoots the value set here, error message "Undervoltage" is indicated after the time delay has elapsed.

Data type	Value	Information	Resolution
UINT	0 to 2000	0 to 200% of $U_{NomMains}$	0.1%

5.3.6.2.3 Response time for mains undervoltage ($U_{minMains}$)

Name:
ConfigOutput83 (1st time)
ConfigOutput101 (2nd time)
ConfigOutput83Read (1st time)
ConfigOutput101Read (2nd time)

The error is only triggered if the response value is exceeded in the negative direction without interruption for as long as is specified in this register.

Data type	Value	Information	Resolution
UINT	5 to 60000	For 0.005 to 60 s	0.001 s

5.3.6.3 Undervoltage monitoring in 6-point mode

It is possible to define up to 6 limit values and response times for undervoltage monitoring.

5.3.6.3.1 Undervoltage limit of the microgrid ($U_{MinMains}$)

Name:
ConfigOutput74 (1st mains)
ConfigOutput100 (2nd mains)
ConfigOutput110 (3rd mains)
ConfigOutput112 (4th mains)
ConfigOutput114 (5th mains)
ConfigOutput116 (6th mains)
ConfigOutput74Read (1st mains)
ConfigOutput100Read (2nd mains)
ConfigOutput110Read (3rd mains)
ConfigOutput112Read (4th mains)
ConfigOutput114Read (5th mains)
ConfigOutput115Read (6th mains)

Data type	Value	Information	Resolution
UINT	0 to 2000	0 to 200% of $U_{NomMains}$	0.1%

5.3.6.3.2 Response time for mains undervoltage ($U_{minMains}$)

Name:
ConfigOutput83 (1st mains)
ConfigOutput101 (2nd mains)
ConfigOutput111 (3rd mains)
ConfigOutput113 (4th mains)
ConfigOutput115 (5th mains)
ConfigOutput117 (6th mains)
ConfigOutput83Read (1st mains)
ConfigOutput101Read (2nd mains)
ConfigOutput111Read (3rd mains)
ConfigOutput113Read (4th mains)
ConfigOutput115Read (5th mains)
ConfigOutput117Read (6th mains)

Data type	Value	Information	Resolution
UINT	5 to 60000	For 0.005 to 60 s	0.001 s

5.3.6.4 Microgrid monitoring

Microgrid (autonomous network) is a small power grid that only supplies a small area and is usually not connected to other power grids, i.e. it can operate autonomously.

5.3.6.4.1 Overvoltage limit of the mains ($U_{maxMains}$)

Name:
ConfigOutput106
ConfigOutput106Read

If one of the concatenated mains voltages overshoots the value set here, error message "Standalone mains monitoring" is indicated after the time delay has elapsed.

Data type	Value	Information	Resolution
UINT	0 to 2000	0 to 200% of $U_{NomMains}$	0.1%

5.3.6.4.2 Undervoltage limit of the mains ($U_{minMains}$)

Name:
ConfigOutput107
ConfigOutput107Read

If one of the interlinked mains voltages undershoots the value set here, error message "Standalone mains monitoring" is indicated after the time delay has elapsed.

Data type	Value	Information	Resolution
UINT	0 to 2000	For 0 to 200% of $U_{NomMains}$	0.1%

5.3.6.4.3 Response time for microgrid limit

Name:
ConfigOutput108
ConfigOutput108Read

An error is triggered only if the response value is exceeded without interruption (in either the positive or negative direction) for as long as is specified in this register.

Data type	Value	Information	Resolution
UINT	5 to 200	For 0.005 to 0.2 s	0.001 s

5.3.6.5 Phase shift monitoring

A phase shift is a sudden change in the voltage curve. It can be caused by a large change in the load.

5.3.6.5.1 Maximum phase difference for a single phase

Name:
ConfigOutput78
ConfigOutput78Read

Triggering occurs if the electrical angle of the voltage curve shifts by more than the set angle on at least one phase.

