# MVR-T215

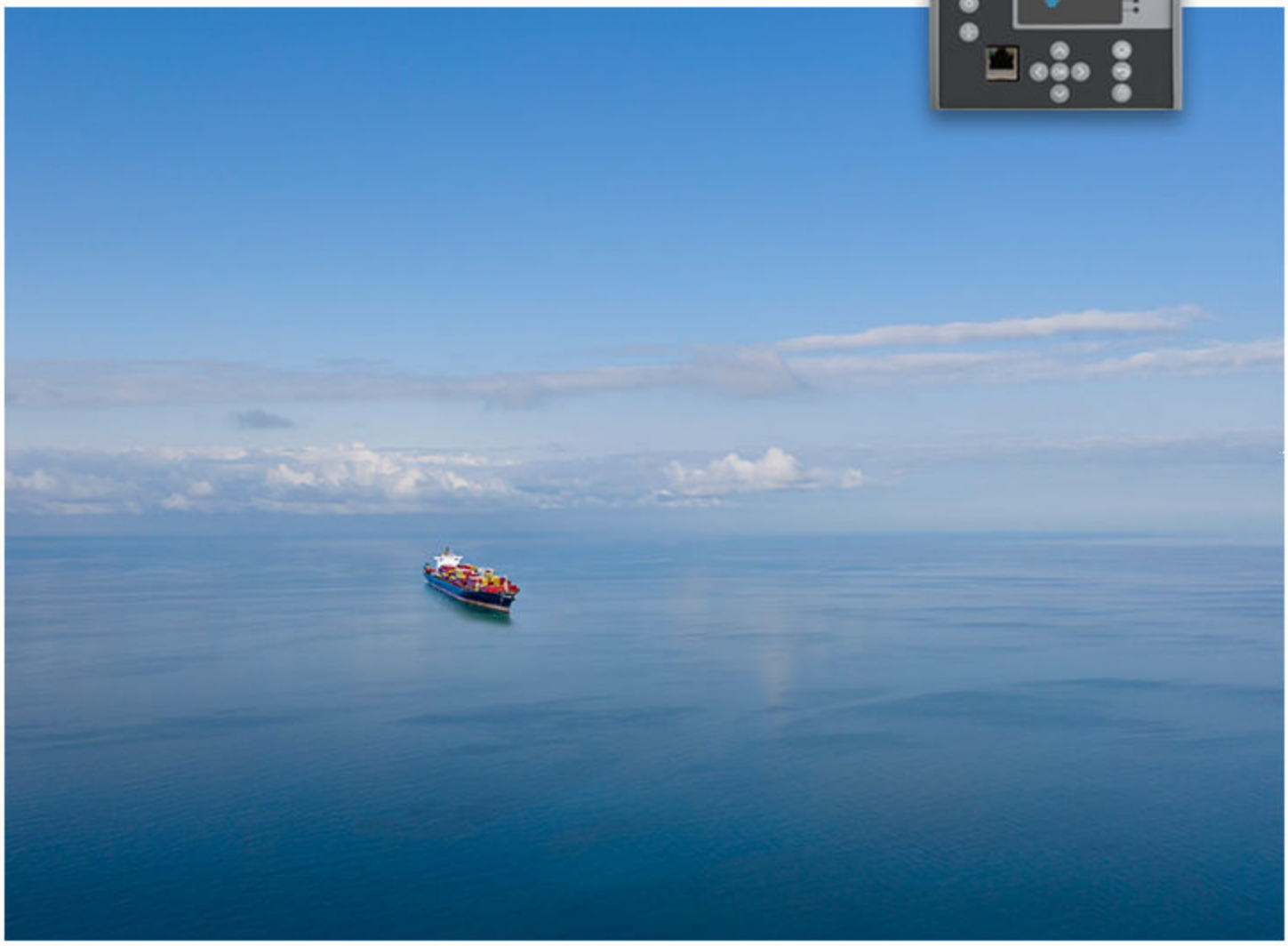
4921240674-D

Transformer protection

**Data sheet**

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## 1. Product description


**1.1 About** 4
**1.2 Applications** 4
**1.3 Features** 5


## 2. Protections


**2.1 Current protections** 6
2.1.1 Non-directional overcurrent protection (I>; 50/51) 6
2.1.2 Non-directional earth fault protection (I0>; 50N/51N) 7
2.1.3 Directional overcurrent protection (Idir>; 67) 8
2.1.4 Negative sequence overcurrent/ phase current reversal/ current unbalance protection (I2>; 46/46R/46L) 9
2.1.5 Circuit breaker failure protection (CBFP; 50BF/52BF) 9
2.1.6 Low-impedance or high-impedance restricted earth fault/cable end differential protection (I0d>; 87N) 10
2.1.7 Harmonic overcurrent protection (Ih>; 50H/51H/68H) 11
2.1.8 Arc fault protection (IArc>/I0Arc>; 50Arc/50NArc) (optional) 12
**2.2 Voltage protections** 12
2.2.1 Undervoltage protection (U<; 27) 12
2.2.2 Overvoltage protection (U>; 59) 13
2.2.3 Neutral overvoltage protection (U0>; 59N) 14
2.2.4 Sequence voltage protection (U1/U2>/<; 47/27P/59NP) 15
**2.3 Frequency protections** 16
2.3.1 Overfrequency and underfrequency protection (f>/<; 81O/81U) 16
2.3.2 Rate-of-change of frequency protection (df/dt>/<; 81R) 16
**2.4 Power protections** 17
2.4.1 Overpower (P>; 32O), underpower (P<; 32U) and reverse power (Pr; 32R) protection 17
**2.5 Transformer protections** 18
2.5.1 Transformer thermal overload protection (TT>; 49T) 18
2.5.2 Transformer status monitoring 18
2.5.3 Underimpedance protection (Z<; 21U) 19
2.5.4 Volts-per-hertz overexcitation protection (V/Hz>; 24) 19
2.5.5 Automatic voltage regulator (90) 20
**2.6 Control functions** 21
2.6.1 Synchrocheck (ΔV/Δa/Δf; 25) 21
2.6.2 Cold load pick-up (68) CLP 22
2.6.3 Object control and monitoring 22
2.6.4 Programmable stage (PSx>/<; 99) 23
2.6.5 Indicator object monitoring 23
2.6.6 Setting group selection 23
**2.7 Monitoring functions** 24
2.7.1 Voltage transformer supervision (60) 24
2.7.2 Circuit breaker wear monitoring 24
2.7.3 Disturbance recorder 25
2.7.4 Current transformer supervision 25
2.7.5 Current total harmonic distortion 26
2.7.6 Voltage memory 26


## 3. Technical specifications


**3.1 Electromagnetic compatibility** 28
**3.2 Mechanical durability** 29
**3.3 Environment** 30
**3.4 Safety** 30

## 4. Hardware


**4.1 Processor and power supply** ... **32**
4.1.1 Auxiliary supply ... 32
4.1.2 Isolated digital inputs ... 33
4.1.3 Digital outputs ... 33
4.1.4 Communication ports ... 34
**4.2 Current measurement module** ... **34**
**4.3 Voltage measurement module** ... **36**
**4.4 Power and energy measurement** ... **36**
**4.5 Frequency measurement** ... **37**
**4.6 Digital inputs and outputs** ... **37**
4.6.1 Digital input module (option card B) ... 37
4.6.2 Digital output module (option card C) ... 38
**4.7 Analogue inputs** ... **38**
4.7.1 RTD input module (option card F) ... 38
**4.8 Analogue outputs** ... **38**
4.8.1 Analogue output module (mA out & mA in) (option card I) ... 38
**4.9 Additional communication options** ... **39**
4.9.1 Double RJ45 Ethernet & IRIG-B communication module (option card G) ... 39
4.9.2 Double ST 100 Mbps Ethernet communication module (option card H) ... 39
4.9.3 Double LC 100 Mbps Ethernet communication module (option card J) ... 40
4.9.4 Double RJ-45 (HSR, PRP) Ethernet communication module (option card K) ... 40
4.9.5 RS-232 & serial fiber communication module (option cards L to O) ... 41
**4.10 Arc protection module (option card D)** ... **41**
**4.11 MVR-21x display** ... **42**
4.11.1 Display ... 42
**4.12 Folios and configuration** ... **43**
**4.13 Mechanical specifications** ... **43**
**4.14 Environment** ... **44**
**4.15 Safety** ... **44**
**4.16 Dimensions** ... **44**


## 5. Ordering information


**5.1 MVR Ordering** ... **45**
**5.2.1 Disclaimer** ... **46**
**5.2.2 Copyright** ... **46**

# 1. Product description

## 1.1 About

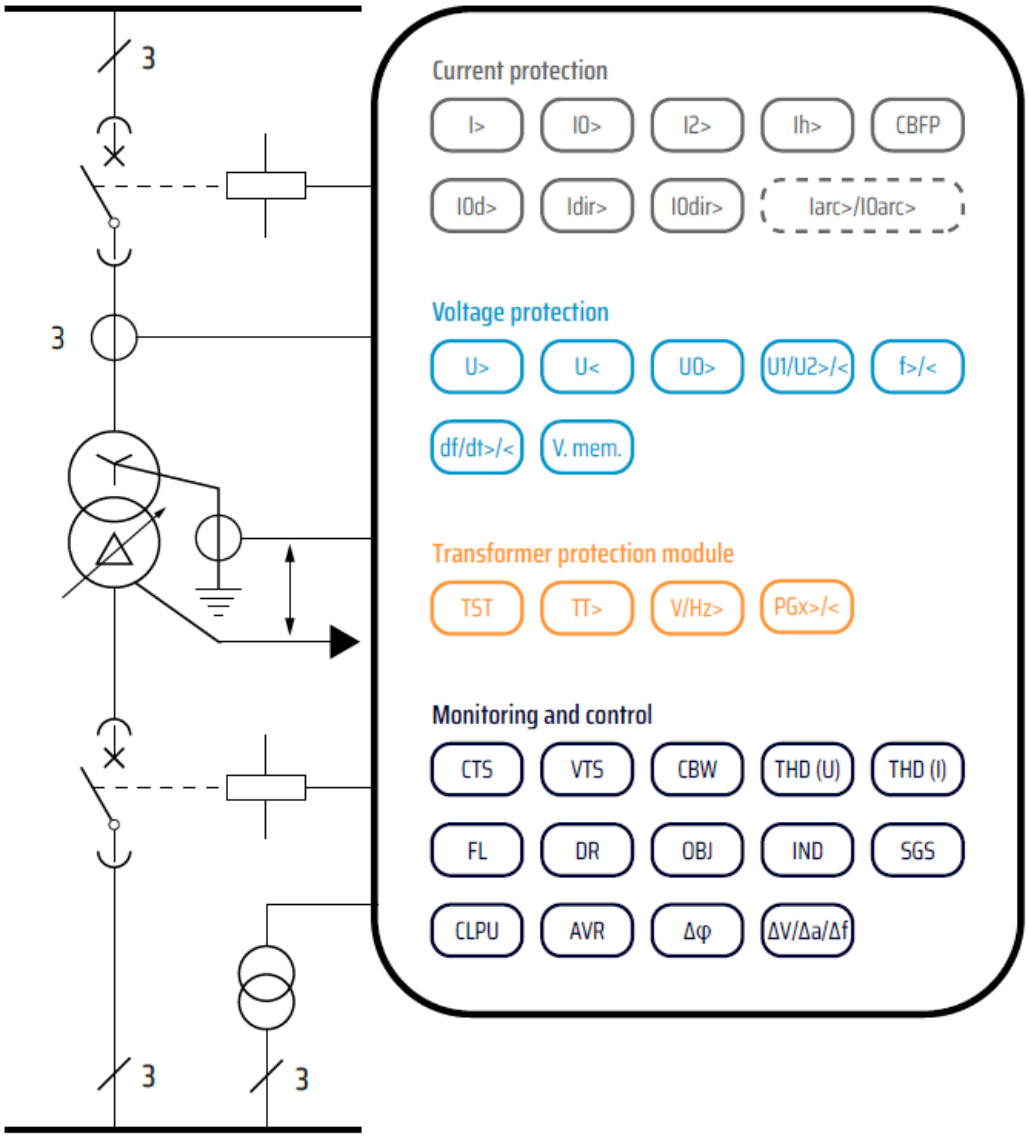
The MVR-T215 (transformer protection) is a voltage regulating device. It comes with current-based and voltage-based protection functions, which makes the relay suitable for combined transformer voltage regulation and back-up protection. The transformer monitoring module is included as a standard feature, and it provides statistical information for preventive maintenance purposes. MVR-T215 communicates using various protocols, including the IEC 61850.

## 1.2 Applications

A wiring example and key ANSI functions are shown below.

