TURCK

Your Global Automation Partner

BL20-E-3EMM-…
Energy Measurement Modules

Instructions for Use

Contents

1 About these instructions

These instructions describe the setup, functions and use of the product and help you to operate the product according to its intended purpose. Read these instructions carefully before using the product. This will prevent the risk of personal injury and damage to property. Keep these instructions safe during the service life of the product. If the product is passed on, pass on these instructions as well.

1.1 Target groups

These instructions are written for specifically trained personnel and must be read carefully by anyone entrusted with the installation, commissioning, operation, maintenance, disassembly or disposal of the device.

When using the device in Ex areas, the user must also have knowledge of explosion protection (IEC/EN 60079-14 etc.).

1.2 Explanation of symbols

The following symbols are used in these instructions:

	DANGER DANGER indicates a hazardous situation with a high level of risk, which, if not avoided, will result in death or serious injury.
	WARNING WARNING indicates a hazardous situation with a medium level of risk, which, if not avoided, will result in death or serious injury.
	CAUTION CAUTION indicates a hazardous situation with a medium level of risk, which, if not avoided, will result in moderate or minor injury.
	NOTICE CAUTION indicates a situation which, if not avoided, may cause damage to property.
	NOTE NOTE indicates tips, recommendations and important information about special action steps and issues. The notes simplify your work and help you to avoid additional work.
▶	**MANDATORY ACTION** This symbol denotes actions that the user must carry out.
➩	**RESULT OF ACTION** This symbol denotes the relevant results of an action.

1.3 Other documents

Besides this document, the following material can be found on the Internet at **www.turck.com**:

- Data sheet
- Instruction for use for BL20gateways
- Declarations of conformity (current version)
- Approvals

1.4 Feedback about these instructions

We make every effort to ensure that these instructions are as informative and as clear as possible. If you have any suggestions for improving the design or if some information is missing in the document, please send your suggestions to **techdoc@turck.com**.

2 Notes on the product

2.1 Product identification

These instructions are valid for the following BL20 energy measurement modules:

- BL20-E-3EMM-CT (ID 100027913)
- BL20-E-3EMM- RC (ID 100027914)

2.2 Scope of delivery

The delivery consists of the following:

- Energy measurement module
- Quick Start Guide

2.3 Turck service

Turck supports you in your projects – from the initial analysis right through to the commissioning of your application. The Turck product database at www.turck.com offers you several software tools for programming, configuring or commissioning, as well as data sheets and CAD files in many export formats.

The contact data for Turck branches is provided at [▸ 67].

3 For your safety

The product is designed according to state of the art technology. Residual hazards, however, still exist. Observe the following safety instructions and warnings in order to prevent danger to persons and property. Turck accepts no liability for damage caused by failure to observe these safety instructions.

3.1 Intended use

The BL20 energy measurement module BL20-E-3EMM-… is part of the BL20 system and is used to measure relevant data (voltage, current, power, energy) of a 1- or 3-phase network (max. 300 VAC between phase conductor and neutral conductor) for efficient energy management. Alternating currents up to 5 A can be detected via current transformers. The data collected in the energy measurement module is forwarded via the internal module bus of the BL20 station to the BL20 gateway and from there to the higher-level controller.

The energy measurement module can be operated at the following BL20 gateways:

- BL20-E-GW-EN (from VN 04-00)
- BL20-E-GW-EN/ET (from VN 04-00)

The device must only be used as described in these instructions. Any other use is not in accordance with the intended use. Turck accepts no liability for any resulting damage.

3.2 Obvious misuse

The device is not suitable for:

- The measurement of direct currents (DC)
- Direct measurement of currents
- The use outside the switch cabinet

3.3 General safety notes

- The device must only be fitted, installed, operated, parameterized and maintained by trained and qualified personnel.
- Only operate the device within the limits stated in the technical specifications.
- Only use the device in compliance with the applicable national and international regulations, standards and laws.
- Only mount, dismount and wire the device when it is de-energized. Secure against reconnection of the voltage.
- The wiring of the complete system must be protected against accidental contact and must be provided with the appropriate warning notices. Protection against accidental contact is only ensured if the mounting rail is properly grounded.
- Cover open contacts at the end of every station with an end plate.
- BL20-E-3EMM-CT: Depending on the connection, only load the device with the maximum permissible input current of 1 A or 5 A. Use current transformers with appropriate conversion ratio.
- BL20-E-3EMM-RC: Observe the maximum input voltage of the device.

4 Product description

The BL20 energy measurement module BL20-E-3EMM-… has 16 push-in terminals for connection of current transformers (BL20-E-3EMM-CT) or Rogowski coils (BL20-E-3EMM-RC).

The following current transformers or Rogowski coils can be connected to the devices:

- Current transformers (CT) with 1 A and 5 A output current
- Rogowski coils (RC) with a maximum rated output voltage of 655 mV/kA at 50 Hz (RMS values)

The energy measurement module can capture the following measured values:

- Current
- Voltage
- Reactive, apparent and active power
- Reactive, apparent and active energy
- Power factor
- Frequency
- Phase angle
- Total Harmonic Distortion (THD)

4.1 Device overview

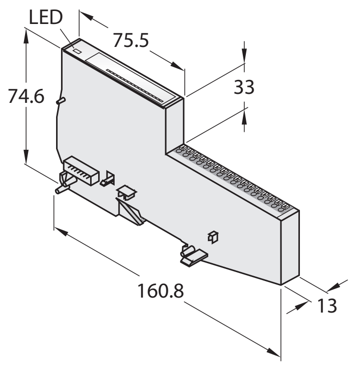


Fig. 1: Dimensions BL20-E-3EMM

Assignment of the connection terminals BL20-E-3EMM-CT

Terminal no.	Terminal designation	Operation mode	Phase/ neutral conductor
1	U_1	Voltage measurement	Phase 1
2	I_1+ (1 A)	Current measurement, 1 A current transformer	
3	I_1+ (5 A)	Current measurement, 5 A current transformer	
4	I_1-	Current measurement, 1 A and 5 A current trans-former	
5	U_2	Voltage measurement	Phase 2
6	I_2+ (1 A)	Current measurement, 1 A current transformer	
7	I_2+ (5 A)	Current measurement, 5 A current transformer	
7	I_2-	Current measurement, 1 A and 5 A current transformer	
9	U_3	Voltage measurement	Phase 3
10	I_3+ (1 A)	Current measurement, 1 A current transformer	
11	I_3+ (5 A)	Current measurement, 5 A current transformer	
12	I_3-	Current measurement, 1 A and 5 A current transformer	
13	N	Voltage measurement	Neutral conductor
14	I_N+ (1 A)	Current measurement, 1 A current transformer	
15	I_N+ (5 A)	Current measurement, 5 A current transformer	
16	I_N-	Current measurement	

Assignment of the connection terminals BL20-E-3EMM-RC

Terminal no.	Terminal designation	Operation mode	Phase/ neutral conductor
1	U_1	Voltage measurement	Phase 1
2	n. c.	Not connected	
3	RC_1+	Current measurement, Rogowski coil	
4	RC_1-		
5	U_2	Voltage measurement	Phase 2
6	n. c.	Not connected	
7	RC_2+	Current measurement, Rogowski coil	
7	RC_2-		
9	U_3	Voltage measurement	Phase 3
10	n. c.	Not connected	
11	RC_3+	Current measurement, Rogowski coil	
12	RC_3-		
13	N	Voltage measurement	Neutral conductor
14	n. c.	Not connected	
15	RC_N+	Current measurement, Rogowski coil	
16	RC_N-		

4.1.1 Block diagram

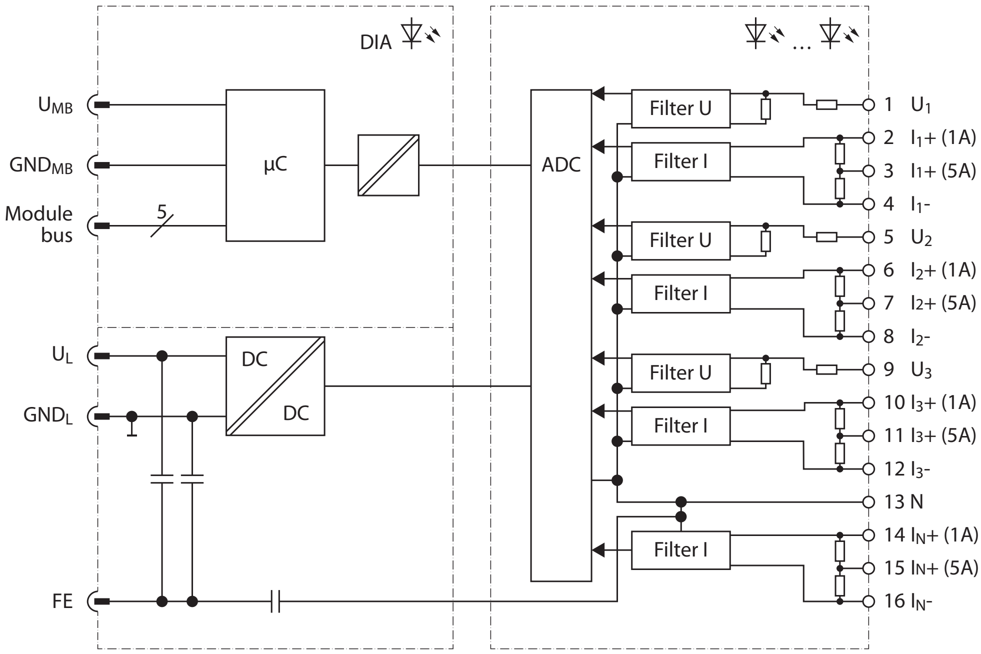


Fig. 2: Block diagram BL20-E-3EMM-CT

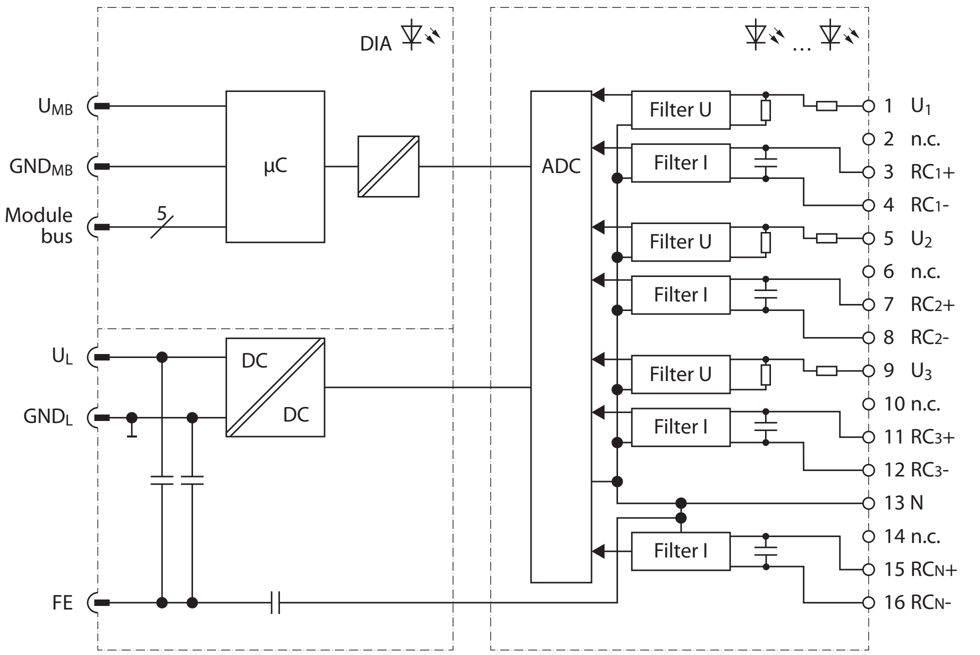


Fig. 3: Block diagram BL20-E-3EMM-RC

4.1.2 Display elements

The device has the following LED indicators:

- Status of the three phases L1, L2, L3 for current measurement (LED I1…I3) and voltage measurement (LED U1…U3)
- Status of the neutral conductor N (LED IN)
- Module status (LED ST)

4.2 Properties and features

- Shock and vibration tested
- Degree of protection IP20
- Fieldbus independent
- Electronics and connection technology in one housing
- Connection technology: Push-in terminals
- Electronics galvanically isolated from the field
- Current and voltage measurement via 3 channels for up to 3 phases
- Separate channel for the neutral conductor
- BL20-E-3EMM-CT: Connection of current transformers with 1 A or 5 A output
- BL20-E-3EMM-RC: Connection og Rogowski coils (RC) with a maximum rated output power of 655 mV/kA at 50 Hz (RMS values)
- Rated voltage: 230 VAC (phase conductor voltage)
- Max. 300 VAC between outer conductor and neutral conductor (3 phase system)
- Star or delta connection in 3 phases L1, L2, L3 and neutral conductor (N)
- Overvoltage category III (according to IEC 61010-1)
- Nominal voltage spike 4 kV
- Nominal frequency range 42…70 Hz
- Harmonic analysis up to 51st harmonic vibration at 50-Hz signals
- True RMS with high-resolution delta sigma modulation
- Sampling rate 8 kbps
- Accuracy:
  - 0.5 % for current and voltage measurement (measuring range end value)
  - 1.0 % for calculated values

4.3 Operating principle

The energy measurement module measures the electrical data of a 1-, 2- or 3-phase supply network. Voltage measurement is realized in the device by direct connection of the phases (L1, L2, L3) and neutral to the terminals U1, U2, U3 and N of the module. The current is measured by connecting 1 A or 5 A current transformers (BL20-E-3EMM-CT) or Rogowski coils (BL20-E-3EMM-RC) to the terminals I_1, I_2, I_3 and I_N. The measured values of the currents and voltages are available as effective values. From the measured values, the energy measurement module calculates various measured variables such as power (active, apparent and reactive power), energy (active, apparent and reactive energy), power factor, phase angle and frequency. The results of the measurements are made available in the process data of the module via a register interface.

4.4 Functions and operating modes

4.4.1 Current and voltage measurement

The voltage is measured internally via the direct connection of the three phases L1, L2, L3 and N of a power supply network. The current of the three phases is fed in via current transformers (BL20-E-3EMM-CT) or Rogowski coils (BL20-E-3EMM-RC).

The energy measurement module provides the following measured values per phase (L1, L2, L3):

Voltage

- RMS current L1, L2, L3
- RMS current average L1, L2, L3
- RMS current fundamental L1, L2, L3
- THD (Total Harmonic Distortion) voltage L1, L2, L3
- Phase angle voltage (U_{L1} - U_{L2}, U_{L2} - U_{L3}, U_{L1} - U_{L3})
- Peak value L1…L3
- Line voltage (L1 - L2, L1 - L3 and L2 - L3)

Current

- RMS current L1, L2, L3
- RMS current average L1, L2, L3
- RMS current fundamental L1, L2, L3
- THD (Total Harmonic Distortion) voltage L1, L2, L3
- Current unbalance L1…L3
- Total current
- Phase angle current (I_{L1} - I_{L2}, I_{L2} - I_{L3}, I_{L1} - I_{L3})
- Peak value L1…L3

Current and voltage

- Phase angle current/voltage (I_{L1} - I_{L2}, I_{L2} - I_{L3}, I_{L1} - I_{L3})

4.4.2 Energy and power measurement

The device calculates both the power and the energy demand for each of the three phases. For active and reactive energy, values are available for the individual phases as well as an overall value.

