Relion® 670 SERIES

Generator protection REG670
Version 2.2
Product guide
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## 1. Document revision history

Table 1. Document revision history

<table>
<thead>
<tr>
<th>Document revision</th>
<th>Date</th>
<th>Product revision</th>
<th>History</th>
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<td>-</td>
<td>2017-07</td>
<td>2.2.0</td>
<td>First release for product version 2.2</td>
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<td>A</td>
<td>2017-10</td>
<td>2.2.1</td>
<td>Ethernet ports with RJ45 connector added. Enhancements/updates made to GENPDIF, ZMFPDIS and ZMFCPDIS.</td>
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<tr>
<td>D</td>
<td>2018-07</td>
<td>2.2.2</td>
<td>LDCM galvanic X.21 added. Function PTRSTHR added. Ordering section updated.</td>
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<td>E</td>
<td>2018-11</td>
<td>2.2.2</td>
<td>Technical data updated for PSM, EF4PTOC and T2WPDIS/T3WPDIS. Corrections/enhancements made to OC4PTOC, TRPTTR, UV2PTUV and OV2PTOV. Case dimensions updated.</td>
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<td>G</td>
<td>2018-12</td>
<td>2.2.3</td>
<td>Functions CHMMHAI, VHMMHAI, DELVSPVC, DELISPVC and DELSPVC added. Updates/enhancements made to ZMFPDIS, ZMFCPDIS, CCRBRF, REALCOMP, PTRSTHR and FNKEYMDx. Ordering section updated.</td>
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<td>2019-05</td>
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2. Application
The REG670 is used for protection, control and monitoring of generators and generator-transformer blocks from relatively small units up to the largest generating units. The IED has a comprehensive function library, covering the requirements for most generator applications. The large number of analog inputs available enables, together with the large functional library, integration of many functions in one IED. In typical applications two IED units can provide total functionality, also providing a high degree of redundancy. REG670 can as well be used for protection and control of shunt reactors.

Stator earth fault protection, both traditional 95% as well as 100% injection and 3rd harmonic based are included. When the injection based protection is used, 100% of the machine stator winding, including the star point, is protected under all operating modes. The 3rd harmonic based 100% stator earth fault protection uses 3rd harmonic differential voltage principle. Injection based 100% stator earth fault protection can operate even when machine is at standstill. Well proven algorithms for pole slip, underexcitation, rotor earth fault, negative sequence current protections, and so on, are included in the IED.

The generator differential protection in the REG670 adapted to operate correctly for generator applications where factors as long DC time constants and requirement on short trip time have been considered.

As many of the protection functions can be used as multiple instances there are possibilities to protect more than one object in one IED. It is possible to have protection for an auxiliary power transformer integrated in the same IED having main protections for the generator. The concept thus enables very cost effective solutions.

The REG670 also enables valuable monitoring possibilities as many of the process values can be transferred to an operator HMI.

The wide application flexibility makes this product an excellent choice for both new installations and for refurbishment in existing power plants.

Forcing of binary inputs and outputs is a convenient way to test wiring in substations as well as testing configuration logic in the IEDs. Basically it means that all binary inputs and outputs on the IED I/O modules (BOM, BIM, IOM & SOM) can be forced to arbitrary values.

Central Account Management is an authentication infrastructure that offers a secure solution for enforcing access control to IEDs and other systems within a substation. This incorporates management of user accounts, roles and certificates and the distribution of such, a procedure completely transparent to the user.

The Flexible Product Naming allows the customer to use an IED-vendor independent IEC 61850 model of the IED. This customer model will be exposed in all IEC 61850 communication, but all other aspects of the IED will remain unchanged (e.g., names on the local HMI and names in the tools). This offers significant flexibility to adapt the IED to the customers’ system and standard solution.

Communication via optical connections ensures immunity against disturbances.

By using patented algorithm REG670 (or any other product from 670 series) can track the power system frequency in quite wide range from 9Hz to 95Hz (for 50Hz power system). In order to do that preferably the three-phase voltage signal from the generator terminals shall be connected to the IED. Then IED can adopt its filtering algorithm in order to properly measure phasors of all current and voltage signals connected to the IED. This feature is essential for proper operation of the protection during generator start-up and shut-down procedure.

REG670 can be used in applications with the IEC/UCA 61850-9-2LE process bus with up to eight merging units (MU) depending on the other functionality included in the IED.
Description of configuration A20

Figure 1. Typical generator protection application with generator differential and back-up protection, including 12 analog inputs transformers in half 19" case size.
Figure 2. Enhanced generator protection application with generator differential and back-up protection, including 24 analog inputs in full 19” case size. Optional pole slip protection, 100% stator earth fault protection and overall differential protection can be added.
Description of configuration C30

Figure 3. Unit protection including generator and generator transformer protection with 24 analog inputs in full 19” case size. Optional pole slip protection and 100% stator earthfault protection can be added.
The basic delivery includes one binary input module and one binary output module, which is sufficient for the default configured I/O to trip and close circuit breaker. All IEDs can be reconfigured with the help of the application configuration tool in PCM600. The IED can be adapted to special applications and special logic can be developed, such as logic for automatic opening of disconnectors and closing of ring bays, automatic load transfer from one busbar to the other, and so on.

The basic IED configuration is provided with the signal matrix, single line diagram and the application configuration prepared for the functions included in the product by default. All parameters should be verified by the customer, since these are specific to the system, object or application. Optional functions and optional I/O ordered will not be configured at delivery. It should be noted that the standard only includes one binary input and one binary output module and only the key functions such as tripping are connected to the outputs in the signal matrix tool. The required total I/O must be calculated and specified at ordering.

The configurations are as far as found necessary provided with application comments to explain why the signals have been connected in the special way. On request, ABB is available to support the re-configuration work, either directly or to do the design checking.
3. Available functions

The following tables list all the functions available in the IED. Those functions that are not exposed to the user or do not need to be configured are not described in this manual.

### Main protection functions

Table 2. Example of quantities

2 = number of basic instances
0-3 = option quantities
3-A03 = optional function included in packages A03 (refer to ordering details)

<table>
<thead>
<tr>
<th>IEC 61850 or function name</th>
<th>ANSI</th>
<th>Function description</th>
<th>Generator</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>REG670 (Customized)</td>
<td>REG670 (A20)</td>
</tr>
<tr>
<td><strong>Differential protection</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T2WPDIF 87T</td>
<td>87</td>
<td>Transformer differential protection, two winding</td>
<td>0-2</td>
</tr>
<tr>
<td>T3WPDIF 87T</td>
<td>87</td>
<td>Transformer differential protection, three winding</td>
<td>0-2</td>
</tr>
<tr>
<td>HZPDIF 87</td>
<td>00-06</td>
<td>High impedance differential protection, single phase</td>
<td>3-A02</td>
</tr>
<tr>
<td>GENPDIF 87G</td>
<td>0-2</td>
<td>Generator differential protection</td>
<td>1</td>
</tr>
<tr>
<td>REFPDIF 87N</td>
<td>0-3</td>
<td>Restricted earth fault protection, low impedance</td>
<td>1-A01</td>
</tr>
<tr>
<td><strong>Impedance protection</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZMHPDIS 21</td>
<td>0-4</td>
<td>Full-scheme distance protection, mho characteristic</td>
<td>3</td>
</tr>
<tr>
<td>ZDMRDIS 21D</td>
<td>0-2</td>
<td>Directional impedance element for mho characteristic</td>
<td>1</td>
</tr>
<tr>
<td>ZMFBDIS 21</td>
<td>0-1</td>
<td>High speed distance protection, quad and mho characteristic</td>
<td>0-1</td>
</tr>
<tr>
<td>ZMFCDIS 21</td>
<td>0-1</td>
<td>High speed distance protection for series comp. lines, quad and mho characteristic</td>
<td>0-1</td>
</tr>
<tr>
<td>PSSPAM 78</td>
<td>0-1</td>
<td>Poleslip/out-of-step protection</td>
<td>1-B22</td>
</tr>
<tr>
<td>OOSPPAM 78</td>
<td>0-1</td>
<td>Out-of-step protection</td>
<td>1-B22</td>
</tr>
<tr>
<td>LEXPDIS 40</td>
<td>0-2</td>
<td>Loss of excitation</td>
<td>1</td>
</tr>
<tr>
<td>ROTIPDH 21</td>
<td>0-1</td>
<td>Sensitive rotor earth fault protection, injection based</td>
<td>1-B31</td>
</tr>
<tr>
<td>STIPDH 21</td>
<td>0-1</td>
<td>100% stator earth fault protection, injection based</td>
<td>1-B32</td>
</tr>
<tr>
<td>ZGVPDIS 21</td>
<td>0-2</td>
<td>Underimpedance protection for generators and transformers</td>
<td>1</td>
</tr>
</tbody>
</table>
# Back-up protection functions

<table>
<thead>
<tr>
<th>IEC 61850 or ANSI function name</th>
<th>Function description</th>
<th>Generator</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>REG670 (Customized)</td>
<td>REG670 (A20)</td>
</tr>
<tr>
<td><strong>Current protection</strong></td>
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<td>0-4</td>
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<tr>
<td>PHPIOC 50</td>
<td>Instantaneous phase overcurrent protection</td>
<td>0-6</td>
</tr>
<tr>
<td>OC4PTOC 51_67(1)</td>
<td>Directional phase overcurrent protection, four steps</td>
<td>0-6</td>
</tr>
<tr>
<td>EFPIOC 50N</td>
<td>Instantaneous residual overcurrent protection</td>
<td>0-2</td>
</tr>
<tr>
<td>EF4PTOC 51N 67N(2)</td>
<td>Directional residual overcurrent protection, four steps</td>
<td>0-6</td>
</tr>
<tr>
<td>NS4PTOC 46I2</td>
<td>Four step directional negative phase sequence overcurrent protection</td>
<td>0-2</td>
</tr>
<tr>
<td>SDPSDE 67N</td>
<td>Sensitive directional residual overcurrent and power protection</td>
<td>0-2</td>
</tr>
<tr>
<td>TRPTTR 49</td>
<td>Thermal overload protection, two time constants</td>
<td>0-3</td>
</tr>
<tr>
<td>CCRBF 50BF</td>
<td>Breaker failure protection</td>
<td>0-4</td>
</tr>
<tr>
<td>CC-PDS 52PD</td>
<td>Pole discordance protection</td>
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<tr>
<td>GUPPDUP 37</td>
<td>Directional underpower protection</td>
<td>0-4</td>
</tr>
<tr>
<td>GPPPOOP 32</td>
<td>Directional overpower protection</td>
<td>0-4</td>
</tr>
<tr>
<td>NS2PTOC 46I2</td>
<td>Negative sequence time overcurrent protection for machines</td>
<td>0-2</td>
</tr>
<tr>
<td>AEGPVO 50AE</td>
<td>Accidental energizing protection for synchronous generator</td>
<td>0-2</td>
</tr>
<tr>
<td>VRPVOC 51V</td>
<td>Voltage restrained overcurrent protection</td>
<td>0-3</td>
</tr>
<tr>
<td>GSPTR 49S</td>
<td>Stator overload protection</td>
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</tr>
<tr>
<td>GRPTTR 49R</td>
<td>Rotor overload protection</td>
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</tr>
<tr>
<td><strong>Voltage protection</strong></td>
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<td>0-2</td>
</tr>
<tr>
<td>UV2PTUV 27</td>
<td>Two step undervoltage protection</td>
<td>0-2</td>
</tr>
<tr>
<td>OV2PTOV 59</td>
<td>Two step overvoltage protection</td>
<td>0-2</td>
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<tr>
<td>ROV2PTOV 59N</td>
<td>Two step residual overvoltage protection</td>
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<tr>
<td>OEXPVPH 24</td>
<td>Overexcitation protection</td>
<td>0-2</td>
</tr>
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<td>VDCPTOV 60</td>
<td>Voltage differential protection</td>
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<tr>
<td>STEFPHI 59THD</td>
<td>100% stator earth fault protection, 3rd harmonic based</td>
<td>0-1</td>
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<tr>
<td><strong>Frequency protection</strong></td>
<td></td>
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</tr>
<tr>
<td>SAPTU 81</td>
<td>Underfrequency protection</td>
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<td>IEC 61850 or function name</td>
<td>ANSI</td>
<td>Function description</td>
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<td>---------------------------</td>
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<tr>
<td></td>
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<tr>
<td>SAPTOF</td>
<td>81</td>
<td>Overfrequency protection</td>
</tr>
<tr>
<td>SAPFRC</td>
<td>81</td>
<td>Rate-of-change of frequency protection</td>
</tr>
<tr>
<td>FTAQFVR</td>
<td>81A</td>
<td>Frequency time accumulation protection</td>
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</table>