**More information**
See the **Protections** chapter for a full list of the protections.

**Transformer protection wiring (T215)**



## 1.3 Features

| | Functions |
|---|---|
| High performance, good usability | • Full protection for transformers<br>• Bay control, alarm, measurement and monitoring<br>• Large customisable HMI with configurable Mimic diagram<br>• Configurable LEDs<br>• Large flash memory for events, logs, recordings and documentation<br>  ◦ 15,000 events and 100 disturbance recordings<br>• Easy-to-use and powerful MVR Utility Software for setting, configuration and analysing<br>• Full set of communication protocols, including IEC 61850 |
| Versatile protection design | • Fast, versatile and dependable protection functions over a wide frequency range (6 to 75 Hz)<br>• Suitable for the most demanding protection applications |
| Modularity | • Fully modular hardware construction<br>• Plug in more I/O or communication cards to meet the application requirements |
| Usability | • Sophisticated setting aids<br>• Highly customisable HMI<br>• Storage of PDF or other supportive documents<br>• Extensive user log information<br>  ◦ Setting changes<br>  ◦ Other operational history |
| Performance | • Sub-cycle instantaneous trip times<br>• Logics editor for ladder logic functionality<br>• Up to 100 disturbance records, of up to 10 seconds each<br>• 10,000 events stored in non-volatile memory |
| Savings in engineering time | • MVR Utility Software free-of-charge software suite with an intuitive and easy-to-use human-machine interface<br>• Download all relay settings instantly using native 100 Mb/s Ethernet connection (front port or rear port) |
| Standardised hardware | • Standardised hardware design, for simpler logistics and stock management<br>• Five CT inputs with configurable secondary currents<br>• Configurable digital input voltage thresholds |
| Communication | • Native Ethernet communication<br>• A variety of standard protocols including the IEC 61850 substation communication standard with fast GOOSE messaging |
| IEC 61850 & IEEE 1588 | • High-availability Seamless Redundancy (HSR) support<br>• Parallel Redundancy Protocol (PRP) support<br>• Precision Time Protocol (PTP) according to IEEE 1588 |

# 2. Protections

## 2.1 Current protections

### 2.1.1 Non-directional overcurrent protection (I>; 50/51)

**Table 2.1** Technical data for the non-directional overcurrent function

| | |
|---|---|
| Measurement inputs | |
| Current inputs | Phase current inputs: $I_{L1}$ (A), $I_{L2}$ (B), $I_{L3}$ (C) |
| Current input magnitudes | RMS phase currents<br>TRMS phase currents<br>Peak-to-peak phase currents |
| Pick-up | |
| Pick-up current setting | 0.10...50.00 × $I_n$, setting step 0.01 × $I_n$ |
| Inrush 2nd harmonic blocking | 0.10...50.00 %$I_{fund}$, setting step 0.01 %$I_{fund}$ |
| Inaccuracy:<br>- Current<br>- 2nd harmonic blocking | <br>±0.5 %$I_{set}$ or ±15 mA (0.10...4.0 × $I_{set}$)<br>±1.0 %-unit of the 2nd harmonic setting |
| Operation time | |
| Definite time function operating time setting | 0.00...1800.00 s, setting step 0.005 s |
| Inaccuracy:<br>- Definite time: $I_m/I_{set}$ ratio > 3<br>- Definite time: $I_m/I_{set}$ ratio = 1.05...3 | <br>±1.0 % or ±20 ms<br>±1.0 % or ±30 ms |
| IDMT setting parameters:<br>- k Time dial setting for IDMT<br>- A IDMT constant<br>- B IDMT constant<br>- C IDMT constant | <br>0.01...25.00, step 0.01<br>0...250.0000, step 0.0001<br>0...5.0000, step 0.0001<br>0...250.0000, step 0.0001 |
| Inaccuracy:<br>- IDMT operating time<br>- IDMT minimum operating time | <br>±1.5 % or ±20 ms<br>±20 ms |
| Retardation time (overshoot) | <30 ms |
| Instant operation time | |
| Start time and instant operation time (trip):<br>- $I_m/I_{set}$ ratio > 3<br>- $I_m/I_{set}$ ratio = 1.05...3 | <br><35 ms (typically 25 ms)<br><50 ms |
| Start time and instant operation time (trip):<br>- $I_m/I_{set}$ ratio = 2<br>- $I_m/I_{set}$ ratio = 5<br>- $I_m/I_{set}$ ratio = 10 | <br>Typically 25 ms<br>Typically 16 ms<br>Typically 12 ms |
| Reset | |
| Reset ratio | 97 % of the pick-up current setting |
| Reset time setting<br>Inaccuracy: Reset time | 0.010...10.000 s, step 0.005 s<br>±1.0 % or ±50 ms |
| Instant reset time and start-up reset | <50 ms |

**NOTE** The release delay does **not** apply to phase-specific tripping!

## 2.1.2 Non-directional earth fault protection (I0>; 50N/51N)

**Table 2.2** Technical data for the non-directional earth fault function

| | |
|---|---|
| Measurement inputs | |
| Current input (selectable) | Residual current channel $I_{01}$ (Coarse)<br>Residual current channel $I_{02}$ (Fine)<br>Calculated residual current: $I_{L1}$ (A), $I_{L2}$ (B), $I_{L3}$ (C) |
| Current input magnitudes | RMS residual current ($I_{01}$, $I_{02}$ or calculated $I_0$)<br>TRMS residual current ($I_{01}$ or $I_{02}$)<br>Peak-to-peak residual current ($I_{01}$ or $I_{02}$) |
| Pick-up | |
| Used magnitude | Measured residual current I01 (1 A)<br>Measured residual current I02 (0.2 A)<br>Calculated residual current I0Calc (5 A) |
| Pick-up current setting | 0.0001...40.00 × $I_n$, setting step 0.0001 × $I_n$ |
| Inaccuracy:<br>- Starting I01 (1 A)<br>- Starting I02 (0.2 A)<br>- Starting I0Calc (5 A) | <br>±0.5 %$I0_{set}$ or ±3 mA (0.005...10.0 × $I_{set}$)<br>±1.5 %$I0_{set}$ or ±1.0 mA (0.005...25.0 × $I_{set}$)<br>±1.0 %$I0_{set}$ or ±15 mA (0.005...4.0 × $I_{set}$) |
| Operating time | |
| Definite time function operating time setting | 0.00...1800.00 s, setting step 0.005 s |
| Inaccuracy:<br>- Definite time: $I_m/I_{set}$ ratio > 3<br>- Definite time: $I_m/I_{set}$ ratio = 1.05...3 | <br>±1.0 % or ±20 ms<br>±1.0 % or ±30 ms |
| IDMT setting parameters:<br>- k Time dial setting for IDMT<br>- A IDMT constant<br>- B IDMT constant<br>- C IDMT constant | <br>0.01...25.00, step 0.01<br>0...250.0000, step 0.0001<br>0...5.0000, step 0.0001<br>0...250.0000, step 0.0001 |
| Inaccuracy:<br>- IDMT operating time<br>- IDMT minimum operating time | <br>±1.5 % or ±20 ms<br>±20 ms |
| Retardation time (overshoot) | <30 ms |
| Instant operation time | |
| Start time and instant operation time (trip):<br>- $I_m/I_{set}$ ratio > 3.5<br>- $I_m/I_{set}$ ratio = 1.05...3.5 | <br><50 ms (typically 35 ms)<br><55 ms |
| Reset | |
| Reset ratio | 97 % of the pick-up current setting |
| Reset time setting<br>Inaccuracy: Reset time | 0.010...10.000 s, step 0.005 s<br>±1.0 % or ±50 ms |
| Instant reset time and start-up reset | <50 ms |

**NOTE** The operation and reset time accuracy does **not** apply when the measured secondary current in I02 is 1...20 mA. The pick-up is tuned to be more sensitive and the operation times vary because of this.

## 2.1.3 Directional overcurrent protection (Idir>; 67)

**Table 2.3** Technical data for the directional overcurrent function

| | |
|---|---|
| Input signals | |
| Current inputs | Phase current inputs: $I_{L1}$ (A), $I_{L2}$ (B), $I_{L3}$ (C) |
| Current input magnitudes | RMS phase currents<br>TRMS phase currents<br>Peak-to-peak phase currents |
| Current input calculations | Positive sequence current angle |
| Voltage inputs | $U_{L1}$, $U_{L2}$, $U_{L3}$<br>$U_{L12}$, $U_{L23}$, $U_{L31}$ + U0 |
| Voltage input calculations | Positive sequence voltage angle |
| Pick-up | |
| Characteristic direction | Directional, non-directional |
| Operating sector center | -180.0...180.0 deg, setting step 0.1 deg |
| Operating sector size (+/-) | 1.00...170.00 deg, setting step 0.10 deg |
| Pick-up current setting | 0.10...40.00 × $I_n$, setting step 0.01 × $I_n$ |
| Inaccuracy:<br>- Current<br>- U1/I1 angle (U > 15 V)<br>- U1/I1 angle (U = 1...15 V) | <br>±0.5 %$I_{set}$ or ±15 mA (0.10...4.0 × $I_{set}$)<br>±0.20°<br>±1.5° |
| Operation time | |
| Definite time function operating time setting | 0.00...1800.00 s, setting step 0.005 s |
| Inaccuracy:<br>- Definite time: $I_m/I_{set}$ ratio > 3<br>- Definite time: $I_m/I_{set}$ ratio = 1.05...3 | <br>±1.0 % or ±20 ms<br>±1.0 % or ±35 ms |
| IDMT setting parameters:<br>- k Time dial setting for IDMT<br>- A IDMT constant<br>- B IDMT constant<br>- C IDMT constant | <br>0.01...25.00, step 0.01<br>0...250.0000, step 0.0001<br>0...5.0000, step 0.0001<br>0...250.0000, step 0.0001 |
| Inaccuracy:<br>- IDMT operating time<br>- IDMT minimum operating time | <br>±1.5 % or ±20 ms<br>±20 ms |
| Instant operation time | |
| Start time and instant operation time (trip):<br>- $I_m/I_{set}$ ratio > 3<br>- $I_m/I_{set}$ ratio = 1.05...3 | <br><40 ms (typically 30 ms)<br><50 ms |
| Reset | |
| Reset ratio:<br>- Current<br>- U1/I1 angle | <br>97 % of the pick-up current setting<br>2.0° |
| Reset time setting<br>Inaccuracy: Reset time | 0.010...10.000 s, step 0.005 s<br>±1.0 % or ±50 ms |
| Instant reset time and start-up reset | <50 ms |

**NOTE** The minimum voltage for direction solving is 1.0 V secondary. During three-phase short-circuits the angle memory is active for 0.5 seconds in case the voltage drops below 1.0 V.

### 2.1.4 Negative sequence overcurrent/ phase current reversal/ current unbalance protection (I2>; 46/46R/46L)

**Table 2.4** Technical data for the current unbalance function

| | |
|---|---|
| Measurement inputs | |
| Current inputs | Phase current inputs: $I_{L1}$ (A), $I_{L2}$ (B), $I_{L3}$ (C) |
| Current input calculations | Positive sequence current (I1)<br>Negative sequence current (I2) |
| Pick-up | |
| Used magnitude | Negative sequence component I2pu<br>Relative unbalance I2/I1 |
| Pick-up setting | 0.01...40.00 × $I_n$, setting step 0.01 × $I_n$ (I2pu)<br>1.00...200.00 %, setting step 0.01 % (I2/I1) |
| Minimum phase current (at least one phase above) | 0.01...2.00 × $I_n$, setting step 0.01 × $I_n$ |
| Inaccuracy:<br>- Starting I2pu<br>- Starting I2/I1 | <br>±1.0 %-unit or ±100 mA (0.10...4.0 × $I_n$)<br>±1.0 %-unit or ±100 mA (0.10...4.0 × $I_n$) |
| Operating time | |
| Definite time function operating time setting | 0.00...1800.00 s, setting step 0.005 s |
| Inaccuracy:<br>- Definite time ($I_m/I_{set}$ ratio > 1.05) | <br>±1.5 % or ±60 ms |
| IDMT setting parameters:<br>- k Time dial setting for IDMT<br>- A IDMT Constant<br>- B IDMT Constant<br>- C IDMT Constant | <br>0.01...25.00, step 0.01<br>0...250.0000, step 0.0001<br>0...5.0000, step 0.0001<br>0...250.0000, step 0.0001 |
| Inaccuracy:<br>- IDMT operating time<br>- IDMT minimum operating time | <br>±2.0 % or ±30 ms<br>±20 ms |
| Retardation time (overshoot) | <5 ms |
| Instant operation time | |
| Start time and instant operation time (trip):<br>- $I_m/I_{set}$ ratio > 1.05 | <br><70 ms |
| Reset | |
| Reset ratio | 97 % of the pick-up setting |
| Reset time setting<br>Inaccuracy: Reset time | 0.010...10.000 s, step 0.005 s<br>±1.5 % or ±60 ms |
| Instant reset time and start-up reset | <55 ms |

### 2.1.5 Circuit breaker failure protection (CBFP; 50BF/52BF)

**Table 2.5** Technical data for the circuit breaker failure protection function

| | |
|---|---|
| Measurement inputs | |
| Current inputs | Phase current inputs: $I_{L1}$ (A), $I_{L2}$ (B), $I_{L3}$ (C) |

| | |
|---|---|
| | Residual current channel $I_{01}$ (Coarse)<br>Residual current channel $I_{02}$ (Fine) |
| Current input magnitudes | RMS phase currents<br>RMS residual current ($I_{01}$, $I_{02}$ or calculated $I_0$) |
| Pick-up | |
| Monitored signals | Digital input status, digital output status, logical signals |
| Pick-up current setting:<br>- IL1...IL3<br>- I01, I02, I0Calc | <br>0.10...40.00 × $I_N$, setting step 0.01 × $I_N$<br>0.005...40.00 × $I_N$, setting step 0.005 × $I_N$ |
| Inaccuracy:<br>- Starting phase current (5A)<br>- Starting I01 (1 A)<br>- Starting I02 (0.2 A)<br>- Starting I0Calc (5 A) | <br>±0.5 %$I_{SET}$ or ±15 mA (0.10...4.0 × $I_{SET}$)<br>±0.5 %$I0_{SET}$ or ±3 mA (0.005...10.0 × $I_{SET}$)<br>±1.5 %$I0_{SET}$ or ±1.0 mA (0.005...25.0 × $I_{SET}$)<br>±1.0 %$I0_{SET}$ or ±15 mA (0.005...4.0 × $I_{SET}$) |
| Operation time | |
| Definite time function operating time setting | 0.050...1800.000 s, setting step 0.005 s |
| Inaccuracy:<br>- Current criteria ($I_M/I_{SET}$ ratio 1.05→)<br>- DO or DI only | <br>±1.0 % or ±55 ms<br>±15 ms |
| Reset | |
| Reset ratio | 97 % of the pick-up current setting |
| Reset time | <50 ms |