The energy measurement module provides the following measured values per phase (L1, L2, L3):

Power

- Active power L1, L2, L3
- Reactive power L1, L2, L3
- Apparent power L1, L2, L3
- Active power fundamental L1, L2, L3
- Reactive power fundamental L1, L2, L3
- Apparent power fundamental L1, L2, L3
- Power factor L1, L2, L3

Energy

- Active energy accumulated L1, L2, L3
- Reactive energy accumulated L1, L2, L3
- Apparent energy accumulated L1, L2, L3
- Active energy fundamental accumulated L1, L2, L3
- Reactive energy fundamental accumulated L1, L2, L3
- Apparent energy fundamental accumulated L1, L2, L3
- Active energy positive accumulated L1 + L2 + L3
- Active energy negative accumulated L1 + L2 + L3
- Reactive energy positive accumulated L1 + L2 + L3
- Reactive energy negative accumulated L1 + L2 + L3

The energy is classified into motor (positive sign = energy draw) and generator (negative sign = energy supply) active energy as well as inductive and capacitive reactive energy.

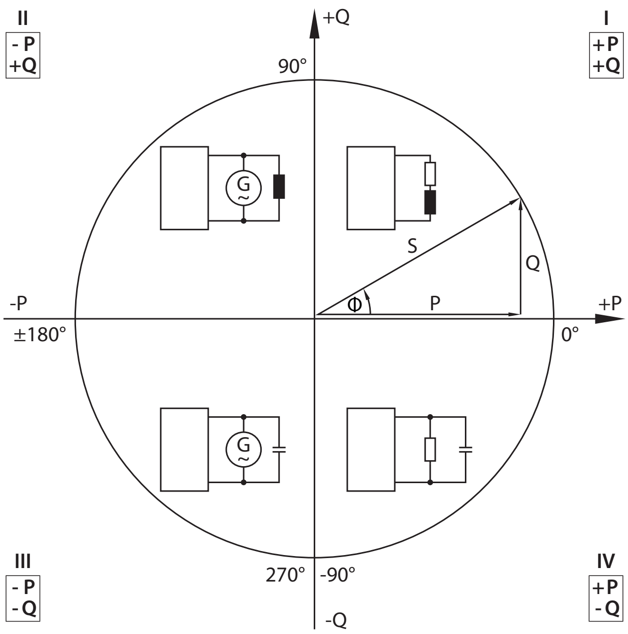


Fig. 4: Four-quadrant representation of active and reactive power for motor and generator operation

4.4.3 Frequency measurement

The device measures the line frequency for each phase separately or combined.

- Line frequency L1, L2, L3
- Line frequency combined L1...L3

4.4.4 Register interface

The energy measurement module BL20-E-3EMM-… provides an internal register interface. Up to eight measured values can be transmitted simultaneously through eight data channels via the process data to the gateway and from there to the higher-level controller. Each data channel can be assigned with data from a register of the register interface. Which measured values are mapped into the data channels and output via the process data is defined either statically via the module parameters or dynamically via the process input data of the module [49].

4.5 BL20 accessories

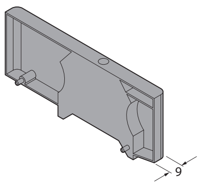
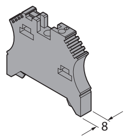
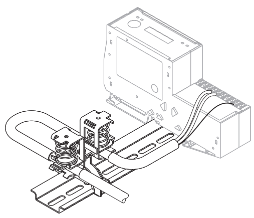
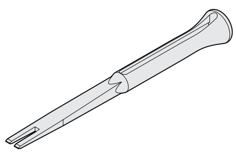
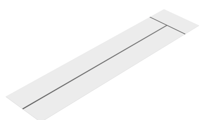
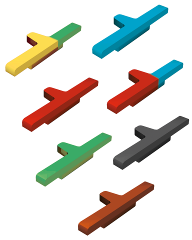
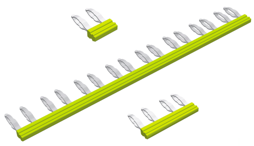
Figure	Type	ID	Description
	BL20-ABPL	6827123	End plate Mechanical end of BL20 station to the right, 2 pieces
	BL20-WEW-35/2-SW	6827124	End bracket black Mechanical fixation of BL20 station, 10 pieces
	BS3511/KLBUE4-31.5	6827342	Shielding terminal
	ZBW5	6827129	Tension spring tool
	BL20-LABEL/SCHEIBE	6827070	Labels for electronic modules in slice design, 3 × DIN A5 sheet, slice, pre-perforated (laser printing), 3 × 19 labels

Figure	Type	ID	Description
	BL20-ANBZ-…		Color coding for clear potential identification of the connection level on the base modules:
	BL20-ANBZ-BL	6827072	10 × strip of 6, blue
	BL20-ANBZ-RT	6827073	10 × strip of 6, red
	BL20-ANBZ-GN	6827074	10 × strip of 6, green
	BL20-ANBZ-SW	6827075	10 × strip of 6, black
	BL20-ANBZ-BR	6827076	10 × strip of 6, brown
	BL20-ANBZ-RT/BL-BED	6827077	10 × strip of 6, red/blue
	BL20-ANBZ-GN/GE-BED	6827078	10 × strip of 6, green/yellow
	BL20-ANBZ-WS	6827079	10 × strip of 6, white
	BL20-QV/…		Cross connector relay (QVR) For bridging the 4th connection level (14/24) for base modules for relays (10 pieces)
	BL20-QV/1	6827104	1 grid
	BL20-QV/2	6827105	2 grid
	BL20-QV/3	6827106	3 grid
	BL20-QV/4	6827107	4 grid
	BL20-QV/5	6827108	5 grid
	BL20-QV/6	6827109	6 grid
	BL20-QV/7	6827110	7 grid
	BL20-QV/8	6827111	8 grid

5 Mounting

WARNING
Open electrical contacts
Danger to life due to electric shock when using 120/230 VAC
▶ Cover open contacts on the last base module of each station with end plate or place a power feeding module (24 V) to form a new potential group.

- A BL20 station consists of at least one gateway and one electronic module.
- BL20 stations must be mounted on the DIN rail using two end brackets (BL20-WEW-35/2-SW).
- The BL20 station can be mounted vertically or horizontally.
- For vertical installation, the gateway can be positioned either above or below. In this case, sufficient ventilation and heat dissipation must be ensured.
- Keep space to the left of the gateway free for the first end bracket.
- Mount the end plate after the last BL20 module.
- The gateway is the first electronics component on a BL20 station.
- The gateway is followed by the I/O modules in any order.
- Power Feeding and Bus Refreshing modules are used for potential separation and can be mounted between the other modules if necessary.
- If required, potential distribution modules can be used. A maximum of two potential distribution modules may be mounted directly next to each other.
- Protect the installation site against heat radiation, rapid temperature fluctuations, dust, dirt, moisture and other environmental influences.

Mounting the DIN rail

Recommendation for mounting the BL20 system on a DIN rail in the control cabinet:

- ▶ Mount the DIN rail on a rust-proof, electrically conductive mounting plate. A reference potential for protective and functional earth can be established through the mounting plate.

The minimum thickness of the mounting plate depends on the material:

  - Steel and stainless steel: min. 2mm
  - Aluminum: min. 3 mm

- ▶ Fasten the DIN rail to the mounting plate using suitable rivets (A) or screws (B) as shown in the figure below ”DIN rail mounting”. The choice of rivets or screws depends on the condition of the mounting plate.
- ▶ When mounting several DIN rails on top of each other: ensure sufficient distance between the top-hat rails (C). The arrangement of the components in the control cabinet depends on the application.
- ▶ Keep a distance of min. 10 mm to passive components.
- ▶ Keep a distance of min. 75 mm to active components (e. g. power supply units).

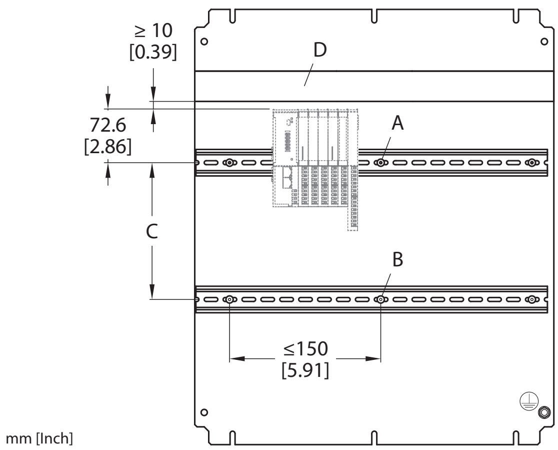


Fig. 5: DIN rail mounting

5.1 Mounting ECO modules

- The gateway must already be mounted.
- The ECO modules are mounted on the DIN rail to the right of the gateway.

- ▶ Insert the groove of the ECO module into the DIN rail from below.
- ▶ Swing the upper end of the ECO module backwards.
- ▶ Press the ECO module against the DIN rail until the locking hook audibly engages.
- ▶ Push the ECO module to the left until the two lateral snap-in hooks on the left engage.

5.2 Mounting end bracket and end plate

- BL20 stations must be mounted on the DIN rail using two end brackets (BL20-WEW-35/2-SW).
- The first end bracket must be mounted in front of the gateway.
- The second end bracket is integrated in the end plate and must be mounted after the last module.

Mounting the end bracket in front of the gateway

- ▶ If necessary, loosen the screw in the end bracket.
- ▶ Snap the end bracket onto the DIN rail on the left of the gateway.
- ▶ Push the end bracket close to the gateway.
- ▶ Screw the end bracket tight.

Mounting the end plate

- ▶ If necessary, loosen the screw in the end bracket.
- ▶ Insert the end bracket into the recess provided in the end plate.
- ▶ The end bracket and end plate should be held so that the connectors on the end plate are facing the last module of the BL20 station.
- ▶ Snap the end plate with the end bracket onto the mounting rail.
- ▶ Press the end plate with the end bracket tightly against the last module of the BL20 station.
- ▶ Insert the connectors of the end plate firmly into the recesses of the module.
- ▶ Screw the end bracket tight through the end plate.

6 Connecting

The device has 16 push-in terminals for connecting a supply network (L1, L2, L3 and N), 1 A or 5 A current transformers or Rogowski coils. The permissible conductor cross-section is 0.2… 1.5 mm² depending on the conductor used [▸ 64].

WARNING
Connecting devices under voltage
Danger to life due to dangerous contact voltage

- Before connecting external devices: de-energize all connection lines to the device.

6.1 Connecting the power supply

The module is part of the BL20 system and is supplied with voltage via the module bus from the BL20 gateway or from power feeding or bus refreshing modules. An additional voltage supply for the module is not necessary.

6.2 Voltage measurement

WARNING
Voltage measurement above the permissible nominal input voltage
Danger to life due to dangerous voltages if the device is destroyed
- Always connect voltages above the permissible nominal input voltage of the device via voltage transformers.
- Select an appropriate voltage transformer ratio to ensure that the secondary voltages of the transformers do not exceed the nominal input voltage of the BL20-E-3EMM-….

WARNING
Incorrect connection of current and voltage paths
Danger to life due to dangerous voltages if the device is destroyed
- Observe the terminal assignment of the device.
- Do not mix up current and voltage paths.
- If necessary, use fuses in voltage paths.

WARNING
Incorrect grounding of the system
Danger to life due to dangerous contact voltage
- Connect terminal point N to the neutral conductor of the supply system or always ground the neutral conductor N to avoid dangerous overvoltages if the connected current transformer fails.

The device has four push-in terminals (U1, U2, U3 and N) for voltage measurement within a supply network.

- Connect the phases L1, L2, L3 and the neutral conductor N of the supply network to the energy measurement module according to the pin assignment.

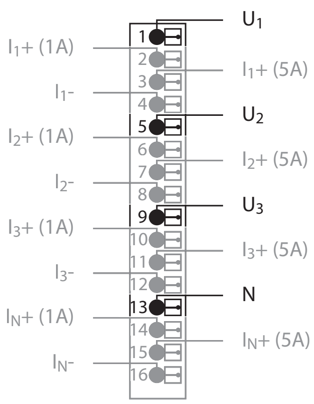


Fig. 6: Pin assignment BL20-E-3EMM-CT for voltage measurement

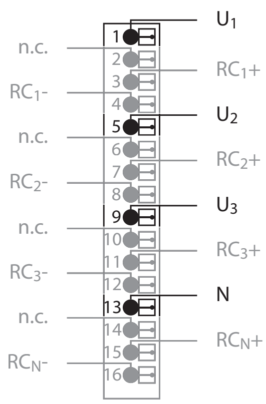


Fig. 7: Pin assignment BL20-E-3EMM-RC for voltage measurement

6.3 Current measurement

WARNING
Current measurement without current transformer or rogowski coil
Danger to life and burns due to dangerous voltage, destruction of the device
- BL20-E-3EMM-CT: Only carry out current measurement with a current transformer.
- BL20-E-3EMM-RC: Only carry out current measurements with Rogowski coils.

WARNING
Incorrect connection of current and voltage paths
Danger to life due to dangerous voltages if the device is destroyed
- Observe the terminal assignment of the device.
- Do not mix up current and voltage paths.
- If necessary, use fuses in voltage paths.

The device has twelve (BL20-E-3EMM-CT) or respectively eight (BL20-E-3EMM-RC) push-in terminals for measuring the currents of 1-, 2- or 3-phase loads.

- Connect the phases L1, L2, L3 and the neutral conductor N of the supply network to the energy measurement module via current transformers or Rogowski coils according to the pin assignment.

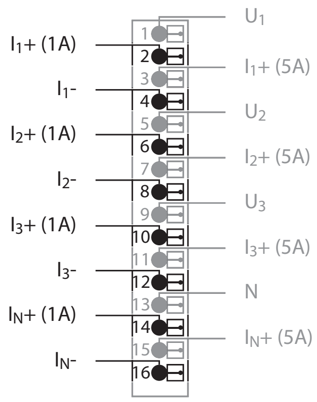


Fig. 8: Terminal assignment BL20-E-3EMM-CT for voltage measurement with 1 A current transformer

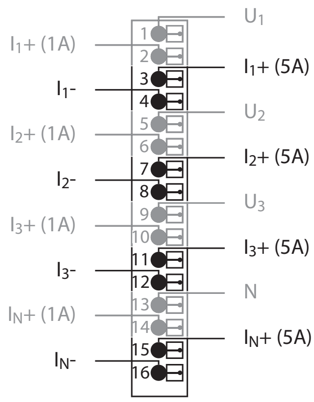


Fig. 9: Terminal assignment BL20-E-3EMM-CT for current measurement with 5 A current transformer

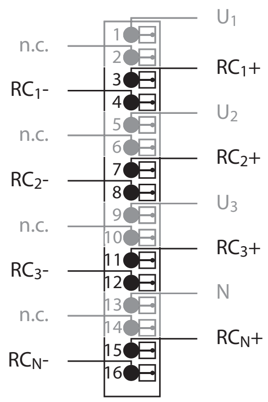


Fig. 10: Terminal assignment BL20-E-3EMM-RC for current measurement with Rogowski coils

6.4 Connecting current transformers to BL20-E-3EMM-CT

WARNING
Open secondary side of the current transformer
Danger to life due to dangerous electrical voltage at the output of the current transformer

- Do not operate the current transformer in no-load operation.
- Connect the current transformer output to BL20-E-3EMM-CT in the de-energized state. Then apply current to the primary side of the current transformer.