Data type	Value	Information	Resolution
UINT	0 to 990	For 0 to 99°	0.1°

5.3.6.5.2 Maximum phase difference for three phases

Name:
ConfigOutput79
ConfigOutput79Read

Triggering occurs if the electrical angle of the voltage curve shifts by more than the set angle on all 3 phases.

Data type	Value	Information	Resolution
UINT	0 to 990	For 0 to 99°	0.1°

5.3.6.5.3 Minimum voltage for phase shift monitoring

Name:
ConfigOutput88
ConfigOutput88Read

A minimum voltage can be set. Phase shift monitoring is only active if the voltage on all 3 phases exceeds this value.

Data type	Value	Information	Resolution
UINT	0 to 2000	For 0 to 200% of $U_{NomMains}$	0.1%

5.3.6.6 Network frequency change

5.3.6.6.1 Response value for mains frequency change (df/dt)

Name:
ConfigOutput80
ConfigOutput80Read

For df/dt monitoring, the frequency change in each period is compared to the previous period.

If this value overshoots the limit value set here for the specified number of periods in each of the periods and if the sign of the frequency change is always the same, error message "Df/dt (mains frequency change)" is indicated.

Data type	Value	Information	Resolution
UINT	0 to 1000	For 0 to 100 Hz/s	0.1 Hz/s

5.3.6.6.2 Number of periods for mains frequency change (df/dt)

Name:
ConfigOutput87
ConfigOutput87Read

The number of periods for monitoring the mains frequency change is set in this register. For triggering, the response value must be overshot continuously for at least as many periods as specified in this register.

Data type	Value	Information	Resolution
UINT	1 to 250	-	-

5.3.6.7 DO5 function

5.3.6.7.1 Assigning monitoring functions

Name:
ConfigOutput81
ConfigOutput81Read

This digital output can be set after the defined response time has elapsed depending on the assignment of the mains' monitoring variables.

Data type	Values
UINT	See the bit structure.

Bit structure:

Bit	Description	Value	Error notification
0	Overvoltage (of a phase)	0	Do not assign function
		1	Assign function
1	Undervoltage (of a phase)	0	Do not assign function
		1	Assign function
2	Overfrequency	0	Do not assign function
		1	Assign function
3	Underfrequency	0	Do not assign function
		1	Assign function
4	Voltage asymmetry	0	Do not assign function
		1	Assign function
5	Phase shift - 1-/3-phase	0	Do not assign function
		1	Assign function
6	Df/dt exceeded	0	Do not assign function
		1	Assign function
7	Undervoltage 2 (of a phase)	0	Do not assign function
		1	Assign function
8	Overvoltage 2 (of a phase)	0	Do not assign function
		1	Assign function
9	Underfrequency 2	0	Do not assign function
		1	Assign function
10	Overfrequency 2	0	Do not assign function
		1	Assign function
11	Microgrid monitoring	0	Do not assign function
		1	Assign function
12 - 15	Reserved	-	

5.3.7 Busbar

5.3.7.1 Busbar nominal voltage (U_{NomBus})

Name:
ConfigOutput03
ConfigOutput03Read

This is needed for converting the percentages based on this nominal value into physical units.

Data type	Value	Information	Resolution
UINT	70 to 65000	For 70 to 65000 V	1 V

5.3.7.2 Multiplier for busbar

Name:
ConfigOutput05
ConfigOutput05Read

Used to convert the measured value into the physical quantity. The multiplier is applied to the respective input value.

100 thus means a multiplier factor of 1 (measured value not changed).

Data type	Value	Information	Resolution
UINT	1 to 65535	For 0.01 to 655.35	0.01

5.3.7.3 Minimum busbar voltage (U_{Bmin})

Name:
ConfigOutput40
ConfigOutput40Read

Configurable threshold for zero voltage monitoring of the busbar based on the nominal voltage of the busbar. DO3 is set when the configured threshold is undershot.