**Multipurpose protection**

| CVGAPC | General current and voltage protection | 0-9 | 6   | 6   | 6   |

**General calculation**

| SMAIHPAC | Multipurpose filter | 0-6 |
## Control and monitoring functions

<table>
<thead>
<tr>
<th>IEC 61850 or function name</th>
<th>ANSI</th>
<th>Function description</th>
<th>Generator</th>
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<tr>
<td></td>
<td></td>
<td>REG670 (Customized)</td>
<td>REG670 (A30)</td>
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<tr>
<td>Control</td>
<td></td>
<td></td>
<td>REG670 (A30)</td>
</tr>
<tr>
<td>SESRSYN</td>
<td>25</td>
<td>Synchrocheck, energizing check and synchronizing</td>
<td>0-2</td>
</tr>
<tr>
<td>APC30</td>
<td>3</td>
<td>Control functionality for up to 6 bays, max 30 objects (6CBs), including interlocking (see Table A)</td>
<td>0-1</td>
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<tr>
<td>QCBAY</td>
<td></td>
<td>Bay control</td>
<td>1+5/APC30</td>
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<tr>
<td>LOCREM</td>
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<td>Handling of LR-switch positions</td>
<td>1+5/APC30</td>
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<td>LOCREMCTRL</td>
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<td>LHMI control of PSTO</td>
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<td>SXCBR</td>
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<td>Circuit breaker</td>
<td>18</td>
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<td>TCMYLTC</td>
<td>84</td>
<td>Tap changer control and supervision, 6 binary inputs</td>
<td>0-4</td>
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<tr>
<td>TCLYLTC</td>
<td>84</td>
<td>Tap changer control and supervision, 32 binary inputs</td>
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<td>SLGAPC</td>
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<td>Logic rotating switch for function selection and LHMI presentation</td>
<td>15</td>
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<td>VSGAPC</td>
<td></td>
<td>Selector mini switch</td>
<td>30</td>
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<td>DPGAPC</td>
<td></td>
<td>Generic communication function for Double Point indication</td>
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<tr>
<td>SPC8GAPC</td>
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<td>Single point generic control function 8 signals</td>
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<td>AUTOBITS</td>
<td></td>
<td>Automation bits, command function for DNP3.0</td>
<td>3</td>
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<tr>
<td>SINGLECMD</td>
<td></td>
<td>Single command, 16 signals</td>
<td>8</td>
</tr>
<tr>
<td>I103CMD</td>
<td></td>
<td>Function commands for IEC 60870-5-103</td>
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<td>I103GENCMD</td>
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<td>Function commands generic for IEC 60870-5-103</td>
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<tr>
<td>I103POSCMD</td>
<td></td>
<td>IED commands with position and select for IEC 60870-5-103</td>
<td>50</td>
</tr>
<tr>
<td>I103POSCMDV</td>
<td></td>
<td>IED direct commands with position for IEC 60870-5-103</td>
<td>50</td>
</tr>
<tr>
<td>I103IEDCMD</td>
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<td>IED commands for IEC 60870-5-103</td>
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<tr>
<td>IEC 61850 or function name</td>
<td>ANSI</td>
<td>Function description</td>
<td>Generator</td>
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<td>----------------------------</td>
<td>------</td>
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<td>REG670</td>
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<tr>
<td>I103USRCMD</td>
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<td>Function commands user defined for IEC 60870-5-103</td>
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<td><strong>Secondary system supervision</strong></td>
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<td>CCSSPVC</td>
<td>87</td>
<td>Current circuit supervision</td>
<td>0-5</td>
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<td>FUFSVPVC</td>
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<td>Fuse failure supervision</td>
<td>0-3</td>
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<td>VDSPVC</td>
<td>60</td>
<td>Fuse failure supervision based on voltage difference</td>
<td>0-2</td>
</tr>
<tr>
<td>DELVSPVC</td>
<td>7V_78</td>
<td>Voltage delta supervision, 2 phase</td>
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</tr>
<tr>
<td>DELISPVC</td>
<td>71</td>
<td>Current delta supervision, 2 phase</td>
<td>4</td>
</tr>
<tr>
<td>DELSPVC</td>
<td>78</td>
<td>Real delta supervision, real</td>
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</tr>
<tr>
<td><strong>Logic</strong></td>
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<tr>
<td>SMPPTRC</td>
<td>94</td>
<td>Tripping logic</td>
<td>12</td>
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<tr>
<td>SMAGAPC</td>
<td></td>
<td>General start matrix block</td>
<td>12</td>
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<tr>
<td>STARTCOMB</td>
<td></td>
<td>Start combinator</td>
<td>32</td>
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<tr>
<td>TMAGAPC</td>
<td></td>
<td>Trip matrix logic</td>
<td>12</td>
</tr>
<tr>
<td>ALMCALH</td>
<td></td>
<td>Logic for group alarm</td>
<td>5</td>
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<tr>
<td>WRNCALH</td>
<td></td>
<td>Logic for group warning</td>
<td>5</td>
</tr>
<tr>
<td>INDICALH</td>
<td></td>
<td>Logic for group indication</td>
<td>5</td>
</tr>
<tr>
<td>AND, GATE, INV, LLD, OR, PULSETIMER, RSMEMORY, SRMEMORY, TIMERSET, XOR</td>
<td></td>
<td>Basic configurable logic blocks (see Table 3)</td>
<td>40-420</td>
</tr>
<tr>
<td>ANDQT, INDCOMBSPQT, INDEXTSPQT, INVALIDQT, INVERTERQT, ORQT, PULSETIMERQT, RSMEMORYQT, SRMEMORYQT, TIMERSETQT, XORQT</td>
<td></td>
<td>Configurable logic blocks Q/T (see Table 5)</td>
<td>0-1</td>
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### Table 3. Total number of instances for basic configurable logic blocks

<table>
<thead>
<tr>
<th>Basic configurable logic block</th>
<th>Total number of Instances</th>
</tr>
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<tbody>
<tr>
<td>AND</td>
<td>280</td>
</tr>
<tr>
<td>GATE</td>
<td>40</td>
</tr>
<tr>
<td>INV</td>
<td>420</td>
</tr>
<tr>
<td>LLD</td>
<td>40</td>
</tr>
<tr>
<td>OR</td>
<td>298</td>
</tr>
<tr>
<td>PULSETIMER</td>
<td>40</td>
</tr>
<tr>
<td>RSMEMORY</td>
<td>40</td>
</tr>
<tr>
<td>SRMEMORY</td>
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</tr>
<tr>
<td>TIMERSET</td>
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</tr>
<tr>
<td>XOR</td>
<td>40</td>
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Table 4. Number of function instances in APC30

<table>
<thead>
<tr>
<th>Function name</th>
<th>Function description</th>
<th>Total number of instances</th>
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<td>SCILO</td>
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<td>BB_ES</td>
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<tr>
<td>A1A2_BS</td>
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<td>A1A2_DC</td>
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<td>BH_LINE_A</td>
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<td>BH_LINE_B</td>
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<td>DB_LINE</td>
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<td>ABC_LINE</td>
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<td>QCRSV</td>
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<td>RESIN1</td>
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<td>RESIN2</td>
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<td>POS_EVAL</td>
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<td>QCBAY</td>
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<td>LOCREM</td>
<td>Handling of LR-switch positions</td>
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<td>XLNPROXY</td>
<td>Proxy for signals from switching device via GOOSE</td>
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<tr>
<td>GOOSEXLNRCV</td>
<td>GOOSE function block to receive a switching device</td>
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Table 5. Total number of instances for configurable logic blocks Q/T

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<thead>
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<th>Configurable logic blocks Q/T</th>
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<td>ANDQT</td>
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<td>INDCOMBSPTQ</td>
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<td>INDEXTSPTQ</td>
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<td>INVALIDQT</td>
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<tr>
<td>INVERTERQT</td>
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<tr>
<td>ORQT</td>
<td>120</td>
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<tr>
<td>PULSETIMERQT</td>
<td>40</td>
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<tr>
<td>RSMEMORYQT</td>
<td>40</td>
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<tr>
<td>SRMEMORYQT</td>
<td>40</td>
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<tr>
<td>TIMERSETQT</td>
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<tr>
<td>XORQT</td>
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Table 6. Total number of instances for extended logic package

<table>
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<th>Extended configurable logic block</th>
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<td>AND</td>
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<td>GATE</td>
<td>49</td>
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<tr>
<td>INV</td>
<td>220</td>
</tr>
<tr>
<td>LLD</td>
<td>49</td>
</tr>
<tr>
<td>OR</td>
<td>220</td>
</tr>
<tr>
<td>PULSETIMER</td>
<td>89</td>
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<td>RSMEMORY</td>
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<td>SLGAPC</td>
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<td>SRMEMORY</td>
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<td>TIMERSET</td>
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<tr>
<td>VSGAPC</td>
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<tr>
<td>XOR</td>
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</tr>
<tr>
<td>IEC 61850 or function name</td>
<td>ANSI</td>
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<tr>
<td>----------------------------</td>
<td>------</td>
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<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Monitoring</strong></td>
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<tr>
<td>CVMMXN</td>
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<tr>
<td>CMMXU</td>
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<td>VMXXU</td>
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<td>CMSQI</td>
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<td>VMSQI</td>
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<td>VNMMXU</td>
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<td>EVENT</td>
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<tr>
<td>DRPRDRE, A4RADR,</td>
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<td>SPGAPC</td>
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<tr>
<td>SPI6GAPC</td>
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<td>MVGAPC</td>
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<td>BINSTATREP</td>
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<td>RANGE_XP</td>
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<tr>
<td>SSIML</td>
<td>71</td>
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<td>SSCBR</td>
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<td>LOLSPTR</td>
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<td></td>
<td>HS</td>
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<td>I103MEAS</td>
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<td>I103MEASUSR</td>
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<td>I103AR</td>
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<td>IEC 61850 or function name</td>
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<td>I03FLTPROT</td>
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<td>I03IED</td>
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<td>I03SUPERV</td>
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<td>I03USRDEF</td>
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<td>L4UFCNT</td>
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<td>TEILGAPC</td>
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<td>51TF</td>
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<td>CHMMHAI</td>
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<td>VHMMHAI</td>
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<td>Metering</td>
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<td>PCFCNT</td>
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<td>ETPMMTR</td>
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## Communication

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<tr>
<th>IEC 61850 or function name</th>
<th>ANSI</th>
<th>Function description</th>
<th>Generator</th>
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<tbody>
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<td></td>
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<td>REG670 (Customized)</td>
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<tr>
<td>Station communication</td>
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<td>REG670</td>
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<td>LONSPA, SPA</td>
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<td>SPA communication protocol</td>
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<td>ADE</td>
<td></td>
<td>LON communication protocol</td>
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<td>HORZCOMM</td>
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<td>Network variables via LON</td>
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<td>DNP3.0 communication general protocol</td>
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<td>MST1TCP, MST2TCP, MST3TCP,</td>
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<td>DNP3.0 for TCP/IP communication protocol</td>
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<td>MST4TCP</td>
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<td>REG670</td>
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<td>IEC 61850-8-1</td>
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<td>IEC 61850</td>
<td>1</td>
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<td>GOOSEINTLKRCV</td>
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<td>Horizontal communication via GOOSE for interlocking</td>
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<td>GOOSEBINRCV</td>
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<td>GOOSE binary receive</td>
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<td>GOOSEDPRCV</td>
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<td>GOOSE function block to receive a double point value</td>
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<td>GOOSEINTRCV</td>
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<td>GOOSE function block to receive a measurand value</td>
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<td>GOOSESPPRCV</td>
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<td>GOOSE function block to receive a single point value</td>
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<td>Multiple command and transmit</td>
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<td>OPTICAL103</td>
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<td>IEC 60870-5-103 Optical serial communication</td>
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<td>RS485103</td>
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<td>PCMACCS</td>
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<td>IED configuration protocol</td>
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<td>Field service tool access</td>
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<td>IEC 61850-9-2 Process bus communication, 8 merging units</td>
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<td>ACTIVLOG</td>
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<td>IEC 62439-3 High-availability seamless redundancy</td>
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<td>IEC 61850 or function name</td>
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<td>Function description</td>
<td>Generator</td>
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<td></td>
<td>REG670 (Customized)</td>
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<td>PMUCONF, PMUREPORT, PHASORREPORT1, ANALOGREPORT1, BINARYREPORT1, SMAI1 - SMAI12, 3PHSUM, PMUSTATUS</td>
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<td>Synchrophasor report, 16 phasors (see Table 7)</td>
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<td>PTP</td>
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<tr>
<td>RCHLCCH</td>
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<td>Access point diagnostic for redundant Ethernet ports</td>
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<td>QUALEXP</td>
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<td>IEC 61850 quality expander</td>
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</table>

### Remote communication

| BinSigRec1_12M, BinSigRec1_22M, BinSigTran1_12M, BinSigTran1_22M | Binary signal transfer, 2Mbit receive/transmit | 3 | 3 | 3 | 3 |
| LDCMTRN | Transmission of analog data from LDCM | 1 | 1 | 1 | 1 |
| LDCMTRN_2M | Transmission of analog data from LDCM, 2Mbit | 6 | 6 | 6 | 6 |
| LDCMRecBinS2_2M | Receive binary status from LDCM, 2Mbit | 3 | 3 | 3 | 3 |
| LDCMRecBinS3_2M | Receive binary status from remote LDCM, 2Mbit | 3 | 3 | 3 | 3 |
### Table 7. Number of function instances in Synchrophasor report, 16 phasors

<table>
<thead>
<tr>
<th>Function name</th>
<th>Function description</th>
<th>Number of instances</th>
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<tr>
<td>PMUCONF</td>
<td>Configuration parameters for C37.118 2011 and IEEE1344 protocol</td>
<td>1</td>
</tr>
<tr>
<td>PMUREPORT</td>
<td>Protocol reporting via IEEE 1344 and C37.118</td>
<td>2</td>
</tr>
<tr>
<td>PHASORREPORT1</td>
<td>Protocol reporting of phasor data via IEEE 1344 and C37.118, phasors 1-8</td>
<td>2</td>
</tr>
<tr>
<td>ANALOGREPORT1</td>
<td>Protocol reporting of analog data via IEEE 1344 and C37.118, analogs 1-8</td>
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</tr>
<tr>
<td>BINARYREPORT1</td>
<td>Protocol reporting of binary data via IEEE 1344 and C37.118, binary 1-8</td>
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</tr>
<tr>
<td>SMAI1–SMAI12</td>
<td>Signal matrix for analog inputs</td>
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</tr>
<tr>
<td>3PHSUM</td>
<td>Summation block 3 phase</td>
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<tr>
<td>PMUSTATUS</td>
<td>Diagnostics for C37.118 2011 and IEEE1344 protocol</td>
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### Basic IED functions

Table 8. Basic IED functions

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<tr>
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<tbody>
<tr>
<td>INTERRSIG</td>
<td>Self supervision with internal event list</td>
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<tr>
<td>TIMESYNCHGEN</td>
<td>Time synchronization module</td>
</tr>
<tr>
<td>BININPUT, SYNCHCAN, SYMCHGPS, SYMCHCMPPS, SYMCHLON, SYMCHPHT, SYMCHPPS, SNTP, SYMCSHPA</td>
<td>Time synchronization</td>
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<tr>
<td>TIMEZONE</td>
<td>Time synchronization</td>
</tr>
<tr>
<td>IRIG-B</td>
<td>Time synchronization</td>
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<tr>
<td>SETGRPS</td>
<td>Number of setting groups</td>
</tr>
<tr>
<td>ACTVGRP</td>
<td>Parameter setting groups</td>
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<tr>
<td>TESTMODE</td>
<td>Test mode functionality</td>
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<tr>
<td>CHNGLCK</td>
<td>Change lock function</td>
</tr>
<tr>
<td>SMBI</td>
<td>Signal matrix for binary inputs</td>
</tr>
<tr>
<td>SMBO</td>
<td>Signal matrix for binary outputs</td>
</tr>
<tr>
<td>SMMI</td>
<td>Signal matrix for mA inputs</td>
</tr>
<tr>
<td>SMAI1-SMAI12</td>
<td>Signal matrix for analog inputs</td>
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<tr>
<td>3PHSUM</td>
<td>Summation block 3 phase</td>
</tr>
<tr>
<td>ATHSTAT</td>
<td>Authority status</td>
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<tr>
<td>ATHCHCK</td>
<td>Authority check</td>
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<tr>
<td>AUTHMAN</td>
<td>Authority management</td>
</tr>
<tr>
<td>FTPACCS</td>
<td>FTP access with password</td>
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<tr>
<td>ALTMS</td>
<td>Time master supervision</td>
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<tr>
<td>ALTIM</td>
<td>Time management</td>
</tr>
<tr>
<td>COMSTATUS</td>
<td>Protocol diagnostic</td>
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4. Differential protection

**Generator differential protection GENPDIF**
Short circuit between the phases of the stator windings causes normally very large fault currents. The short circuit gives risk of damages on insulation, windings and stator iron core. The large short circuit currents cause large forces, which can cause damage even to other components in the power plant, such as turbine and generator-turbine shaft.

To limit the damage due to stator winding short circuits, the fault clearance must be as fast as possible (instantaneous). If the generator block is connected to the power system close to other generating blocks, the fast fault clearance is essential to maintain the transient stability of the non-faulted generators.

Normally, the short circuit fault current is very large, that is, significantly larger than the generator rated current. There is a risk that a short circuit can occur between phases close to the neutral point of the generator, thus causing a relatively small fault current. The fault current can also be limited due to low excitation of the generator. Therefore, it is desired that the detection of generator phase-to-phase short circuits shall be relatively sensitive, detecting small fault currents.

It is also of great importance that the generator differential protection does not trip for external faults, with large fault currents flowing from the generator.