WARNING
Incorrect connection of current and voltage paths
Danger to life due to dangerous voltages if the device is destroyed

- Observe the terminal assignment of the device.
- Do not mix up current and voltage paths.
- If necessary, use fuses in voltage paths.

The device has 16 push-in terminals for connecting a maximum of four 1 A or four 5 A current transformers. A mixed operation with 1 A and 5 A current transformers is not possible.

- Connect the current transformer to the energy measuring module according to the terminal assignment.

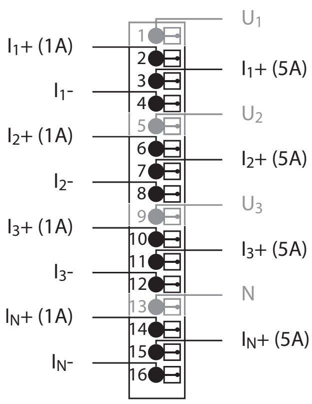


Fig. 11: Terminal assignment BL20-E-3EMM-CT

6.4.1 Maximum length of the connection cable for current transformers

To avoid overloading or damaging the connected current transformer, the maximum specified secondary apparent power of the current transformer S_{Sek_max} in VA must be observed. The total secondary load resistance, also called burden resistance, is the sum of the resistance of the connection line R_L and the internal resistance of the energy measuring module R_{In} and must be below a defined resistance value. The maximum resistance of the connection line Rl_max$_{L_max}$ is calculated as a function of S_{Sek_max} as follows, where the output of the current transformer (e.g. 5 A current transformer) is connected to the connection of the energy measuring module (e.g. 5 A connection).

$$R_{L\_max} = \frac{S_{Sek\_max}}{{I_{Sek\_max}}^2} - R_{In}$$

Fig. 12: Formula for calculating the maximum line resistance

Measured variable		**Meaning**
R_{L_max}	Maximum line resistance	Value to be calculated in Ω
S_{Sek_max}	Maximum secondary apparent power of the current transformer in VA	according to data sheet of the current transformer (if necessary also called load or load resistance)
I_{Sek_max}	Maximum secondary current of the current transformer	1 A or 5 A (depending on the application)
R_{In}	Internal resistance of the energy measurement module	
	Secondary current = 1 A	60 mΩ
	Secondary current = 5 A	10 mΩ

6.4.2 Required secondary apparent power of the current transformer

The following table shows an overview of the minimum required secondary apparent power of the current transformer in VA, which is necessary to operate the current transformer. The minimum required secondary apparent power is calculated as a function of the secondary current of the current transformer, the conductor cross-section (using the example of a copper cable at 20 °C operating temperature) and the length of the connecting cable.

Maximum secondary current of the current transformer	**1 A**			**5 A**		
Wire cross section	**1.0 mm²**	**1.5 mm²**	**2.5 mm²**	**1.0 mm²**	**1.5 mm²**	**2.5 mm²**
Line length	Minimum secondary apparent power of the current transformer VA					
1 m	0.0357	0.0238	0.0143	0.8929	1.301	0.3571
2 m	0.0714	0.0476	0.0286	1.7857	2.351	0.7143
3 m	0.1071	0.0714	0.0429	2.6786	3.401	1.0714
4 m	0.1429	0.0952	0.0571	3.5714	4.452	1.4286
5 m	0.1786	0.1190	0.0714	4.4643	5.502	1.7857
10 m	0.3571	0.2381	0.1429	8.9286	10.754	3.5714
20 m	0.7143	0.4762	0.2857	17.8571	21.258	7.1429
30 m	1.0714	0.7143	0.4286	26.7857	31.762	10.7143
40 m	1.4286	0.9524	0.5714	35.7143	42.266	14.2857
50 m	1.7857	1.1905	0.7143	44.6429	52.770	17.8571
100 m	3.5714	2.3810	1.4286	89.2857	105.289	35.7143

The secondary apparent power of the selected current transformer must be greater than the sum of the power losses of the copper cable and the energy measurement module.

Power loss of the module:

Secondary current = 1 A:	60 mW
Secondary current = 5 A:	250 mW

6.5 Connecting Rogowski coils to BL20-E-3EMM-RC

The device has a total of 16 push-in terminals. Eight push-in terminals are used to connect Rogowski coils.

WARNING
Incorrect connection of current and voltage paths
Danger to life due to dangerous voltages if the device is destroyed

- Observe the terminal assignment of the device.
- Do not mix up current and voltage paths.
- If necessary, use fuses in voltage paths.

- Connect the Rogowski coils to the energy measuring module according to the terminal assignment.

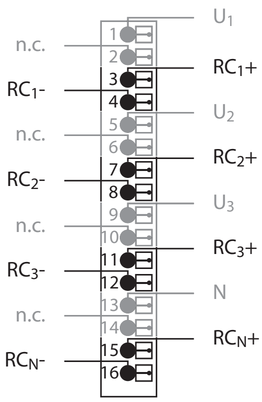


Fig. 13: Terminal assignment BL20-E-3EMM-RC

6.6 Application examples

WARNING
Incorrect grounding of the system
Danger to life due to dangerous contact voltage
- Connect terminal point N to the neutral conductor of the supply system or always ground the neutral conductor N to avoid dangerous overvoltages if the connected current transformer fails.

6.6.1 Energy measurement in a 3-phase supply network (4-wire star connection)

- The voltage is measured via the connections U_1, U_2, U_3 and N.
- The current measurement is done via current transformers or Rogowski coils via terminals I_1, I_2, I_3 and N or RC_1, RC_2, RC_3 and RC_N. Here in the example 1 A current transformers are used.

▶ Set parameter ”connection type” to 0 = ”4WY” [▷ 34].

▶ Connect the three phases (L1, L2, L3) and the neutral (N) as follows.

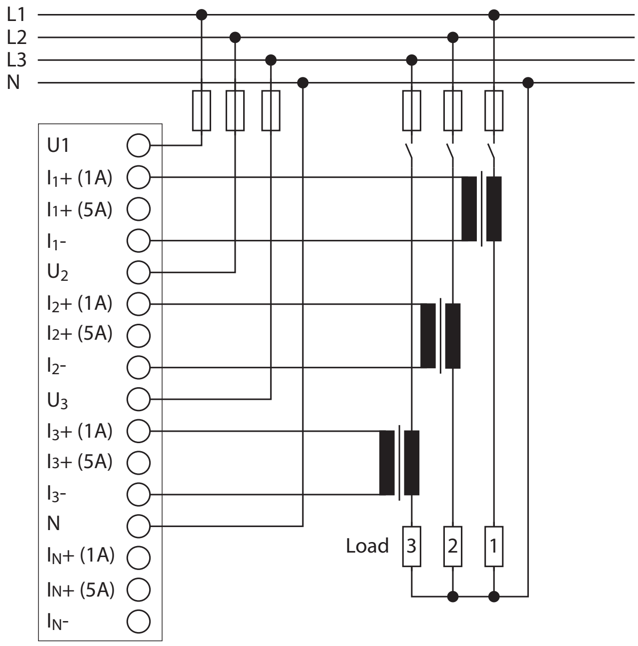


Fig. 14: Energy measurement in a 3-phase supply network (4WY)

▶ Optional: For current measurement at the neutral conductor, connect fourth current transformer between I_n and N.

6.6.2 Energy measurement in a 3-phase supply network (4-wire delta connection)

- The voltage is measured via the connections U_1, U_2, U_3 and N.
- The current measurement is done via current transformers or Rogowski coils via terminals I_1, I_2, I_3 and N or RC_1, RC_2, RC_3 and RC_N. Here in the example 1 A current transformers are used.

▶ Set parameter "connection type" to 1 = " 4WD" [▷ 34].

▶ Connect the three phases (L1, L2, L3) and the neutral (N) as follows.

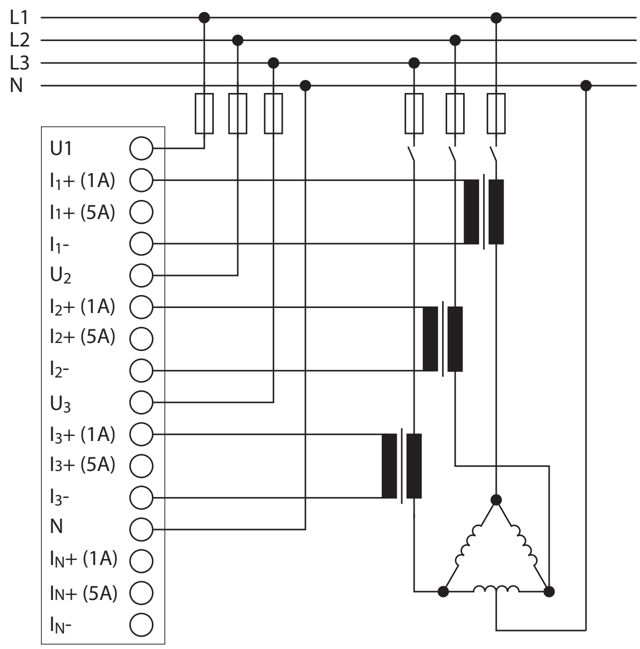


Fig. 15: Energy measurement in a 3-phase supply network (4WD)

▶ Optional: For current measurement at the neutral conductor, connect fourth current transformer between I_n and N.

6.6.3 Energy measurement on a machine (4-wire star connection, 3- and single-phase measurement)

- The voltage is measured via the connections U_1, U_2, U_3 and N.
- The current measurement is done via current transformers or Rogowski coils via terminals I_1, I_2, I_3 and N or RC_1, RC_2, RC_3 and RC_N. Here in the example 1 A current transformers are used.

▶ Set parameter "connection type" to 0 = "4WY" [▹ 34].

▶ Connect the three phases (L1, L2, L3) and the neutral (N) as follows.

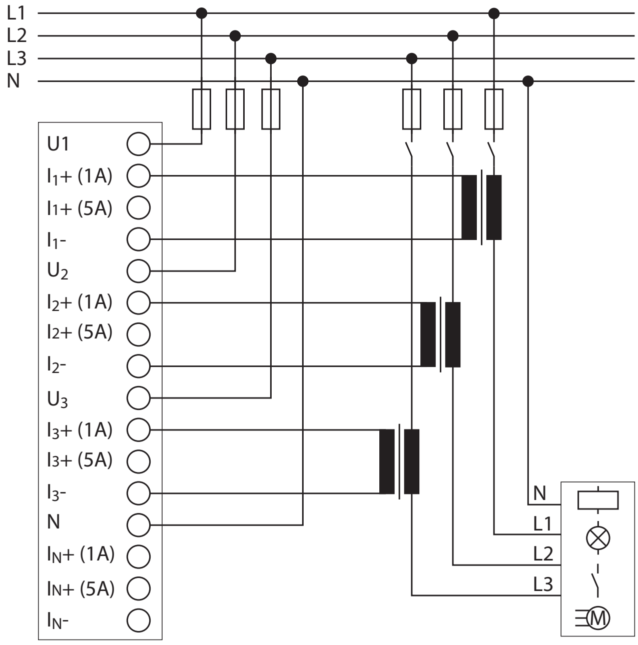


Fig. 16: Energy measurement on a machine (4WY)

Single-phase measurement on a machine (M1P)

- The voltage is measured via U_1 and the neutral conductor N, for example.
- For example, the current is measured via a current transformer or a Rogowski coil via one connection (here I_1+, I_1- or RC_1+ snd RC_1-) and N. Here in the example a 1 A current transformer is used.

▶ Set parameter ″connection type″ to 7 = ″ M1P″ [▹ 34].

▶ Connect phase (L1) and the neutral (N) as follows.

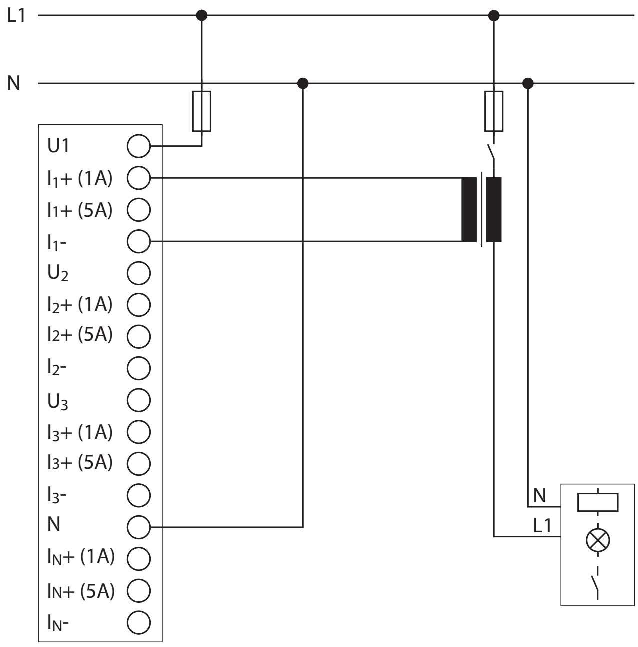


Fig. 17: Single-phase energy measurement on a machine (M1P), example

The single-phase measurement can be carried out on all three phases. Several parallel single-phase measurements are also possible.

6.6.4 Energy measurement on a motor (3-wire delta connection)

NOTICE
Exceeding the maximum permissible voltage for delta connections
Destruction of the device
- In delta circuits, only measure voltages up to max. 300 VAC phase conductor voltage.

- The voltage is measured via the terminals U_1, U_2 and U_3.
- The current measurement is done via current transformers or Rogowski coils via terminals I_1, I_2, I_3. Here in the example 1 A current transformers are used.

- Set parameter ”connection type” to 2 = ” 3WD_VB” [▸ 34]
- Connect the three phases (L1, L2, L3) and the neutral as follows.