### 2.1.6 Low-impedance or high-impedance restricted earth fault/cable end differential protection (I0d>; 87N)

**Table 2.6** Technical data for the restricted earth fault/cable end differential function

| | |
|---|---|
| Measurement inputs | |
| Current inputs | Phase current inputs: $I_{L1}$ (A), $I_{L2}$ (B), $I_{L3}$ (C)<br>Residual current channel $I_{01}$ (Coarse)<br>Residual current channel $I_{02}$ (Fine) |
| Current input calculations | Calculated bias and residual differential currents |
| Pick-up | |
| Operating modes | Restricted earth fault<br>Cable end differential |
| Characteristics | Biased differential with 3 settable sections and 2 slopes |
| Pick-up current sensitivity setting<br>Slope 1<br>Slope 2<br>Bias (Turnpoint 1 & 2) | 0.01...50.00 % ($I_N$), setting step 0.01 %<br>0.00...150.00 %, setting step 0.01 %<br>0.00...250.00 %, setting step 0.01 %<br>0.01...50.00 × $I_N$, setting step 0.01 × $I_N$ |
| Inaccuracy<br>- Starting | ±3% of the set pick-up value > 0.5 × $I_N$ setting.<br>±5 mA < 0.5 × $I_N$ setting |
| Operation time | |
| Instant operation time<br>1.05 x $I_{SET}$ | <br><30 ms |
| Reset | |

| | |
|---|---|
| Reset ratio | No hysteresis |
| Reset time | <40 ms |

## 2.1.7 Harmonic overcurrent protection (Ih>; 50H/51H/68H)

**Table 2.7** Technical data for the harmonic overcurrent function

| | |
|---|---|
| Measurement inputs | |
| Current inputs | Phase current inputs: $I_{L1}$ (A), $I_{L2}$ (B), $I_{L3}$ (C)<br>Residual current channel $I_{01}$ (Coarse)<br>Residual current channel $I_{02}$ (Fine) |
| Pick-up | |
| Harmonic selection | $2^{nd}$, $3^{rd}$, $4^{th}$, $5^{th}$, $6^{th}$ $7^{th}$, $9^{th}$, $11^{th}$, $13^{th}$, $15^{th}$, $17^{th}$ or $19^{th}$ |
| Used magnitude | Harmonic per unit (× $I_N$)<br>Harmonic relative (Ih/IL) |
| Pick-up setting | 0.05...2.00 × $I_N$, setting step 0.01 × $I_N$ (× $I_N$)<br>5.00...200.00 %, setting step 0.01 % (Ih/IL) |
| Inaccuracy:<br>- Starting × $I_N$<br>- Starting × Ih/IL | <br><0.03 × $I_N$ ($2^{nd}$, $3^{rd}$, $5^{th}$)<br><0.03 × $I_N$ tolerance to Ih ($2^{nd}$, $3^{rd}$, $5^{th}$) |
| Operation time | |
| Definite time function operating time setting | 0.00...1800.00 s, setting step 0.005 s |
| Inaccuracy:<br>- Definite time ($I_M/I_{SET}$ ratio >1.05) | <br>±1.0 % or ±35 ms |
| IDMT setting parameters:<br>k Time dial setting for IDMT<br>A IDMT constant<br>B IDMT constant<br>C IDMT constant | <br>0.01...25.00, step 0.01<br>0...250.0000, step 0.0001<br>0...5.0000, step 0.0001<br>0...250.0000, step 0.0001 |
| Inaccuracy:<br>- IDMT operating time<br>- IDMT minimum operating time | <br>±1.5 % or ±20 ms<br>±20 ms |
| Instant operation time | |
| Start time and instant operation time (trip):<br>$I_M/I_{SET}$ ratio >1.05 | <br><50 ms |
| Reset | |
| Reset ratio | 95 % of the pick-up setting |
| Reset time setting<br>Inaccuracy: Reset time | 0.010...10.000 s, step 0.005 s<br>±1.0 % or ±35 ms |
| Instant reset time and start-up reset | <50 ms |

**NOTE** Harmonics generally: The amplitude of the harmonic content **must** be least 0.02 × $I_N$ when the relative mode (Ih/IL) is used!

Blocking: To achieve fast activation for blocking purposes with the harmonic overcurrent stage, note that the harmonic stage may be activated by a rapid load change or fault situation. An intentional activation lasts for approximately 20 ms if a harmonic component is not present. The harmonic stage stays active if the harmonic content is above the pick-up limit.

Tripping: When using the harmonic overcurrent stage for tripping, please ensure that the operation time is set to 20 ms (DT) or longer to avoid nuisance tripping caused by the above-mentioned reasons.

### 2.1.8 Arc fault protection (IArc>/I0Arc>; 50Arc/50NArc) (optional)

**NOTE** Not approved for marine.

**Table 2.8** Technical data for the arc fault protection function.

| | |
|---|---|
| Measurement inputs | |
| Current inputs | Phase current inputs: $I_{L1}$ (A), $I_{L2}$ (B), $I_{L3}$ (C)<br>Residual current channel $I_{01}$ (Coarse)<br>Residual current channel $I_{02}$ (Fine) |
| Current input magnitudes | Sample-based phase current measurement<br>Sample-based residual current measurement |
| Arc point sensor inputs | Channels S1, S2, S3, S4 (pressure and light sensor, or light-only sensor)<br>Up to three (3) sensors* per channel |
| System frequency operating range | 6.00...75.00 Hz |
| Pick-up | |
| Pick-up current setting (phase current)<br>Pick-up current setting (residual current)<br>Pick-up light intensity | 0.50...40.00 × $I_N$, setting step 0.01 × $I_N$<br>0.10...40.00 × $I_N$, setting step 0.01 × $I_N$<br>8, 25 or 50 kLx (the sensor is selected in the order code) |
| Starting inaccuracy (IArc> and I0Arc>) | ±3 % of the set pick-up value > 0.5 × $I_N$ setting. 5 mA < 0.5 × $I_N$ setting. |
| Point sensor detection radius | 180 degrees |
| Operation time | |
| Light only:<br>- Semiconductor outputs HSO1 and HSO2<br>- Regular relay outputs | <br>Typically 7 ms (3...12 ms)<br>Typically 10 ms (6.5...15 ms) |
| Light + current criteria (zone 1...4):<br>- Semiconductor outputs HSO1 and HSO2<br>- Regular relay outputs | <br>Typically 10 ms (6.5...14 ms)<br>Typically 14 ms (10...18 ms) |
| Arc BI only:<br>- Semiconductor outputs HSO1 and HSO2<br>- Regular relay outputs | <br>Typically 7 ms (2...12 ms)<br>Typically 10 ms (6.5...15 ms) |

**More information**
* See the **Option D: Arc protection Description of options** for the specifications of these sensors.

## 2.2 Voltage protections

### 2.2.1 Undervoltage protection (U<; 27)

**Table 2.9** Technical data for the undervoltage function

| | |
|---|---|
| Measurement inputs | |
| Voltage inputs | $U_{L1}$, $U_{L2}$, $U_{L3}$<br>$U_{L12}$, $U_{L23}$, $U_{L31}$ (+ $U_0$) |
| Voltage input magnitudes | RMS line-to-line or line-to-neutral voltages |
| Pick-up | |
| Pick-up terms | 1 voltage |

| | |
|---|---|
| | 2 voltages<br>3 voltages |
| Pick-up setting | 0.00...120.00 %$U_N$, setting step 0.01 %$U_N$ |
| Inaccuracy:<br>- Voltage | ±1.5 %$U_{SET}$ or ±30 mV |
| Low voltage block | |
| Pick-up setting | 0.00...80.00 %$U_N$, setting step 0.01 %$U_N$ |
| Inaccuracy:<br>- Voltage | ±1.5 %$U_{SET}$ or ±30 mV |
| Operation time | |
| Definite time function operating time setting | 0.00...1800.00 s, setting step 0.005 s |
| Inaccuracy:<br>- Definite time ($U_M/U_{SET}$ ratio 1.05→) | ±1.0 % or ±35 ms |
| IDMT setting parameters:<br>k Time dial setting for IDMT<br>A IDMT constant<br>B IDMT constant<br>C IDMT constant | <br>0.01...25.00, step 0.01<br>0...250.0000, step 0.0001<br>0...5.0000, step 0.0001<br>0...250.0000, step 0.0001 |
| Inaccuracy:<br>- IDMT operating time<br>- IDMT minimum operating time | <br>±1.5 % or ±20 ms<br>±20 ms |
| Instant operation time | |
| Start time and instant operation time (trip):<br>- $U_M/U_{SET}$ ratio 1.05→ | <br><65 ms |
| Retardation time (overshoot) | <30 ms |
| Reset | |
| Reset ratio | 103 % of the pick-up voltage setting |
| Reset time setting<br>Inaccuracy: Reset time | 0.010...10.000 s, step 0.005 s<br>±1.0 % or ±45 ms |
| Instant reset time and start-up reset | <50 ms |

**NOTE** The low-voltage block is not in use when its pick-up setting is set to 0 %. The undervoltage function trip signal is active when the LV block is disabled and the device has no voltage injection.

**NOTE** After the low voltage blocking condition, the undervoltage stage does not trip unless the voltage exceeds the pick-up setting first.

## 2.2.2 Overvoltage protection (U>; 59)

**Table 2.10** Technical data for the overvoltage function

| | |
|---|---|
| Measurement inputs | |
| Voltage inputs | $U_{L1}$, $U_{L2}$, $U_{L3}$<br>$U_{L12}$, $U_{L23}$, $U_{L31}$ (+ $U_0$) |
| Voltage input magnitudes | RMS line-to-line or line-to-neutral voltages |
| Pick-up | |
| Pick-up terms | 1 voltage<br>2 voltages<br>3 voltages |

| | |
|---|---|
| Pick-up setting | 50.00...150.00 %$U_N$, setting step 0.01 %$U_N$ |
| Inaccuracy:<br>- Voltage | ±1.5 %$U_{SET}$ |
| Operating time | |
| Definite time function operating time setting | 0.00...1800.00 s, setting step 0.005 s |
| Inaccuracy:<br>- Definite time ($U_M/U_{SET}$ ratio 1.05→) | ±1.0 % or ±35 ms |
| IDMT setting parameters:<br>k Time dial setting for IDMT<br>A IDMT constant<br>B IDMT constant<br>C IDMT constant | <br>0.01...25.00, step 0.01<br>0...250.0000, step 0.0001<br>0...5.0000, step 0.0001<br>0...250.0000, step 0.0001 |
| Inaccuracy:<br>- IDMT operating time<br>- IDMT minimum operating time | <br>±1.5 % or ±20 ms<br>±20 ms |
| Instant operation time | |
| Start time and instant operation time (trip):<br>- $U_M/U_{SET}$ ratio 1.05→ | <br><50 ms |
| Reset | |
| Reset ratio | 97 % of the pick-up voltage setting |
| Reset time setting<br>Inaccuracy: Reset time | 0.010...10.000 s, step 0.005 s<br>±1.0 % or ±45 ms |
| Instant reset time and start-up reset | <50 ms |

## 2.2.3 Neutral overvoltage protection (U0>; 59N)

**Table 2.11** Technical data for the neutral overvoltage function

| | |
|---|---|
| Measurement inputs | |
| Voltage input (selectable) | Residual voltage from U3 or U4 voltage channel<br>Residual voltage calculated from $U_{L1}$, $U_{L2}$, $U_{L3}$ |
| Voltage input magnitudes | RMS residual voltage $U_0$<br>Calculated RMS residual voltage $U_0$ |
| Pick-up | |
| Pick-up voltage setting | 1.00...50.00 % $U0_N$, setting step 0.01 × $I_N$ |
| Inaccuracy:<br>- Voltage U0<br>- Voltage U0Calc | <br>±1.5 %$U0_{SET}$ or ±30 mV<br>±150 mV |
| Operation time | |
| Definite time function operating time setting | 0.00...1800.00 s, setting step 0.005 s |
| Inaccuracy:<br>- Definite time ($U0_M/U0_{SET}$ ratio 1.05→) | ±1.0 % or ±45 ms |
| IDMT setting parameters:<br>k Time dial setting for IDMT<br>A IDMT constant<br>B IDMT constant<br>C IDMT constant | <br>0.01...25.00, step 0.01<br>0...250.0000, step 0.0001<br>0...5.0000, step 0.0001<br>0...250.0000, step 0.0001 |
| Inaccuracy: | |

| | |
|---|---|
| - IDMT operating time<br>- IDMT minimum operating time | ±1.5 % or ±20 ms<br>±20 ms |
| Instant operation time | |
| Start time and instant operation time (trip):<br>- $U0_M/U0_{SET}$ ratio 1.05→ | <50 ms |
| Reset | |
| Reset ratio | 97 % of the pick-up voltage setting |
| Reset time setting<br>Inaccuracy: Reset time | 0.000 ... 150.000 s, step 0.005 s<br>±1.0 % or ±50 ms |
| Instant reset time and start-up reset | <50 ms |

## 2.2.4 Sequence voltage protection (U1/U2>/<; 47/27P/59NP)

**Table 2.12** Technical data for the sequence voltage function

| | |
|---|---|
| Measurement inputs | |
| Voltage inputs | $U_{L1}$, $U_{L2}$, $U_{L3}$<br>$U_{L12}$, $U_{L23}$, $U_{L31}$ (+ $U_0$) |
| Voltage input calculations | Positive sequence voltage (I1)<br>Negative sequence voltage (I2) |
| Pick-up | |
| Pick-up setting | 5.00...150.00 %$U_N$, setting step 0.01 %$U_N$ |
| Inaccuracy:<br>- Voltage | ±1.5 %$U_{SET}$ or ±30 mV |
| Low voltage block | |
| Pick-up setting | 1.00...80.00 %$U_N$, setting step 0.01 %$U_N$ |
| Inaccuracy:<br>-Voltage | ±1.5 %$U_{SET}$ or ±30 mV |
| Operation time | |
| Definite time function operating time setting | 0.00...1800.00 s, setting step 0.005 s |
| Inaccuracy<br>-Definite Time ($U_M/U_{SET}$ ratio 1.05→) | ±1.0 % or ±35 ms |
| IDMT setting parameters:<br>k Time dial setting for IDMT<br>A IDMT constant<br>B IDMT constant<br>C IDMT constant | <br>0.01...25.00, step 0.01<br>0...250.0000, step 0.0001<br>0...5.0000, step 0.0001<br>0...250.0000, step 0.0001 |
| Inaccuracy:<br>- IDMT operating time<br>- IDMT minimum operating time | ±1.5 % or ±20 ms<br>±20 ms |
| Instant operation time | |
| Start time and instant operation time (trip):<br>- $U_M/U_{SET}$ ratio <0.95/1.05→ | <65 ms |
| Reset | |
| Reset ratio | 97 or 103 % of the pick-up voltage setting |
| Reset time setting | 0.010...10.000 s, step 0.005 s |

| | |
|---|---|
| Inaccuracy: Reset time | ±1.0 % or ±35 ms |
| Instant reset time and start-up reset | <50 ms |