To combine fast fault clearance, as well as sensitivity and selectivity, the generator differential protection is normally the best choice for phase-to-phase generator short circuits.

**Generator differential protection GENPDIF** is also well suited for protection of shunt reactors or small busduct.

**Transformer differential protection T2WPDIF/T3WPDIF**
The Transformer differential protection is provided with internal CT ratio matching, vector group compensation and settable zero sequence current elimination.

The function can be provided with up to six three-phase sets of current inputs if enough HW is available. All current inputs are provided with percentage bias restraint features, making the IED suitable for two- or three-winding transformer in multi-breaker station arrangements.
Two-winding applications

- Two-winding power transformer
- Two-winding power transformer with unconnected delta tertiary winding
- Two-winding power transformer with two circuit breakers and two CT-sets on one side
- Two-winding power transformer with two circuit breakers and two CT-sets on both sides

Three-winding applications

- Three-winding power transformer with all three windings connected
- Three-winding power transformer with two circuit breakers and two CT-sets on one side
- Autotransformer with two circuit breakers and two CT-sets on two out of three sides

Figure 4. CT group arrangement for differential protection

The setting facilities cover the application of the differential protection to all types of power transformers and auto-transformers with or without load tap changer as well as shunt reactors and local feeders within the station. An adaptive stabilizing feature is included for heavy through-fault currents. By introducing the load tap changer position, the differential protection pick-up can be set to optimum sensitivity thus covering internal faults with low fault current level.

Stabilization is included for inrush and overexcitation currents respectively, cross-blocking is also available. Adaptive stabilization is also included for system recovery inrush and CT saturation during external faults. A high set unrestrained differential current protection element is included for a very high speed tripping at high internal fault currents.

Included is an sensitive differential protection element based on the theory of negative sequence current component. This element offers the best possible coverage of power transformer windings turn to turn faults.

High impedance differential protection, single phase HZPDIF

High impedance differential protection, single phase (HZPDIF) functions can be used when the involved CT cores have the same turns ratio and similar magnetizing characteristics. It utilizes an external CT secondary current summation by wiring. Actually all CT secondary circuits which are involved in the differential scheme are connected in parallel. External series resistor, and a voltage dependent resistor which are both mounted externally to the IED, are also required.

The external resistor unit shall be ordered under IED accessories in the Product Guide.

HZPDIF can be used to protect generator stator windings, tee-feeders or busbars, reactors, motors, auto-transformers, capacitor banks and so on. One such function block is used for a high-impedance restricted earth fault protection. Three such function blocks are used to form three-phase, phase-segregated differential protection.

Restricted earth-fault protection, low impedance REFPDIF

Restricted earth-fault protection, low-impedance function (REFPDIF) can be used on all directly or low-impedance earthed windings. The REFPDIF function provides high sensitivity and high speed tripping as it protects each winding separately and thus does not need inrush stabilization.

The REFPDIF function is a percentage biased function with an additional zero sequence current directional comparison criterion. This gives excellent sensitivity and stability during through faults.

REFPDIF can also protect autotransformers. Five currents are measured at the most complicated configuration as shown in Figure 5.
5. Impedance protection

Full-scheme distance measuring, Mho characteristic ZMHPDIS
The numerical mho line distance protection is an up to four zone full scheme protection for back-up detection of short circuit and earth faults.

The full scheme technique provides back-up protection of power lines with high sensitivity and low requirement on remote end communication.

The zones have fully independent measuring and settings, which gives high flexibility for all types of lines.

Built-in selectable zone timer logic is also provided in the function.

The function can be used as under impedance back-up protection for transformers and generators.

Directional impedance element for Mho characteristic ZDMRDIR
The phase-to-earth impedance elements can be optionally supervised by a phase unselective directional function (phase unselective, because it is based on symmetrical components).

High speed distance protection, quadrilateral and mho ZMFPDIS
The high speed distance protection (ZMFPDIS) provides a sub-cycle, down towards a half-cycle operate time. Its six zone, full scheme protection concept is entirely suitable in applications with single-phase autoreclosing.

Each measurement zone is designed with the flexibility to operate in either quadrilateral or mho characteristic mode. This can even be decided separate for the phase-to-ground or phase-to-phase loops. The six zones can operate either independent of each other, or their start can be linked (per zone) through the phase selector or the first starting zone. This can provide fast operate times for evolving faults.

The operation of the phase-selection is primarily based on a current change criteria (i.e. delta quantities), however there is also a phase selection criterion operating in parallel which bases its operation on voltage and current phasors exclusively. Additionally the directional element provides a fast and correct directional decision under difficult operating conditions, including close-in three-phase faults, simultaneous faults and faults with only zero-sequence in-feed. During phase-to-earth faults on heavily loaded power lines there is an adaptive load compensation algorithm that prevents overreaching of the distance zones in the load exporting end, improving the selectivity of the function. This also reduces underreach in the importing end.

High speed distance protection for series comp. lines, quad and mho characteristic ZMFCPDIS
The high speed distance protection (ZMFCPDIS) is fundamentally the same function as ZMFPDIS but provides more flexibility in zone settings to suit more complex applications, such as series compensated lines. In operation for series compensated networks, the parameters of the directional function are altered to handle voltage reversal.

Each measurement zone is designed with the flexibility to operate in either quadrilateral or mho characteristic mode. This can even be decided separate for the phase-to-ground or phase-to-phase loops. The six zones can operate either independent of each other, or their start can be linked (per zone) through the phase selector or the first starting zone. This can provide fast operate times for evolving faults.

The operation of the phase-selection is primarily based on a current change criteria (i.e. delta quantities), however there is also a phase selection criterion operating in parallel which bases its operation on voltage and current phasors exclusively. Additionally the directional element provides a fast and correct directional decision under difficult operating conditions, including close-in three-phase faults, simultaneous faults and faults with only zero-sequence in-feed. During phase-to-earth faults on heavily loaded power lines there is an adaptive load compensation algorithm that prevents overreaching of the distance zones in the load exporting end, improving the selectivity of the function.
function. This also reduces underreach in the importing end.

The ZMFCDIS function has another directional element with phase segregated outputs STTDFwLx and STTDRVLx (where, x = 1-3) based on the transient components. It provides directionality with high speed, dependability and security, which is also suitable for extra high voltage and series compensated lines where the fundamental frequency signals are distorted.

**Pole slip protection PSPPPAM**

Sudden events in an electric power system such as large changes in load, fault occurrence or fault clearance, can cause power oscillations referred to as power swings. In a non-recoverable situation, the power swings become so severe that the synchronism is lost, a condition referred to as pole slipping. The main purpose of the pole slip protection (PSPPPAM) is to detect, evaluate, and take the required action for pole slipping occurrences in the power system.

**Out-of-step protection OOSPPAM**

The out-of-step protection (OOSPPAM ) function in the IED can be used for both generator protection and as well for line protection applications.

The main purpose of the OOSPPAM function is to detect, evaluate, and take the required action during pole slipping occurrences in the power system.

The OOSPPAM function detects pole slip conditions and trips the generator as fast as possible, after the first pole-slip if the center of oscillation is found to be in zone 1, which normally includes the generator and its step-up power transformer. If the center of oscillation is found to be further out in the power system, in zone 2, more than one pole-slip is usually allowed before the generator-transformer unit is disconnected. A parameter setting is available to take into account the circuit breaker opening time. If there are several out-of-step relays in the power system, then the one which finds the center of oscillation in its zone 1 should operate first.

Two current channels I3P1 and I3P2 are available in OOSPPAM function to allow the direct connection of two groups of three-phase currents; that may be needed for very powerful generators, with stator windings split into two groups per phase, when each group is equipped with current transformers. The protection function performs a simple summation of the currents of the two channels I3P1 and I3P2.

**Loss of excitation LEXPDIS**

There are limits for the under-excited operation of a synchronous machine. A reduction of the excitation current weakens the coupling between the rotor and the stator. The machine may lose the synchronism and start to operate like an induction machine. Then, the reactive power consumption will increase. Even if the machine does not lose synchronism it may not be acceptable to operate in this state for a long time. Reduction of excitation increases the generation of heat in the end region of the synchronous machine. The local heating may damage the insulation of the stator winding and the iron core.

To prevent damages to the generator it should be tripped when excitation is lost.

**Sensitive rotor earth fault protection, injection based ROTIPHIZ**

The sensitive rotor earth fault protection (ROTIPHIZ) is used to detect earth faults in the rotor windings of generators. ROTIPHIZ is applicable for all types of synchronous generators.

To implement the above concept, a separate injection box is required. The injection box generates a square wave voltage signal at a certain preset frequency which is fed into the rotor winding.

The magnitude of the injected voltage signal and the resulting injected current is measured through a resistive shunt located within the injection box. These two measured values are fed to the IED. Based on these two measured quantities, the protection IED determines the rotor winding resistance to ground. The resistance value is then compared with the preset fault resistance alarm and trip levels.

The protection function can detect earth faults in the entire rotor winding and associated connections.

Requires injection unit REX060 and a coupling capacitor unit REX061 for correct operation.

**100% stator earth fault protection, injection based STTIPHIZ**

The 100% stator earth-fault protection (STTIPHIZ) is used to detect earth faults in the stator windings of generators and motors. STTIPHIZ is applicable for generators connected to the power system through a unit transformer in a block connection. An independent signal with a certain frequency different from the generator rated frequency is injected into the stator circuit. The response of this injected signal is used to detect stator earth faults.

To implement the above concept, a separate injection box is required. The injection box generates a square wave voltage signal which for example can be fed into the secondary winding of the generator neutral point voltage transformer or grounding transformer. This signal propagates through this transformer into the stator circuit.
The magnitude of the injected voltage signal is measured on the secondary side of the neutral point voltage transformer or grounding transformer. In addition, the resulting injected current is measured through a resistive shunt located within the injection box. These two measured values are fed to the IED. Based on these two measured quantities, the IED determines the stator winding resistance to ground. The resistance value is then compared with the preset fault resistance alarm and trip levels.

When the synchronous machine is at standstill, the protection function can not only detect the earth fault at the generator star point, but also along the stator windings and at the generator terminals, including the connected components such as voltage transformers, circuit breakers, excitation transformer and so on. The protection function is fully operative in all operating conditions when stable measurements are achieved. Both function STTIPHIZ and ROV2PTOV shall be configured and shall operate in parallel in the same REG670 in order to perform the 100% stator earth-fault protection function. The function STTIPHIZ performs the earth-fault protection based on the injection principle in order to protect the section of the stator windings close to the generator neutral point; the function ROV2PTOV performs the standard 95% stator earth-fault protection based on the neutral point fundamental frequency displacement voltage.

The 100% stator earth fault protection requires the injection unit REX060 and optional shunt resistor unit REX062 for correct operation.

Underimpedance protection for generators and transformers ZGVPDIS
The under impedance protection (ZGVPDIS) function is a three zone full scheme impedance protection using offset mho characteristics for detecting faults in the generator, generator-transformer and transmission system. The three zones have fully independent measuring loops and settings. The functionality also comprises an under voltage seal-in feature to ensure issuing of a trip even if the current transformer goes into saturation and, in addition, the positive-sequence-based load encroachment feature for the second and the third impedance zone. Built-in compensation for the step-up transformer vector group connection is available.

6. Wide area measurement system
Synchrophasor report, 16 phasors
Configuration parameters for IEEE1344 and C37.118 protocol PMUCONF

The IED supports the following IEEE synchrophasor standards:
- IEEE 1344-1995 (Both measurements and data communication)
- IEEE Std C37.118-2005 (Both measurements and data communication)
- IEEE Std C37.118.1-2011 and C37.118.1a-2014 (Measurements)
- IEEE Std C37.118.2-2011 (Data communication)

PMUCONF contains the PMU configuration parameters for both IEEE C37.118 and IEEE 1344 protocols. This means all the required settings and parameters in order to establish and define a number of TCP and/or UDP connections with one or more PDC clients (synchrophasor client). This includes port numbers, TCP/UDP IP addresses, and specific settings for IEEE C37.118 as well as IEEE 1344 protocols.

Protocol reporting via IEEE 1344 and C37.118 PMUREPORT
The phasor measurement reporting block moves the phasor calculations into an IEEE C37.118 and/or IEEE 1344 synchrophasor frame format. The PMUREPORT block contains parameters for PMU performance class and reporting rate, the IDCODE and Global PMU ID, format of the data streamed through the protocol, the type of reported synchrophasors, as well as settings for reporting analog and digital signals.

The message generated by the PMUREPORT function block is set in accordance with the IEEE C37.118 and/or IEEE 1344 standards.

There are settings for Phasor type (positive sequence, negative sequence or zero sequence in case of 3-phase phasor and L1, L2 or L3 in case of single phase phasor), PMU's Service class (Protection or Measurement), Phasor representation (polar or rectangular) and the data types for phasor data, analog data and frequency data.

Synchrophasor data can be reported to up to 8 clients over TCP and/or 6 UDP group clients for multicast or unicast transmission of phasor data from the IED. More information regarding synchrophasor communication structure and TCP/UDP configuration is available in Application Manual under section C37.118 Phasor Measurement Data Streaming Protocol Configuration.

Multiple PMU functionality can be configured in the IED, which can stream out same or different data at different reporting rates or different performance (service) classes.
7. Current protection

**Instantaneous phase overcurrent protection PHPIOC**
The instantaneous three phase overcurrent (PHPIOC) function has a low transient overreach and short tripping time to allow use as a high set short-circuit protection function.

**Directional phase overcurrent protection, four steps OC4PTOC**
Directional phase overcurrent protection, four steps (OC4PTOC) has an inverse or definite time delay for each step.

All IEC and ANSI inverse time characteristics are available together with an optional user defined time characteristic.

The directional function needs voltage as it is voltage polarized with memory. The function can be set to be directional or non-directional independently for each of the steps.

A second harmonic blocking level can be set for the function and can be used to block each step individually.

**Instantaneous residual overcurrent protection EFPIOC**
The Instantaneous residual overcurrent protection (EFPIOC) has a low transient overreach and short tripping times to allow the use for instantaneous earth-fault protection, with the reach limited to less than the typical eighty percent of the line at minimum source impedance. EFPIOC is configured to measure the residual current from the three-phase current inputs and can be configured to measure the current from a separate current input.

**Directional residual overcurrent protection, four steps EF4PTOC**
Directional residual overcurrent protection, four steps (EF4PTOC) can be used as main protection for phase-to-earth faults. It can also be used to provide a system back-up, for example, in the case of the primary protection being out of service due to communication or voltage transformer circuit failure.

EF4PTOC has an inverse or definite time delay independent for each step.

All IEC and ANSI time-delayed characteristics are available together with an optional user-defined characteristic.

EF4PTOC can be set to be directional or non-directional independently for each step.

IDIr, UPol and IPol can be independently selected to be either zero sequence or negative sequence.

A second harmonic blocking can be set individually for each step.

Directional operation can be combined together with the corresponding communication logic in permissive or blocking teleprotection scheme. The current reversal and weak-end infeed functionality are available as well.

The residual current can be calculated by summing the three-phase currents or taking the input from the neutral CT.

**Four step directional negative phase sequence overcurrent protection NS4PTOC**
Four step directional negative phase sequence overcurrent protection (NS4PTOC) has an inverse or definite time delay independent for each step separately.