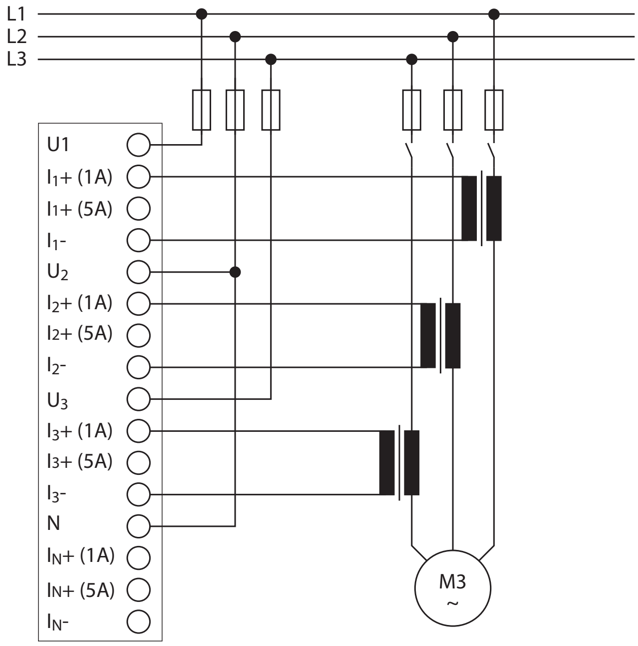


Fig. 18: Energy measurement on a motor (3WD)

6.6.5 Energy measurement on a machine (4-wire star connection, non-blondel compliant)

- Voltage measurement is done as 2-phase measurement via the connections U1, U3 and N.
- The current measurement is done via current transformers or Rogowski coils via terminals I_1, I_2, I_3 and N or RC_1, RC_2, RC_3 and RC_N. Here in the example 1 A current transformers are used.

▶ Set parameter ”connection type” to 4 = ”4WYNB”.

▶ Connect the three phases (L1, L2, L3) and the neutral (N) as follows.

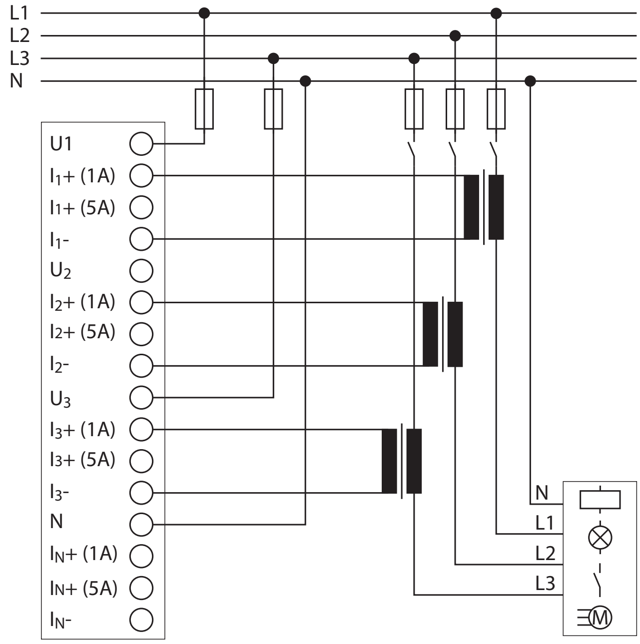


Fig. 19: Energy measurement on a machine, non-blondel compliant(4WYNB)

6.6.6 Energy measurement on a motor (4-wire delta connection, non-blondel compliant)

- Voltage measurement is done as 2-phase measurement via the connections U1, U3 and N.
- The current measurement is done via current transformers or Rogowski coils via the terminals I_1 and I_3 or RC_1 and RC_3. The connection of a third current transformer or a third Rogowski coil to I_2 or RC_2 is optional. Here in the example 1 A current transformers are used.

▶ Set parameter "connection type" to 5 = "4WDNB".

▶ Connect the three phases (L1, L3, L2 optional) and the neutral (N) as follows.

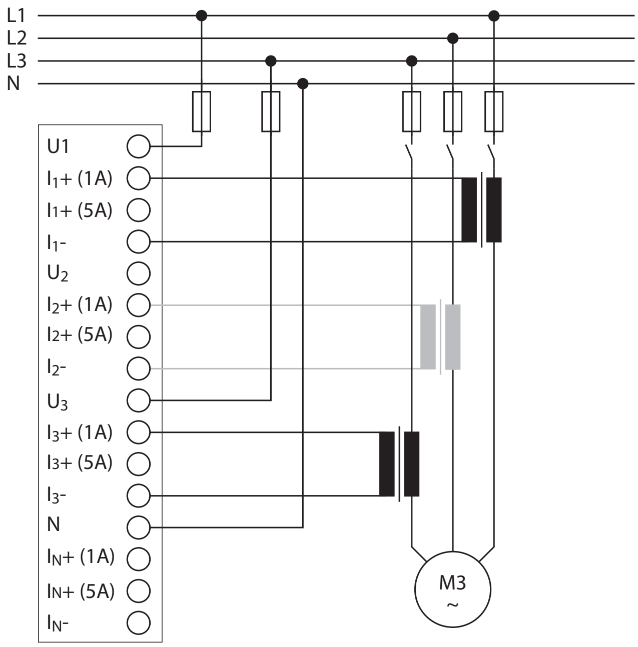


Fig. 20: Energy measurement on a motor, non-blondel compliant (4WDNB)

NOTE
If only two current transformers or Rogowski coils are used, IL2 can be calculated in the energy measurement module. To do this, the parameter **IL2 calculation activated** has to be set to **1 = yes** [▷ 34].

6.6.7 2-phase energy measurement in a 3-phase network

- The voltage measurement is carried out on two phases exemplary using connections U_1 and U_2 and N.
- The current measurement is done via current transformers or Rogowski coils via the terminals I_1 and I_2 as well as I_N or RC_1 and RC_2 as well as RC_N. Here in the example 1 A current transformers are used.

▶ Set parameter "connection type" to 6 = " 3Wx" [34]

▶ Connect the two phases (L1 and L2) and the neutral (N) as follows.

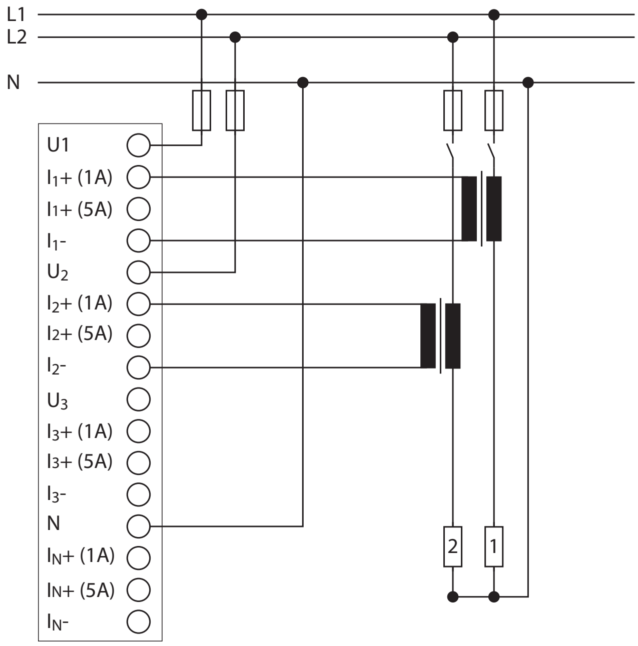


Fig. 21: Energy measurement in a 2-phase supply network (3Wx)

7 Commissioning

The energy measurement module is part of the BL20 system and can only be commissioned in conjunction with a BL20 gateway. Commissioning of the BL20 gateways is described in the respective gateway operating instructions.

8 Parameterizing and configuring

8.1 Parameters

The module has 32 byte parameters.

Byte no.	**Bit no.**							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	-	-	IL2 calculation enabled	Line frequency	Connection mode			Transformer secondary current (CT variant only)
1	-	-	Phase assignment voltage U3		Phase assignment voltage U2		Phase assignment voltage U1	
2	-	-	Phase assignment current I3		Phase assignment current I2		Phase assignment current I1	
3	Transformer ratio (P/S) LSB							
4	Transformer ratio (P/S) MSB							
5	-	-	-	-	-	Apparent power/energy calculation		
6	Line nominal voltage							
7	-	-	-	-	-	Cut-off frequency high-pass filter		
8	-	Resolution (I, P)			-	-	Total current calculation	
9	-	Disable channel						
Activate alarm								
10	Current unbalance upper limit	Power factor l ower limit	Frequency lower limit	Frequency upper limit	Current lower limit	Current upper limit	Voltage lower limit	Voltage upper limit
Alarm limits								
11	Alarm upper limit voltage Ln (LSB)							
12	Alarm upper limit voltage Ln (MSB)							
13	Alarm lower limit voltage Ln (LSB)							
14	Alarm lower limit voltage Ln (MSB)							
15	Alarm upper limit current Ln (LSB)							
16	Alarm upper limit current Ln (MSB)							
17	Alarm lower limit current Ln (LSB)							
18	Alarm lower limit current Ln (MSB)							
19	Alarm upper limit frequency							
20	Alarm lower limit frequency							
21	Alarm lower limit power factor							
22	Alarm upper limit current unbalance (LSB)							
23	Alarm upper limit current unbalance (MSB)							
Process values								
24	Process value index ch 0							
25	Process value index ch 1							
…	…							
30	Process value index ch 6							
31	Process value index ch 7							

Meaning of the parameter bits

The default values are written in **bold**.

Parameters	Value Dec.	Hex.	Bit assignment	Meaning	Description
Transformer secondary current (only BL20-E-3EMM-CT)	**0**	**0x00**	**0b0**	**CT 1 A**	The 1 A input of the CT variant is used.
	1	0x01	0b1	CT 5 A	The 1 A input of the CT variant is used.
Connection type	**0**	**0x00**	**0b000**	**4WY**	4-wire star connection [▹ 25] [▹ 27]
	1	0x01	0b001	4WD	4-wire delta connection
	2	0x02	0b010	3WD_VB	3-wire delta connection (max. phase conductor voltage: 300 VAC) VB' = VA - VC, [▹ 29]
	3	0x03	0b011	3WD_VABC	3-wire delta connection (max. phase conductor voltage: 300 VAC) VA' = VA - VB; VB' = VA - VC; VC' = VC - VB
	4	0x04	0b100	4WYNB	4-wire delta connection (non-blondel compliant) 2-phase voltage measurement on phase 1 and 3. The voltage on phase 2 is calculated with VB = -VA - VC. The current measurement is carried out over all phases. [▹ 30]
	5	0x05	0b101	4WDNB	4-wire delta connection (non-blondel compliant) 2-phase voltage measurement on phase 1 and 3. The voltage on phase 2 is calculated with VB = -VA. The current measurement is carried out over all phases. [▹ 31]
	6	0x06	0b110	3Wx	3-Wire, 2 phases ▪ 3WR: 3-wire residential star connection ▪ 3WN: 3-wire network star connection
	7	0x07	0b111	M1P	max. 4-wires max. 3 single-phase systems, same neutral conductor (star connection)
Line frequency	**0**	**0x00**	**0b0**	**50 Hz**	The line frequency of the voltage to be measured is 50 Hz.
	1	0x01	0b1	60 Hz	The line frequency of the voltage to be measured is 60 Hz.
IL2 calculation enabled	**0**	**0x00**	**0b0**	**No**	Current IL2 is measured.
	1	0x01	0b1	Yes	Current IL2 is calculated from the two currents IL1 and IL3: IL2 = -IL1 - IL3

Parameters	Value Dec.	Hex.	Bit assignment	Meaning	Description
Phase assignment	Voltage and current can be redirected within the device. The phase assignment indicates where the voltage or current of the 3 phases L1, L2 or L3 is output.				
Phase assignment voltage U1	**0**	**0x00**	**0b00**	**U1 at UL1**	Voltage U1 is output at UL1.
	1	0x01	0b01	U2 at UL1	Voltage U2 is output at UL1.
	2	0x02	0b10	U3 at UL1	Voltage U3 is output at UL1.
Phase assignment voltage U2	0	0x00	0b00	U1 at UL2	Voltage U1 is output at UL2.
	1	**0x01**	**0b01**	**U2 at UL2**	Voltage U2 is output at UL2.
	2	0x02	0b10	U3 at UL2	Voltage U3 is output at UL2.
Phase assignment voltage U3	0	0x00	0b00	U1 at UL3	Voltage U1 is output at UL3.
	1	0x01	0b01	U2 at UL3	Voltage U2 is output at UL3.
	2	**0x02**	**0b10**	**U3 at UL3**	Voltage U3 is output at UL3.
Phase assignment current I1	**0**	**0x00**	**0b00**	**I1 at IL1**	Current I1 is output at IL1.
	1	0x01	0b01	I2 at IL1	Current I2 is output at IL1.
	2	0x02	0b10	I3 at IL1	Current I3 is output at IL1.
Phase assignment current I2	0	0x00	0b00	I1 an IL2	Current I1 is output at IL2.
	1	**0x01**	**0b01**	**I2 an IL2**	Current I2 is output at IL2.
	2	0x02	0b10	I3 an IL2	Current I3 is output at IL2.
Phase assignment current I3	0	0x00	0b00	I1 an IL3	Current I1 is output at IL3.
	1	0x01	0b01	I2 an IL3	Current I2 is output at IL3.
	2	**0x02**	**0b10**	**I3 an IL3**	Current I3 is output at IL3.
Transformer ratio (P/S)					
■ BL20-E-3EMM-CT	**1**… 65535	**0x01** …0xFFFF		Specifies the conversion ratio (P/S = primary/secondary) of the current transformer. Example: 5 = 5:1 current transformer	
■ BL20-E-3EMM-RC	1… 65535, **33300**	0x01 … 0xFFFF, **0x8214**		Specifies the conversion ratio (P/S = primary/secondary) of the Rogowski coil, i.e. how many mV the Rogowski coil outputs for 1 kA. Example: 33300 = 333 mV/kA	
Calculation of apparent power and apparent energy	The calculation of apparent power and apparent energy is performed either on the basis of the voltage measured by the device or on the basis of the nominal voltage specified by the user in the "Line nominal voltage" parameter.				
	0	**0x00**	**0b000**	deactivated	The voltage measured by the device serves as the basis for calculating apparent power and apparent energy.
	1	0x01	0b001	Basic nominal voltage L1	The voltage specified in the "Line nominal voltage" parameter is used as a basis for calculating apparent power and apparent energy of phase L1, L2 or L3.
	2	0x02	0b010	Basic nominal voltage L2	
	4	0x04	0b100	Basic nominal voltage L3	
Line nominal voltage	0… 255, **230**	0x00… 0xFF, **0xE6**			Line nominal voltage in V