# 2.3 Frequency protections

## 2.3.1 Overfrequency and underfrequency protection (f>/<; 81O/81U)

**Table 2.13** Technical data for the overfrequency and underfrequency function

| | |
|---|---|
| Input signals | |
| Sampling mode | Fixed<br>Tracking |
| Frequency reference 1<br>Frequency reference 2<br>Frequency reference 3 | CT1IL1, CT2IL1, VT1U1, VT2U1<br>CT1IL2, CT2IL2, VT1U2, VT2U2<br>CT1IL3, CT2IL3, VT1U3, VT2U3 |
| Pick-up | |
| f> pick-up setting<br>f< pick-up setting | 10.00...70.00 Hz, setting step 0.01 Hz<br>7.00...65.00 Hz, setting step 0.01 Hz |
| Inaccuracy (sampling mode):<br>- Fixed<br>- Tracking | <br>±20 mHz (50/60 Hz fixed frequency)<br>±20 mHz (U > 30 V secondary)<br>±20 mHz (I > 30 % of rated secondary) |
| Operation time | |
| Definite time function operating time setting | 0.00...1800.00 s, setting step 0.005 s |
| Inaccuracy:<br>- Definite time ($I_M/I_{SET}$ ratio +/- 50 mHz) | <br>±1.5 % or ±50 ms (max. step size: 100 mHz) |
| Instant operation time | |
| Start time and instant operation time (trip):<br>- $I_M/I_{SET}$ ratio +/- 50 mHz (Fixed)<br>- $I_M/I_{SET}$ ratio +/- 50 mHz (Tracking) | <br><70 ms (max. step size: 100 mHz)<br><3 cycles or <60 ms (max. step size: 100 mHz) |
| Reset | |
| Reset ratio | 0.020 Hz |
| Instant reset time and start-up reset:<br>- $I_M/I_{SET}$ ratio +/- 50 mHz (Fixed)<br>- $I_M/I_{SET}$ ratio +/- 50 mHz (Tracking) | <br><110 ms (max. step size: 100 mHz)<br><3 cycles or <70 ms (max. step size: 100 mHz) |

**NOTE** The secondary voltage must exceed 2 volts or the current must exceed 0.25 amperes (peak-to peak) in order for the function to measure frequency.

**NOTE** The frequency is measured two seconds after a signal is received.

## 2.3.2 Rate-of-change of frequency protection (df/dt>/<; 81R)

**Table 2.14** Technical data of the rate-of-change of frequency function

| | |
|---|---|
| Input signals | |
| Sampling mode | Fixed<br>Tracking |
| Frequency reference 1<br>Frequency reference 2<br>Frequency reference 3 | CT1IL1, CT2IL1, VT1U1, VT2U1<br>CT1IL2, CT2IL2, VT1U2, VT2U2<br>CT1IL3, CT2IL3, VT1U3, VT2U3 |

| | |
|---|---|
| Pick-up | |
| Df/dt>/< pick-up setting | 0.15...1.00 Hz/s, setting step 0.01 Hz |
| f> limit | 10.00...70.00 Hz, setting step 0.01 Hz |
| f< limit | 7.00...65.00 Hz, setting step 0.01 Hz |
| Pick-up inaccuracy | |
| Df/dt | ±5.0 %$I_{SET}$ or ±20 mHz/s |
| Frequency | ±15 mHz (U > 30 V secondary)<br>±20 mHz (I > 30 % of rated secondary) |
| Operation time | |
| Definite time function operating time setting | 0.00...1800.00 s, setting step 0.005 s |
| Inaccuracy:<br>- Definite time ($I_M/I_{SET}$ ratio +/- 50 mHz) | ±1.5 % or ±110 ms (max. step size: 100 mHz) |
| Start time and instant operation time (trip): | |
| $f_M/f_{SET}$ ratio +/- 20 mHz (overreach) | <180 ms |
| $f_M/f_{SET}$ ratio +/- 200 mHz (overreach) | <90 ms |
| Reset | |
| Reset ratio (frequency limit) | 0.020 Hz |
| Instant reset time and start-up reset<br>- $f_M/f_{SET}$ ratio +/- 50 mHz | <2 cycles or <60 ms (max. step size: 100 mHz) |

**NOTE** The frequency is measured two seconds after a signal is received.

# 2.4 Power protections

## 2.4.1 Overpower (P>; 32O), underpower (P<; 32U) and reverse power (Pr; 32R) protection

**Table 2.15** Technical data for the power protection functions

| | |
|---|---|
| Measurement inputs | |
| Current inputs | Phase current inputs: $I_{L1}$ (A), $I_{L2}$ (B), $I_{L3}$ (C) |
| Voltage inputs | $U_{L1}$, $U_{L2}$, $U_{L3}$<br>$U_{L12}$, $U_{L23}$, $U_{L31}$ (+ $U_0$) |
| Calculated measurement | Three-phase active power |
| Pick-up | |
| P><br>Prev> | 0.10...150 000.00 kW, setting step 0.01 kW<br>-15 000.00...-1.00 kW, setting step 0.01 kW |
| P<<br>Low-power blocking $P_{SET}$< | 0.00...150 000.00 kW, setting step 0.01 kW<br>0.00...100 000.00 kW, setting step 0.01 kW |
| Inaccuracy:<br>- Active power | Typically <1.0 %$P_{SET}$ |
| Operation time | |
| Definite time function operating time setting | 0.00...1800.00 s, setting step 0.005 s |
| Inaccuracy:<br>- Definite time ($P_M/P_{SET}$ ratio 1.05→) | ±1.0 % or ±35 ms |
| Instant operation time | |

| | |
|---|---|
| Start time and instant operation time (trip):<br>- $P_M/P_{SET}$ ratio 1.05→ | <50 ms |
| Reset | |
| Reset ratio | 97 or 103 %$P_{SET}$ |
| Reset time setting<br>Inaccuracy: Reset time | 0.000...150.000 s, step 0.005 s<br>±1.0 % or ±35 ms |
| Instant reset time and start-up reset | <50 ms |

# 2.5 Transformer protections

## 2.5.1 Transformer thermal overload protection (TT>; 49T)

**Table 2.16** Technical data for the transformer thermal overload protection function

| | |
|---|---|
| Measurement inputs | |
| Current inputs | Phase current inputs: $I_{L1}$ (A), $I_{L2}$ (B), $I_{L3}$ (C) |
| Current input magnitudes | TRMS phase currents (up to the 31st harmonic) |
| Setting specifications | |
| Time constants τ | 1 heating, 1 cooling |
| Time constant value | 0.0...500.00 min, step 0.1 min |
| Service factor (maximum overloading) | 0.01...5.00 × $I_N$, step 0.01 × $I_N$ |
| Thermal model biasing | - Ambient temperature (Set –60.0...500.0 deg, step 0.1 deg)<br>- Negative sequence current |
| Thermal replica temperature estimates | Selectable between ºC and ºF |
| Outputs | |
| - Alarm 1<br>- Alarm 2<br>- Thermal trip<br>- Trip delay<br>- Restart inhibit | 0...150 %, step 1 %<br>0...150 %, step 1 %<br>0...150 %, step 1 %<br>0.000...3600.000 s, step 0.005 s<br>0...150 %, step 1 % |
| Inaccuracy | |
| - Starting<br>- Operating time | ±0.5 % of the set pick-up value<br>±5 % or ± 500 ms |

## 2.5.2 Transformer status monitoring

**Table 2.17** Technical data for the transformer status monitoring function

| | |
|---|---|
| Features | |
| Control scale | Common transformer data settings for all functions in the transformer module, the protection logic, the HMI and the I/O. |
| Settings | Transformer application nominal data |
| Other features | Status hours counters (normal load, overload, high overload)<br>Transformer status signals<br>Transformer data for functions |
| Outputs | |
| Light/no load | $I_M < 0.2 \times I_N$ |
| Inrush HV side detected | $I_M < 0.2 \times I_N \rightarrow I_M > 1.3 \times I_N$ |

| | |
|---|---|
| Inrush LV side detected | $I_M < 0.2 \times I_N \rightarrow I_M > 1.3 \times I_N$ |
| Load normal | $I_M > 0.2 \times I_N$... $I_M < 1.0 \times I_N$ |
| Overloading | $I_M > 1.0 \times I_N$... $I_M < 1.3 \times I_N$ |
| High overload | $I_M > 1.3 \times I_N$ |
| Inaccuracy | |
| Current detection | ±3 % of the set pick-up value > $0.5 \times I_N$ setting. 5 mA < $0.5 \times I_N$ setting |
| Detection time | ±0.5 % or ±10 ms |

## 2.5.3 Underimpedance protection (Z<; 21U)

**Table 2.18** Technical data for the underimpedance function

| | |
|---|---|
| Measurement inputs | |
| Current inputs | Phase current inputs: $I_{L1}$ (A), $I_{L2}$ (B), $I_{L3}$ (C) |
| Voltage inputs | $U_{L1}$, $U_{L2}$, $U_{L3}$<br>$U_{L12}$, $U_{L23}$, $U_{L31}$ + $U_0$ |
| Calculated impedances | Phase-to-phase impedances<br>Phase-to-ground impedances<br>Positive sequence impedance |
| Pick-up | |
| Pick-up setting | 0.1...150.0 Ω, setting step 0.1 Ω |
| Inaccuracy:<br>- Impedance calculation | Typically <1.0 $\%Z_{SET}$ |
| Operation time | |
| Definite time function operating time setting | 0.00...1800.00 s, setting step 0.005 s |
| Inaccuracy:<br>- Definite time ($Z_M/Z_{SET}$ ratio <0.95) | ±1.0 % or ±25 ms |
| Instant operation time | |
| Start time and instant operation time (trip):<br>- $Z_M/Z_{SET}$ ratio <0.95 | <45 ms |
| Reset | |
| Reset ratio | 103 $\%Z_{SET}$ |
| Reset time setting<br>Inaccuracy: Reset time | 0.010...150.000 s, step 0.005 s<br>±1.0 % or ±25 ms |
| Instant reset time and start-up reset | <45 ms |

## 2.5.4 Volts-per-hertz overexcitation protection (V/Hz>; 24)

**Table 2.19** Technical data for the volts-per-hertz overexcitation protection function

| | |
|---|---|
| Measurement inputs | |
| Voltage input | $U_{L1}$, $U_{L2}$, $U_{L3}$<br>$U_{L12}$, $U_{L23}$, $U_{L31}$ |
| Voltage input magnitude | Maximum line-to-line voltage |
| Frequency reference 1<br>Frequency reference 2<br>Frequency reference 3 | CT1IL1, CT2IL1, VT1U1, VT2U1<br>CT1IL2, CT2IL2, VT1U2, VT2U2<br>CT1IL3, CT2IL3, VT1U3, VT2U3 |

| | |
|---|---|
| Pick-up | |
| Pick-up setting | 0.01...75.00 %, setting step 0.01 % |
| Inaccuracy:<br>- V/Hz | ±1.0 % |
| Operation time | |
| Definite time function operating time setting | 0.00...1800.00 s, setting step 0.005 s |
| Inaccuracy:<br>- Definite time ($VHZ_M/VHZ_{SET}$ ratio 1.05) | ±1.0 % or ±25 ms |
| Instant operation time | |
| Start time and instant operation time (trip):<br>- $VHZ_M/VHZ_{SET}$ ratio 1.05) | <40 ms |
| Reset | |
| Reset ratio | 97 % of the pick-up setting |
| Reset time setting<br>Inaccuracy: Reset time | 0.000...150.000 s, step 0.005 s<br>±1.0 % or ±25 ms |
| Instant reset time and start-up reset | <40 ms |

## 2.5.5 Automatic voltage regulator (90)

**Table 2.20** Technical data for the automatic voltage regulator function

| | |
|---|---|
| Measurement inputs | |
| Voltage inputs | $U_{L1}$, $U_{L2}$, $U_{L3}$<br>$U_{L12}$, $U_{L23}$, $U_{L31}$ + $U_0$<br>U4 channel voltage |
| Voltage input magnitudes | RMS line-to-line voltages<br>U4 channel RMS voltage |
| Current inputs | Phase current inputs: $I_{L1}$ (A), $I_{L2}$ (B), $I_{L3}$ (C) |
| Current input magnitudes (I> blocking) | RMS phase currents |
| Pick-up | |
| Pick-up area (U>/<, U>>/<<, U>>>/<<<)<br>Tap step effect (1...70 steps)<br>I> blocking | 0.10...30.00 %$U_N$, setting step 0.01 %$U_N$<br>0.01...10.00 %$U_N$, setting step 0.01 %$U_N$<br>0.00...40.00 × $I_N$, setting step 0.01 × $I_N$ |
| Inaccuracy:<br>- Voltage<br>- Current | <br>±1.5 %$U_{SET}$<br>±0.5 %$I_{SET}$ or ±15 mA (0.10...4.0 × $I_{SET}$) |
| Operating time | |
| Control pulse min/max and time between<br>Definite time function operating time setting | 0.00...1800.00 s, setting step 0.005 s<br>0.00...1800.00 s, setting step 0.005 s |
| Inaccuracy:<br>- Definite time ($U_M/U_{SET}$ ratio 1.05→) | <br>±1.5 % or ±50 ms |
| Integrated operating time setting:<br>- Multiplier (k) | <br>0.000...1800.00, setting step 0.005 |
| Inaccuracy:<br>- IDMT operating time<br>- IDMT minimum operating time | <br>±1.5 % or ±35 ms<br>±20 ms |
| Instant operation time | |

| | |
|---|---|
| Start time and instant operation time (trip):<br>- $U_M/U_{SET}$ ratio 1.05→ | <50 ms |
| Reset | |
| Reset ratio:<br>- Voltage<br>- Current | <br>95/105 % of the pick-up voltage setting<br>97 % of the pick-up current setting |
| Reset time setting<br>Inaccuracy: Reset time | 0.010...10.000 s, step 0.005 s<br>±1.0 % or ±35 ms |
| Instant reset time and start-up reset | <50 ms |