All IEC and ANSI time delayed characteristics are available together with an optional user defined characteristic.

The directional function is voltage polarized.

NS4PTOC can be set directional or non-directional independently for each of the steps.

NS4PTOC can be used as main protection for unsymmetrical fault; phase-phase short circuits, phase-phase-earth short circuits and single phase earth faults.

NS4PTOC can also be used to provide a system backup for example, in the case of the primary protection being out of service due to communication or voltage transformer circuit failure.

Directional operation can be combined together with corresponding communication logic in permissive or blocking teleprotection scheme. The same logic as for directional zero sequence current can be used. Current reversal and weak-end infeed functionality are available.

**Sensitive directional residual overcurrent and power protection SDEPSDE**
In isolated networks or in networks with high impedance earthing, the earth fault current is significantly smaller than the short circuit currents. In addition to this, the magnitude of the fault current is almost independent on the fault location in the network. The protection can be selected to use either the residual current or residual power component $3U0 \cdot 3I0 \cdot \cos \varphi$, for operating quantity with maintained short circuit capacity. There is also available one nondirectional 3I0 step and one 3U0 overvoltage tripping step.
No specific sensitive current input is needed. Sensitive directional residual overcurrent and power protection (SDEPSDE) can be set as low 0.25% of IBase.

**Thermal overload protection, two time constants TRPTTR**

If a power transformer reaches very high temperatures the equipment might be damaged. The insulation within the transformer will experience forced ageing. As a consequence of this the risk of internal phase-to-phase or phase-to-earth faults will increase.

The thermal overload protection (TRPTTR) estimates the internal heat content of the transformer (temperature) continuously. This estimation is made by using a thermal model of the transformer with two time constants, which is based on current measurement.

Two warning levels are available. This enables actions in the power system to be done before dangerous temperatures are reached. If the temperature continues to increase to the trip value, the protection initiates a trip of the protected transformer.

The estimated time to trip before operation is presented.

**Breaker failure protection CCRBRF**

Breaker failure protection (CCRBRF) ensures a fast backup tripping of the surrounding breakers in case the own breaker fails to open. CCRBRF measurement criterion can be current based, CB position based or an adaptive combination of these two conditions.

A current based check with extremely short reset time is used as check criterion to achieve high security against inadvertent operation.

CB position check criteria can be used where the fault current through the breaker is small.

CCRBRF provides three different options to select how \(t_1\) and \(t_2\) timers are run:

1. By external start signals which is internally latched
2. Follow external start signal only
3. Follow external start signal and the selected \(\text{FunctionMode}\)

CCRBRF can be single- or three-phase initiated to allow its use with single phase tripping applications. For the three-phase application of the CCRBRF the current criteria can be set to operate only if "2 elements operates out of three phases and neutral" for example; two phases or one phase plus the residual current start. This gives a higher security to the backup trip command.

The CCRBRF function can be programmed to give a single- or three-phase retrip to its own breaker to avoid unnecessary tripping of surrounding breakers at an incorrect initiation due to mistakes during testing.

**Pole discordance protection CCPDSC**

An open phase can cause negative and zero sequence currents which cause thermal stress on rotating machines and can cause unwanted operation of zero sequence or negative sequence current functions.

Normally the own breaker is tripped to correct such a situation. If the situation persists the surrounding breakers should be tripped to clear the unsymmetrical load situation.

The Pole discordance protection function (CCPDSC) operates based on information from auxiliary contacts of the circuit breaker for the three phases with additional criteria from unsymmetrical phase currents when required.

**Directional over/underpower protection GOPPDOP/GUPPDUP**

The directional over-/under-power protection (GOPPDOP/GUPPDUP) can be used wherever a high/low active, reactive or apparent power protection or alarming is required. The functions can alternatively be used to check the direction of active or reactive power flow in the power system. There are a number of applications where such functionality is needed. Some of them are:

- generator reverse power protection
- generator low forward power protection
- detection of over/under excited generator
- detection of reversed active power flow
- detection of high reactive power flow
- excessive line/cable loading with active or reactive power
- generator reverse power protection

Each function has two steps with definite time delay.

By using optional metering class CT inputs accuracy of 0.5% can be achieved for steam turbine applications.

**Voltage-restrained time overcurrent protection VRPVOC**

Voltage-restrained time overcurrent protection (VRPVOC) function can be used as generator backup protection against short-circuits.

The overcurrent protection feature has a settable current level that can be used either with definite time or inverse time characteristic. Additionally, it can be voltage controlled/restrained.

One undervoltage step with definite time characteristic is also available within the function in order to provide...
functionality for overcurrent protection with undervoltage seal-in.

**Negative sequence time overcurrent protection for machines NS2PTOC**
Negative-sequence time overcurrent protection for machines (NS2PTOC) is intended primarily for the protection of generators against possible overheating of the rotor caused by negative sequence current in the stator current.

The negative sequence currents in a generator may, among others, be caused by:

- Unbalanced loads
- Line to line faults
- Line to earth faults
- Broken conductors
- Malfunction of one or more poles of a circuit breaker or a disconnector

NS2PTOC can also be used as a backup protection, that is, to protect the generator in case line protections or circuit breakers fail to clear unbalanced system faults.

To provide an effective protection for the generator for external unbalanced conditions, NS2PTOC is able to directly measure the negative sequence current. NS2PTOC also has a time delay characteristic which matches the heating characteristic of the generator

\[ I_2^2 t = K \]

as defined in standard IEEE C50.13.

where:
- \( I_2 \) is negative sequence current expressed in per unit of the rated generator current
- \( t \) is operating time in seconds
- \( K \) is a constant which depends of the generators size and design

NS2PTOC has a wide range of \( K \) settings and the sensitivity and capability of detecting and tripping for negative sequence currents down to the continuous capability of a generator.

In order to match the heating characteristics of the generator a reset time parameter can be set.

A separate definite time delayed output is available as an alarm feature to warn the operator of a potentially dangerous situation.

**Accidental energizing protection for synchronous generator AEGPVOC**
Inadvertent or accidental energizing of off-line generators has occurred often enough due to operating errors, breaker head flashovers, control circuit malfunctions, or a combination of these causes.

Inadvertently energized generator operates as induction motor drawing a large current from the system. The voltage supervised overcurrent protection is used to detect the inadvertently energized generator.

Accidental energizing protection for synchronous generator (AEGPVOC) takes the maximum phase current input and maximum phase to phase voltage inputs from the terminal side. AEGPVOC is enabled when the terminal voltage drops below the specified voltage level for the preset time.

**Stator overload protection GSPTTR**
The generator overload function, (GSPTTR) is used to protect the stator winding against excessive temperature as a result of overcurrents. The functions operating characteristic is designed in accordance with the American standard IEEE-C50.13.

If internal generator components exceed its design temperature limit, damage can be the result. Damage to generator insulation can range from minor loss of life to complete failure, depending on the severity and duration of the temperature excursion. Excess temperature can also cause mechanical damage due to thermal expansion. Since temperature increases with current, it is logical to apply overcurrent elements with inverse time characteristics.

For its operation the function either measures the true RMS current of the stator winding or waited sum of the positive and negative sequence components in the stator winding.

The function is designed to work on 50/60 Hz systems.

**Rotor overload protection GRPTTR**
The generator overload function, (GRPTTR) is used to protect the rotor winding against excessive temperature as a result of overcurrents. The functions operating characteristic is designed in accordance with the American standard IEEE-C50.13.

If internal generator components exceed its design temperature limit, damage can be the result. Damage to generator insulation can range from minor loss of life to complete failure, depending on the severity and duration of the temperature excursion. Excess temperature can also cause mechanical damage due to thermal expansion. Rotor components such as bars and end rings are vulnerable to this damage. Since temperature increases with current, it is logical to apply overcurrent elements with inverse time characteristics.

For its operation the function either measures the true RMS current of the excitation transformer or calculates the DC current in the rotor winding. The rotor winding DC current can be calculated from the AC currents measured on either high voltage side (HV) or low voltage.
side (LV) side of the excitation transformer. For the HV side measurement ratings of the excitation transformer shall be given. The use of the DC current is default (i.e. recommended) measurement for generators with static excitation system. When the DC current is used, the function can provide a DC current ripple alarm, due to possible problem with the static excitation equipment. The rotor DC current can be also sent to the plant supervisory system via communication channel or displayed on the IED built-in HMI.

The function can also detect undercurrent condition in the rotor winding which indicates either underexcitation or loss of excitation condition of the generator.

The function is designed to work on 50/60 Hz systems.

8. Voltage protection

Two-step undervoltage protection UV2PTUV
Undervoltages can occur in the power system during faults or abnormal conditions. The two-step undervoltage protection function (UV2PTUV) can be used to open circuit breakers to prepare for system restoration at power outages or as a long-time delayed back-up to the primary protection.

UV2PTUV has two voltage steps, each with inverse or definite time delay.

It has a high reset ratio to allow settings close to the system service voltage.

Two step overvoltage protection OV2PTOV
Overvoltages may occur in the power system during abnormal conditions such as sudden power loss, tap changer regulating failures, and open line ends on long lines.

OV2PTOV has two voltage steps, each of them with inverse or definite time delayed.

OV2PTOV has a high reset ratio to allow settings close to system service voltage.

Two step residual overvoltage protection ROV2PTOV
Residual voltages may occur in the power system during earth faults.

Two step residual overvoltage protection (ROV2PTOV) function calculates the residual voltage from the three-phase voltage input transformers or measures it from a single voltage input transformer fed from an open delta or neutral point voltage transformer.

ROV2PTOV has two voltage steps, each with inverse or definite time delay.

A reset delay ensures operation for intermittent earth faults.

Overexcitation protection OEXPVPH
When the laminated core of a power transformer or generator is subjected to a magnetic flux density beyond its design limits, stray flux will flow into non-laminated components that are not designed to carry flux. This will cause eddy currents to flow. These eddy currents can cause excessive heating and severe damage to insulation and adjacent parts in a relatively short time. The function has settable inverse operating curves and independent alarm stages.

Voltage differential protection VDCPTOV
A voltage differential monitoring function is available. It compares the voltages from two three phase sets of voltage transformers and has one sensitive alarm step and one trip step.

100% Stator earth fault protection, 3rd harmonic based STEFPHIZ
Stator earth fault is a fault type having relatively high fault rate. The generator systems normally have high impedance earthing, that is, earthing via a neutral point resistor. This resistor is normally dimensioned to give an earth fault current in the range 3 ~ 15 A at a solid earth-fault directly at the generator high voltage terminal. The relatively small earth fault currents give much less thermal and mechanical stress on the generator, compared to the short circuit case, which is between conductors of two phases. Anyhow, the earth faults in the generator have to be detected and the generator has to be tripped, even if longer fault time compared to internal short circuits, can be allowed.

In normal non-faulted operation of the generating unit the neutral point voltage is close to zero, and there is no zero sequence current flow in the generator. When a phase-to-earth fault occurs the neutral point voltage will increase and there will be a current flow through the neutral point resistor.

To detect an earth fault on the windings of a generating unit one may use a neutral point overvoltage protection, a neutral point overcurrent protection, a zero sequence overvoltage protection or a residual differential protection. These protections are simple and have served well during many years. However, at best these simple schemes protect only 95% of the stator winding. They leave 5% close to the neutral end unprotected. Under unfavorable conditions the blind zone may extend up to 20% from the neutral.

The 95% stator earth fault protection measures the fundamental frequency voltage component in the generator star point and it operates when the fundamental frequency voltage exceeds the preset...
value. By applying this principle approximately 95% of the stator winding can be protected. In order to protect the last 5% of the stator winding close to the neutral end the 3rd harmonic voltage measurement can be performed. In 100% Stator E/F 3rd harmonic protection either the 3rd harmonic voltage differential principle, the neutral point 3rd harmonic undervoltage principle or the terminal side 3rd harmonic overvoltage principle can be applied. However, differential principle is strongly recommended. Combination of these two measuring principles provides coverage for entire stator winding against earth faults.

![Diagram of stator winding with protection principles](https://example.com/iec10000202-1-en.vsd)

**Figure 6. Protection principles for STEFPHIZ function**

9. Frequency protection

**Underfrequency protection SAPTUF**

Underfrequency occurs as a result of a lack of generation in the network.

Underfrequency protection (SAPTUF) measures frequency with high accuracy, and is used for load shedding systems, remedial action schemes, gas turbine startup and so on. Separate definite time delays are provided for operate and restore.

SAPTUF is provided with undervoltage blocking.

The operation is based on positive sequence voltage measurement and requires two phase-phase or three phase-neutral voltages to be connected.

**Overfrequency protection SAPTOF**

Overfrequency protection function (SAPTOF) is applicable in all situations, where reliable detection of high fundamental power system frequency is needed.

Overfrequency occurs because of sudden load drops or shunt faults in the power network. Close to the generating plant, generator governor problems can also cause over frequency.

SAPTOF measures frequency with high accuracy, and is used mainly for generation shedding and remedial action schemes. It is also used as a frequency stage initiating load restoring. A definite time delay is provided for operate.

SAPTOF is provided with an undervoltage blocking.
The operation is based on positive sequence voltage measurement and requires two phase-phase or three phase-neutral voltages to be connected.

**Rate-of-change of frequency protection SAPFRC**
The rate-of-change of frequency protection function (SAPFRC) gives an early indication of a main disturbance in the system. SAPFRC measures frequency with high accuracy, and can be used for generation shedding, load shedding and remedial action schemes. SAPFRC can discriminate between a positive or negative change of frequency. A definite time delay is provided for operate. SAPFRC is provided with an undervoltage blocking. The operation is based on positive sequence voltage measurement and requires two phase-phase or three phase-neutral voltages to be connected.

**Frequency time accumulation protection FTAQFVR**
Frequency time accumulation protection (FTAQFVR) is based on measured system frequency and time counters. FTAQFVR for generator protection provides the START output for a particular settable frequency limit, when the system frequency falls in that settable frequency band limit and positive sequence voltage within settable voltage band limit. The START signal triggers the individual event timer, which is the time spent within the given frequency band, and the accumulation timer, which is the cumulative time spent within the given frequency band. Once the timers reach their limit, an alarm or trip signal is activated to protect the turbine against the abnormal frequency operation. This function is blocked during generator start-up or shut down conditions by monitoring the circuit breaker position and current threshold value. The function is also blocked when the system positive sequence voltage magnitude deviates from the given voltage band limit which can be enabled by *EnaVoltCheck* setting.

It is possible to create functionality with more than one frequency band limit by using multiple instances of the function. This can be achieved by a proper configuration based on the turbine manufacturer specification.

10. **Multipurpose protection**

**General current and voltage protection CVGAPC**
The protection module is recommended as a general backup protection with many possible application areas due to its flexible measuring and setting facilities.

The built-in overcurrent protection feature has two settable current levels. Both of them can be used either with definite time or inverse time characteristic. The overcurrent protection steps can be made directional with selectable voltage polarizing quantity. Additionally they can be voltage and/or current controlled/restrained. 2nd harmonic restraining facility is available as well. At too low polarizing voltage the overcurrent feature can be either blocked, made non directional or ordered to use voltage memory in accordance with a parameter setting.

Additionally two overvoltage and two undervoltage steps, either with definite time or inverse time characteristic, are available within each function.