Parameters	Value Dec.	Value Hex.	Bit assignment	Meaning	Description
Cut-off frequency high-pass filter	0	0x00	0b000	77.39 Hz	3 dB cut-off frequency high-pass filter
	1	0x01	0b001	39.275 Hz	
	2	0x02	0b010	19.79 Hz	
	3	0x03	0b100	9.935 Hz	
	4	0x04	0b100	4.98 Hz	
	5	0x05	0b101	2.495 Hz	
	6	**0x06**	**0b110**	**1.25 Hz**	
	7	0x07	0b111	0.625 Hz	
Total current calculation	**0**	**0x0**	0b00	**IL1 + IL2 + IL3**	The total current is calculated by adding the individual currents at L1, L2 and L3. Depending on the setting, the individual current at the neutral conductor is taken into account in the calculation.
	1	0x01	0b01	IL1 + IL2 + IL3 + IN	
	2	0x02	0b10	IL1 + IL2 + IL3 + IN	
Resolution (I, P)	0	0x00	0b000	Reserved	Resolution for the display of the measured values current and power in mA or W, depending on the application Default: ▪ BL20-E-3EMM-CT: 2 = 1 mA, 1 W ▪ BL20-E-3EMM-RC: 3 = 10 mA, 10 W
	1	0x01	0b001	0.1 mA, 0.1 W	
	2	0x02	0b010	1 mA, 1 W	
	3	0x03	0b011	10 mA, 10 W	
	4	0x04	0b100	100 mA, 100 W	
	5	0x05	0b101	1000 mA, 1000 W	
	6	0x06	0b110	Reserved	
	7	0x07	0b111	Reserved	
Deactivate channel	Deactivating a channel affects the process data of the channel. Example: Bit 5 = 1 → channel U2 is deactivated All process data resulting from the voltage measurement at L2 (e.g. "Voltage RMS value L2 ", "Active power L2", "Reactive power L2", etc.) are not determined further and may contain invalid values. The "Data valid" bit in the process output data of the module [▸ 54] remains = 0 for the corresponding channel.				
	0	**0x00**	0b00000000	**None**	**No channel deactivated**
	1	0x01	0b00000001	Channel I1	Channel I1 deactivated
	2	0x02	0b00000010	Channel I2	Channel I2 deactivated
	4	0x04	0b00000100	Channel I3	Channel I3 deactivated
	8	0x08	0b00001000	Channel IN	Channel IN deactivated
	16	0x10	0b00010000	Channel U1	Channel U1 deactivated
	32	0x20	0b00100000	Channel U2	Channel U2 deactivated
	64	0x40	0b01000000	Channel U3	Channel U3 deactivated
Activate alarm	**0**	**0x0**	0b00000000	**None**	No alarm activated
	1	0x01	0b00000001	Voltage upper limit Ln	Activates the voltage alarm (maximum value)
	2	0x02	0b00000010	Voltage lower limit Ln	Activates the voltage alarm (minimum value)
	4	0x04	0b00000100	Current upper limit Ln	Activates the current alarm (maximum value)

Parameters	Value Dec.	Value Hex.	Bit assignment	Meaning	Description
	8	0x08	0b00001000	Current lower limit Ln	Activates the current alarm (minimum value)
	16	0x10	0b00010000	Frequency upper limit Ln	Activates the frequency alarm (maximum value)
	32	0x20	0b00100000	Frequency lower limit Ln	Activates the frequency alarm (minimum value)
	64	0x40	0b01000000	Power factor lower limit	Activates the alarm for the power factor (minimum value)
	128	0x80	0b10000000	Current unbalance upper limit	Activates the alarm for the current unbalance upper limit (maximum value)
Alarm upper limit voltage Ln	0… 65535, **0**	0… 0xFFFF, **0x00**		Limit value for voltage (maximum value) in V, device limits: 30…300 V, e.g.: Upper limit 10000 = 100 V	
Alarm lower limit voltage Ln	0… 65535, **0**	0… 0xFFFF, **0x00**		Limit value for voltage (minimum value) in V, device limits: 30…300 V, e.g.: Lower limit 4000 = 40 V	
Alarm upper limit current Ln	0… 65535, **0**	0… 0xFFFF, **0x00**		Limit value for current (maximum value) in mA, depending on the selected resolution in parameter "Resolution (I, P)", e.g.: 0x2328 = 900 mA (at resolution 0.1 mA)	
Alarm lower limit current Ln	0… 65535, **0**	0… 0xFFFF, **0x00**		Limit value for current (minimum value) in mA, depending on the selected resolution in parameter "Resolution (I, P)", e.g.: 0x03E8 = 100 mA (at resolution 0.1 mA)	
Alarm upper limit frequency	0… 255, **0**	0x00… 0xFF, **0x00**		Limit value for the frequency (maximum value) in Hz, device limits: 42…70 Hz, e.g.: upper limit 60 = 60 Hz	
Alarm lower limit frequency	0… 255, **0**	0x00… 0xFF, **0x00**		Limit value for the frequency (minimum value) in Hz device limits: 42…70 Hz z. e.g.: Lower limit 45 = 45 Hz	
Alarm lower limit power factor	0…1, **0**	0x00… 0xFF, **0x00**		Limit value for the power factor (minimum value), 1 = 0xFF e.g.: Lower limit 0x7F = 0.5	
Alarm upper limit current unbalance	0… 65535, **0**	0… 0xFFFF, **0x00**		Limit value for current unbalance (maximum value) in mA, depending on the selected resolution in parameter "Resolution (I, P)", e.g.: 0x03E8 = 100 mA (at resolution 0.1 mA)	
Process value ch0… ch7	Index for the process value that is to be mapped to the channel in the process output data [▸ 54] of the module [▸ 49].				
Process value index ch 0			16 bit process data		Mapped by index specification in process output data byte 8 and 9
Process value index ch 1			16 bit process data		Mapped by index specification in process output data byte 10 and 11
Process value index ch 2			16 bit process data		Mapped by index specification in process output data byte 12 and 13
Process value index ch 3			16 bit process data		Mapped by index specification in process output data byte 14 and 15
Process value index ch 4			32 bit process data		Mapped by index specification in process output data byte 16 and 19
Process value index ch 5			32 bit process data		Mapped by index specification in process output data byte 20 and 23

Parameters	Value Dec.	Hex.	Bit assignment	Meaning	Description
Process value index ch 6			32 bit process data		Mapped by index specification in process output data byte 24 and 27
Process value index ch 7			32 bit process data		Mapped by index specification in process output data byte 28 and 31

8.1.1 Parameterizing limit value alarms

In addition to the measured values, limit value alarms (parameter byte 10) can be activated and limit values can be defined defined (parameter bytes 11…23). The exceeding or falling below of limit values is then output in the process input data (bytes 3…5) as a process alarm.

8.2 Measured value

For the measured values, a distinction is made between standard measured values (16 bit measured values) and accumulated measured values (32 bit measured values). The accumulated measured values are counter values. The standard measured values occupy the indices 1…66 of the register interface, the accumulated measured values the indices 128…167. In addition, index 255 contains the module's diagnostics, which can also be mapped to the process data.

Standard measured values (16 bits) can be mapped into all data channels. They always occupy 16 bits, regardless of the size of the data channel into which they are mapped. Accumulated measured values can only be mapped into the four 32-bit data channels.

For the input of the measured value indices one byte per index is reserved in the parameters. In the process data, the indices are entered with 2 bytes per index.

<table>
<tr><th colspan="2">Measured value index</th><th rowspan="2">Measured value</th><th colspan="2" rowspan="2">Description/dependencies</th></tr>
<tr><th>Dec.</th><th>Hex.</th></tr>
<tr><td>0</td><td>0x00</td><td>Enable dynamic interface</td><td colspan="2">No value selected
The index defines whether the measured values to be output are specified via the process data or via the parameters [▸ 49].</td></tr>
<tr><td>1</td><td>0x01</td><td>RMS voltage L1</td><td>■ Standard calculation: L1 - N
■ Connection type = 3WD: L1 - L2</td><td rowspan="3">Calculation depending on the "Connection type" parameter [▸ 34]
No valid measurement if:
■ Voltage input deactivated
or
■ Undervoltage at voltage input</td></tr>
<tr><td>2</td><td>0x02</td><td>RMS voltage L2</td><td>■ Standard calculation: L2 - N
■ Connection type = 3WD: L1 - L3</td></tr>
<tr><td>3</td><td>0x03</td><td>RMS voltage L3</td><td>■ Standard calculation: L3 - N
■ Connection type = 3WD: L2 - L3</td></tr>
<tr><td>4</td><td>0x04</td><td>RMS voltage average L1</td><td colspan="2" rowspan="3">Averaging over 200 ms over 10 (50 Hz) or 12 cycles (60 Hz)
No valid measurement if:
■ Voltage input deactivated
or
■ Undervoltage at voltage input</td></tr>
<tr><td>5</td><td>0x05</td><td>RMS voltage average L2</td></tr>
<tr><td>6</td><td>0x06</td><td>RMS voltage average L3</td></tr>
<tr><td>8</td><td>0x08</td><td>RMS current L1</td><td colspan="2" rowspan="4">No valid measurement if:
■ Current input deactivated
or
■ Undercurrent at current input</td></tr>
<tr><td>9</td><td>0x09</td><td>RMS current L2</td></tr>
<tr><td>10</td><td>0x0A</td><td>RMS current L3</td></tr>
<tr><td>11</td><td>0x0B</td><td>RMS current N</td></tr>
<tr><td>12</td><td>0x0C</td><td>RMS current average L1</td><td colspan="2" rowspan="3">Averaging over 200 ms over 10 (50 Hz) or 12 cycles (60 Hz)
No valid measurement if:
■ Current input deactivated
or
■ Undercurrent at current input</td></tr>
<tr><td>13</td><td>0x0D</td><td>RMS current average L2</td></tr>
<tr><td>14</td><td>0x0E</td><td>RMS current average L3</td></tr>
<tr><td>16</td><td>0x10</td><td>Current unbalance L1…L3</td><td colspan="2">Value of the largest deviation of one of the three currents from the average value
The average value is calculated from the currents at L1, L2 and L3. If one or two phases are deactivated, the mean value is calculated from the current or currents of the activated phase(s).
No valid measurement if this is valid for all channels:
■ Current input deactivated
or
■ Undercurrent at current input</td></tr>
</table>

Measured value index		Measured value	Description/dependencies
Dec.	Hex.		
17	0x11	Total current	Calculation from all currents of phases L1, L2 and L3 depending on the "Total current calculation" parameter [▷ 34] No valid measurement if this is valid for **all** channels: ■ Current input deactivated or ■ Undercurrent at current input
18	0x12	Line frequency L1	Measurement range: 42…70 Hz If the measured frequency is outside the measuring range, the value set in the "Mains frequency" parameter [▷ 34] is displayed. No valid measurement if: ■ Voltage input deactivated or ■ Undervoltage at voltage input (the frequency measurement is carried out at the voltage input)
19	0x13	Line frequency L2	
20	0x14	Line frequency L3	
21	0x15	Line frequency combined L1...L3	Measurement range: 42…70 Hz If the measured frequency is outside the measuring range, the value set in the "Mains frequency" parameter [▷ 34] is displayed. No valid measurement if this is valid for **all** channels: ■ Voltage input deactivated or ■ Undervoltage at voltage input
22	0x16	Phase angle UL1 - UL2	No valid measurement if: ■ Voltage input deactivated or ■ Undervoltage at voltage input
23	0x17	Phase angle UL2 - UL3	
24	0x18	Phase angle UL1 - UL3	
25	0x19	Phase angle IL1 - IL2	No valid measurement if: ■ Current input deactivated or ■ Undercurrent at current input
26	0x1A	Phase angle IL2 - IL3	
27	0x1B	Phase angle IL1 - IL3	
28	0x1C	Phase angle UL1 - IL1	No valid measurement if: ■ Voltage or respective current input deactivated or ■ Undervoltage at voltage input or undercurrent at current input
29	0x1D	Phase angle UL2 - IL2	
30	0x1E	Phase angle UL3 - IL3	
31	0x1F	Power factor L1	No valid measurement if: ■ Voltage or respective current input deactivated or ■ No load conntected, s. diagnostics "No load L…" [▷ 60]
32	0x20	Power factor L2	
33	0x21	Power factor L3	
34	0x22	Active power L1, L2, L3	No valid measurement if: ■ Voltage or respective current input deactivated or ■ Undervoltage at voltage input or undercurrent at current input
35	0x23	Active power L2	
36	0x24	Active power L3	
37	0x25	Reactive power L1	
38	0x26	Reactive power L2	
39	0x27	Reactive power L3	
40	0x28	Apparent power L1	
41	0x29	Apparent power L2	
42	0x2A	Apparent power L3	

Measured value index Dec.	Hex.	Measured value	Description/dependencies
43	0x2B	RMS voltage fundamental L1	Measurement of the fundamental voltage, no measurement of harmonics Depending on the "Mains frequency" parameter [▹ 34], 50 Hz or 60 Hz is assumed as the fundamental frequency. No valid measurement if: ▪ Voltage input deactivated or ▪ Undervoltage at voltage input
44	0x2C	RMS voltage fundamental L2	
45	0x2D	RMS voltage fundamental L3	
46	0x2E	RMS current fundamental L1	Measurement of the fundamental voltage, no measurement of harmonics Depending on the "Mains frequency" parameter [▹ 34], 50 Hz or 60 Hz is assumed as the fundamental frequency. No valid measurement if: ▪ Current input deactivated or ▪ Undercurrent at current input
47	0x2F	RMS current fundamental L2	
48	0x30	RMS current fundamental L3	
49	0x31	Active power fundamental L1	Measurement of the fundamental voltage, no measurement of harmonics Depending on the "Mains frequency" parameter [▹ 34], 50 Hz or 60 Hz is assumed as the fundamental frequency. No valid measurement if: ▪ Voltage or respective current input deactivated or ▪ Undervoltage at voltage input or undercurrent at current input
50	0x32	Active power fundamental L2	
51	0x33	Active power fundamental L3	
52	0x34	Reactive power fundamental L1	
53	0x35	Reactive power fundamental L2	
54	0x36	Reactive power fundamental L3	
55	0x37	Apparent power fundamental L1	
56	0x38	Apparent power fundamental L1	
57	0x39	Apparent power fundamental L1	
58	0x3A	THD voltage L1	(sum voltage of all harmonics / voltage of the fundamental) × 100
59	0x3b	THD voltage L2	
60	0x3C	THD voltage L3	
61	0x3D	THD current L1	(sum of current of all harmonics / current of the fundamental) × 100
62	0x3E	THD current L2	
63	0x3F	THD current L3	
64	0x40	Line voltage L1 - L2	No valid measurement if: ▪ Voltage input deactivated ▪ Undervoltage at voltage input ▪ Parameter ”Connection type” = „3Wx” or „M1P” [▹ 34]
65	0x41	Line voltage L1 - L3	
66	0x42	Line voltage L2 - L3	

Measured value index Dec.	Hex.	Measured value	Description/dependencies
128	0x80	Effective energy accumulated L1	The measured value is measured and accumulated as long as the measurement process is enabled. The measurement process for accumulated measured values is started via the process data for the corresponding data channel via a "Counter gate" bit and reset via a "Counter reset" bit [56].
129	0x81	Effective energy accumulated L2	
130	0x82	Effective energy accumulated L3	
131	0x83	Reactive energy accumulated L1	
132	0x84	Reactive energy accumulated L2	
133	0x85	Reactive energy accumulated L1	
134	0x86	Apparent energy accumulated L1	
135	0x87	Apparent energy accumulated L2	
136	0x88	Apparent energy accumulated L1	
137	0x89	Effective energy fundamental accumulated L1	The measured value is measured and accumulated as long as the measurement process is enabled. Depending on the "Mains frequency" parameter [34], 50 Hz or 60 Hz is assumed as the fundamental frequency. The measurement process for accumulated measured values is started via the process data for the corresponding data channel via a "Counter gate" bit and reset via a "Counter reset" bit [56].
138	0x8A	Effective energy fundamental accumulated L2	
139	0x8B	Effective energy fundamental accumulated L3	
140	0x8C	Reactive energy fundamental accumulated L1	
141	0x8D	Reactive energy fundamental accumulated L2	
142	0x8E	Reactive energy fundamental accumulated L3	
143	0x8F	Apparent energy fundamental accumulated L1	
144	90	Apparent energy fundamental accumulated L2	
145	91	Apparent energy fundamental accumulated L3	

Measured value index Dec.	Hex.	Measured value	Description/dependencies
146	92	Active energy positive accumulated L1 + L2 + L3	The measured value is measured and accumulated as long as the measurement process is enabled. The measurement process for accumulated measured values is started via the process data for the corresponding data channel via a "Counter gate" bit and reset via a "Counter reset" bit [▸ 56].
147	93	Active energy negative accumulated L1 + L2 + L3	
148	94	Reactive energy positive accumulated L1 + L2 + L3	
149	95	Reactive energy negative accumulated L1 + L2 + L3	
150	96	Peak value voltage L1…L3	Detection of the highest measured voltage peak in the measurement period The measurement process for accumulated measured values is started via the process data for the corresponding data channel via a "Counter gate" bit and reset via a "Counter reset" bit [▸ 56].
151	97	Peak value current L1…L3	Detection of the highest measured current peak in the measurement period The measurement process for accumulated measured values is started via the process data for the corresponding data channel via a "Counter gate" bit and reset via a "Counter reset" bit [▸ 56]. **Note:** Changes to the "Resolution" (P/I) and "Converter ratio" parameters interrupt the measurement and require a reset of the value via the "Counter reset" reset bit.
255	FF	Diagnosis	No measured value, if necessary, the module diagnostics can be mapped into a 32-bit data channel via this index.