Data type	Value	Information	Resolution
UINT	0 to 1000	For 0 to 100% of U_{NomBus}	0.1%

5.3.8 Synchronization

5.3.8.1 Synchronization mode

Name:
ConfigOutputPacked01
ConfigOutput17 to ConfigOutput19

If multiple mode bits are set at the same time, then no mode will be selected (type BOOL).

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	ConfigOutput17	0	Synchronization mode ≠ Slip
		1	Synchronization mode = Slip
1	ConfigOutput18	0	Synchronization mode ≠ Check
		1	Synchronization mode = Check
2	ConfigOutput19	0	Synchronization mode ≠ Dead bus
		1	Synchronization mode = Dead bus
3 - 7	Reserved	-	

5.3.8.2 Synchronization configuration

Name:
ConfigOutput56
ConfigOutput56Read

This register contains parameters for configuring which mains or voltages should be synchronized with each other.

Data type	Values
UINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0 - 1	Synchronization configuration (synchronization mains - mains being synchronized)	00	X4 - X6: Synchronization mains 1 - Synchronization mains 2
		01	X4 - X5: Synchronization mains 1 - Busbar
		10	X4 - X3: Synchronization mains 1 - Generator
		11	X5 - X3: Busbar - Generator
2 - 7	Reserved	0	
8	Synchronization output	0	Digital output 4
		1	Digital output 6 - output must be configured as a synchronization output.
9 - 15	Reserved	0	

5.3.8.3 Max. differential frequency (df_{max})

Name:
ConfigOutput11
ConfigOutput11Read

The requirement for outputting a switch-on command on the DO4 is that the frequency undershoots this differential frequency setting. This value specifies the upper frequency.

Data type	Value	Information	Resolution
UINT	2 to 49	For 0.02 to 0.49 Hz	0.01 Hz

5.3.8.4 Min. differential frequency (df_{min})

Name:
ConfigOutput12
ConfigOutput12Read

The requirement for outputting a switch-on command on the DO4 is that the frequency overshoots this differential frequency setting. This value specifies the lower frequency.

Data type	Value	Information	Resolution
INT	-49 to 0	For -0.49 to 0 Hz	0.01 Hz

5.3.8.5 Max. differential voltage (dU_{max})

Name:
ConfigOutput13
ConfigOutput13Read

A switch-on command on DO4 is only output if this configured differential voltage percentage based on the synchronization mains' nominal voltage is not exceeded.

Data type	Value	Information	Resolution
UINT	1 to 300	For 0.1 to 30% of U_{NomSyn}	0.1%

5.3.8.6 Max. permitted differential angle (ϕ_{Max})

Name:
ConfigOutput14
ConfigOutput14Read

A switch-on command on DO4 is only output if the configured differential angle between the two synchronization mains is not exceeded.

Data type	Value	Information	Resolution
UINT	1 to 600	For 0.1 to 60°	0.1°

5.3.8.7 Phase rotation of synchronization network 1 (dα)

Name:
ConfigOutput15
ConfigOutput15Read

This parameter specifies how many degrees the synchronization mains lags behind the mains being synchronized.

Data type	Value	Information	Resolution
UINT	0 to 3600	For 0 to 360°	0.1°

5.3.8.8 Pulse duration of the switch-on relay

Name:
ConfigOutput47 (DO4)
ConfigOutput95 (DO6)
ConfigOutput47Read (DO4)
ConfigOutput95Read (DO6)

The duration of the switch-on pulse can be adjusted for the following switching units.

Data type	Values	Information	Resolution
UINT	40 to 1000	For 0.04 to 1 s	0.001 s

5.3.8.9 Switching response time of the power switch

Name:
ConfigOutput48 (DO4)
ConfigOutput96 (DO6)
ConfigOutput48Read (DO4)
ConfigOutput96Read (DO6)

The actuation time of the generator power switch corresponds to the lead time of the switch-on command. The switch-on command is executed before the point of synchronization according to the amount of time defined here.

Data type	Value	Information	Resolution
UINT	40 to 300	For 0.04 to 0.3 s	0.001 s

5.3.8.10 Dead bus voltage ($U_{BminSync}$)

Name:
ConfigOutput58
ConfigOutput58Read

Configurable threshold for dead bus synchronization based on the nominal voltage of the busbar.