The general function suits applications with underimpedance and voltage controlled overcurrent solutions. The general function can also be utilized for generator transformer protection applications where positive, negative or zero sequence components of current and voltage quantities are typically required.

Additionally, generator applications such as loss of field, inadvertent energizing, stator or rotor overload, circuit breaker head flash-over and open phase detection are just a few of possible protection arrangements with these functions.

**Rotor earth fault protection using CVGAPC**
The field winding, including the rotor winding and the non-rotating excitation equipment, is always insulated from the metallic parts of the rotor. The insulation resistance is high if the rotor is cooled by air or by hydrogen. The insulation resistance is much lower if the rotor winding is cooled by water. This is true even if the insulation is intact. A fault in the insulation of the field circuit will result in a conducting path from the field winding to earth. This means that the fault has caused a field earth fault.

The field circuit of a synchronous generator is normally unearthed. Therefore, a single earth fault on the field winding will cause only a very small fault current. Thus the earth fault does not produce any damage in the generator. Furthermore, it will not affect the operation of a generating unit in any way. However, the existence of a single earth fault increases the electric stress at other points in the field circuit. This means that the risk for a second earth fault at another point on the field winding has increased considerably. A second earth fault will cause a field short-circuit with severe consequences.

The rotor earth fault protection is based on injection of an AC voltage to the isolated field circuit. In non-faulted conditions there will be no current flow associated to this injected voltage. If a rotor earth fault occurs, this condition will be detected by the rotor earth fault protection. Depending on the generator owner philosophy this operational state will be alarmed and/or the generator will be tripped. An injection unit RXTTE4
and an optional protective resistor on plate are required for correct rotor earth fault protection operation.

11. General calculation

**Multipurpose filter SMAIHPAC**
The multi-purpose filter function block (SMAIHPAC) is arranged as a three-phase filter. It has very much the same user interface (e.g. inputs and outputs) as the standard pre-processing function block SMAI. However the main difference is that it can be used to extract any frequency component from the input signal. Thus it can, for example, be used to build sub-synchronous resonance protection for synchronous generator.

12. Secondary system supervision

**Current circuit supervision CCSSPVC**
Open or short circuited current transformer cores can cause unwanted operation of many protection functions such as differential, earth-fault current and negative-sequence current functions.

Current circuit supervision (CCSSPVC) compares the residual current from a three phase set of current transformer cores with the neutral point current on a separate input taken from another set of cores on the current transformer.

A detection of a difference indicates a fault in the circuit and is used as alarm or to block protection functions expected to give inadvertent tripping.

**Fuse failure supervision FUFSPVC**
The aim of the fuse failure supervision function (FUFSVPVC) is to block voltage measuring functions at failures in the secondary circuits between the voltage transformer and the IED in order to avoid inadvertent operations that otherwise might occur.

The fuse failure supervision function basically has three different detection methods, negative sequence and zero sequence based detection and an additional delta voltage and delta current detection.

The negative sequence detection algorithm is recommended for IEDs used in isolated or high-impedance earthed networks. It is based on the negative-sequence quantities.

The zero sequence detection is recommended for IEDs used in directly or low impedance earthed networks. It is based on the zero sequence measuring quantities.

The selection of different operation modes is possible by a setting parameter in order to take into account the particular earthing of the network.

A criterion based on delta current and delta voltage measurements can be added to the fuse failure supervision function in order to detect a three phase fuse failure, which in practice is more associated with voltage transformer switching during station operations.

**Fuse failure supervision VDSPVC**
Different protection functions within the protection IED operates on the basis of measured voltage at the relay point. Some example of protection functions are:

- Distance protection function.
- Undervoltage function.
- Energisation function and voltage check for the weak infed logic.

These functions can operate unintentionally, if a fault occurs in the secondary circuits between voltage instrument transformers and the IED. These unintentional operations can be prevented by fuse failure supervision (VDSPVC).

VDSPVC is designed to detect fuse failures or faults in voltage measurement circuit, based on phase wise comparison of voltages of main and pilot fused circuits. VDSPVC blocking output can be configured to block functions that need to be blocked in case of faults in the voltage circuit.

**Voltage based delta supervision DELVSPVC**
Delta supervision function is used to quickly detect (sudden) changes in the network. This can, for example, be used to detect faults in the power system networks and islanding in grid networks. Voltage based delta supervision (DELVSPVC) is needed at the grid interconnection point.

**Current based delta supervision DELISPVC**
Delta supervision function is used to quickly detect (sudden) changes in the network. This can, for example, be used to detect disturbances in the power system network. Current based delta supervision (DELISPVC) provides selectivity between load change and the fault.

Present power system has many power electronic devices or FACTS devices, which injects a large number of harmonics into the system. The function has additional features of 2nd harmonic blocking and 3rd harmonic start level adaption. The 2nd harmonic blocking secures the operation during the transformer charging, when high inrush currents are supplied into the system.
Delta supervision of real input DELSPVC
Delta supervision functions are used to quickly detect (sudden) changes in the power system. Real input delta supervision (DELSPVC) function is a general delta function. It is used to detect the change measured qualities over a settable time period, such as:
- Power
- Reactive power
- Temperature
- Frequency
- Power factor

13. Control
Synchrocheck, energizing check, and synchronizing SESRSYN
The Synchronizing function allows closing of asynchronous networks at the correct moment including the breaker closing time, which improves the network stability.

Synchrocheck, energizing check, and synchronizing (SESRSYN) function checks that the voltages on both sides of the circuit breaker are in synchronism, or with at least one side dead to ensure that closing can be done safely.

SESRSYN function includes a built-in voltage selection scheme for double bus and 1½ breaker or ring busbar arrangements.

Manual closing as well as automatic reclosing can be checked by the function and can have different settings.

For systems, which can run asynchronously, a synchronizing feature is also provided. The main purpose of the synchronizing feature is to provide controlled closing of circuit breakers when two asynchronous systems are in phase and can be connected. The synchronizing feature evaluates voltage difference, phase angle difference, slip frequency and frequency rate of change before issuing a controlled closing of the circuit breaker. Breaker closing time is a setting.

However this function can not be used to automatically synchronize the generator to the network.

Apparatus control APC
The apparatus control functions are used for control and supervision of circuit breakers, disconnectors and earthing switches within a bay. Permission to operate is given after evaluation of conditions from other functions such as interlocking, synchrocheck, operator place selection and external or internal blockings.

Apparatus control features:
- Select-Execute principle to give high reliability
- Selection function to prevent simultaneous operation
- Selection and supervision of operator place
- Command supervision
- Block/deblock of operation
- Block/deblock of updating of position indications
- Substitution of position and quality indications
- Overriding of interlocking functions
- Overriding of synchrocheck
- Operation counter
- Suppression of mid position

Two types of command models can be used:
- Direct with normal security
- SBO (Select-Before-Operate) with enhanced security

Normal security means that only the command is evaluated and the resulting position is not supervised. Enhanced security means that the command is evaluated with an additional supervision of the status value of the control object. The command sequence with enhanced security is always terminated by a CommandTermination service primitive and an AddCause telling if the command was successful or if something went wrong.

Control operation can be performed from the local HMI with authority control if so defined.

Interlocking
The interlocking function blocks the possibility to operate primary switching devices, for instance when a disconnector is under load, in order to prevent material damage and/or accidental human injury.

Each apparatus control function has interlocking modules included for different switchyard arrangements, where each function handles interlocking of one bay. The interlocking function is distributed to each IED and is not dependent on any central function. For the station-wide interlocking, the IEDs communicate via the system-wide interbay bus (IEC 61850-8-1) or by using hard wired binary inputs/outputs. The interlocking conditions depend on the circuit configuration and apparatus position status at any given time.

For easy and safe implementation of the interlocking function, the IED is delivered with standardized and tested software interlocking modules containing logic for the interlocking conditions. The interlocking conditions can be altered, to meet the customer’s specific requirements, by adding configurable logic by means of the graphical configuration tool.
Switch controller SCSWI
The Switch controller (SCSWI) initializes and supervises all functions to properly select and operate switching primary apparatuses. The Switch controller may handle and operate on one multi-phase device or up to three one-phase devices.

Circuit breaker SXCBR
The purpose of Circuit breaker (SXCBR) is to provide the actual status of positions and to perform the control operations, that is, pass all the commands to primary apparatuses in the form of circuit breakers via binary output boards and to supervise the switching operation and position.

Circuit switch SXSWI
The purpose of Circuit switch (SXSWI) function is to provide the actual status of positions and to perform the control operations, that is, pass all the commands to primary apparatuses in the form of disconnectors or earthing switches via binary output boards and to supervise the switching operation and position.

Reservation function QCRSV
The purpose of the reservation (QCRSV) function is primarily to transfer interlocking information between IEDs in a safe way and to prevent double operation in a bay, switchyard part, or complete substation.

Reservation input RESIN
The Reservation input (RESIN) function receives the reservation information from other bays. The number of instances is the same as the number of involved bays (up to 60 instances are available).

Bay control QCBAY
The Bay control (QCBAY) function is used together with Local remote and local remote control functions to handle the selection of the operator place per bay. QCBAY also provides blocking functions that can be distributed to different apparatuses within the bay.

Proxy for signals from switching device via GOOSE XLNPROXY
The proxy for signals from switching device via GOOSE (XLNPROXY) gives an internal representation of the position status and control response for a switch modelled in a breaker IED. This representation is identical to that of an SXCBR or SXSWI function.

GOOSE function block to receive a switching device GOOSEXLRNCV
The GOOSE XLN Receive component is used to collect information from another device's XCBR/XSWI logical node sent over process bus via GOOSE. The GOOSE XLN Receive component includes 12 different outputs (and their respective channel valid bits) with defined names to ease the 61850 mapping of the GOOSE signals in the configuration process.

Local remote LOCREM/Local remote control LOCREMCTRL
The signals from the local HMI or from an external local/remote switch are connected via the function blocks local remote (LOCREM) and local remote control (LOCREMCTRL) to the Bay control (QCBAY) function block. The parameter ControlMode in function block LOCREM is set to choose if the switch signals are coming from the local HMI or from an external hardware switch connected via binary inputs.

Tap changer position reading TCMYLTC and TCLYLTC
On-load tap-changer position can be monitored on-line. This can be done by either using BCD coded binary input signals or alternatively via an mA input signal. The actual tap-position can be used by the transformer or overall differential protection function in order to enable more sensitive pickup setting. This will in turn make differential protection more sensitive for low level internal faults such as winding turn-to-turn faults.

Logic rotating switch for function selection and LHMI presentation SLGAPC
The logic rotating switch for function selection and LHMI presentation (SLGAPC) (or the selector switch function block) is used to get an enhanced selector switch functionality compared to the one provided by a hardware selector switch. Hardware selector switches are used extensively by utilities, in order to have different functions operating on pre-set values. Hardware switches are however sources for maintenance issues, lower system reliability and an extended purchase portfolio. The selector switch function eliminates all these problems.

Selector mini switch VSGAPC
The Selector mini switch (VSGAPC) function block is a multipurpose function used for a variety of applications, as a general purpose switch.

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Single point generic control 8 signals SPC8GAPC
The Single point generic control 8 signals (SPC8GAPC) function block is a collection of 8 single point commands that can be used for direct commands for example reset of LEDs or putting IED in "ChangeLock" state from remote. In this way, simple commands can be sent directly to the IED outputs, without confirmation. Confirmation (status) of the result of the commands is supposed to be achieved by other means, such as binary inputs and SPGAPC function blocks. The commands can be pulsed or steady with a settable pulse time.

Automation bits, command function for DNP3.0 AUTOBITS
Automation bits function for DNP3 (AUTOBITS) is used within PCM600 to get into the configuration of the commands coming through the DNP3 protocol. The AUTOBITS function plays the same role as functions GOOSEBINRCV (for IEC 61850) and MULTICMDRCV (for LON).

Single command, 16 signals
The IEDs can receive commands either from a substation automation system or from the local HMI. The command function block has outputs that can be used, for example, to control high voltage apparatuses or for other user defined functionality.

14. Logic

Tripping logic SMPPTRC
A function block for protection tripping and general start indication is always provided as a basic function for each circuit breaker. It provides a settable pulse prolongation time to ensure a trip pulse of sufficient length, as well as all functionality necessary for correct co-operation with autoreclosing functions.

The trip function block includes a settable latch function for the trip signal and circuit breaker lockout.

The trip function can collect start and directional signals from different application functions. The aggregated start and directional signals are mapped to the IEC 61850 logical node data model.

General start matrix block SMAGAPC
The Start Matrix (SMAGAPC) merges start and directional output signals from different application functions and creates a common start and directional output signal (STDIR) to be connected to the Trip function.

The purpose of this functionality is to provide general start and directional information for the IEC 61850 trip logic data model SMPPTRC.

Trip matrix logic TMAGAPC
The trip matrix logic (TMAGAPC) function is used to route trip signals and other logical output signals to different output contacts on the IED.

The trip matrix logic function has 3 output signals and these outputs can be connected to physical tripping outputs according to the specific application needs for settable pulse or steady output.

Group alarm logic function ALMCALH
The group alarm logic function (ALMCALH) is used to route several alarm signals to a common indication, LED and/or contact, in the IED.

Group warning logic function WRNCALH
The group warning logic function (WRNCALH) is used to route several warning signals to a common indication, LED and/or contact, in the IED.

Group indication logic function INDCALH
The group indication logic function (INDCALH) is used to route several indication signals to a common indication, LED and/or contact, in the IED.

Basic configurable logic blocks
The basic configurable logic blocks do not propagate the time stamp and quality of signals (have no suffix QT at the end of their function name). A number of logic blocks and timers are always available as basic for the user to adapt the configuration to the specific application needs. The list below shows a summary of the function blocks and their features.

These logic blocks are also available as part of an extension logic package.

- **AND** function block. The AND function is used to form general combinatory expressions with boolean variables. The AND function block has up to four inputs and two outputs. One of the outputs is inverted.

- **GATE** function block is used for whether or not a signal should be able to pass from the input to the output.

- **INVERTER** function block that inverts the input signal to the output.

- **LLD** function block. Loop delay used to delay the output signal one execution cycle.

- **OR** function block. The OR function is used to form general combinatory expressions with boolean variables. The OR function block has up to six inputs and two outputs. One of the outputs is inverted.
• **PULSETIMER** function block can be used, for example, for pulse extensions or limiting of operation of outputs, settable pulse time.

• **RSMEMORY** function block is a flip-flop that can reset or set an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if, after a power interruption, the flip-flop resets or returns to the state it had before the power interruption. **RESET** input has priority.

• **SRMEMORY** function block is a flip-flop that can set or reset an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if, after a power interruption, the flip-flop resets or returns to the state it had before the power interruption. **SET** input has priority.

• **TIMERSET** function has pick-up and drop-out delayed outputs related to the input signal. The timer has a settable time delay.

• **XOR** is used to generate combinatory expressions with boolean variables. XOR has two inputs and two outputs. One of the outputs is inverted. The output signal **OUT** is 1 if the input signals are different and 0 if they are the same.

### Configurable logic blocks Q/T

The configurable logic blocks QT propagate the time stamp and the quality of the input signals (have suffix QT at the end of their function name).

The function blocks assist the user to adapt the IEDs' configuration to the specific application needs. The list below shows a summary of the function blocks and their features.