8.2.1 Measured value representation

Measured value index Dec.	Hex.	Measured value	Represen-tation	Max. value	Unit	Conversion factor
0	0x0	Enable dynamic interface				
1	0x01	RMS voltage L1	0x01 = 0.01 V	300	V	× (1/100)
2	0x02	RMS voltage L2				
3	0x03	RMS voltage L3				
4	0x04	RMS voltage average L1				
5	0x05	RMS voltage average L2				
6	0x06	RMS voltage average L3				
7	0x07	Reserved	-			
8	0x08	RMS current L1	Depending on the resolution: 0x01 = 0.1 mA, 1 mA, 10 mA, 100 mA, 1000 mA	65535 × (resolution/1000)	A	× (resolution/1000)
9	0x09	RMS current L2				
10	0x0A	RMS current L3				
11	0x0B	RMS current N				
12	0x0C	RMS current average L1				
13	0x0D	RMS current average L2				
14	0x0E	RMS current average L3				
15	0x0F	Reserved	-			
16	0x10	Current unbalance L1…L3	Depending on the resolution: 0x01 = 0.1 mA, 1 mA, 10 mA, 100 mA, 1000 mA	65535 × (resolution/1000)	A	× (resolution/1000)
17	0x11	Total current				
18	0x12	Line frequency L1	60 Hz = 0x1E00	70	Hz	× (1/128)
19	0x13	Line frequency L2				
20	0x14	Line frequency L3				
21	0x15	Line frequency combined L1…L3				
22	0x16	Phase angle UL1 - UL2	360° = 0x7FFF	360	°	× (360/32767)
23	0x17	Phase angle UL2 - UL3				
24	0x18	Phase angle UL1 - UL3				
25	0x19	Phase angle IL1 - IL2				
26	0x1A	Phase angle IL2 - IL3				
27	0x1B	Phase angle IL1 - IL3				
28	0x1C	Phase angle UL1 - IL1				
29	0x1D	Phase angle UL2 - IL2				
30	0x1E	Phase angle UL3 - IL3				
31	0x1F	Power factor L1	1 = 0x3FFF	1	-	× (1/16383)
32	0x20	Power factor L2				
33	0x21	Power factor L3				

Measured value index Dec.	Hex.	Measured value	Represen-tation	Max. value	Unit	Conversion factor
34	0x22	Active power L1, L2, L3	Depending on the resolution: 0x01 = 0.1 W, 1 W, 10 W, 100 W, 1000 W	± 32767 × resolution	W	× (resolution)
35	0x23	Active power L2				
36	0x24	Active power L3				
37	0x25	Reactive power L1			Var	
38	0x26	Reactive power L2				
39	0x27	Reactive power L3				
40	0x28	Apparent power L1			VA	
41	0x29	Apparent power L2				
42	0x2A	Apparent power L3				
43	0x2B	RMS voltage fundamental L1	0x01 = 0.01 V	300	V	× (1/100)
44	0x2C	RMS voltage fundamental L2				
45	0x2D	RMS voltage fundamental L3				
46	0x2E	RMS current fundamental L1	Depending on the resolution: 0x01 = 0.1 mA, 1 mA, 10 mA, 100 mA, 1000 mA	65535 × (resolution/1000)	A	× (resolution/1000)
47	0x2F	RMS current fundamental L2				
48	0x30	RMS current fundamental L3				
49	0x31	Active power fundamental L1	Depending on the resolution: 0x01 = 0.1 W, 1 W, 10 W, 100 W, 1000 W	± 32767 × resolution	W	× (resolution)
50	0x32	Active power fundamental L2				
51	0x33	Active power fundamental L3				
52	0x34	Reactive power fundamental L1			Var	
53	0x35	Reactive power fundamental L2				
54	0x36	Reactive power fundamental L3				
55	0x37	Apparent power fundamental L1			VA	
56	0x38	Apparent power fundamental L1				
57	0x39	Apparent power fundamental L1				

Measured value index Dec.	Hex.	Measured value	Represen-tation	Max. value	Unit	Conversion factor
58	0x3A	THD voltage L1	4 = 0x7FFF	4	-	× (4/32767)
59	0x3b	THD voltage L2				
60	0x3C	THD voltage L3				
61	0x3D	THD current L1				
62	0x3E	THD current L2				
63	0x3F	THD current L3				
64	0x40	Line voltage L1 - L2	0x01 = 0.01 V	655.35	V	× (1/100)
65	0x41	Line voltage L1 - L3				
66	0x42	Line voltage L2 - L3				
128	0x80	Effective energy accumulated L1	0x01 = 0.1 Wh	± 214748364.7	Wh	× (1/10)
129	0x81	Effective energy accumulated L2				
130	0x82	Effective energy accumulated L3				
131	0x83	Reactive energy accumulated L1	0x01 = 0.1 Varh	± 214748364.7	Varh	× (1/10)
132	0x84	Reactive energy accumulated L2				
133	0x85	Reactive energy accumulated L1				
134	0x86	Apparent energy accumulated L1	0x01 = 0.1 Vah	± 214748364.7	Vah	× (1/10)
135	0x87	Apparent energy accumulated L2				
136	0x88	Apparent energy accumulated L1				
137	0x89	Effective energy fundamental accumulated L1	0x01 = 0.1 Wh	± 214748364.7	Wh	× (1/10)
138	0x8A	Effective energy fundamental accumulated L2				
139	0x8B	Effective energy fundamental accumulated L3				
140	0x8C	Reactive energy fundamental accumulated L1	0x01 = 0.1 Varh	± 214748364.7	Varh	× (1/10)
141	0x8D	Reactive energy fundamental accumulated L2				
142	0x8E	Reactive energy fundamental accumulated L3				

Measured value index Dec.	Hex.	Measured value	Represen-tation	Max. value	Unit	Conversion factor
143	0x8F	Apparent energy fundamental accumulated L1	0x01 = 0.1 Vah	± 214748364.7	Vah	× (1/10)
144	90	Apparent energy fundamental accumulated L2				
145	91	Apparent energy fundamental accumulated L3				
146	92	Active energy positive accumulated L1 + L2 + L3	0x01 = 0.1 Wh	± 214748364.7	Wh	× (1/10)
147	93	Active energy negative accumulated L1 + L2 + L3				
148	94	Reactive energy positive accumulated L1 + L2 + L3	0x01 = 0.1 Varh	± 214748364.7	Varh	× (1/10)
149	95	Reactive energy negative accumulated L1 + L2 + L3				
150	96	Peak value voltage L1…L3	0x01 = 0.01 V	21474836.47	V	× (1/100)
151	97	Peak value current L1…L3	Depending on the resolution: 0x01 = 0.1 mA, 1 mA, 10 mA, 100 mA, 1000 mA	(2147483647 × (resolution/1000)	A	× (resolution/1000)
255	FF	Diagnosis	-			

8.3 Mapping measured values into the process data via the register interface

Up to eight measured values [▸ 40] can be mapped into the process data of the energy measurement module simultaneously via eight data channels using the internal register interface. Each data channel can be assigned with data from a register of the register interface.

Four 16-bit data channels are available for the transmission of standard measured values and four 32-bit data channels are available for the transmission of accumulated measured values.

Which measured values are mapped to the data channels and output via the process data is defined either by static configuration [▸ 49] via the module parameters or by dynamic configuration [▸ 49] via the process input data of the module.

Mapping diagnostic data into the process data

The register interface also allows the diagnostic data to be mapped into the process output data of the module via index 255 [▸ 40].

8.3.1 Static configuration of measured values via parameters

Static configuration via the module parameters [▸ 49] always has priority.

The measured values to be output by the energy measurement module are defined statically for each data channel via the module parameters.

One byte per index is reserved in the parameters for entering the measured value indices.

- ▶ Define the measured value index [▸ 40] in parameter "Process value index ch0…Process value index" (parameter byte 24…31).

8.3.2 Dynamic configuration of measured values via process data (dynamic interface)

The dynamic configuration via the process data is only used if the parameter "Process value index ch..." (bytes 24...31) for the respective data channel is set to **0 = enable dynamic interface** or no measured value index has been selected.

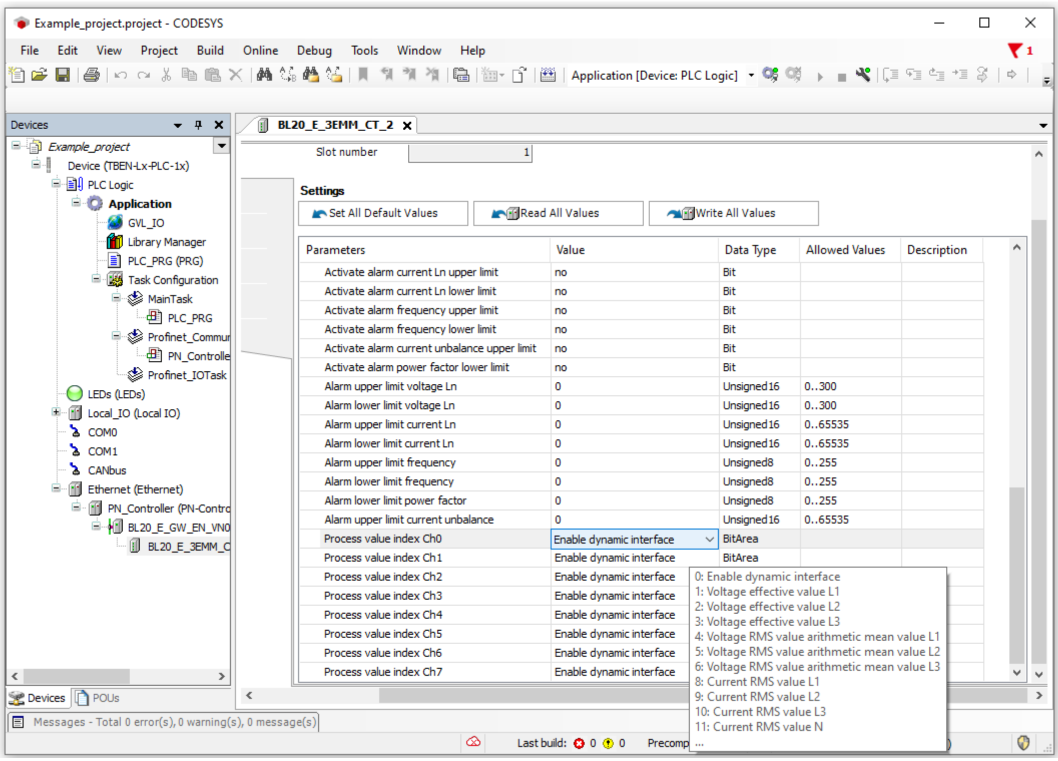


Fig. 22: Enable dynamic interface, example CODESYS

Using the dynamic interface

Each individual data channel of the energy measurement module can be used to measure several measured values. The measurement is performed sequentially and must be programmed via the control unit. The **DIY toggle**bit in the process output data of the energy measurement module is used for feedback of the measured value change on the data channel.