Data type	Value	Information	Resolution
UINT	0 to 1000	For 0 to 100% of U_{NomBus}	0.1%

5.3.8.11 2-phase synchronization for commissioning tests

Name:
ConfigOutput93
ConfigOutput93Read

2-phase synchronization for commissioning tests.

Data type	Values
UINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	Synchronization	0	3-phase synchronization (normal operation)
		1	2-phase synchronization with L1 and L2 (commissioning tests with 2-phase simulation design)
1 - 7	Reserved	0	

5.3.9 Maximum value buffer and power meter

5.3.9.1 Pulse value of energy meter output

Name:
ConfigOutput46
ConfigOutput46Read

Output DO2 emits pulses whose frequency is proportional to the measured energy. For details, see "Pulse value of energy meter output" on page 45. This register has no effect on registers "ConfigOutput54" on page 73 and "ConfigOutput55" on page 74.

When set to 0, meter output is disabled.

Data type	Value	Information	Resolution
UINT	0 to 65535	For 0 to 65535 kWh/pulse	1 kWh/pulse

5.3.9.2 Count value for active energy meter and reactive energy meter

Name:
ConfigOutput94
ConfigOutput94Read

This parameter is used to configure the resolution of active and reactive energy counters.

Data type	Value	Information	Resolution
UINT	0 to 65535	-	1 kWh

5.3.9.3 Maximum value buffer and meter buffer

These registers are used for nonvolatile storage of the maximum value and meter level values. After restarting, the stored maximum values and meter states are loaded back into their registers and the module's internal work meter is reset. It is possible to reset or write to the stored maximum values and meter states using an acyclic register.

The maximum values are recorded from the effective measured values before the configurable filter. The maximum values are readable and writable as acyclic registers.

5.3.9.3.1 Maximum phase current

Name:
Reading: ConfigOutput49 (generator I1)
Reading: ConfigOutput50 (generator I2)
Reading: ConfigOutput51 (generator I3)
Writing: ConfigOutput60 (generator I1)
Writing: ConfigOutput61 (generator I2)
Writing: ConfigOutput62 (generator I3)

Data type	Value	Information	Resolution
INT	-32768 to 32767	-	1 A

5.3.9.3.2 Maximum total active power (supplied power)

Name:
Reading: ConfigOutput52
Writing: ConfigOutput63

Depending on the status of the "Power measurement mode" parameter in the "ConfigOutput21" on page 55 register, either the total power or the fundamental power is added together or compared.

Data type	Value	Information	Resolution
INT	-32768 to 32767	-	1 kW

5.3.9.3.3 Maximum neutral conductor current

Name:
Reading: ConfigOutput53
Writing: ConfigOutput64

Data type	Value	Information	Resolution
INT	-32768 to 32767	-	1 A

5.3.9.3.4 Active energy counter

Name:
Reading: ConfigOutput54 (delivered (producing))
Reading: ConfigOutput71 (drawn (consuming))
Writing: ConfigOutput66 (delivered (producing))
Writing: ConfigOutput69 (drawn (consuming))

Depending on the status of the "Power measurement mode" parameter in the "ConfigOutput21" on page 55 register, either the total power or the fundamental power is added together or compared.

The resolution can be configured (see register "ConfigOutput94" on page 72).

Data type	Value	Information	Resolution
DINT	-2,147,483,648 to 2,147,483,647	-	Default: 100 kWh

5.3.9.3.5 Reactive energy counter

Name:
Reading: ConfigOutput55 (reactive energy meter delivered (producing))
Reading: ConfigOutput72 (reactive energy meter drawn (consuming))
Writing: ConfigOutput67 (reactive energy meter delivered (producing))
Writing: ConfigOutput70 (reactive energy meter drawn (consuming))

Depending on the status of the "Power measurement mode" parameter in the "ConfigOutput21" on page 55 register, either the total power or the fundamental power is added together or compared.