• **ANDQT** AND function block. The function also propagates the time stamp and the quality of input signals. Each block has four inputs and two outputs where one is inverted.

• **INDEXTSPQT** extracts individual signals from a group signal input. The value part of single position input is copied to **SI_OUT** output. The time part of single position input is copied to **TIME** output. The quality bits in the common part and the indication part of inputs signal are copied to the corresponding quality output.

• **INVALIDQT** function which sets quality invalid of outputs according to a "valid" input. Inputs are copied to outputs. If input **VALID** is 0, or if its quality invalid bit is set, all outputs invalid quality bit will be set to invalid. The time stamp of an output will be set to the latest time stamp of **INPUT** and **VALID** inputs.

• **INVERTERQT** function block that inverts the input signal and propagates the time stamp and the quality of the input signal.

• **ORQT** OR function block that also propagates the time stamp and the quality of the input signals. Each block has six inputs and two outputs where one is inverted.

• **PULSETIMERQT** Pulse timer function block can be used, for example, for pulse extensions or limiting of operation of outputs. The function also propagates the time stamp and the quality of the input signal.

• **RSMEMORYQT** function block is a flip-flop that can reset or set an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if the block after a power interruption should return to the state before the interruption, or be reset. The function also propagates the time stamp and the quality of the input signal.

• **SRMEMORYQT** function block is a flip-flop that can set or reset an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if the block after a power interruption should return to the state before the interruption, or be reset. The function also propagates the time stamp and the quality of the input signal.

• **TIMERSETQT** function has pick-up and drop-out delayed outputs related to the input signal. The timer has a settable time delay. The function also propagates the time stamp and the quality of the input signal.

• **XORQT** XOR function block. The function also propagates the time stamp and the quality of the input signals. Each block has two outputs where one is inverted.

### Extension logic package

The logic extension block package includes additional trip matrix logic and configurable logic blocks.

### Fixed signal function block FXDSIGN

The Fixed signals function (FXDSIGN) has nine pre-set (fixed) signals that can be used in the configuration of an IED, either for forcing the unused inputs in other function blocks to a certain level/value, or for creating...
certain logic. Boolean, integer, floating point, string types of signals are available.

One FXDSIGN function block is included in all IEDs.

**Delay on timer with input signal integration TIGAPC**
The integrator function (TIGAPC) integrates input pulses and compares the integrated time with a settable time delay to operate. Moreover, the time delay to reset the output is settable in this function.

**Elapsed time integrator with limit transgression and overflow supervision TEIGAPC**
The Elapsed time integrator function (TEIGAPC) is a function that accumulates the elapsed time when a given binary signal has been high.

The main features of TEIGAPC

- Applicable to long time integration (≤999 999.9 seconds).
- Supervision of limit transgression conditions and overflow.
- Possibility to define a warning or alarm with the resolution of 10 milliseconds.
- Retaining of the integration value.
- Possibilities for blocking and reset.
- Reporting of the integrated time.

**Boolean to integer conversion, 16 bit B16I**
Boolean to integer conversion, 16 bit (B16I) is used to transform a set of 16 boolean (logical) signals into an integer.

**Boolean to integer conversion with logical node representation, 16 bit BTIGAPC**
Boolean to integer conversion with logical node representation, 16 bit (BTIGAPC) is used to transform a set of 16 boolean (logical) signals into an integer. The block input will freeze the output at the last value.

**Integer to Boolean 16 conversion IB16**
Integer to boolean 16 conversion function (IB16) is used to transform an integer into a set of 16 boolean (logical) signals.

**Integer to Boolean 16 conversion with logic node representation ITBGAPC**
Integer to boolean 16 conversion with logic node representation function (ITBGAPC) is used to transform an integer which is transmitted over IEC 61850 and received by the function to 16 boolean (logic) output signals.

**Comparator for integer inputs INTCOMP**
The function gives the possibility to monitor the level of integer values in the system relative to each other or to a fixed value. It is a basic arithmetic function that can be used for monitoring, supervision, interlocking and other logics.

**Comparator for real inputs REALCOMP**
The function gives the possibility to monitor the level of real value signals in the system relative to each other or to a fixed value. It is a basic arithmetic function that can be used for monitoring, supervision, interlocking and other logics.

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15. Monitoring

**Measurements CVMMXN, CMMXU, VNMMXU, VMMXU, CMSQI, VMSQI**
The measurement functions are used to get on-line information from the IED. These service values make it possible to display on-line information on the local HMI and on the substation automation system about:

- measured voltages, currents, frequency, active, reactive and apparent power and power factor
- measured analog values from merging units
- primary phasors
- positive, negative and zero sequence currents and voltages
- mA, input currents
- pulse counters

**Supervision of mA input signals**
The main purpose of the function is to measure and process signals from different measuring transducers. Many devices used in process control represent various parameters such as frequency, temperature and DC battery voltage as low current values, usually in the range 4-20 mA or 0-20 mA.

Alarm limits can be set and used as triggers, e.g. to generate trip or alarm signals.

The function requires that the IED is equipped with the mA input module.

**Disturbance report DRPRDRE**
Complete and reliable information about disturbances in the primary and/or in the secondary system together with continuous event-logging is accomplished by the disturbance report functionality.

Disturbance report (DRPRDRE), always included in the IED, acquires sampled data of all selected analog input and binary signals connected to the function block with a maximum of 40 analog and 352 binary signals.

The Disturbance report functionality is a common name for several functions.
The Disturbance report function is characterized by great flexibility regarding configuration, starting conditions, recording times, and large storage capacity. A disturbance is defined as an activation of an input to the AnRADR or BnRBDR function blocks, which are set to trigger the disturbance recorder. All connected signals from start of pre-fault time to the end of post-fault time will be included in the recording. Disturbance record will have visible settings from all function instances that are configured in the application configuration tool. Every disturbance report recording is saved in the IED in the standard Comtrade format as a reader file HDR, a configuration file CFG, and a data file DAT. The same applies to all events, which are continuously saved in a ring-buffer. The local HMI is used to get information about the recordings. The disturbance report files can be uploaded to PCM600 for further analysis using the disturbance handling tool.

Event list DRPRDRE
Continuous event-logging is useful for monitoring the system from an overview perspective and is a complement to specific disturbance recorder functions. The event list logs all binary input signals connected to the Disturbance recorder function. The list may contain up to 1000 time-tagged events stored in a ring-buffer.

Indications DRPRDRE
To get fast, condensed and reliable information about disturbances in the primary and/or in the secondary system it is important to know, for example binary signals that have changed status during a disturbance. This information is used in the short perspective to get information via the local HMI in a straightforward way. There are three LEDs on the local HMI (green, yellow and red), which will display status information about the IED and the Disturbance recorder function (triggered).

The Indication list function shows all selected binary input signals connected to the Disturbance recorder function that have changed status during a disturbance.

Event recorder DRPRDRE
Quick, complete and reliable information about disturbances in the primary and/or in the secondary system is vital, for example, time-tagged events logged during disturbances. This information is used for different purposes in the short term (for example corrective actions) and in the long term (for example functional analysis). The event recorder logs all selected binary input signals connected to the Disturbance recorder function. Each recording can contain up to 150 time-tagged events.

The event recorder information is available for the disturbances locally in the IED.

The event recording information is an integrated part of the disturbance record (Comtrade file).

Trip value recorder DRPRDRE
Information about the pre-fault and fault values for currents and voltages are vital for the disturbance evaluation. The Trip value recorder calculates the values of all selected analog input signals connected to the Disturbance recorder function. The result is magnitude and phase angle before and during the fault for each analog input signal.

The trip value recorder information is available for the disturbances locally in the IED.

The trip value recorder information is an integrated part of the disturbance record (Comtrade file).

Disturbance recorder DRPRDRE
The Disturbance recorder function supplies fast, complete and reliable information about disturbances in the power system. It facilitates understanding system behavior and related primary and secondary equipment during and after a disturbance. Recorded information is used for different purposes in the short perspective (for example corrective actions) and long perspective (for example functional analysis).

The Disturbance recorder acquires sampled data from selected analog and binary signals connected to the Disturbance recorder function (maximum 40 analog and 352 binary signals). The binary signals available are the same as for the event recorder function.

The function is characterized by great flexibility and is not dependent on the operation of protection functions. It can record disturbances not detected by protection functions. Up to ten seconds of data before the trigger instant can be saved in the disturbance file.

The disturbance recorder information for up to 100 disturbances are saved in the IED and the local HMI is used to view the list of recordings.

Event function
When using a Substation Automation system with LON or SPA communication, time-tagged events can be sent at change or cyclically from the IED to the station level.
These events are created from any available signal in the IED that is connected to the Event function (EVENT). The EVENT function block is used for LON and SPA communication.

Analog, integer and double indication values are also transferred through the EVENT function.

**Generic communication function for Single Point indication SPGAPC**
Generic communication function for Single Point indication (SPGAPC) is used to send one single logical signal to other systems or equipment in the substation.

**Generic communication function for measured values MVGAPC**
Generic communication function for measured values (MVGAPC) function is used to send the instantaneous value of an analog signal to other systems or equipment in the substation. It can also be used inside the same IED, to attach a RANGE aspect to an analog value and to permit measurement supervision on that value.

**Estimated value expander block RANGE_XP**
The current and voltage measurements functions (CVMMXN, CMMXU, VMXXMU and VNMMXU), current and voltage sequence measurement functions (CMSQI and VMSQI) and IEC 61850 generic communication I/O functions (MVGAPC) are provided with measurement supervision functionality. All measured values can be supervised with four settable limits: low-low limit, low limit, high limit and high-high limit. The measure value expander block (RANGE_XP) has been introduced to enable translating the integer output signal from the measuring functions to 5 binary signals: below low-low limit, below low limit, normal, above high limit or above high-high limit. The output signals can be used as conditions in the configurable logic or for alarming purpose.

**Insulation supervision for gas medium function SSIMG**
Insulation supervision for gas medium (SSIMG) is used for monitoring the circuit breaker condition. Binary information based on the gas pressure in the circuit breaker is used as input signals to the function. In addition, the function generates alarms based on received information.

**Insulation supervision for liquid medium SSIML**
Insulation supervision for liquid medium (SSIML) is used for monitoring the oil insulated device condition. For example, transformers, shunt reactors, and so on. Binary information based on the oil level in the oil insulated devices are used as input signals to the function. In addition, the function generates alarms based on the received information.

**Circuit breaker condition monitoring SSCBR**
The circuit breaker condition monitoring function (SSCBR) is used to monitor different parameters of the breaker condition. The breaker requires maintenance when the number of operations reaches a predefined value. For a proper functioning of the circuit breaker, it is essential to monitor the circuit breaker operation, spring charge indication or breaker wear, travel time, number of operation cycles and estimate the accumulated energy during arcing periods.

**Event counter with limit supervision L4UFCNT**
The Limit counter (L4UFCNT) provides a settable counter with four independent limits where the number of positive and/or negative flanks on the input signal are counted against the setting values for limits. The output for each limit is activated when the counted value reaches that limit.

Overflow indication is included for each up-counter.

**Running hour-meter TEILGAPC**
The Running hour-meter (TEILGAPC) function is a function that accumulates the elapsed time when a given binary signal has been high.

The main features of TEILGAPC are:
- Applicable to very long time accumulation (≤ 99999.9 hours)
- Supervision of limit transgression conditions and rollover/overflow
- Possibility to define a warning and alarm with the resolution of 0.1 hours
- Retain any saved accumulation value at a restart
- Possibilities for blocking and reset
- Possibility for manual addition of accumulated time
- Reporting of the accumulated time

**Estimation of transformer winding insulation life LOLSPTR**
Estimation of transformer winding insulation life (LOLSPTR) is used to calculate transformer winding hot spot temperature using the empirical formulae. It is also used to estimate transformer loss of life from the winding hot spot temperature value. The transformer winding insulation is degraded when the winding hot spot temperature exceeds certain limit. LOLSPTR gives warning and alarm signals when the winding hot spot temperature reaches a set value.

Hot spot temperature calculation requires top oil temperature at a given time. This value can either be a measured value taken through sensors or the one calculated by the function. This decision is made based on the top oil temperature sensor quality. Top oil
Temperature calculation is done using the method explained in IEC 60076-7 standard.

Inputs required for hot spot temperature calculation are:
• Transformer oil time constant
• Winding time constant
• Loss ratio at different tap positions
• Ambient temperature around the transformer

The oil and winding time constants can be calculated by the function based on transformer parameters if the inputs are not available from the transformer manufacturer.

Ambient temperature to the function can either be provided through the sensor or monthly average ambient temperature settings. This decision is made based on the ambient temperature sensor quality. Additionally, LOLSPTR function provides difference between measured value and calculated value of the top oil temperature.

Additionally, the function calculates loss of life in form of days and years. This information is updated at settable intervals, for example, hourly or daily. Transformer winding percentage loss of life is calculated every day and the information is provided as total percentage loss of life from the installation date and yearly percentage loss of life.

**Through fault monitoring PTRSTHR**
The through fault monitoring function PTRSTHR is used to monitor the mechanical stress on a transformer and place it against its designed withstand capability. During through faults, the fault-current magnitude is higher as the allowed overload current range. At low fault current magnitudes which are below the overload capability of the transformer, mechanical effects are considered less important unless the frequency of fault occurrence is high. Since through fault current magnitudes are typically closer to the extreme design capabilities of the transformer, mechanical effects are more significant than thermal effects.

For other power system objects, for example, an overhead line, this function can be used to make a log of all START and/or TRIP operations of the protection IED.

**Current harmonic monitoring CHMMHAI**
Current harmonic monitoring function CHMMHAI is used to monitor the current part of the power quality of a system. It calculates the total harmonic distortion (THD) with respect to fundamental signal amplitude, and the total demand distortion (TDD) with respect to maximum demand load current. These indices indicate the current signal quality factor.

Additionally, the function is used to calculate the numerical multiple of rated frequency harmonics amplitude and harmonic distortion up to the 5th order. It helps the user to know the predominant harmonic frequencies order and their amplitudes present in the system. The function also calculates the crest factor to indicate the effectiveness of the signal. All calculations in the harmonic monitoring function are based on IEEE 1459 and IEEE 519 standards.

The current harmonic function monitors the harmonic distortion and demand distortion values constantly. Whenever these value crosses their set limit levels, a warning signal will be initiated. If the warning signal persists continuously for the set time, an alarm signal will be generated.

**Voltage harmonic monitoring VHMMHAI**
Voltage harmonic monitoring function VHMMHAI is used to monitor the voltage part of the power quality of a system. It calculates the total harmonic distortion (THD) with respect to the fundamental signal amplitude which indicates the voltage signal quality factor.

Additionally, the function is used to calculate the numerical multiple of rated frequency harmonics amplitude and harmonic distortion up to the 5th order. It helps the user to know the predominant harmonic frequencies order and their amplitudes present in the system. The function also calculates the crest factor to indicate the effectiveness of the signal. All calculations in the harmonic monitoring function are based on IEEE 1459 and IEEE 519 standards.

The voltage harmonic function monitors the harmonic distortion value constantly. Whenever these value crosses their set limit levels, a warning signal will be initiated. If the warning signal persists continuously for the set time, an alarm signal will be generated.