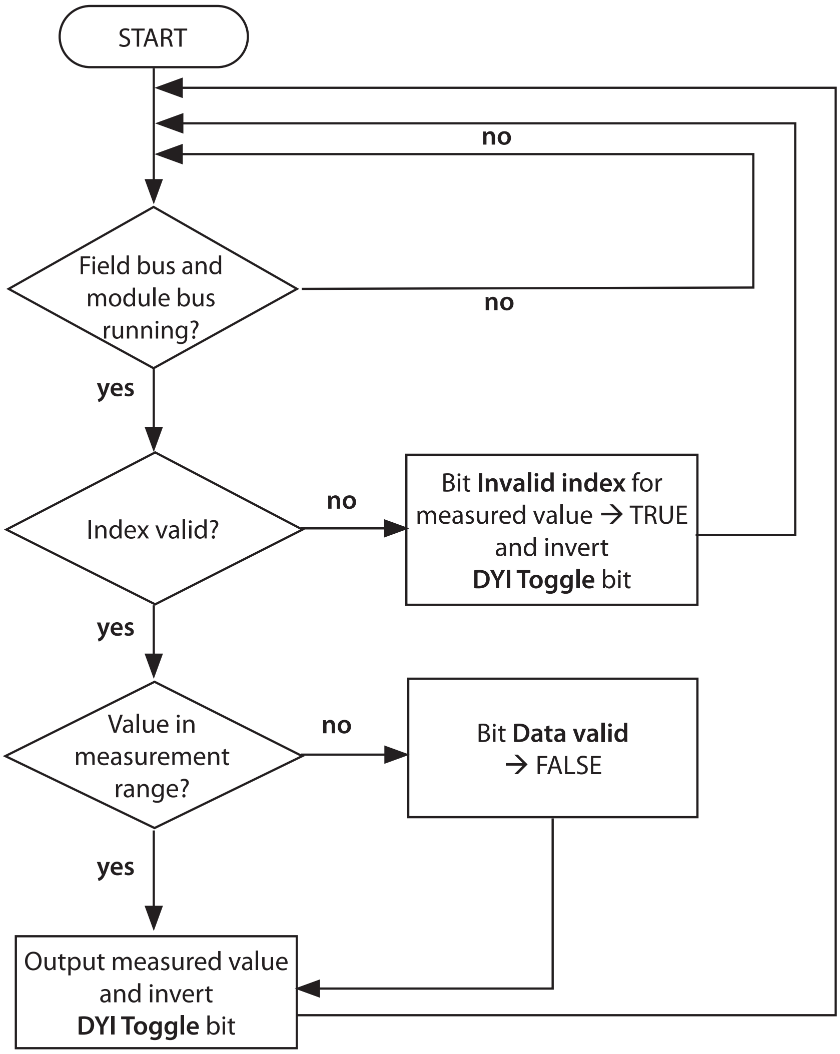


Fig. 23: Dynamic interface

Example program for the dynamic configuration

Global variables

```
VAR_GLOBAL
quiIndex iui          : UINT;
ProcessValue          : UINT;
ixDataValid           : BOOL;
ixIndexInvalid        : BOOL;
ixDYIToggle           : BOOL;
END_VAR
```

Local variables

```
VAR
ixDYIToggleOld        : BOOL;
uiStep                : UINT;
uiVoltage             : UINT;
uiCurrent             : UINT;
uifrequency           : UINT;:
END_VAR
```

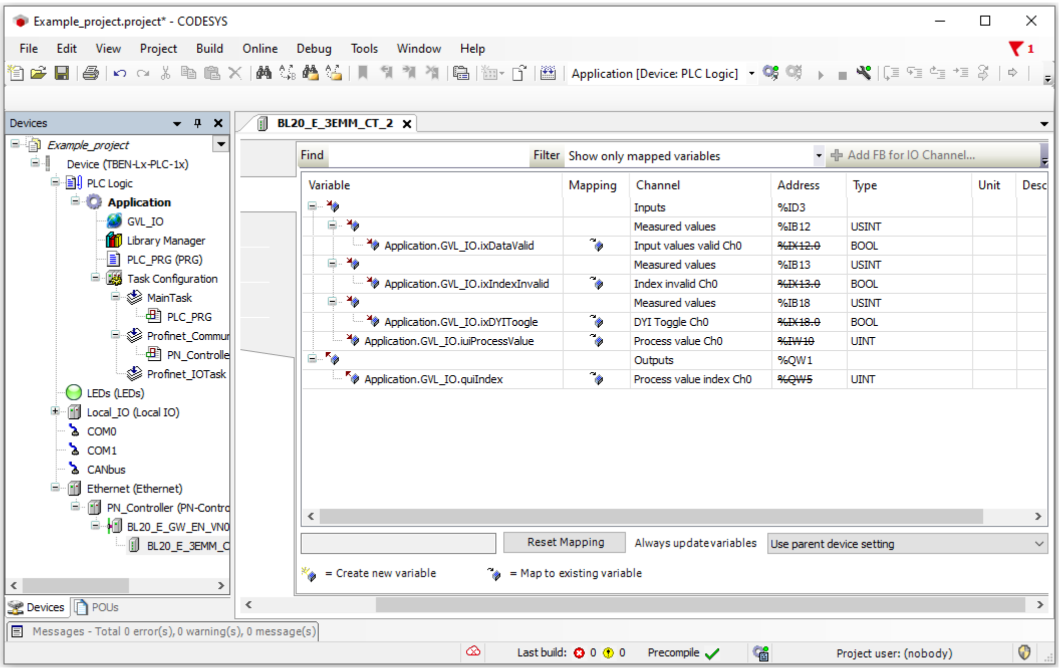


Fig. 24: CODESYS: Variable mapping in the example program

Program

```
IF (PN_Controller.GetBusState() =2) THEN      // fieldbus must be running
CASE uiStep OF
0: // voltage measurement L1
gvl_io.quiIndex := 1;                         // set the correct index
IF GVL_IO.ixDYIToggle <> ixDYIToggleOld THEN  // DIY toggle bit changed
uiVoltage := GVL_IO.iuiProcessValue;          // save process value
uiStep := uiStep +10;                         // next step
END_IF
10:// current measurement L1
gvl_io.quiIndex := 8;                         // set the correct index
IF GVL_IO.ixDYIToggle <> ixDYIToggleOld THEN  // DIY toggle bit changed
uiCurrent := GVL_IO.iuiProcessValue;          // save process value
uiStep := uiStep +10;                         // next step
END_IF
20: // frequency measurement L1
gvl_io.quiIndex := 18;                        // set the correct index
IF GVL_IO.ixDYIToggle <> ixDYIToggleOld THEN  // DIY toggle bit changed
uifrequency := GVL_IO.iuiProcessValue;        // save process value
uiStep := 0;                                  // next step
END_IF
END_CASE                                      // save DIY toggle bit
ixDYIToggleOld := GVL_IO.ixDYIToggle;
END_IF
```

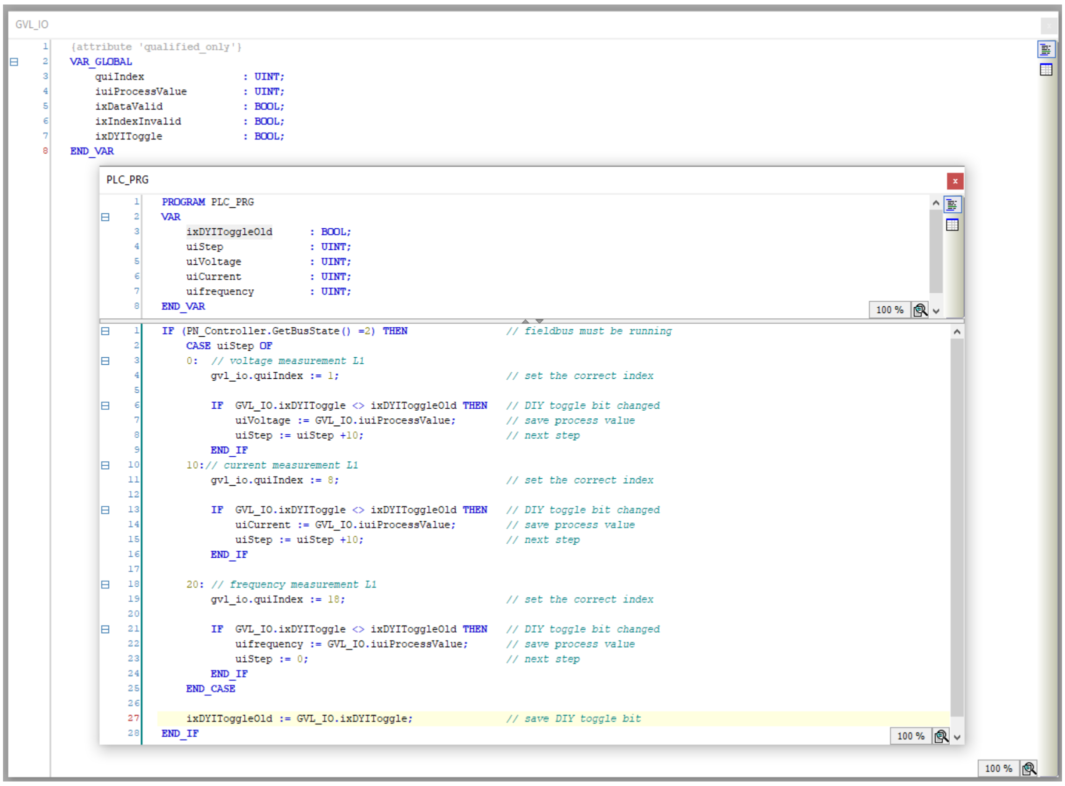


Fig. 25: CODESYS: example program

9 Operating

The energy measurement terminal sets the following for each data channel **Index invalid** bit (process output data byte 1), a **valid data** bit (process output data byte 0) and a **DYI toggle** bit (process output data byte 6)

The **Index invalid** bit is set if the index specified by the controller is invalid. The **valid data** bit is set if the data available in the process output data is valid for a measured value. The **valid data** bit is set to zero if the output value is outside the measuring range (e.g. 30…300 V for voltage measurement). The **DYI toggle** bit always changes the value when a measured value change takes place on a data channel and thus reports the execution of the measured value change back to the controller.

9.1 Process input data

Byte	**Bit no.**							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	**Counter reset**				**Counter gate**			
	Ch7	Ch6	Ch5	Ch4	Ch7	Ch6	Ch5	Ch4
1…7	Reserved							
8	Process value index ch 0 LSB							
9	Process value index ch 0 MSB							
…	…							
22	Process value index ch 7 LSB							
23	Process value index ch 7 MSB							
24…31	Reserved							

Meaning of the process data bits

Bit	**Value**	**Meaning**
Counter reset ch4…ch7	0	Reset inactive
	1	Reset of the measured value counter to 0 counter reset for 32 bit measured values [▸ 56]) The measured value remains 0 as long as the reset bit is 0. The measured value counter must then be enabled again via the "Counter gate" bit. The reset has a higher priority than the release via the "Counter gate" bit.
Counter gate ch 4…ch 7	0	Counter not enabled or stopped, the measured value remains constant
	1	Enabling the measured value counter counter gate for 32-bit measured values [▸ 56]) The measured value is summed up until the enable is withdrawn or the counter is reset via the reset bit.
Process value index ch0…ch3	0…63	Index of the measured values (index 0…151, 255 [▸ 49]), to be mapped into the data channels in the process output data of the module. 16 bit measured values (indices 0…63) can be mapped into all data channels ch0…ch7. 32 bit measured values (index 128…151, 255) must be mapped to 32-bit data channels ch4…ch7.
Process value index ch4…ch7	0…151, 255	

9.2 Process output data

The device supplies an "invalid index" bit (process output data byte 1), a "data ready" bit (process output data byte 0) and a "value overflow" (process output data byte 2) for each measured value.

The "DYI toggle" bit indicates a measured value change on a data channel via a status change (0 ←→ 1) [▹ 59].

Byte	**Bit no.**							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Data valid ch0…ch7								
0	Ch7	Ch6	Ch5	Ch4	Ch3	Ch2	Ch1	Ch0
Index invalid ch0…ch7								
1	Ch7	Ch6	Ch5	Ch4	Ch3	Ch2	Ch1	Ch0
Value overflow ch0…ch7								
2	Ch7	Ch6	Ch5	Ch4	Ch3	Ch2	Ch1	Ch0
Status								
3	Upper current unbalance overrun	Lower limit power factor underrun	Lower limit frequency underrun	Upper limit frequency overrun	Lower limit current un-derrun	Upper limit current overrun	Lower limit voltage underrun	Upper limit voltage overrun
Status								
4	-	Lower limit power factor underrun	Lower limit frequency underrun	Upper limit frequency overrun	Lower limit current underrun	Upper limit current overrun	Lower limit voltage underrun	Upper limit voltage overrun
Status								
5	-	Lower limit power factor underrun	Lower limit frequency underrun	Upper limit frequency overrun	Lower limit current underrun	Upper limit current overrun	Lower limit voltage underrun	Upper limit voltage overrun
DYI toggle ch0…ch7								
6	Ch7	Ch6	Ch5	Ch4	Ch3	Ch2	Ch1	Ch0
7	Reserved							
Process values ch0…ch3 (16-bit values)								
8	Process value ch 0 LSB							
9	Process value ch 0 MSB							
…	…							
14	Process value ch 3 LSB							
15	Process value ch 3 MSB							
Process values ch4…ch7 (32-bit values)								
16	Process value ch 4 LLSB							
17	Process value ch 4 LSB							
18	Process value ch 4 MSB							
19	Process value ch 4 MMSB							
…								
28	Process value ch 7 LLSB							
29	Process value ch 7 LSB							
30	Process value ch 7 MSB							
31	Process value ch 7 MMSB							

Meaning of the process data bits

Bit	Value	Meaning
Data valid ch0…ch7	0	The data available in the data channel is not current or not valid. Possible causes: ▪ Energy measurement currently not possible due to active parameter change ▪ Measured value is outside the permissible measured value limits ▪ the channel has been deactivated
	1	The data available in the data channel is current or valid.
Index invalid ch0…ch7	0	Index valid
	1	The index specified in the process input data for the data channel is not valid. Possible causes: ▪ 32-bit measured value index specified for 16-bit data channel (ch0…ch3) ▪ Undefined index specified
Value overflow ch0…ch7	0	The measured value at the data channel is within the permissible measured value limits.
	1	The bit indicates a measured value overflow at the data channel. Maximum or minimum values: ▪ 16-bit data channel (ch0…ch3): 65535 (UINT), ± 32767 (INT) ▪ 32-bit data channel (ch4…ch7): ± 2147483647 (DINT) ▶ If necessary, adjust the resolution on the channel.
Upper limit voltage overrun L…	0	These bits indicate whether the measured value limits [▶ 34] set by the user have been exceeded or not reached. 0 = no exceeding or falling below of the parameterized upper or lower limits 1 = exceeding or falling below of the parameterized upper or lower limits
	1	
Lower limit voltage underrun L…	0	
	1	
Upper limit current overrun L…	0	
	1	
Lower limit current underrun L…	0	
	1	
Upper limit frequency overrun	0	
	1	
Lower limit frequency underrun	0	
	1	
Lower limit power factor underrun	0	
	1	
Upper current unbalance overrun	0	
	1	

Bit	Value	Meaning
DYI toggle ch0…ch7	0	Toggle bit
	1	The status change of the bit indicates whether a measured value change has taken place on the data channel.
Process value ch0…ch7		Measured value which is mapped via the register interface into the data channel (defined via process input data [▹ 53]) Resolution/representation (see "Mapping measured values into the process data via the register interface" [▹ 49]

9.3 Enable and reset accumulated 32-bit measured values (counter values)

In the process data, one gate bit "Counter gate" (process input data byte 0) and one reset bit "Counter reset" (process input data byte 0) are assigned to each 32-bit measured value (counter) to control the counter value. The measuring process starts with setting the gate bit (0 → 1). Resetting the gate bit (1 → 0) stops the measuring process and the measured value remains constant. Setting the reset bit (0 → 1) resets the measured value to 0. The measured value remains 0 until the reset bit is reset (1 → 0). The counter is only restarted if "counter reset" = 0. The "counter reset" bit overwrites the enable by the "counter gate" bit.