# 2.6 Control functions

## 2.6.1 Synchrocheck (ΔV/Δa/Δf; 25)

**Table 2.21** Technical data for the synchrocheck function

| | |
|---|---|
| Input signals | |
| Voltage inputs | U1, U2, U3 or U4 voltage channel |
| Voltage input magnitudes | RMS line-to-line or line-to-neutral voltages<br>U3 or U4 voltage channel RMS |
| Pick-up | |
| U diff < setting | 2.00...50.00 $\%U_N$, setting step 0.01 $\%U_N$ |
| Angle diff < setting | 3.0...90.0 deg, setting step 0.10 deg |
| Freq diff < setting | 0.05...0.50 Hz, setting step 0.01 Hz |
| Inaccuracy:<br>- Voltage<br>- Frequency<br>- Angle | <br>±3.0 $\%U_{SET}$ or ±0.3 $\%U_N$<br>±25 mHz (U> 30 V secondary)<br>±1.5° (U> 30 V secondary) |
| Reset | |
| Reset ratio:<br>- Voltage<br>- Frequency<br>- Angle | <br>99 % of the pick-up voltage setting<br>20 mHz<br>±2.0° |
| Activation time | |
| Activation (to LD/DL/DD)<br>Activation (to Live Live) | <35 ms<br><60 ms |
| Reset | <40 ms |
| Bypass modes | |
| Voltage check mode (excluding LL) | LL+LD, LL+DL, LL+DD, LL+LD+DL, LL+LD+DD, LL+DL+DD, bypass |
| U live > limit<br>U dead < limit | 0.10...100.00 $\%U_N$, setting step 0.01 $\%U_N$<br>0.00...100.00 $\%U_N$, setting step 0.01 $\%U_N$ |

**NOTE** The minimum voltage for direction and frequency solving is 20.0 $\%U_N$.

## 2.6.2 Cold load pick-up (68) CLP

**Table 2.22** Technical data for the cold load pick-up function

| | |
|---|---|
| Measurement inputs | |
| Current inputs | Phase current inputs: $I_{L1}$ (A), $I_{L2}$ (B), $I_{L3}$ (C) |
| Current input magnitudes | RMS phase currents |
| Pick-up | |
| Pick-up current setting<br>- $I_{LOW}/I_{HIGH}/I_{OVER}$ | 0.01...40.00 × $I_N$, setting step 0.01 × $I_N$ |
| Reset ratio | 97 % of the pick-up current setting |
| Inaccuracy:<br>- Current | ±0.5 %$I_{SET}$ or ±15 mA (0.10...4.0 × $I_{SET}$) |
| Operation time | |
| Definite time function operating time settings:<br>- $t_{SET}$<br>- $t_{MAX}$<br>- $t_{MIN}$ | <br>0.000...1800.000 s, setting step 0.005 s<br>0.000...1800.000 s, setting step 0.005 s<br>0.000...1800.000 s, setting step 0.005 s |
| Inaccuracy:<br>- Definite time ($I_M/I_{SET}$ ratio = 1.05/0.95) | ±1.0 % or ±45 ms |
| Instant operation time | |
| CLPU activation and release | <45 ms (measured from the trip contact) |

**NOTE** A single-phase current (IL1, IL2 or IL3) is enough to prolong or release the blocking during an overcurrent condition.

## 2.6.3 Object control and monitoring

**Table 2.23** Technical data for the object control and monitoring function

| | |
|---|---|
| General | |
| Number of objects | 5 |
| Supported object types | Circuit breaker<br>Circuit breaker with withdrawable cart<br>Disconnector (MC)<br>Disconnector (GND) |
| Signals | |
| Input signals | Digital inputs<br>Software signals |
| Output signals | Close command output<br>Open command output |
| Operation time | |
| Breaker traverse time setting | 0.02...500.00 s, setting step 0.02 s |
| Max. close/open command pulse length | 0.02...500.00 s, setting step 0.02 s |
| Control termination time out setting | 0.02...500.00 s, setting step 0.02 s |
| Inaccuracy:<br>- Definite time operating time | ±0.5 % or ±10 ms |
| Breaker control operation time | |

| | |
|---|---|
| External object control time | <75 ms |
| Object control during auto-reclosing | See the technical sheet for the auto-reclosing function. |

**Table 2.24** Technical data for the circuit breaker wear monitoring function

| | |
|---|---|
| Pick-up | |
| Breaker characteristics settings:<br>- Nominal breaking current<br>- Maximum breaking current<br>- Operations with nominal current<br>- Operations with maximum breaking current | <br>0.00...100.00 kA, setting step 0.001 kA<br>0.00...100.00 kA, setting step 0.001 kA<br>0...200 000 operations, setting step 1 operation<br>0...200 000 operations, setting step 1 operation |
| Pick-up setting for Alarm 1 and Alarm 2 | 0...200 000 operations, setting step 1 operation |
| Inaccuracy | |
| Inaccuracy for current/operations counter:<br>- Current measurement element<br>- Operation counter | <br>0.1× $I_N$ > I < 2 × $I_N$ ±0.2 % of the measured current, rest 0.5 %<br>±0.5 % of operations deducted |

## 2.6.4 Programmable stage (PSx>/<; 99)

The programmable stage is a stage that the user can program to create more advanced applications, either as an individual stage or together with programmable logic. The device has ten programmable stages, and each can be set to follow one to three analog measurements. The programmable stages have three available pick up terms options: overX, underX and rate-of-change of the selected signal. Each stage includes a definite time delay to trip after a pick-up has been triggered.

The programmable stage cycle time is 5 ms. The pick-up delay depends on which analog signal is used as well as its refresh rate (typically under a cycle in a 50 Hz system).

## 2.6.5 Indicator object monitoring

**Table 2.25** Technical data for the indicator object monitoring function

| | |
|---|---|
| General | |
| Number of objects | 5 |
| Supported object types | Disconnector (GND)<br>Custom object image |
| Signals | |
| Input signals | Digital inputs<br>Software signals |

## 2.6.6 Setting group selection

**Table 2.26** Technical data for the setting group selection function

| | |
|---|---|
| Settings and control modes | |
| Setting groups | 8 independent, control-prioritized setting groups |
| Control scale | Common for all installed functions which support setting groups |
| Control mode | |
| Local | Any binary signal available in the device |
| Remote | Force change overrule of local controls either from the setting tool, HMI or SCADA |

| | |
|---|---|
| Operation time | |
| Reaction time | <5 ms from receiving the control signal |

# 2.7 Monitoring functions

## 2.7.1 Voltage transformer supervision (60)

**Table 2.27** Technical data for the voltage transformer supervision function

| | |
|---|---|
| Measurement inputs | |
| Voltage inputs | $U_{L1}$, $U_{L2}$, $U_{L3}$<br>$U_{L12}$, $U_{L23}$, $U_{L31}$ |
| Voltage input magnitudes | RMS line-to-line or line-to-neutral voltages |
| Pick-up | |
| Pick-up settings:<br>- Voltage (low pick-up)<br>- Voltage (high pick-up)<br>- Angle shift limit | <br>0.05...0.50 × $U_N$, setting step 0.01 × $U_N$<br>0.50...1.10 × $U_N$, setting step 0.01 × $U_N$<br>2.00...90.00 deg, setting step 0.10 deg |
| Inaccuracy:<br>- Voltage<br>- U angle (U> 1 V) | <br>±1.5 %$U_{SET}$<br>±1.5° |
| External line/bus side pick-up (optional) | 0 → 1 |
| Time delay for alarm | |
| Definite time function operating time setting | 0.00...1800.00 s, setting step 0.005 s |
| Inaccuracy:<br>- Definite time ($U_M/U_{SET}$ ratio > 1.05/0.95) | <br>±1.0 % or ±35 ms |
| Instant operation time (alarm):<br>- $U_M/U_{SET}$ ratio > 1.05/0.95 | <br><80 ms |
| VTS MCB trip bus/line (external input) | <50 ms |
| Reset | |
| Reset ratio | 97/103 % of the pick-up voltage setting |
| Reset time setting<br>Inaccuracy: Reset time | 0.010...10.000 s, step 0.005 s<br>±2.0 % or ±80 ms |
| Instant reset time and start-up reset | <50 ms |
| VTS MCB trip bus/line (external input) | <50 ms |

**NOTE** When turning on the auxiliary power of a device, the normal condition of a stage has to be fulfilled before tripping.

## 2.7.2 Circuit breaker wear monitoring

**Table 2.28** Technical data for the circuit breaker wear monitoring function

| | |
|---|---|
| Pick-up | |
| Breaker characteristics settings:<br>- Nominal breaking current<br>- Maximum breaking current<br>- Operations with nominal current<br>- Operations with maximum breaking current | <br>0.00...100.00 kA, setting step 0.001 kA<br>0.00...100.00 kA, setting step 0.001 kA<br>0...200 000 operations, setting step 1 operation<br>0...200 000 operations, setting step 1 operation |

| | |
|---|---|
| Pick-up setting for Alarm 1 and Alarm 2 | 0...200 000 operations, setting step 1 operation |
| Inaccuracy | |
| Inaccuracy for current/operations counter:<br>- Current measurement element<br>- Operation counter | 0.1× $I_N$ > I < 2 × $I_N$ ±0.2 % of the measured current, rest 0.5 %<br>±0.5 % of operations deducted |

## 2.7.3 Disturbance recorder

**Table 2.29** Technical data for the disturbance recorder function

| | |
|---|---|
| Recorded values | |
| Recorder analog channels | 0...20 channels<br>Freely selectable |
| Recorder digital channels | 0...95 channels<br>Freely selectable analog and binary signals<br>5 ms sample rate (FFT) |
| Performance | |
| Sample rate | 8, 16, 32 or 64 samples/cycle |
| Recording length | 0.000...1800.000 s, setting step 0.001 s<br>The maximum length is determined by the chosen signals. |
| Number of recordings | 0...100, 60 MB of shared flash memory reserved<br>The maximum number of recordings according to the chosen signals and operation time setting combined |

## 2.7.4 Current transformer supervision

**Table 2.30** Technical data for the current transformer supervision function

| | |
|---|---|
| Measurement inputs | |
| Current inputs | Phase current inputs: $I_{L1}$ (A), $I_{L2}$ (B), $I_{L3}$ (C)<br>Residual current channel $I_{01}$ (Coarse)<br>Residual current channel $I_{02}$ (Fine) |
| Current input magnitudes | RMS phase currents<br>RMS residual current ($I_{01}$, $I_{02}$) |
| Pick-up | |
| Pick-up current settings:<br>- $I_{SET}$ high limit<br>- $I_{SET}$ low limit<br>- $I_{SUM}$ difference<br>- $I_{SET}$ ratio<br>- I2/I1 ratio | <br>0.10...40.00 × $I_N$, setting step 0.01 × $I_N$<br>0.10...40.00 × $I_N$, setting step 0.01 × $I_N$<br>0.10...40.00 × $I_N$, setting step 0.01 × $I_N$<br>0.01...100.00 %, setting step 0.01 %<br>0.01...100.00 %, setting step 0.01 % |
| Inaccuracy:<br>- Starting IL1, IL2, IL3<br>- Starting I2/I1<br>- Starting I01 (1 A)<br>- Starting I02 (0.2 A) | <br>±0.5 %$I_{SET}$ or ±15 mA (0.10...4.0 × $I_{SET}$)<br>±1.0 %$I2_{SET}$ / $I1_{SET}$ or ±100 mA (0.10...4.0 × $I_N$)<br>±0.5 %$I0_{SET}$ or ±3 mA (0.005...10.0 × $I_{SET}$)<br>±1.5 %$I0_{SET}$ or ±1.0 mA (0.005...25.0 × $I_{SET}$) |
| Time delay for alarm | |
| Definite time function operating time setting | 0.00...1800.00 s, setting step 0.005 s |
| Inaccuracy_<br>- Definite time ($I_M/I_{SET}$ ratio > 1.05) | <br>±2.0 % or ±80 ms |

| | |
|---|---|
| Instant operation time (alarm):<br>- $I_M/I_{SET}$ ratio > 1.05 | <80 ms (<50 ms in differential protection relays) |
| Reset | |
| Reset ratio | 97/103 % of the pick-up current setting |
| Instant reset time and start-up reset | <80 ms (<50 ms in differential protection relays) |

## 2.7.5 Current total harmonic distortion

**Table 2.31** Technical data for the total harmonic distortion function

| | |
|---|---|
| Input signals | |
| Current inputs | Phase current inputs: $I_{L1}$ (A), $I_{L2}$ (B), $I_{L3}$ (C)<br>Residual current channel $I_{01}$ (Coarse)<br>Residual current channel $I_{02}$ (Fine) |
| Current input magnitudes | Current measurement channels (FFT result) up to the 31$^{st}$ harmonic component. |
| Pick-up | |
| Operating modes | Power THD<br>Amplitude THD |
| Pick-up setting for all comparators | 0.10...200.00 % , setting step 0.01 % |
| Inaccuracy | ±3 % of the set pick-up value > 0.5 × $I_N$ setting; 5 mA < 0.5 × $I_N$ setting. |
| Time delay | |
| Definite time function operating time setting for all timers | 0.00...1800.00 s, setting step 0.005 s |
| Inaccuracy:<br>- Definite time operating time<br>- Instant operating time, when $I_M/I_{SET}$ ratio > 3<br>- Instant operating time, when $I_M/I_{SET}$ ratio 1.05 < $I_M/I_{SET}$ < 3 | ±0.5 % or ±10 ms<br>Typically <20ms<br>Typically <25 ms |
| Reset | |
| Reset time | Typically <10 ms |
| Reset ratio | 97 % |

## 2.7.6 Voltage memory

**Table 2.32** Technical data for the voltage memory function

| | |
|---|---|
| Measurement inputs | |
| Voltage inputs | $U_{L1}$, $U_{L2}$, $U_{L3}$<br>$U_{L12}$, $U_{L23}$, $U_{L31}$ + $U_0$ |
| Current inputs (back-up frequency) | Phase current inputs: $I_{L1}$ (A), $I_{L2}$ (B), $I_{L3}$ (C) |
| Pick-up | |
| Pick-up voltage setting<br>Pick-up current setting (optional) | 2.00...50.00 %$U_N$, setting step 0.01 x %$U_N$<br>0.01...50.00 × $I_N$, setting step 0.01 × $I_N$ |
| Inaccuracy:<br>- Voltage<br>- Current | ±1.5 %$U_{SET}$ or ±30 mV<br>±0.5 %$I_{SET}$ or ±15 mA (0.10...4.0 × $I_{SET}$) |

| | |
|---|---|
| Operation time | |
| Angle memory activation delay | <20 ms (typically 5 ms) |
| Maximum active time | 0.020...50.000 s, setting step 0.005 s |
| Inaccuracy:<br>- Definite time ($U_M/U_{SET}$ ratio >1.05) | ±1.0 % or ±35 ms |
| Angle memory | |
| Angle drift while voltage is absent | ±1.0° per 1 second |
| Reset | |
| Reset ratio:<br>- Voltage memory (voltage)<br>- Voltage memory (current) | <br>103 % of the pick-up voltage setting<br>97 % of the pick-up current setting |
| Reset time | <50 ms |