The resolution can be configured (see register "ConfigOutput94" on page 72).

Data type	Value	Information	Resolution
DINT	-2,147,483,648 to 2,147,483,647	-	Default: 100 kvarh

5.4 Communication registers

5.4.1 General registers

5.4.1.1 Digital outputs 05 - 06 and various control bits

Name:
DigitalOutputPacked01
DigitalOutput05
DigitalOutput06
ResetGeneratorErrors
ResetMainsErrors
InvertDO5

The module's default configuration is that the generator and mains error bits are reset by the module. If this should be done by the user, then the module needs to be configured accordingly using the following registers.

- Generator error: "ConfigOutput21" on page 55
- Network error: "ConfigOutput22" on page 63

(data point applied as BOOL)

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	DigitalOutput05	0	Reset output 5
		1	Set output 5
1	DigitalOutput06	0	Reset output 6
		1	Set output 6
2	ResetGeneratorErrors	0	Does not reset generator error bits
		1	Resets generator error bits
3	ResetMainsErrors	0	Do not reset mains error bits
		1	Reset mains error bits
4	InvertDO5	0	Do not invert Output 5
		1	Invert output 5 of the mains monitoring function
5 - 7	Reserved	0	

5.4.1.2 Status of digital outputs

Name:
StatusDigitalOutputPacked01
StatusDigitalOutput01 to StatusDigitalOutput06
StatusInput16 to StatusInput17

(data point applied as BOOL)

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	StatusDigitalOutput01	0	Current state of output 1 = LOW
		1	Current state of output 1 = HIGH
...		...	
5	StatusDigitalOutput06	0	Current state of output 6 = LOW
		1	Current state of output 6 = HIGH
6	StatusInput17	0	Status DO OK
		1	Status DO overload
7	StatusInput16	0	Status 24 V output supply OK
		1	Status 24 V output supply undervoltage

5.4.1.3 Generator network error registers

Name:
StatusInputPacked01
StatusInput01 to StatusInput11
StatusInput31 to StatusInput32
StatusInput18

This register is the error register for the generator mains (error bits are of type BOOL). With regard to bits 9, 11 and 12, please also observe the description of the "Power measurement mode" parameter in the register "ConfigOutput21" on page 55.

Data type	Values
UINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	StatusInput01	0	Overvoltage (one phase), OK
		1	Overvoltage (one phase), present
1	StatusInput02	0	Undervoltage (one phase), OK
		1	Undervoltage (one phase), present
2	StatusInput03	0	Over-frequency, OK
		1	Over-frequency, present
3	StatusInput04	0	Under-frequency, OK
		1	Under-frequency, present
4	StatusInput05	0	Voltage asymmetry, OK
		1	Voltage asymmetry, present
5	StatusInput06	0	Current asymmetry, OK
		1	Current asymmetry, present
6	StatusInput07	0	Maximum neutral conductor current, OK
		1	Maximum neutral conductor current exceeded
7	StatusInput08	0	Short circuit-current, OK
		1	Short circuit-current, present
8	StatusInput09	0	Dependent overcurrent OK
		1	Dependent overcurrent occurring
9	StatusInput10	0	Capacitive reactive power (exciter failure), OK
		1	Capacitive reactive power (exciter failure), present
10	StatusInput11	0	Ready, OK
		1	Not ready
11	StatusInput31	0	No generator overload
		1	Generator overload
12	StatusInput32	0	No generator feedback
		1	Generator feedback
13 - 14	Reserved	-	
15	StatusInput18	0	Undervoltage 2 (of a phase) OK
		1	Undervoltage 2 (of a phase) occurring

StatusInput11

The error message "Not ready" is triggered if the X20 I/O supply drops below 18 VDC.

5.4.1.4 Power network error registers

Name:
StatusInputPacked02
StatusInput24 to StatusInput30
StatusInput33

This register is the error register for the mains (error bits are of type BOOL).