16. Metering

**Pulse-counter logic PCFCNT**
Pulse-counter logic (PCFCNT) function counts externally generated binary pulses, for instance pulses coming from an external energy meter, for calculation of energy consumption values. The pulses are captured by the binary input module and then read by the PCFCNT function. A scaled service value is available over the station bus. The special Binary input module with enhanced pulse counting capabilities must be ordered to achieve this functionality.
Function for energy calculation and demand handling ETPMMTR

Power system measurement (CVMMXN) can be used to measure active as well as reactive power values. Function for energy calculation and demand handling (ETPMMTR) uses measured active and reactive power as input and calculates the accumulated active and reactive energy pulses, in forward and reverse direction. Energy values can be read or generated as pulses. Maximum demand power values are also calculated by the function. This function includes zero point clamping to remove noise from the input signal. As output of this function: periodic energy calculations, integration of energy values, calculation of energy pulses, alarm signals for limit violation of energy values and maximum power demand, can be found.

The values of active and reactive energies are calculated from the input power values by integrating them over a selected time $t_{\text{Energy}}$. The integration of active and reactive energy values will happen in both forward and reverse directions. These energy values are available as output signals and also as pulse outputs. Integration of energy values can be controlled by inputs (STARTACC and STOPACC) and EnaAcc setting and it can be reset to initial values with RSTACC input.

The maximum demand for active and reactive powers are calculated for the set time interval $t_{\text{Energy}}$ and these values are updated every minute through output channels. The active and reactive maximum power demand values are calculated for both forward and reverse direction and these values can be reset with RSTDMD input.

Figure 7. Local human-machine interface

The LHMI of the IED contains the following elements
- Graphical display capable of showing a user defined single line diagram and provide an interface for controlling switchgear.
- Navigation buttons and five user defined command buttons to shortcuts in the HMI tree or simple commands.
- 15 user defined three-color LEDs.
- Communication port for PCM600.

The LHMI is used for setting, monitoring and controlling.

17. Human machine interface

Local HMI

18. Basic IED functions

Time synchronization

The time synchronization function is used to select a common source of absolute time for the synchronization of the IED when it is a part of a protection system. This makes it possible to compare events and disturbance data between all IEDs within a station automation system and in between sub-stations. A common source shall be used for IED and merging unit when IEC/UCA 61850-9-2LE process bus communication is used. For Phasor Measurement Unit (PMU) an accurate time synchronization is essential to allow the comparison of
phasors measured at different locations in a Wide Area Monitoring System (WAMS).

Precision time protocol PTP
PTP according to IEEE 1588-2008 and specifically its profile IEC/IEEE 61850-9-3 for power utility automation is a synchronization method that can be used to maintain a common time within a station. This time can be synchronized to the global time using, for instance, a GPS receiver. If PTP is enabled on the IEDs and the switches that connect the station are compatible with IEEE 1588, the station will become synchronized to one common time with an accuracy of under 1us. Using an IED as a boundary clock between several networks will keep 1us accuracy on three levels or when using an HSR, 15 IEDs can be connected in a ring without losing a single microsecond in accuracy.

19. Ethernet

Access points
An access point is an Ethernet communication interface for single or redundant station communication. Each access point is allocated with one physical Ethernet port, two physical Ethernet ports are allocated if redundant communication is activated for the access point.

Access points diagnostics
The access point diagnostics function blocks (RCHLCCH, SCHLCCH and FRONTSTATUS) supervise communication. SCHLCCH is used for communication over the rear Ethernet ports, RCHLCCH is used for redundant communications over the rear Ethernet ports and FRONTSTATUS is used for communication over the front port. All access point function blocks include output signal for denial of service.

Redundant communication
IEC 62439-3 redundant communication PRP
Redundant communication according to IEC 62439-3 PRP-0, IEC 62439-3 PRP-1 parallel redundancy protocol (PRP) is available as an option when ordering IEDs. PRP according to IEC 62439-3 uses two optical Ethernet ports.

IEC 62439-3 High-availability seamless redundancy HSR
Redundant station bus communication according to IEC 62439-3 Edition 2 High-availability seamless redundancy (HSR) is available as an option when ordering IEDs. Redundant station bus communication according to IEC 62439-3 uses two optical Ethernet ports.

The HSR ring supports the connection of up to 30 relays. If more than 30 relays are to be connected, it is recommended to split the network into several rings to guarantee the performance for real-time applications.

Routes
A route is a specified path for data to travel between the source device in a subnetwork to the destination device in a different subnetwork. A route consists of a destination address and the address of the gateway to be used when sending data to the destination device, see Figure 9.

Communication protocols
Each IED is provided with several communication interfaces enabling it to connect to one or many substation level systems or equipment, either on the Substation Automation (SA) bus or Substation Monitoring (SM) bus.

Available communication protocols are:
- IEC 61850-8-1 communication protocol
- IEC/UCA 61850-9-2LE communication protocol
- LON communication protocol
- SPA communication protocol
- IEC 60870-5-103 communication protocol

Several protocols can be combined in the same IED.
IEC 61850-8-1 communication protocol
IEC 61850 Ed.1 or Ed.2 can be chosen by a setting in PCM600. The IED is equipped with up to six (order dependent) optical Ethernet rear ports for IEC 61850-8-1 station bus communication. The IEC 61850-8-1 communication is also possible from the electrical Ethernet front port. IEC 61850-8-1 protocol allows intelligent electrical devices (IEDs) from different vendors to exchange information and simplifies system engineering. IED-to-IED communication using GOOSE and client-server communication over MMS are supported. Disturbance recording file (COMTRADE) uploading can be done over MMS or FTP.

The front port is only intended for PCM600 communication, maintenance, training and test purposes due to risk of interference during normal operation.

IEC 61850 quality expander QUALEXP
The quality expander component is used to display the detailed quality of an IEC/UCA 61850-9-2LE analog channel. The component expands the channel quality output of a Merging Unit analog channel received in the IED as per the IEC 61850-7-3 standard. This component can be used during the ACT monitoring to get the particular channel quality of the Merging Unit.

IEC/UCA 61850-9-2LE communication protocol
Optical Ethernet port communication standard IEC/UCA 61850-9-2LE for process bus is supported. IEC/UCA 61850-9-2LE allows Non Conventional Instrument Transformers (NCIT) with Merging Units (MUs) or stand-alone MUs to exchange information with the IED, and simplifies SA engineering. IEC/UCA 61850-9-2LE uses the same port as IEC 61850-8-1.

LON communication protocol
Existing stations with ABB station bus LON can be extended with use of the optical LON interface (glass or plastic). This allows full SA functionality including peer-to-peer messaging and cooperation between the IEDs.

SPA communication protocol
A single glass or plastic port is provided for the ABB SPA protocol. This allows extensions of simple substation automation systems but the main use is for Substation Monitoring Systems SMS.

IEC 60870-5-103 communication protocol
A single glass or plastic port is provided for the IEC 60870-5-103 standard. This allows design of simple substation automation systems including equipment from different vendors. Disturbance files uploading is provided.

Measurands for IEC 60870-5-103 I103MEAS
I103MEAS is a function block that reports all valid measuring types depending on the connected signals. The set of connected inputs will control which ASDUs (Application Service Data Units) are generated.

Measurands user-defined signals for IEC 60870-5-103 I103MEASUSR
I103MEASUSR is a function block with user-defined input measurands in monitor direction. These function blocks include the FunctionType parameter for each block in the private range, and the Information number parameter for each block.

Function status auto-recloser for IEC 60870-5-103 I103AR
I103AR is a function block with defined functions for autorecloser indications in monitor direction. This block includes the FunctionType parameter, and the Information number parameter is defined for each output signal.

Function status earth-fault for IEC 60870-5-103 I103EF
I103EF is a function block with defined functions for earth fault indications in monitor direction. This block includes the FunctionType parameter; the Information number parameter is defined for each output signal.

Function status fault protection for IEC 60870-5-103 I103FLTPROT
I103FLTPROT is used for fault indications in monitor direction. Each input on the function block is specific for a certain fault type and therefore must be connected to a correspondent signal present in the configuration. For example: 68_TRGEN represents the General Trip of the device and must be connected to the general trip signal SMPPTRC_TRIP or equivalent.

IED status for IEC 60870-5-103 I103IED
I103IED is a function block with defined IED functions in monitor direction. This block uses the parameter FunctionType; the Information number parameter is defined for each input signal.

Supervision status for IEC 60870-5-103 I103SUPERV
I103SUPERV is a function block with defined functions for supervision indications in monitor direction. This block includes the FunctionType parameter; the Information number parameter is defined for each output signal.

Status for user-defined signals for IEC 60870-5-103 I103USRDEF
I103USRDEF comprises function blocks with user-defined input signals in monitor direction. These function blocks include the FunctionType parameter for each block in the private range, and the Information number parameter for each input signal.
Function commands for IEC 60870-5-103 I103CMD

I103CMD is a command function block in control direction with pre-defined output signals. The signals are in steady state, not pulsed, and stored in the IED in case of restart.

IED commands for IEC 60870-5-103 I103IEDCMD

I103IEDCMD is a command block in control direction with defined IED functions. All outputs are pulsed and they are NOT stored. Pulse-time is a hidden parameter.

Function commands user-defined for IEC 60870-5-103 I103USRCMD

I103USRCMD is a command block in control direction with user-defined output signals. These function blocks include the FunctionType parameter for each block in the private range, and the Information number parameter for each output signal.

Function commands generic for IEC 60870-5-103 I103GENCMD

I103GENCMD is used for transmitting generic commands over IEC 60870-5-103. The function has two output signals, CMD_OFF and CMD_ON, that can be used to implement double-point command schemes.

The I103GENCMD component can be configured as either 2 pulsed ON/OFF or 2 steady ON/OFF outputs. The ON output is pulsed with a command with value 2, while the OFF output is pulsed with a command with value 1. If in steady mode is ON asserted and OFF deasserted with command 2 and vice versa with command 1.

IED commands with position and select for IEC 60870-5-103 I103POSCMD

I103POSCMD has double-point position indicators that are getting the position value as an integer (for example, from the POSITION output of the SCSWI function block) and sending it over IEC 60870-5-103 (1=OPEN; 2=CLOSE). The standard does not define the use of values 0 and 3. However, when connected to a switching device, these values are transmitted.

The BLOCK input will block only the signals in monitoring direction (the position information), not the commands via IEC 60870-5-103. The SELECT input is used to indicate that the monitored apparatus has been selected (in a select-before-operate type of control).

DNP3.0 communication protocol

An electrical RS485 serial port, optical serial ports on the serial communication module (SLM), optical Ethernet ports are available for DNP3.0 communication. DNP3.0 Level 2 communication with unsolicited events, time synchronization and disturbance reporting is provided for communication to RTUs, Gateways or HMI systems.

Multiple command and transmit

When IEDs are used in Substation Automation systems with LON, SPA or IEC 60870-5-103 communication protocols, the Event and Multiple Command function blocks are used as the communication interface for vertical communication to station HMI and gateway, and as interface for horizontal peer-to-peer communication (over LON only).

21. Remote communication

Analog and binary signal transfer to remote end

Three analog and eight binary signals can be exchanged between two IEDs. This functionality is mainly used for the line differential protection. However it can be used in other products as well. An IED can communicate with up to 4 remote IEDs.

Binary signal transfer

The remote end data communication is used for the transmission of analog values for line differential protection or for the transmission of only binary signals between IEDs. The binary signals are freely configurable and can thus be used for any purpose, such as communication scheme related signals, transfer trip and/or other binary signals between IEDs.

Communication between two IEDs requires that each IED is equipped with a Line Data Communication Module (LDCM). The LDCM then acts as an interface to 64 kbit/s and 2Mbit/s communication channels for duplex communication between the IEDs. In 2Mbit/s mode, each LDCM can send and receive up to 9 analog and up to 192 binary signals simultaneously. In 64kbit/s mode, the LDCM can be configured to work in either analog mode or binary mode. In analog mode, the IED can send and receive up to 3 analog signals and up to 8 binary signals. In binary mode, the LDCM can send and receive only binary data (up to 192 binary signals).

The IED can be equipped with up to four short range, medium range or long range LDCMs.

Line data communication module, short, medium and long range LDCM

The line data communication module (LDCM) is used for communication between the IEDs situated at a distance <110 km/68 miles or from the IED to the optical-to-electrical converter with G.703 or G.703EL interface located at a distance < 3 km/1.9 miles away. The LDCM module sends and receives data to and from another.
LDCM module. The IEEE/ANSI C37.94 standard format is used.

This feature can be used, for example, in power stations to exchange up to 192 binary signals (e.g. tripping, signaling, alarming) between the generator and HV station in power plants.

**Galvanic X.21 line data communication module X.21-LDCM**
A module with built-in galvanic X.21 converter which e.g. can be connected to modems for pilot wires is also available.

**Galvanic interface G.703 resp G.703E1**
The external galvanic data communication converter G.703/G.703E1 makes an optical-to-galvanic conversion for connection to a multiplexer. These units are designed for 64 kbit/s resp 2Mbit/s operation. The converter is delivered with 19" rack mounting accessories.

### 22. Hardware description

#### Hardware modules

**Numeric processing module NUM**
The numeric processing module (NUM) is a CPU module that handles all protection functions and logic.

NUM provides up to 4 optical (type LC) or galvanic (type RJ45) Ethernet ports (one basic and three optional).

**Power supply module PSM**
The power supply module is used to provide the correct internal voltages and full isolation between the IED and the battery system. An internal fail alarm output is available.

Alternative connectors of Ring lug or Compression type can be ordered.

**Binary input module BIM**
The binary input module has 16 optically isolated inputs and is available in two versions, one standard and one with enhanced pulse counting capabilities on the inputs to be used with the pulse counter function. The binary inputs are freely programmable and can be used for the input of logical signals to any of the functions. They can also be included in the disturbance recording and event-recording functions. This enables extensive monitoring and evaluation of operation of the IED and for all associated electrical circuits.

**Binary output module BOM**
The binary output module has 24 independent output relays and is used for trip output or any signaling purpose.

**Static binary output module SOM**
The static binary output module has six fast static outputs and six change over output relays for use in applications with high speed requirements.

**Binary input/output module IOM**
The binary input/output module is used when only a few input and output channels are needed. The ten standard output channels are used for trip output or any signaling purpose. The two high speed signal output channels are used for applications where short operating time is essential. Eight optically isolated binary inputs cater for required binary input information.

**mA input module MIM**
The milli-ampere input module is used to interface transducer signals in the –20 to +20 mA range from for example OLTC position, temperature or pressure transducers. The module has six independent, galvanically separated channels.

**Optical Ethernet module**
The optical Ethernet module (OEM) provides two additional optical Ethernet ports. The port connectors are of optical (type LC) or galvanic (type RJ45) Ethernet ports.

**Serial and LON communication module (SLM) for SPA/IEC 60870-5-103, LON and DNP 3.0**
The Serial and LON communication module (SLM) is used for SPA, IEC 60870-5-103, DNP3 and LON communication. SLM has two optical communication ports for plastic/plastic, plastic/glass or glass/glass fiber cables. One port is used for serial communication (SPA, IEC 60870-5-103 or DNP3 port) and the other port is used for LON communication.

**Line data communication module LDCM**
Each module has one optical port, one for each remote end to which the IED communicates.