**NOTE** Voltage memory is activated only when all line voltages fall below set pick-up value.

**NOTE** Voltage memory activation captures healthy situation voltage angles, one cycle before actual activation (50Hz/ 20ms before “bolted” fault)

# 3. Technical specifications

## 3.1 Electromagnetic compatibility

| Emission | Standard | Class | Value |
|---|---|---|---|
| Conducted Disturbance Emission | IEC 60255-26 | A | 0.15 to 30 MHz<br>IACS E10 Setup according to CISPR 16.<br>Conducted emission measured from 10kHz |
| | IEC 61000-6-4 | A | |
| Radiated emission (below 1 GHz) | IEC 60255-26 | | 30 to 1000 MHz |
| | IEC 61000-6-4 | A | IACS E10 Setup according to CISPR 16.<br>Radiated emission measured from 150 kHz to 2000 MHz |
| Radiated emission (above 1 GHz) | IEC 60255-26 | | 1 to 6 GHz |
| | IEC 61000-6-4 | A | |

| Immunity | Standard | Level | Value |
|---|---|---|---|
| Electrostatic Discharge | IEC 60255-26 | | 8 kV air discharge |
| | IEC 61000-4-2<br>IACS E10 | 3 | 6 kV direct discharge |
| Radiated immunity | IEC 60255-26 | | 10 V/m; 80 MHz to 1 GHz; 1.4 GHz to 2.7 GHz<br>IACS E10 80 MHz to 2 GHz 10 V/m 3 s dwell time |
| | ENV 50204 (GSM) | 3 | 10 V/m; 2 W at 0.6 m |
| Fast transient/burst immunity | IEC 60225-26 | | 2 kV |
| | IEC 61000-4-4<br>IACS E10 | 3 | 2 kV<br>2 kV |
| Surge immunity | IEC 60255-26 | | 1 kV symmetrical (line to line) |
| | IEC 61000-4-5<br>IACS E10 | 3 | 2 kV unsymmetrical (line to earth)<br>0.5 kV symmetrical (line to line) (only for IACS E10)<br>1 kV unsymmetrical (line to earth) (only for IACS E10) |
| Conducted immunity | IEC 60255-26 | | 0.15 to 80 MHz; 10 V |
| | IEC 61000-4-6 | 3 | IACS E10 3 s dwell time. |
| Power frequency magnetic field immunity | IEC 60255-26 | | 30 A/m continuous |
| | IEC 61000-4-8 | 4 | 300 A/m; 1 s to 3 s |
| Pulse magnetic field immunity | IEC 61000-4-9 | 5 | 1000 A/m |
| Damped oscillatory magnetic field immunity | IEC 61000-4-10 | 4 | 30 A/m |
| Oscillatory transient immunity – Ring wave | IEC 61000-4-12 | 4 | 100 kHz<br>4 kV common mode |
| | | | 2 kV differential mode |
| Oscillatory transient immunity – Slow damped oscillatory wave | IEC 61000-4-18<br>ANSI/IEEE Std C37.90.1 | 3 | 100 kHz<br>1 kV differential mode<br>2.5 kV common mode |
| Oscillatory transient immunity – Slow damped oscillatory wave | IEC 60255-26<br>IEC 61000-4-18 | 3 | 1.0 MHz<br>2.5 kV common mode |
| | ANSI/IEEE Std C37.90.1 | | 2.5 kV differential mode |

| Immunity | Standard | Level | Value |
|---|---|---|---|
| Voltage dips | IEC 60255-26 | | 0 % |
| | IEC 61000-4-11 | | DC 10 ms |
| | IEC 61000-4-29 | | AC 0.5 cycle (10 ms) |
| Voltage dips | IEC 60255-26 | | 40 % |
| | IEC 61000-4-11 | | DC 200 ms |
| | IEC 61000-4-29 | | AC 10/12 cycles (10 ms)<br>Tested both 50/60 Hz |
| Voltage dips | IEC 60255-26 | | 70 % |
| | IEC 61000-4-11 | | DC 500 ms |
| | IEC 61000-4-29 | | AC 25/30 cycles (10 ms) |
| Voltage interruptions | IEC 60255-26 | | 0 % |
| | IEC 61000-4-11<br>IACS E10 | | DC 5 s (3 interruptions w. 10 s interval) DC 30 s/60 s (3 interruptions w. 60 s interval) |
| | IEC 61000-4-29<br>IACS E10 | | AC 250 cycles (5 s)<br>(3 interruptions w. 10 s interval)<br>AC 30 s (3 interruptions w. 90 s interval)<br>1 additional interruption during booting |
| Voltage variations permanent | IACS E10 | | DC +30 % 24H<br>DC -15 % 15 min<br>AC +6 % V AC/+5 % Hz 15 min<br>AC +6 % V AC/-5 % Hz 15 min<br>AC -10 % V AC/-5 % Hz 15min<br>AC -10 % V AC/+5 % Hz 15 min |
| Voltage variations transient | IACS E10 | | AC +20 % V AC 1.5 s/+10 % Hz 5 s<br>AC -20 % V AC 1.5 s/-10 % Hz 5 s |
| Ripple | IEC 60255-26 | | 15 % of DC; 100 Hz |
| | IEC 61000-4-17 | | |
| Power Frequency Immunity | IEC 60255-26 | | 150 V, 50 Hz, common mode |
| | IEC 61000-4-16 | | 300 V, 50 Hz, differential mode |

## 3.2 Mechanical durability

| Energised | Standard | Class | Value |
|---|---|---|---|
| Vibration response | IEC 60255-27<br>IEC 60255-21-1 | 2 | 10 to 58.1 Hz: 0.15 mmpp<br>58.1 to 150 Hz: 1 g<br>1 cycle in each axis |
| Vibration | IACS E10 | | 3 to 13.2 Hz 2 mmpp<br>13.2 to 100 Hz 0.7 g |
| Shock response | IEC 60255-27<br>IEC 60255-21-2 | 2 | 10 g; 11 ms |

| De-energised | Standard | Class | Value |
|---|---|---|---|
| Vibration endurance | IEC 60255-27<br>IEC 60255-21-1 | 2 | 10 to 150 Hz; 2 g acceleration;<br>20 sweep cycles |
| Shock withstand | IEC 60255-27 | 2 | 30 g; 11 ms |

| De-energised | Standard | Class | Value |
|---|---|---|---|
| | IEC 60255-21-2 | | |
| Bump | IEC 60255-27<br>IEC 60255-21-2 | 2 | 20 g; 16 ms |

## 3.3 Environment

| General | Standard | Value |
|---|---|---|
| Cold non-operation | I<br>EC 60255-27<br>IEC 60255-1<br>IACS E10 | -25 °C; 16 h |
| Dry heat operation | IEC 60255-27<br>IEC 60255-1<br>IACS E10 | 60 °C; 16 h |
| Damp heat (static) | IEC 60255-27<br>IEC 60255-1 | 55 °C; 93 % RH; 10 days |
| Cyclic temperature with humidity (damp heat cyclic) | IEC 60255-27<br>IEC 60255-1<br>IACS E10 | 55 °C @ 93 % RH; 25 °C @ 97 % RH, 12 h + 12 h; 6 cycles<br>55 °C @ 95 % RH; 12 h + 12 h; 2 cycles |
| Change of temperature | IEC 60255-1 | 5 cycles; -25 °C to 70 °C |

| Storage | Standard | Value |
|---|---|---|
| Low temperature storage | IEC 60255-27<br>IEC 60255-1 | -40 °C; 16 h |
| High temperature storage | IEC 60255-27<br>IEC 60255-1 | 70 °C; 16 h |

## 3.4 Safety

| Electrical | Standard | Value |
|---|---|---|
| Insulation resistance | IEC 60255-27<br>IACS E10 | Before environmental tests:<br>>100 MΩ at DC 500 V<br>>100 MΩ at DC 500 V (Uw >65 V)<br>>10 MΩ at DC 50 V (Uw <65 V)<br>After environmental tests:<br>>10 MΩ at DC 500 V (Uw >65 V)<br>>1 MΩ at DC 50 V (Uw <65 V) |
| Reverse polarity | IEC 60255-27 | |
| Gradual shut down/start-up tests | IEC 60255-27 | |
| Impulse voltage | IEC 60255-27 | 5 kV; 1.2/50 µs; 0.5 J |
| Power frequency dielectric withstand | IEC 60255-27 | 3.5 kV; 50 Hz; 1 min (PS, DI, DO, I, RS485 AO)<br>4.35 kV; 50 Hz; 1 min (U) |
| Protective bonding impedance | IEC 60255-27 | <0.1 Ω at 20 A 60 s |
| Insulation class | | Class I |
| Over-voltage CAT | IEC 60255-27 | III |

| Enclosure | Standard | Value |
| --- | --- | --- |
| Dust/water ingress | IEC 60255-27<br>IEC 60529 | IP 54 (front), IP 20 (back) |

# 4. Hardware

## 4.1 Processor and power supply

**Table 4.1** General information for the CPU module

| | |
|---|---|
| Terminal block connection | |
| Screw connection terminal block (standard) | Phoenix Contact MSTB 2,5/5-ST-5,08 |
| Spring cage terminal block (option) | Phoenix Contact FKC 2,5/20-STF-5,08 |
| Solid or stranded wire<br>Nominal cross section | 2.5 $mm^2$ |
| RS-485 serial terminal block connection | |
| Screw connection terminal block (standard) | Phoenix Contact MC 1,5/ 5-ST-3,81 |
| Spring cage terminal block (option) | Phoenix Contact FK-MCP 1,5/ 5-ST-3,81 |
| Solid or stranded wire<br>Nominal cross section | 1.5 $mm^2$ |

### 4.1.1 Auxiliary supply

**Table 4.2** Power supply model H

| | |
|---|---|
| Rated values | |
| Rated auxiliary voltage | 100...120 V DC |
| Power consumption | < 7 W (no option cards)<br>< 15 W (maximum number of option cards) |
| Maximum permitted interrupt time | < 60 ms with 110 VDC |
| DC ripple | < 15 % |
| Other | |
| Minimum recommended fuse rating | MCB C2 |

**Table 4.3** Power supply model L

| | |
|---|---|
| Rated values | |
| Rated auxiliary voltage | 24...48 VDC |
| Power consumption | < 7 W (no option cards)<br>< 15 W (maximum number of option cards) |
| Maximum permitted interrupt time | < 90 ms with 24 VDC |
| DC ripple | < 15 % |
| Other | |
| Minimum recommended fuse rating | MCB C2 |

### 4.1.2 Isolated digital inputs

**Table 4.4** CPU model-isolated digital inputs, with thresholds defined by order code

| | |
|---|---|
| Number of digital inputs | 3 |
| Rated values | |
| Rated auxiliary voltage | 265 V (AC/DC) |
| Nominal voltage | Order code defined: 24, 110, 220 V (AC/DC)<br>**Caution:** When the working voltage is above 150 V AC, do not mix AC and DC voltage inside any relay groups or digital input groups. |
| Pick-up threshold<br>Release threshold | Order code defined: 19, 90,170 V<br>Order code defined: 14, 65, 132 V |
| Scanning rate | 5 ms |
| Settings | |
| Pick-up delay | Software settable: 0...1800 s |
| Polarity | Software settable: Normally On/Normally Off |
| Current drain | 2 mA |

### 4.1.3 Digital outputs

**Table 4.5** Digital outputs (Normally Open)

| | |
|---|---|
| Number of digital outputs | 4 |
| Rated values | |
| Rated auxiliary voltage | 265 V (AC/DC)<br>**Caution:** When the working voltage is above 150 V AC, do not mix AC and DC voltage inside any relay groups or digital input groups. |
| Continuous carry | 5 A |
| Make and carry 0.5 s<br>Make and carry 3 s | 30 A<br>15 A |
| Breaking capacity, DC (L/R = 40 ms)<br>at 48 VDC<br>at 110 VDC<br>at 220 VDC | <br>1 A<br>0.4 A<br>0.2 A |
| Control rate | 5 ms |
| Settings | |
| Polarity | Software settable: Normally Open / Normally Closed |

**Table 4.6** Digital outputs (Change-Over)

| | |
|---|---|
| Number of digital outputs | 1 configurable (plus 1 for fault signaling) |
| Rated values | |
| Rated auxiliary voltage | 265 V (AC/DC)<br>**Caution:** When the working voltage is above 150 V AC, do not mix AC and DC voltage inside any relay groups or digital input groups. |
| Continuous carry | 2.5 A |
| Make and carry 0.5 s<br>Make and carry 3 s | 30 A<br>15 A |

| | |
|---|---|
| Breaking capacity, DC (L/R = 40 ms)<br>at 48 VDC<br>at 110 VDC<br>at 220 VDC | <br>1 A<br>0.3 A<br>0.15 A |
| Control rate | 5 ms |
| Settings | |
| Polarity | Software settable: Normally Open / Normally Closed |

### 4.1.4 Communication ports

| | |
|---|---|
| **Front panel local communication port** | |
| Port, media | Ethernet RJ-45, Copper |
| Number of ports | 1 |
| Port protocols | PC-protocols, FTP, Telnet |
| Data transfer rate | 100 MB |
| System integration | Cannot be used for system protocols, only for local programming |
| **Rear panel system communication port A** | |
| Port, media | Ethernet RJ-45, Copper |
| Number of ports | 1 |
| Port protocols | Modbus TCP, DNP 3.0, FTP, Telnet, IEC 61850, IEC-104 |
| Data transfer rate | 100 MB |
| System integration | Can be used for system protocols and for local programming |
| **Rear panel system communication port B** | |
| Port, media | RS-485, Copper |
| Number of ports | 1 |
| Port protocols | Modbus RTU, DNP 3.0, IEC-103, IEC-101, SPA |
| Data transfer rate | 65580 kB/s |
| System integration | Can be used for system protocols |