Data type	Values
USINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	StatusInput24	0	Overvoltage (one phase), OK
		1	Overvoltage (one phase), present
1	StatusInput25	0	Undervoltage (one phase), OK
		1	Undervoltage (one phase), present
2	StatusInput26	0	Over-frequency, OK
		1	Over-frequency, present
3	StatusInput27	0	Under-frequency, OK
		1	Under-frequency, present
4	StatusInput28	0	Voltage asymmetry, OK
		1	Voltage asymmetry, present
5	StatusInput29	0	Phase shift monitoring OK
		1	Phase shift error (1/3 of a phase)
6	StatusInput30	0	Df/dt OK
		1	Df/dt error
7	StatusInput33	0	Undervoltage 2 (of a phase) OK
		1	Undervoltage 2 (of a phase) occurring

StatusInput33

The data point is only valid if 2-point mode is configured (see register "ConfigOutput22" on page 63). This bit only appears in the I/O mapping in Automation Studio if the corresponding status information is enabled in the I/O configuration ("Mains configuration / Additional status information" menu option).

5.4.1.5 General error registers

Name:
StatusInputPacked03
StatusInput12 to StatusInput15
StatusInput19 to StatusInput23

This register is the error register for general error messages (error bits are of type BOOL).

Data type	Values
UINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	StatusInput12	0	All phases of the generator mains OK
		1	Failure of at least one phase of the generator mains
1	StatusInput13	0	All phases of the busbar OK
		1	Failure of at least one phase of the busbar
2	StatusInput14	0	All phases of synchronization network 1 OK
		1	Failure of at least one phase of synchronization network 1
3	StatusInput15	0	All phases of synchronization network 2 OK
		1	Failure of at least one phase of synchronization network 2
4	StatusInput19	0	Phase sequence of generator voltage OK
		1	Phase sequence of generator voltage incorrect
5	StatusInput20	0	Phase sequence of generator current OK
		1	Phase sequence of generator current incorrect
6	StatusInput21	0	Phase sequence of busbar OK
		1	Phase sequence of busbar incorrect
7	StatusInput22	0	Direction of rotation of synchronization network 1 OK
		1	Direction of rotation of synchronization network 1 incorrect
8	StatusInput23	0	Direction of rotation of synchronization network 2 OK
		1	Direction of rotation of synchronization network 2 incorrect
9 - 15	Reserved	-	

StatusInput12 to StatusInput15: Phase failure is detected if at least one of the phases of the respective terminal fails.

StatusInput19 to StatusInput23 are status bits for detecting a change of rotation.

5.4.1.6 Power network error registers (continued)

Name:
StatusInputPacked04
StatusInput34 to StatusInput37

The register is the error register for the network (error bits are assigned as BOOL).

Data type	Values
UINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	StatusInput34	0	Overvoltage 2 (of a phase) OK
		1	Overvoltage 2 (of a phase) occurring
1	StatusInput35	0	Underfrequency 2 OK
		1	Underfrequency 2 occurring
2	StatusInput36	0	Overfrequency 2 OK
		1	Overfrequency 2 occurring
3	StatusInput37	0	Microgrid monitoring OK
		1	Microgrid monitoring tripped
4 - 15	Reserved	-	

5.4.1.7 Generator network error registers (continued)

Name:
StatusInputPacked05
StatusInput38 to StatusInput40

The register is the error register for the generator network (error bits are assigned as BOOL).

Data type	Values
UINT	See the bit structure.

Bit structure:

Bit	Description	Value	Information
0	StatusInput38	0	Overvoltage 2 (of a phase) OK
		1	Overvoltage 2 (of a phase) occurring
1	StatusInput39	0	Underfrequency 2 OK
		1	Underfrequency 2 occurring
2	StatusInput40	0	Overfrequency 2 OK
		1	Overfrequency 2 occurring
3 - 15	Reserved	-	

5.4.2 Generator mains measured values

5.4.2.1 Phase currents of the generator

Name:
AnalogInput01 (I1)
AnalogInput02 (I2)
AnalogInput03 (I3)

Phase currents of the generator

Data type	Value	Information	Resolution
INT	-32768 to 32767	-	1 A

5.4.2.2 Neutral conductor current of generator I_n

Name:
AnalogInput05

Data type	Value	Information	Resolution
INT	-32768 to 32767	-	1 A

5.4.2.3 Current average of generator I1, I2, I3

Name:
AnalogInput04

Data type	Value	Information	Resolution
INT	-32768 to 32767	-	1 A

5.4.2.4 Dynamic current average of generator (I_{m_dyn})

Name:
AnalogInput06

Describes the change in the average current value.