Counter gate	0	0	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0
Counter reset	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0
Counter value	0	0	1	2	3	4	4	4	4	0	0	0	1	2	3	0	0	0	1	2	3	3	3

Fig. 26: Gate-reset function

9.4 LED displays

The device has the following LED indicators:

- LED DIA: Hardware diagnostics, module bus communication
- LED 1…8: Status messages of the phases, limit value diagnostics

LED DIA	Meaning
Red flashing (0.5 Hz)	Module diagnostics ▶ Check the channels for diagnostic messages.
Red	Module bus communication disturbed ▶ Check whether more than two neighboring electronic modules have been pulled. ▶ Check module bus supply or supply at the gateway.
Off	No error message or diagnostics

LED U1	Meaning
Green	Voltage on phase L1 within the permissible range (30…300 V)
Green flashing (0.5 Hz)	Voltage on phase L1 outside the parameterized limits
Red flashing (0.5 Hz)	Voltage on phase L1 outside the permissible range (30…300 V)
Off	Channel inactive

LED I1	Meaning
Green	Current on phase L1 within the permissible range
Green flashing (0.5 Hz)	Current on phase L1 outside the parameterized limits
Red	Phase L1 not connected
Red flashing (0.5 Hz)	Current on phase L1 outside the permissible range ■ BL20-E-3EMM-CT: 1-A-connection: < 30 mA or > 1.1 A or 5-A-connection: < 100 mA or > 5.5 A ■ BL20-E-3EMM-RC: output voltage of the Rogowski coil: < 10 mV or > 385 mV
Off	Channel inactive

LED U2	Meaning
Green	Voltage on phase L2 within the permissible range (30…300 V)
Green flashing (0.5 Hz)	Voltage on phase L2 outside the parameterized limits
Red flashing (0.5 Hz)	Voltage on phase L2 outside the permissible range (30…300 V)
Off	Channel inactive

LED I2	Meaning
Green	Current on phase L2 within the permissible range
Green flashing (0.5 Hz)	Current on phase L2 outside the parameterized limits
Red	Phase L2 not connected
Red flashing (0.5 Hz)	Current on phase L2 outside the permissible range ■ BL20-E-3EMM-CT: 1-A-connection: < 30 mA or > 1.1 A or 5-A-connection: < 100 mA or > 5.5 A ■ BL20-E-3EMM-RC: output voltage of the Rogowski coil: < 10 mV or > 385 mV
Off	Channel inactive

LED U3	Meaning
Green	Voltage on phase L3 within the permissible range (30…300 V)
Green flashing (0.5 Hz)	Voltage on phase L3 outside the parameterized limits
Red flashing (0.5 Hz)	Voltage on phase L3 outside the permissible range (30…300 V)
Off	Channel inactive

LED I3	Meaning
Green	Current on phase L3 within the permissible range
Green flashing (0.5 Hz)	Current on phase L2 outside the parameterized limits
Red	Phase L3 not connected
Red flashing (0.5 Hz)	Current on phase L3 outside the permissible range ■ BL20-E-3EMM-CT: 1-A-connection: < 30 mA or > 1.1 A or 5-A-connection: < 100 mA or > 5.5 A ■ BL20-E-3EMM-RC: output voltage of the Rogowski coil: < 10 mV or > 385 mV
Off	Channel inactive

LED IN	Meaning
Green	Current on neutral conductor N within the permissible range
Red flashing (0.5 Hz)	Current on neutral conductor N outside the permissible range ■ BL20-E-3EMM-CT: 1-A-connection: < 30 mA or > 1.1 A or 5-A-connection: < 100 mA or > 5.5 A ■ BL20-E-3EMM-RC: output voltage of the Rogowski coil: < 10 mV or > 385 mV
Off	Channel inactive

LED ST	Meaning
Green	Normal operation
Red	Phase Sequence Error
Red flashing (0.5 Hz)	Temperature in the device outside the permissible range
Off	Module inactive, no voltage supply

9.5 Status and diagnostic messages

The device sends the following status and diagnostic messages:

- Status messages for the eight data channels ch 0…ch 7 (invalid index, data ready, value overflow)
- Limit value alarms for the parameterized measured value limits
- General hardware device diagnostics

9.5.1 Status messages of the data channels

The "invalid index" bit is set if the index specified by the controller is invalid. The "data valid" bit indicates the the data present in the process output data for a measured value is valid and is set to 0 if the output value is outside the measuring range. The "DYI toggle" bit uses a status change (0 ←→ 1) to indicate whether a measured value change has taken place on a data channel and thus reports the execution of the measured value change back to the controller.

The "value overflow" bit is set if the module detects an overflow at the channel. Bytes 3…5 contain alarms that indicate when the parameterized measured value limits [▸ 34] are exceeded or not reached.

9.5.2 Limit value alarms

If the alarms are activated, the device sends the following limit value alarms for each of the three phases in the process output data (bytes 3…5) [▸ 54]:

- Upper limit voltage overrun
- Lower limit voltage underrun
- Upper limit current overrun
- Lower limit current underrun
- Upper limit frequency overrun
- Lower limit frequency underrun
- Lower limit power factor underrun
- Upper current unbalance overrun

9.5.3 Hardware device diagnostics

If required, the hardware device diagnostics can be mapped via the measured value index 255 into one of the 32-bit data channels of the process data of the module (s. „Mapping measured values into the process data via the register interface” [▷ 49]

Byte	**Bit no.**							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	-	-	-	-	Module overtemperature	Phase sequence error	Hardware failure	Invalid parameter
Diagnostics voltage L1								
1	-	-	-	-	-	HW lower limit voltage underrun L1	HW upper limit voltage overrun L1	No load L1
Diagnostics voltage L2								
2	-	-	-	-	-	HW lower limit voltage underrun L2	HW upper limit voltage overrun L2	No load L2
Diagnostics voltage L3								
3	-	-	-	-	-	HW lower limit voltage underrun L3	HW upper limit voltage overrun L3	No load L3
Diagnostics current L1								
4	-	-	-	-	-	-	HW lower limit current underrun L1	HW upper limit current overrun L1
Diagnostics current L2								
5	-	-	-	-	-	-	HW lower limit current underrun L2	HW upper limit current overrun L2
Diagnostics current L3								
6	-	-	-	-	-	-	HW lower limit current underrun L3	HW upper limit current overrun L3
Diagnostics current N								
7	-	-	-	-	-	-	HW lower limit current underrun N	HW upper limit current overrun N

Meaning of the diagnostic bits

Bit	**Meaning**
Invalid parameter	Parameter outside the permissible limits
Hardware failure	General error of the hardware of the module (e.g. voltage supply of the module faulty, internal communication error).
Phase sequence error	The phases of the supply network are connected in the wrong order (observe the connection diagrams, see "Connecting" [▷ 18]).
Module overtemperature	The operating temperature measured in the device exceeds the specified limits (see "Technical data" [▷ 64]).
No load L…	No or insufficient load connected to the phase. When this diagnostic is active, no energy is measured. Minimum values for the connected load or power at the terminals of the device (secondary side of the current transformer or Rogowski coil): ■ BL20-E-3EMM-CT: 0.75 W (1 A connection) or 2.5 W (5 A connection) ■ BL20-E-3EMM-RC: 0.25 W

Bit	Meaning
HW upper limit voltage overrun L…	The voltage applied to the phase exceeds the specified limit (> 300 V)
HW lower limit voltage underrun L…	The voltage applied to the phase lies below the specified limit (< 30 V).
HW upper limit current overrun L…	The current applied to the phase (secondary side of the current transformer or Rogowski coil) exceeds the specified limit: ■ BL20-E-3EMM-CT: > 1.1 A (1 A connection) or > 5.5 A (5 A connection) ■ BL20-E-3EMM-RC: Output voltage of the Rogowski coil > 385 V
HW lower limit current underrun L…	The current applied to the phase (secondary side of the current transformer or Rogowski coil) lies below the specified limit: ■ BL20-E-3EMM-CT: < 30 mA (1 A connection) or < 100 mA (5 A connection) ■ BL20-E-3EMM-RC: Output voltage of the Rogowski coil < 10 mV
HW upper limit current overrun N	The current applied to the neutral conductor (secondary side of the current transformer or Rogowski coil) exceeds the specified limit: ■ BL20-E-3EMM-CT: > 1.1 A (1 A connection) or > 5.5 A (5 A connection) ■ BL20-E-3EMM-RC: Output voltage of the Rogowski coil > 385 V

10 Troubleshooting

If the device does not function as expected, first check whether ambient interference is present. If there is no ambient interference present, check the connections of the device for faults.

If there are no faults, there is a device malfunction. In this case, decommission the device and replace it with a new device of the same type.

10.1 Troubleshooting

Error	Cause	Remedy
Measurement inaccuracies at high currents	Overdriving the current inputs	▶ BL20-E-3EMM-CT: Observe the maximum input current of the device. Depending on the connection, currents of up to 1 A or 5 A can be measured.
Negative power consumption despite connected load	Incorrect connection of the current paths	▶ Check wiring.
	Current and voltage paths not connected correspondingly.	▶ Check wiring. Example for correct wiring: Current transformer at phase 1 is connected terminals to I_1, current transformer at phase L2 is connected to terminals I_2, etc.

11 Repair

The device is not intended for repair by the user. The device must be decommissioned if it is faulty. Observe our return acceptance conditions when returning the device to Turck.

11.1 Returning devices

If a device has to be returned, bear in mind that only devices with a decontamination declaration will be accepted. This is available for download at
https://www.turck.de/en/return-service-6079.php
and must be completely filled in, and affixed securely and weather-proof to the outside of the packaging.

12 Decommissioning

DANGER
Decommissioning of devices under voltage
Danger to life due to dangerous contact voltage
- ▶ Disconnect the system from the power supply.

12.1 Dismounting the BL20 station from the DIN rail

Dismount the BL20 station step by step in the following sequence:

WARNING
Dangerous electric voltage at modules with 120/230 VAC
Acute danger to life due to electric shock!
- ▶ Switch off the power supply.
- ▶ Secure the power supply against being switched on again.
- ▶ Ensure that the unit is de-energized.

- ▶ Switch off voltage at gateway and supply modules.
- ▶ Disconnect the connection to the fieldbus.
- ▶ Pull the electronics modules out of the base modules.
- ▶ Disconnect the wiring.
- ▶ Loosen the screws in the end brackets and remove end brackets from the DIN rail.
- ▶ Loosen the base modules and ECO modules from the right and remove them from the DIN rail. If a module in the middle of a station is to be removed, all modules mounted to the right of it must first be removed from the DIN rail.
- ▶ If necessary, remove cross-connectors beforehand (base modules for relay modules).
- ▶ Loosen the gateway from the DIN rail and remove it from the DIN rail.

13 Disposal

The devices must be disposed of properly and do not belong in the domestic waste.

14 Technical data

14.1 General technical data

Technical data	
Supply voltage/auxiliary voltage	The power supply must comply with the conditions of the safety extra low voltage (SELV) in accordance with IEC 364-4-41.
Nominal value (through supply terminal)	24 VDC
Admissible range	According to IEC/EN 61131-2 (18…30 VDC)
Residual ripple	According to IEC/EN 61131-2
Potential isolation	Galvanic
Inputs for energy measurement/module bus	707 VDC, 3.0 kV_{eff}
Connectors	Push-in terminals
General information	
Dimensions (w × l × h)	13 × 160.8 × 74.6 mm
Operating temperature	0…+60 °C
Storage temperature	-25…+85 °C
Relative humidity	15…95 % (indoor), level RH-2, no condensation
Vibration test	According to IEC/EN 60068-2-6
Shock test	According to IEC/EN 60068-2-27
Drop and topple	According to IEC/EN 60068-2-31
Free fall	
Electromagnetic compatibility	According to IEC/EN 61131-2
Degree of protection	IP20
MTTF	183 years acc. to SN 29500 (Ed. 99) 20 °C

Technical data push-in terminals

Technical data	
Insulation stripping length	8 mm
Max. clamping range	0.2…1.5 mm^2
Clampable wires (cross section)	
▪ Rigid	0.2…1.5 mm^2
▪ Flexible	0.2…1.5 mm^2
▪ Flexible with ferrule without plastic sleeve	0.2…1.5 mm^2
▪ Flexible with ferrule with plastic sleeve	0.2…0.75 mm^2
Wire cross section AWG	24…16

14.2 BL20-E-3EMM-CT

Technical data	
Number of channels	3 phases + N
Nominal voltage from supply terminal U_L	24 VDC
Nominal current from supply terminal I_L	≤ 110 mA
Nominal current from module bus I_{MB}	≤ 55 mA
Power loss of the module, typical	max. 1 W
Rated voltage	Phase to N: 277 VAC (max. 300 VAC)
Line voltage	
▪ in star connection	480 VAC
▪ in delta connection	max. 300 VAC
Input signal:	1 A/5 A
Measurement limits	
▪ Current	1-A-measurement: 0.03…1,1 A 5-A-measurement: 0.1…5,5 A
▪ Voltage	Phase to N: 30…300 VAC
Internal resistance	
▪ Secondary current = 1 A ▪ Secondary current = 5 A	60 mΩ 10 mΩ
Frequency range	42…70 Hz
Sample rate	8 kHz, phase angle: 1 kHz
Frequency range	0…3200 Hz
Limit frequency of input filter	7.2 kHz
Harmonic analysis	up to 51st harmonic vibration at 50-Hz signals
Isolation	707 VDC 3.0 kV_{eff}
Impulse withstand voltage	4 kV
Overvoltage category	III
Temperature coefficient U/I	150 ppm/K
Connection terminals	
Neutral conductor	N for all outer conductors
Current measurement (phase)	I_1+ (1 A), I_1+ (5 A) , I_1- I_2+ (1 A), I_2+ (5 A) , I_2- I_3+ (1 A), I_3+ (5 A) , I_3-
Current measurement (neutral conductor)	I_N+, I_N-
Voltage measurement	U_1, U_2, U_3

14.3 BL20-E-3EMM-RC

Technical data	
Number of channels	3 phases + N
Nominal voltage from supply terminal U_L	24 VDC
Nominal current from supply terminal I_L	≤ 110 mA
Nominal current from module bus I_{MB}	≤ 55 mA
Power loss of the module, typical	max. 1 W
Frequency range	42…70 Hz
Rated voltage	Phase to N: 277 VAC (max. 300 VAC)
Line voltage	
■ in star connection	480 VAC
■ in delta connection	max. 300 VAC
Measurement limits	
■ Current	10…385 mV
■ Voltage	Phase to N: 30…300 VAC
Sample rate	8 kHz, phase angle: 1 kHz
Frequency range	0…3200 Hz
Limit frequency of input filter	7.2 kHz
Harmonic analysis	up to 51st harmonic vibration at 50-Hz signals
Isolation	707 VDC 3.0 kV_{eff}
Impulse withstand voltage	4 kV
Overvoltage category	III
Temperature coefficient U/I	150 ppm/K
Connection terminals	
Current measurement (phase)	RC_1+, RC_1- RC_2+, RC_2- RC_3+, RC_3-
Current measurement (neutral conductor)	RC_N+, RC_N-
Voltage measurement	U_1, U_2, U_3

15 Turck branches — contact data

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Austria	Turck GmbH Graumanngasse 7/A5-1, A-1150 Vienna **www.turck.at**
Belgium	TURCK MULTIPROX Lion d'Orweg 12, B-9300 Aalst **www.multiprox.be**
Brazil	Turck do Brasil Automação Ltda. Rua Anjo Custódio Nr. 42, Jardim Anália Franco, CEP 03358-040 São Paulo **www.turck.com.br**
Canada	Turck Canada Inc. 140 Duffield Drive, CDN-Markham, Ontario L6G 1B5 **www.turck.ca**
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