## 4.2 Current measurement module

**Table 4.7** Technical data for the current measurement module

| | |
|---|---|
| Connections | |
| **Measurement channels/CT inputs** | Three phase current inputs: IL1 (A), IL2 (B), IL3 (C)<br>Two residual current inputs: Coarse residual current input I01, Fine residual current input I02 |
| Phase current inputs (A, B, C) | |
| Sample rate | 64 samples per cycle in frequency range 6...75Hz |
| Rated current $I_N$ | 5 A (configurable 0.2...10 A)<br>5 A (configurable 0.2...20 A) |
| Thermal withstand | 20 A (continuous)<br>100 A (for 10 s)<br>500 A (for 1 s)<br>1250 A (for 0.01 s) |
| Frequency measurement range | From 6...75Hz fundamental, up to the 31$^{st}$ harmonic current |

| | |
|---|---|
| Current measurement range | 25 mA...250 A (RMS) |
| Current measurement inaccuracy | 0.005...4.000 × $I_N$ < ±0.5 % or < ±15 mA<br>4...20 × $I_N$ < ±0.5 %<br>20...50 × $I_N$ < ±1.0 % |
| Temperature-dependent current measurement inaccuracy | Reference temperature: 25 °C<br>Operation temperature range: -25 to 55 °C<br>Inaccuracy: An additional ±15 mA per 10 °C |
| Angle measurement inaccuracy | < ±0.2° (I> 0.1 A)<br>< ±1.0° (I≤ 0.1 A) |
| Burden (50/60 Hz) | <0.1 VA |
| Transient overreach | <8 % |
| **Coarse residual current input (I01)** | |
| Rated current $I_N$ | 1 A (configurable 0.1...10 A) |
| Thermal withstand | 25 A (continuous)<br>100 A (for 10 s)<br>500 A (for 1 s)<br>1250 A (for 0.01 s) |
| Frequency measurement range | From 6...75 Hz fundamental, up to the 31$^{st}$ harmonic current |
| Current measurement range | 5 mA...150 A (RMS) |
| Current measurement inaccuracy | 0.002...10.000 × $I_N$ < ±0.5 % or < ±3 mA<br>10...150 × $I_N$ < ±0.5 % |
| Temperature-dependent current measurement inaccuracy | Reference temperature: 25 °C<br>Operation temperature range: -25 to 55 °C<br>Inaccuracy: An additional ±0.8 mA per 10 °C |
| Angle measurement inaccuracy | < ±0.2° (I> 0.05 A)<br>< ±1.0° (I≤ 0.05 A) |
| Burden (50/60Hz) | <0.1 VA |
| Transient overreach | <5 % |
| **Fine residual current input (I02)** | |
| Rated current $I_N$ | 0.2 A (configurable 0.001...10 A) |
| Thermal withstand | 25 A (continuous)<br>100 A (for 10 s)<br>500 A (for 1 s)<br>1250 A (for 0.01 s) |
| Frequency measurement range | From 6...75 Hz fundamental, up to the 31$^{st}$ harmonic current |
| Current measurement range | 1 mA...75 A (RMS) |
| Current measurement inaccuracy | 0.002...25.000 × $I_N$ < ±0.5 % or < ±0.6 mA<br>25...375 × $I_N$ < ±1.0 % |
| Temperature-dependent current measurement inaccuracy | Reference temperature: 25 °C<br>Operation temperature range: -25 to 55 °C<br>Inaccuracy: An additional ±0.4 mA per 10 °C |
| Angle measurement inaccuracy | < ±0.2° (I> 0.01 A)<br>< ±1.0° (I≤ 0.01 A) |
| Burden (50/60Hz) | <0.1 VA |
| Transient overreach | <5 % |
| Screw connection terminal block (standard) | |
| Terminal block | Phoenix Contact FRONT 4-H-6,35 |
| Solid or stranded wire | |

| | |
|---|---|
| Nominal cross section | 4 $mm^2$ |
| Ring lug terminal block connection (option) | |
| Ring terminal dimensions | Max 8mm diameter, with minimum 3,5mm screw hole |

**NOTE** Current measurement accuracy has been verified with 50/60 Hz.

The amplitude difference is 0.2 % and the angle difference is 0.5 degrees higher at 16.67 Hz and other frequencies.

## 4.3 Voltage measurement module

**Table 4.8** Technical data for the voltage measurement module

| | |
|---|---|
| General information | |
| Compatibility | MVR-200 series and MVR-250 series models |
| Connection | |
| Measurement channels/VT inputs | 4 independent VT inputs (U1, U2, U3 and U4) |
| Measurement | |
| Sample rate | 64 samples per cycle in frequency range 6...75Hz |
| Voltage measuring range | 0.50...480.00 V (RMS) |
| Voltage measurement inaccuracy | For 2...480 V AC: ±0.2 % or ±10 mV, whichever is biggest |
| Temperature-dependent voltage measurement inaccuracy | Reference temperature: 25 °C<br>Operation temperature range: -25 to 60 °C<br>Inaccuracy: An additional ±30 mV per 10 °C |
| Angle measurement inaccuracy | ±0.2 degrees (15...300 V)<br>±1.5 degrees (1...15 V) |
| Voltage measurement bandwidth (freq.) | 7...75 Hz fundamental, up to the 31$^{st}$ harmonic voltage |
| Terminal block connection | |
| Screw connection terminal block (standard) | Phoenix Contact PC 5/ 8-STCL1-7,62 |
| Spring cage terminal block (optional) | Phoenix Contact SPC 5/ 8-STCL-7,82 |
| Solid or stranded wire<br>Nominal cross section | 6 $mm^2$ |
| Input impedance | ~24.5 MΩ |
| Burden (50/60 Hz) | <0.02 VA |
| Thermal withstand | 630 $V_{RMS}$ (continuous) |

**NOTE** Voltage measurement accuracy has been verified with 50/60 Hz.

The amplitude difference is 0.2 % and the angle difference is 0.5 degrees higher at 16.67 Hz and other frequencies.

## 4.4 Power and energy measurement

**Table 4.9** Power and energy measurement accuracy

| | |
|---|---|
| Power measurement P, Q, S | Frequency range 6...75 Hz |
| Inaccuracy | 0.3 % <1.2 × $I_N$ or 3 VA secondary<br>1.0 % >1.2 × $I_N$ or 3 VA secondary |
| Energy measurement | Frequency range 6...75 Hz |

| | |
|---|---|
| Energy and power metering inaccuracy | 0.5% down to 1A RMS (50/60Hz) as standard<br>0.2% down to 1A RMS (50/60Hz) option available (see the order code for details) |
| Temperature-dependent power measurement inaccuracy | Reference temperature: 25 °C<br>Operation temperature range: -25 to 60 °C<br>Inaccuracy (UL 100V, IL 5A): An additional ±1.5 W per 10 °C |

## 4.5 Frequency measurement

**Table 4.10** Frequency measurement accuracy.

| Frequency measurement performance | |
|---|---|
| Frequency measuring range | 6...75 Hz fundamental, up to the 31st harmonic current or voltage |
| Inaccuracy | 20 mHz* |

**NOTE** * If one of these conditions is met, the frequency inaccuracy is ±30 mHz:

- f ≠ 50 Hz or 60 Hz.
- Frequency tracking via voltages is applied.
- U < 15 V.

## 4.6 Digital inputs and outputs

### 4.6.1 Digital input module (option card B)

**Table 4.11** Technical data for the digital input module

| | |
|---|---|
| Number of digital inputs | 8 x isolated (2 groups) |
| Rated values | |
| Rated auxiliary voltage | 5...265 V (AC/DC) |
| Current drain | 2 mA |
| Scanning rate<br>Activation/release delay | 5 ms<br>5...11 ms |
| Settings | |
| Pick-up threshold<br>Release threshold | Software settable: 16...200 V, setting step 1 V<br>Software settable: 10...200 V, setting step 1 V |
| Pick-up delay | Software settable: 0...1800 s |
| Drop-off delay | Software settable: 0...1800 s |
| Polarity | Software settable: Normally On/Normally Off |
| Terminal block connection | |
| Screw connection terminal block (standard) | Phoenix Contact MSTB 2,5/10-ST-5,08 |
| Spring cage terminals block (option) | Phoenix Contact FKC 2,5/10-STF-5,08 |
| Solid or stranded wire<br>Nominal cross section | <br>2.5 $mm^2$ |

### 4.6.2 Digital output module (option card C)

**Table 4.12** Technical data for the digital output module

| | |
|---|---|
| Number of digital outputs | 5 |
| Rated values | |
| Rated auxiliary voltage | 265 V (AC/DC) |
| Continuous carry | 5 A |
| Make and carry 0.5 s<br>Make and carry 3 s | 30 A<br>15 A |
| Breaking capacity, DC (L/R = 40 ms)<br>at 48 VDC<br>at 110 VDC<br>at 220 VDC | <br>1 A<br>0.4 A<br>0.2 A |
| Control rate | 5 ms |
| Settings | |
| Polarity | Software settable: Normally On/Normally Off |
| Terminal block connection | |
| Screw connection terminal block (standard) | Phoenix Contact MSTB 2,5/10-ST-5,08 |
| Spring cage terminals block (option) | Phoenix Contact FKC 2,5/10-STF-5,08 |
| Solid or stranded wire<br>Nominal cross section | <br>2.5 $mm^2$ |

## 4.7 Analogue inputs

### 4.7.1 RTD input module (option card F)

**Table 4.13** Technical data for the RTD input module.

| | |
|---|---|
| General information | |
| Hardware configuration code | F |
| Sensors | |
| Channels 1-8 | 2/3/4-wire RTD<br>Pt100 or Pt1000 |
| Terminal block connection | |
| Maximum cross section (solid or stranded wire) | 1.5 $mm^2$ |

## 4.8 Analogue outputs

### 4.8.1 Analogue output module (mA out & mA in) (option card I)

**Table 4.14** Technical data for the analogue output module

| | |
|---|---|
| Signals | |
| Output magnitudes<br>Input magnitudes | 4 × mA output signal (DC)<br>1 × mA input signal (DC) |
| mA input | |
| Range (hardware) | 0...33 mA |

| | |
|---|---|
| Range (measurement)<br>Inaccuracy | 0...24 mA<br>±0.1 mA |
| Update cycle<br>Response time @ 5 ms cycle<br>Update cycle time inaccuracy | 5...10 000 ms, setting step 5 ms<br>~ 15 ms (13...18 ms)<br>Max. +20 ms above the set cycle |
| mA input scaling range<br>Output scaling range | 0...4000 mA<br>-1 000 000.0000...1 000 000.0000, setting step 0.0001 |
| mA output | |
| Inaccuracy @ 0...24 mA | ±0.01 mA |
| Response time @ 5 ms cycle [fixed] | < 5 ms |
| mA output scaling range<br>Source signal scaling range | 0...24 mA, setting step 0.001 mA<br>-1 000 000.000...1 000 000.0000, setting step 0.0001 |
| Terminal block connection | |
| Screw connection terminal block (standard) | Phoenix Contact MSTB 2,5/10-ST-5,08 |
| Spring cage terminals block (option) | Phoenix Contact FKC 2,5/10-STF-5,08 |
| Solid or stranded wire<br>Nominal cross section | <br>2.5 $mm^2$ |

# 4.9 Additional communication options

## 4.9.1 Double RJ45 Ethernet & IRIG-B communication module (option card G)

**Table 4.15** Technical data for the double RJ-45 Ethernet communication module.

| | |
|---|---|
| General information | |
| Hardware configuration code | G |
| Ethernet connector features | |
| Protocols | IEC 61850<br>IEC 104<br>Modbus/TCP<br>DNP3<br>FTP |
| Data transfer rate | 100 MB/s |
| System integration | Can be used for system protocols and for local programming |
| Number of ports | 2 |
| Communication ports | Copper Ethernet RJ-45 |
| IRIG-B Connector | |
| Maximum cross section (solid or stranded wire) | 1.5 $mm^2$ |

## 4.9.2 Double ST 100 Mbps Ethernet communication module (option card H)

**Table 4.16** Technical data for the double ST 100 Mbps Ethernet communication module

| | |
|---|---|
| General information | |
| Dimensions | 74 mm X 179 mm |
| Ports | ST connectors (2) and IRIG-B connector (1) |
| Protocols | |

| | |
|---|---|
| Protocols | IEC61850, DNP/TCP, Modbus/TCP, IEC104 & FTP |
| ST connectors | |
| Connector type | Duplex ST connectors<br>62.5/125 µm or 50/125 µm multimode fiber<br>100BASE-FX |
| Transmitter wavelength | 1260...1360 nm (nominal: 1310 nm) |
| Receiver wavelength | 1100...1600 nm |
| Maximum distance | 2 km |
| IRIG-B Connector | |
| Screw connection terminal block | Phoenix Contact MC 1,5/ 2-ST-3,5 BD:1-2 |
| Solid or stranded wire<br>Nominal cross section | 1.5 $mm^2$ |

### 4.9.3 Double LC 100 Mbps Ethernet communication module (option card J)

**Table 4.17** Technical data for the double LC 100 Mbps Ethernet communication module

| | |
|---|---|
| Protocols | |
| Protocols | HSR and PRP |
| Ports | |
| Quantity of fiber ports | 2 |
| Communication port C & D | LC fiber connector<br>Wavelength 1300 nm |
| Fiber cable | 50/125 µm or 62.5/125 µm multimode (glass) |

### 4.9.4 Double RJ-45 (HSR, PRP) Ethernet communication module (option card K)

**Table 4.18** Technical data for the double RJ-45 100 Mbps Ethernet communication module.

| | |
|---|---|
| General information | |
| Hardware configuration code | K |
| Features | |
| Protocols | IEC 61850<br>IEC 104<br>Modbus/TCP<br>DNP3<br>FTP |
| Redundancy | HSR and PRP |
| Data transfer rate | 100 MB/s |
| System integration | Can be used for system protocols and for local programming |
| Ports | |
| Number of ports | 2 |
| Communication port | Copper Ethernet RJ-45 |

### 4.9.5 RS-232 & serial fiber communication module (option cards L to O)

**Table 4.19** Technical data for the RS-232 & serial fiber communication module.

| | |
|---|---|
| Ports | |
| RS-232 | |
| Serial fiber (GG/PP/GP/PG) | |
| Serial port wavelength | |
| 660 nm | |
| Cable type | |
| 1 mm plastic fiber | |
| Terminal block connections | |
| Spring cage terminals block | Phoenix Contact DFMC 1,5/ 6-STF-3,5 |
| Solid or stranded wire<br>Nominal cross section | <br>1.5 $mm^2$ |

## 4.10 Arc protection module (option card D)

**Table 4.20** Technical data for the point sensor arc protection module

| | |
|---|---|
| Connections | |
| Input arc point sensor channels | S1, S2, S3, S4 (pressure and light, or light only) |
| Sensors* per channel | 3 |
| Maximum cable length | 200 m |
| Performance | |
| Pick-up light intensity | 8, 25 or 50 kLx (the sensor is selectable in the order code) |
| Point sensor detection radius | 180 degrees |
| Start and instant operating time (light only) | Typically <5 ms with dedicated semiconductor outputs (HSO)<br>Typically <10 ms regular output relays |

**More information**
* See the **Option D: Arc protection Description of options** for the specifications of these sensors.