Data type	Value	Information	Resolution
UINT	0 to 65535	-	1 A

5.4.2.5 Line-to-line voltages of the generator

Name:
AnalogInput07 (UG12)
AnalogInput08 (UG23)
AnalogInput09 (UG31)

Data type	Value	Information	Resolution
INT	-32768 to 32767	-	1 V

5.4.2.6 Phase voltages of the generator

Name:
AnalogInput10 (UG 1)
AnalogInput11 (UG 2)
AnalogInput12 (UG 3)

Data type	Value	Information	Resolution
INT	-32768 to 32767	-	1 V

5.4.2.7 Voltage average of the generator

Name:
AnalogInput22

Voltage average of the generator UG12, UG23, UG31 (U~3 average)

Data type	Value	Information	Resolution
INT	-32768 to 32767	-	1 V

5.4.2.8 Filtered generator power values:

Name:
AnalogInput19
AnalogInput20
AnalogInput21

Filtered generator power values:

- Total output (sum of all harmonic frequencies)
- Fundamental frequency power (_H1)

Configuration is explained in the "ConfigOutput21" on page 55 register.

Data type	Value	Information	Resolution
INT	-32768 to 32767	Total active power P/P_H1	1 kW
	-32768 to 32767	Total reactive power Q/Q_H1	1 kvar
	-32768 to 32767	Total apparent power S/S_H1	1 kVA

5.4.2.9 Power factor of generator/cos ϕ

Name:
AnalogInput23

The factor is described in "Power factor of the generator" on page 24 and register "ConfigOutput21" on page 55.

Data type	Value	Information	Resolution
INT	-32768 to 32767	-	0.001

5.4.2.10 Frequency of the generator mains

Name:
AnalogInput24

Data type	Value	Information	Resolution
UINT	0 to 65535	-	0.01 Hz

5.4.2.11 Timestamp for generator voltages and currents

5.4.2.11.1 Timestamp of positive zero crossing of the phase voltage

Name:
AnalogInput38 (UG1)
AnalogInput39 (UG2)
AnalogInput40 (UG3)

Time stamp of pos. zero crossing of phase voltage of the respective generator

Data type	Value	Information	Resolution
DINT	-2,147,483,648 to 2,147,483,647	-	1/4096 µs

5.4.2.11.2 Timestamp of positive zero crossing of the phase current

Name:
AnalogInput41 (I1)
AnalogInput42 (I2)
AnalogInput43 (I3)

Time stamp of pos. zero crossing of phase current of the respective generator

Data type	Value	Information	Resolution
DINT	-2,147,483,648 to 2,147,483,647	-	1/4096 µs

5.4.3 Busbar measured values

5.4.3.1 Line-to-line voltages of the busbar

Name:
AnalogInput13 (UB12)
AnalogInput14 (UB23)
AnalogInput15 (UB31)

Data type	Value	Information	Resolution
INT	-32768 to 32767	-	1 V

5.4.3.2 Phase voltages of the busbar

Name:
AnalogInput16 (UB1)
AnalogInput17 (UB2)
AnalogInput18 (UB3)

Data type	Value	Information	Resolution
INT	-32768 to 32767	-	1 V

5.4.3.3 Frequency of busbar

Name:
AnalogInput35

Data type	Value	Information	Resolution
UINT	0 to 65535	-	0.01 Hz

5.4.4 Measured value of synchronization mains

(for network configuration "Synchronization network 1 / Synchronization network 2")