**Table 4.21** High-Speed Outputs (HSO1...2)

| | |
|---|---|
| Rated values | |
| Rated auxiliary voltage | 250 VDC |
| Continuous carry | 2 A |
| Make and carry 0.5 s<br>Make and carry 3 s | 15 A<br>6 A |
| Breaking capacity, DC (L/R = 40 ms) | 1 A/110 W |
| Control rate | 5 ms |
| Operation delay | <1 ms |
| Polarity | Normally Off |
| Contact material | Semiconductor |

**Table 4.22** Binary input channel

| | |
|---|---|
| Rated values | |
| Voltage withstand | 265 VDC |
| Nominal voltage<br>Pick-up threshold<br>Release threshold | 24 VDC<br>≥16 VDC<br>≤15 VDC |
| Scanning rate | 5 ms |
| Polarity | Normally Off |
| Current drain | 3 mA |

**Table 4.23** Terminal block connections

| | |
|---|---|
| Arc point sensor terminal block connections | |
| Spring cage terminal block | Phoenix Contact DFMC 1,5/ 6-STF-3,5 |
| Solid or stranded wire<br>Nominal cross section | 1.5 $mm^2$ |
| Binary input and HSO terminal block connections | |
| Screw connection terminal block (standard) | Phoenix Contact MSTB 2,5/5-ST-5,08 |
| Spring cage terminals block (option) | Phoenix Contact FKC 2,5/10-STF-5,08 |
| Solid or stranded wire<br>Nominal cross section | 2.5 $mm^2$ |

**NOTE** The polarity must be correct!

# 4.11 MVR-21x display

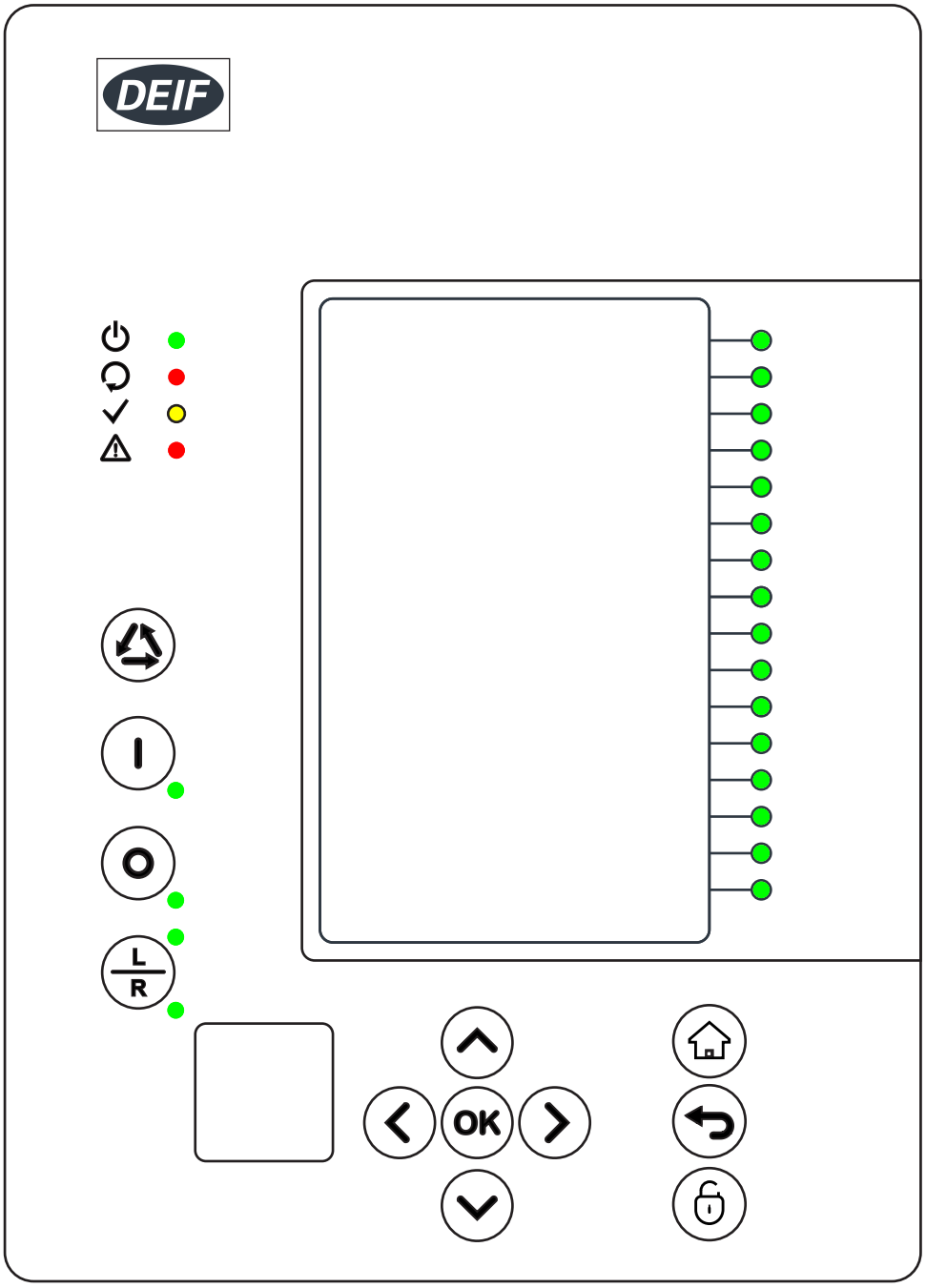
## 4.11.1 Display

**Table 4.24** Technical data for the HMI LCD display

| | |
|---|---|
| Dimensions and resolution | |
| Number of dots/resolution | 320 x 160 |
| Size | 84.78 × 49.90 mm (3.34 × 1.96 in) |
| Display | |
| Type of display | LCD |
| Color | Monochrome |

## 4.12 Folios and configuration

**MVR-21x folio**




To meet marine class society requirements:

- The MVR must be configured so that the **Trip LED** ( ⚠ ● ) is lit whenever a protection activates a breaker trip.
- For each trip protection, select *Trip ON* in the NOC EventMask. In this way, the cause of any trip is shown on the main screen and immediately visible to the operator.

## 4.13 Mechanical specifications

| | | |
|---|---|---|
| Device dimensions | 210 series casing height | ¼ rack 4U, depth 210 mm |
| Package dimensions (W x H x D) | 210 series | 230 x 120 x 210 mm |
| Weight | Device | 1.5 kg |
| | In package | 2.0 kg |

| | | |
|---|---|---|
| Material | Housing | Metal |
| IP protection level | Front | IP54 |
| | Rear | IP20 |
| Tightening torque - M4 nuts | Front | 1.3 N·m for 210 series |

## 4.14 Environment

| | |
|---|---|
| IEC 60255-27 degree of pollution | 2 |
| Maximum altitude above sea level | 2000 m (6561.68 ft) |
| Operation temperature range | -25 °C to +60 °C |

## 4.15 Safety

**Wiring specification**

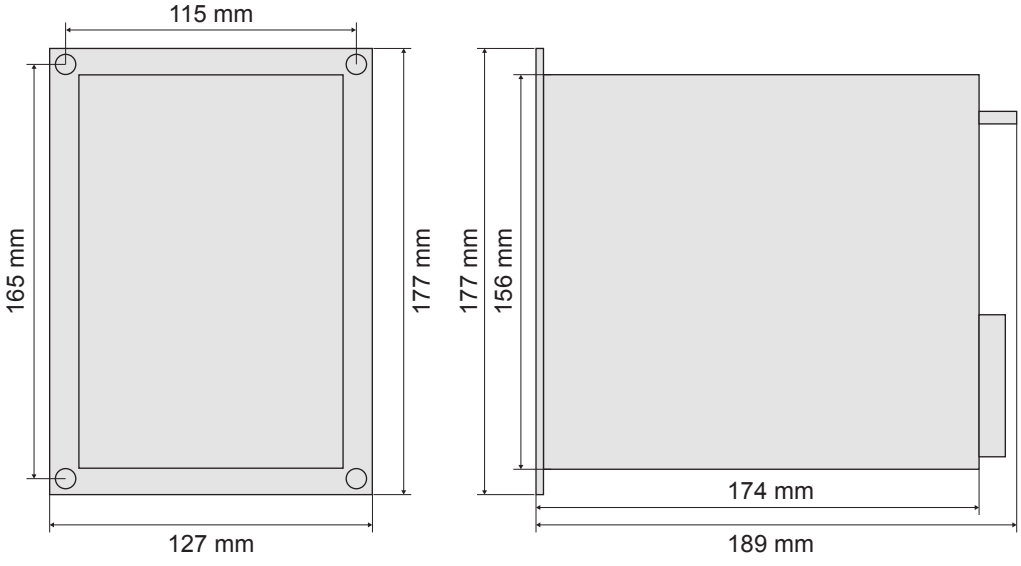
Wiring must be multi-stranded, minimum 90 °C copper conductors only.

**Galvanic isolation**

Ethernet: 550 V, 50 Hz, 1 minute
COM ports: 550 V, 50 Hz, 1 minute
Between Option I (mA I/O) and other I/O ports: 550 V, 50 Hz, 1 minute
Between CT and other I/O ports: 2200 V, 50 Hz, 1 minute
Between Relay and other I/O ports: 2200 V, 50 Hz, 1 minute
Between DI and other I/O ports: 2200 V, 50 Hz, 1 minute
Between PSU and other I/O ports: 2200 V, 50 Hz, 1 minute

## 4.16 Dimensions

**MVR-210 dimensions**

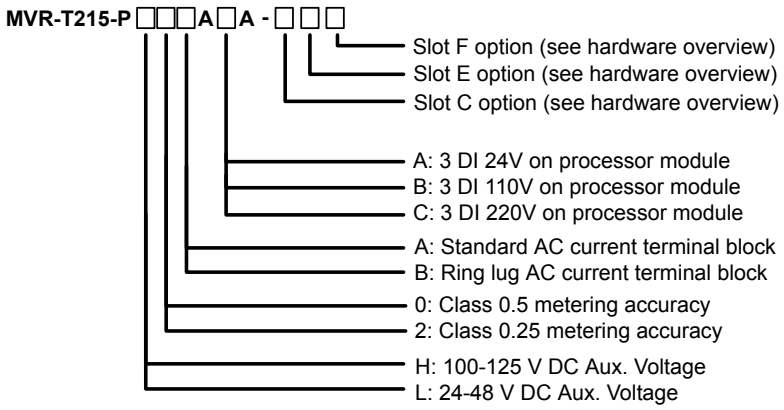


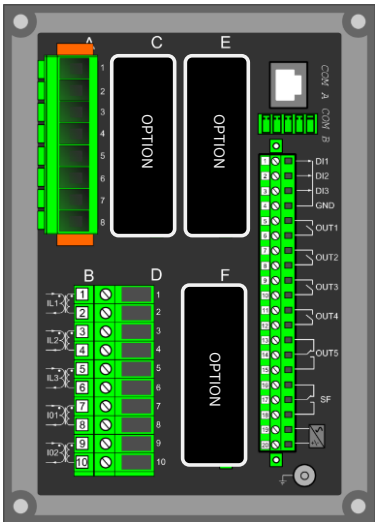
# 5. Ordering information

## 5.1 MVR Ordering

The drawings show the rear view of the MVR without hardware options.

### MVR Transformer relay MVR-T215




### Hardware options overview

| Option | Description |
|---|---|
| **A** | None (empty slot) |
| **B** | 8 x isolated (2 groups) digital inputs<br>• 10 to 200 V DC |
| **C** | 5 x relay outputs<br>• 220 V AC, 3 A<br>• 220 V DC, 0.3 A |
| **D** | Arc protection<br>This option is not included in the marine approval. |
| **F** | RTD analogue input module (8 channels)<br>This option is not included in the marine approval. |
| **G** | 2 x RJ45 100Mb Ethernet & IRIG-B*<br>This option is not included in the marine approval. |
| **H** | 2 x ST 100Mb Ethernet & IRIG-B*<br>This option is not included in the marine approval. |
| **I** | 4 x analogue outputs<br>• 0 to 24 mA scalable<br>1 x analogue input<br>• 0 to 24 mA scalable<br>Max. 2 modules per relay |
| **J** | Double LC 100Mb Ethernet* |
| **K** | 2 x RJ45 100 Mb Ethernet (HSR, PRP redundant protocols)*<br>This option is not included in the marine approval. |

| Option | Description |
|---|---|
| **L** | 1 x RS232 Fiber PP (Plastic-Plastic)* |
| **M** | 1 x RS232 Fiber PG (Plastic-Glass)* |
| **N** | 1 x RS232 Fiber GP (Glass-Plastic)* |
| **O** | 1 x RS232 Fiber GG (Glass-Glass)* |

**NOTE** * Only one additional communication module per relay, to be placed in the last slot (Slot F).

**Additional features**

- 5-year extended warranty
- Conformal coating of printed circuit boards

**NOTE** These features have to be ordered separately.

## 5.2.1 Disclaimer

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