5.4.4.1 Line-to-line voltages

Name:
AnalogInput25 (synchronization network 1 US1)
AnalogInput26 (synchronization network 2 US2)

Data type	Value	Information	Resolution
INT	-32768 to 32767	-	1 V

5.4.4.2 Frequencies

Name:
AnalogInput27 (synchronization network 1)
AnalogInput28 (synchronization network 2)

Data type	Value	Information	Resolution
UINT	0 to 65535	-	0.01 Hz

5.4.5 Measured value of mains

(for "3-phase mains" configuration)

5.4.5.1 Line-to-line voltages of mains

Name:
AnalogInput25 (UN12)
AnalogInput31 (UN23)
AnalogInput32 (UN31)

Data type	Value	Information	Resolution
INT	-32768 to 32767	-	1 V

5.4.5.2 Phase voltages of the generator

Name:
AnalogInput33 (UN1)
AnalogInput34 (UN2)
AnalogInput26 (UN3)

Data type	Value	Information	Resolution
INT	-32768 to 32767	-	1 V

5.4.5.3 Frequency of power mains

Name:
AnalogInput27

Data type	Value	Information	Resolution
UINT	0 to 65535	-	0.01 Hz

5.4.6 Generator monitoring

5.4.6.1 Read unbalanced load meter

Name:
AnalogInput36

The current status of the unbalanced load meter can be tracked in this register (see "Unbalanced load monitoring" on page 29). The unbalanced load counter can be reset with an acyclic trigger bit (see register "ConfigOutput23" on page 54).

Data type	Value	Information	Resolution
UINT	0 to 65535	For 0 to 100%	

5.4.6.2 Reads the unbalanced load current (I_2)

Name:
AnalogInput37

Data type	Value	Information	Resolution
INT	-32768 to 32767	-	1 A

5.4.7 Synchronization

5.4.7.1 Differential angle between synchronization networks

Name:
AnalogInput29

Angular difference between the networks being synchronized.

Specifies by how many degrees the synchronization network is ahead of the network to be synchronized.

Data type	Values	Information	Resolution
INT	-32768 to 32767	-	0.1°

5.4.7.2 Differential voltage between synchronization networks

Name:
AnalogInput30

Differential voltage between the networks being synchronized.

Data type	Value	Information	Resolution
INT	-32768 to 32767	-	1 V

5.5 Minimum cycle time

The minimum cycle time specifies how far the bus cycle can be reduced without communication errors occurring. It is important to note that very fast cycles reduce the idle time available for handling monitoring, diagnostics and acyclic commands.

Minimum cycle time
250 µs

5.6 Minimum I/O update time

The minimum I/O update time for the analog inputs depends on the respective period duration of the measurement signal frequency.

Minimum I/O update time	
At 50 Hz	10 ms

6 UL-Information (deutsch)

Information:

Vor Inbetriebnahme des Moduls ist der Abschnitt **"Safety guidelines" auf Seite 5** **zu beachten.**

Gefahr!

Elektronische Geräte sind grundsätzlich nicht ausfallsicher. Bei Ausfall der Multimess- und Synchronisiereinheit ist der Anwender selbst dafür verantwortlich, dass der angeschlossene Motor bzw. Generator in einen sicheren Zustand gebracht wird.

Danger !

Les appareils électroniques ne sont généralement pas à l'abri des pannes. En cas de défaillance de l'unité de mesure multiple et de synchronisation, il incombe à l'utilisateur de veiller à ce que le moteur ou le générateur connecté soit sécurisé.

Gefahr!

Gefahr von Stromschlag!

Die Feldklemme darf nur im gesteckten Zustand Spannung führen und niemals unter Spannung gezogen, gesteckt oder im abgezogenen Zustand unter Spannung gesetzt werden!

Danger !

Risque d'électrocution !

Le connecteur ne peut conduire la tension que lorsqu'il est connecté. Il est interdit de le déconnecter ou de le connecter si une tension est appliquée ou si une tension lui est appliquée lors de son retrait dans n'importe quelle circonstance !