Alternative modules for Long range (1550 nm single mode), Medium range (1310 nm single mode) and Short range (850 nm multi mode) are available.

**Galvanic RS485 serial communication module**
The Galvanic RS485 communication module (RS485) is used for DNP3.0 and IEC 60870-5-103 communication. The module has one RS485 communication port. The RS485 is a balanced serial communication that can be used either in 2-wire or 4-wire connections. A 2-wire connection uses the same signal for RX and TX and is a multidrop communication with no dedicated Master or slave. This variant requires however a control of the output. The 4-wire connection has separated signals for
RX and TX multidrop communication with a dedicated Master and the rest are slaves. No special control signal is needed in this case.

**GPS time synchronization module GTM**
This module includes a GPS receiver used for time synchronization. The GTM has one SMA contact for connection to an antenna. It also includes an optical PPS ST-connector output.

**IRIG-B Time synchronizing module**
The IRIG-B time synchronizing module is used for accurate time synchronizing of the IED from a station clock.

The Pulse Per Second (PPS) input is supported.

Electrical (BNC) and optical connection (ST) for 0XX and 12X IRIG-B support.

**Transformer input module TRM**
The transformer input module is used to galvanically separate and adapt the secondary currents and voltages generated by the measuring transformers. The module has twelve inputs in different combinations of currents and voltage inputs. Either protection class or metering class CT inputs are available.

Alternative connectors of Ring lug or Compression type can be ordered.

**High impedance resistor unit**
The high impedance resistor unit, with resistors for pick-up value setting and a voltage dependent resistor, is available in a single phase unit and a three phase unit. Both are mounted on a 1/1 19 inch apparatus plate with compression type terminals.

**Layout and dimensions**

**Dimensions**

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**IEC08000163‐3‐en.vsdx**

Figure 10. Case with rear cover

**IEC08000165 ‐3‐en.vsdx**

Figure 11. Case with rear cover and 19" rack mounting kit
Figure 12. A 1/2 x 19” size IED side-by-side with RHGS6.

<table>
<thead>
<tr>
<th>Case size (mm)/(inches)</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>6U, 1/2 x 19”</td>
<td>265.9/</td>
<td>223.7/</td>
<td>247.5/</td>
<td>255.0/</td>
<td>205.8/</td>
<td>190.5/</td>
<td>466.5/</td>
<td>232.5/</td>
<td>482.6/</td>
</tr>
<tr>
<td></td>
<td>10.47</td>
<td>8.81</td>
<td>9.74</td>
<td>10.04</td>
<td>8.10</td>
<td>7.50</td>
<td>18.36</td>
<td>9.15</td>
<td>19</td>
</tr>
<tr>
<td>6U, 3/4 x 19”</td>
<td>265.9/</td>
<td>335.9/</td>
<td>247.5/</td>
<td>255.0/</td>
<td>318.0/</td>
<td>190.5/</td>
<td>466.5/</td>
<td>232.5/</td>
<td>482.6/</td>
</tr>
<tr>
<td></td>
<td>10.47</td>
<td>13.23</td>
<td>9.74</td>
<td>10.04</td>
<td>12.52</td>
<td>7.50</td>
<td>18.36</td>
<td>9.15</td>
<td>19</td>
</tr>
<tr>
<td>6U, 1/1 x 19”</td>
<td>265.9/</td>
<td>448.0/</td>
<td>247.5/</td>
<td>255.0/</td>
<td>430.1/</td>
<td>190.5/</td>
<td>466.5/</td>
<td>232.5/</td>
<td>482.6/</td>
</tr>
<tr>
<td></td>
<td>10.47</td>
<td>17.65</td>
<td>9.74</td>
<td>10.04</td>
<td>16.86</td>
<td>7.50</td>
<td>18.36</td>
<td>9.15</td>
<td>19</td>
</tr>
</tbody>
</table>

The G and H dimensions are defined by the 19” rack mounting kit.

Mounting alternatives
- 19” rack mounting kit
- Flush mounting kit with cut-out dimensions:
  - 1/2 case size (h) 254.3 mm/10.01” (w) 210.1 mm/8.27”
  - 1/1 case size (h) 254.3 mm/10.01” (w) 434.7 mm/17.11”
- Wall mounting kit

Injection equipment hardware

Injection unit REX060
The injection unit REX060 is used to inject voltage and current signals to the generator or motor stator and rotor circuits. REX060 generates two square wave signals with different frequencies for injection into the stator and rotor circuits respectively. The response from the injected voltage and currents are then measured by the REX060 unit and amplified to a level suitable for the analog voltage inputs of IED.

Stator injection module SIM
The SIM module is installed into the REX060 enclosure. The SIM module generates a square wave voltage signal for injection into the stator circuit via the neutral point VT/NTG. The SIM module measures the voltage and current from the injected signal and the IED consecutively calculates the stator to earth impedance. If the calculated impedance is lower than the preset value an ALARM and/or TRIP output is set.

Rotor injection module RIM
The RIM module is installed into the REX060 enclosure. The RIM module generates a square wave voltage signal for injection into the rotor circuit via a capacitor unit REX061 for isolation. The RIM module measures the...
voltage and current from the injected signal and the IED consecutively calculates the rotor to earth impedance. If the calculated impedance is lower than the preset value an ALARM and/or TRIP output is set.

**Coupling capacitor unit REX061**
REX061 isolates the injection circuit from the rotor exciter voltage.

The REX061 coupling capacitor unit grounding point and grounding brush of the rotor shaft should be properly interconnected.

**Shunt resistor unit REX062**
REX062 is typically used when injection is done via a grounding transformer.

**COMBIFLEX Injection equipment**
RXTTE4 and optional protective resistor are used to inject fundamental frequency AC voltage into the rotor circuit.
23. Connection diagrams
The connection diagrams are delivered in the IED Connectivity package as part of the product delivery.

The latest versions of the connection diagrams can be downloaded from http://www.abb.com/protection-control.

Connection diagrams for IEC Customized products
Connection diagram, 670 series 2.2 1MRK002801-AG

Connection diagrams for Configured products
Connection diagram, REG670 2.2, A20X00 1MRK002807-GA
Connection diagram, REG670 2.2, B30X00 1MRK002807-GB
Connection diagram, REG670 2.2, C30X00 1MRK002807-GC

Connection diagrams for ANSI Customized products
Connection diagram, 670 series 2.2 1MRK002802-AG

Connection diagrams for Injection equipment
Connection diagram, Injection unit REX060 1MRK002501-BA
Connection diagram, Generator protection REG670 with injection unit REX060 1MRK002504-BA
Connection diagram, Injection unit REX060 and coupling capacitor unit REX061 1MRK002504-CA
Connection diagram, Injection unit REX060 and optional shunt resistor unit REX062 1MRK002504-DA
Connection diagram, Coupling capacitor unit REX061 1MRK002551-BA
Connection diagram, Shunt resistor unit REX062 1MRK002556-BA
24. Technical data

General

**Definitions**

<table>
<thead>
<tr>
<th>Definition</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference value</td>
<td>The specified value of an influencing factor to which are referred the characteristics of the equipment</td>
</tr>
<tr>
<td>Nominal range</td>
<td>The range of values of an influencing quantity (factor) within which, under specified conditions, the equipment meets the specified requirements</td>
</tr>
<tr>
<td>Operative range</td>
<td>The range of values of a given energizing quantity for which the equipment, under specified conditions, is able to perform its intended functions according to the specified requirements</td>
</tr>
</tbody>
</table>

**Presumptions for Technical Data**

The technical data stated in this document are only valid under the following circumstances:

1. Main current transformers with 1 A or 2 A secondary rating are wired to the IED 1 A rated CT inputs.
2. Main current transformer with 5 A secondary rating are wired to the IED 5 A rated CT inputs.
3. CT and VT ratios in the IED are set in accordance with the associated main instrument transformers. Note that for functions which measure an analogue signal which do not have corresponding primary quantity the 1:1 ratio shall be set for the used analogue inputs on the IED. Example of such functions are: HZPDIF, ROTIPHIZ and STTIPHIZ.
4. Parameter $I_{Base}$ used by the tested function is set equal to the rated CT primary current.
5. Parameter $U_{Base}$ used by the tested function is set equal to the rated primary phase-to-phase voltage.
6. Parameter $S_{Base}$ used by the tested function is set equal to:
   \[ \sqrt{3} \times I_{Base} \times U_{Base} \]
7. The rated secondary quantities have the following values:
   - Rated secondary phase current $I_{r}$ is either 1 A or 5 A depending on selected TRM.
   - Rated secondary phase-to-phase voltage $U_{r}$ is within the range from 100 V to 120 V.
   - Rated secondary power for three-phase system $S_{r} = \sqrt{3} \times U_{r} \times I_{r}$
8. For operate and reset time testing, the default setting values of the function are used if not explicitly stated otherwise.
9. During testing, signals with rated frequency have been injected if not explicitly stated otherwise.
### Energizing quantities, rated values and limits

#### Analog inputs

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency</strong></td>
<td></td>
</tr>
<tr>
<td>Rated frequency $f_r$</td>
<td>50/60 Hz</td>
</tr>
<tr>
<td>Operating range</td>
<td>$f_r \pm 10%$</td>
</tr>
<tr>
<td><strong>Current inputs</strong></td>
<td></td>
</tr>
<tr>
<td>Rated current $I_r$</td>
<td>1 or 5 A</td>
</tr>
<tr>
<td>Operating range</td>
<td>$(0-100) \times I_r$</td>
</tr>
<tr>
<td>Thermal withstand</td>
<td>$100 \times I_r$ for 1 s *)</td>
</tr>
<tr>
<td></td>
<td>$30 \times I_r$ for 10 s</td>
</tr>
<tr>
<td></td>
<td>$10 \times I_r$ for 1 min</td>
</tr>
<tr>
<td></td>
<td>$4 \times I_r$ continuously</td>
</tr>
<tr>
<td>Dynamic withstand</td>
<td>$250 \times I_r$ one half wave</td>
</tr>
<tr>
<td>Burden</td>
<td>$&lt; 20$ mVA at $I_r = 1$ A</td>
</tr>
<tr>
<td></td>
<td>$&lt; 150$ mVA at $I_r = 5$ A</td>
</tr>
</tbody>
</table>

*) max. 350 A for 1 s when COMBITEST test switch is included.

| **Voltage inputs **)      |                                      |
| Rated voltage $U_r$       | 110 or 220 V                         |
| Operating range           | 0 - 340 V                            |
| Thermal withstand         | $450$ V for 10 s                     |
|                           | $420$ V continuously                 |
| Burden                    | $< 20$ mVA at $110$ V               |
|                           | $< 80$ mVA at $220$ V               |

**) all values for individual voltage inputs

Note! All current and voltage data are specified as RMS values at rated frequency.
Table 11. TRM - Energizing quantities, rated values and limits for measuring transformer

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>Frequency</td>
</tr>
<tr>
<td>Rated frequency $f_r$</td>
<td>50/60 Hz</td>
</tr>
<tr>
<td>Operating range</td>
<td>$f_r \pm 10%$</td>
</tr>
<tr>
<td>Current inputs</td>
<td></td>
</tr>
<tr>
<td>Rated current $I_r$</td>
<td>1A, 5 A</td>
</tr>
<tr>
<td>Operating range</td>
<td>$(0-1.8) \times I_r$, $(0-1.6) \times I_r$</td>
</tr>
<tr>
<td>Thermal withstand</td>
<td></td>
</tr>
<tr>
<td>80 $\times I_r$ for 1 s</td>
<td></td>
</tr>
<tr>
<td>25 $\times I_r$ for 10 s</td>
<td></td>
</tr>
<tr>
<td>10 $\times I_r$ for 1 min</td>
<td></td>
</tr>
<tr>
<td>1.8 $\times I_r$ for 30 min</td>
<td></td>
</tr>
<tr>
<td>1.1 $\times I_r$, continuously</td>
<td></td>
</tr>
<tr>
<td>Burden</td>
<td>$&lt; 200$ mVA at $I_r$, $&lt; 350$ mVA at $I_r$</td>
</tr>
<tr>
<td>Voltage inputs *)</td>
<td></td>
</tr>
<tr>
<td>Rated voltage $U_r$</td>
<td>110 or 220 V</td>
</tr>
<tr>
<td>Operating range</td>
<td>0 - 340 V</td>
</tr>
<tr>
<td>Thermal withstand</td>
<td></td>
</tr>
<tr>
<td>450 V for 10 s</td>
<td></td>
</tr>
<tr>
<td>420 V continuously</td>
<td></td>
</tr>
<tr>
<td>Burden</td>
<td>$&lt; 20$ mVA at 110 V, $&lt; 80$ mVA at 220 V</td>
</tr>
</tbody>
</table>

*) all values for individual voltage inputs

Note! All current and voltage data are specified as RMS values at rated frequency

Table 12. MIM - mA input module

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Rated value:</th>
<th>Nominal range:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input resistance</td>
<td>$R_{in} = 194$ Ohm</td>
<td></td>
</tr>
<tr>
<td>Input range</td>
<td>$\pm 5$, $\pm 10$, $\pm 20$ mA</td>
<td></td>
</tr>
<tr>
<td>0-5, 0-10, 0-20, 4-20 mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power consumption</td>
<td></td>
<td></td>
</tr>
<tr>
<td>each mA board</td>
<td>$\leq 2$ $W$</td>
<td></td>
</tr>
<tr>
<td>each mA input</td>
<td>$\leq 0.1$ $W$</td>
<td></td>
</tr>
</tbody>
</table>

Auxiliary DC voltage

Table 13. PSM - Power supply module

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Rated value:</th>
<th>Nominal range:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auxiliary DC voltage, EL (input)</td>
<td>$EL = (24-60)$ V $EL = (90-250)$ V</td>
<td>$EL \pm 20%$ $EL \pm 20%$</td>
</tr>
<tr>
<td>Power consumption</td>
<td>50 W typically</td>
<td></td>
</tr>
<tr>
<td>Auxiliary DC power in-rush</td>
<td>$&lt; 10$ A during 0.1 s</td>
<td></td>
</tr>
<tr>
<td>Supply interruption bridging time</td>
<td>$&lt; 50$ ms</td>
<td></td>
</tr>
</tbody>
</table>
### Binary inputs and outputs

#### Table 14. BIM - Binary input module

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Rated value</th>
<th>Nominal range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binary inputs</td>
<td>16</td>
<td>-</td>
</tr>
<tr>
<td>DC voltage, RL</td>
<td>24/30 V, 48/60 V, 110/125 V, 220/250 V</td>
<td>RL ±20%</td>
</tr>
<tr>
<td>Power consumption</td>
<td>24/30 V, 50 mA</td>
<td>max. 0.05 W/input</td>
</tr>
<tr>
<td></td>
<td>48/60 V, 50 mA</td>
<td>max. 0.1 W/input</td>
</tr>
<tr>
<td></td>
<td>110/125 V, 50 mA</td>
<td>max. 0.2 W/input</td>
</tr>
<tr>
<td></td>
<td>220/250 V, 110 mA</td>
<td>max. 0.5 W/input</td>
</tr>
<tr>
<td>Counter input frequency</td>
<td>10 pulses/s max</td>
<td>-</td>
</tr>
<tr>
<td>Oscillating signal discriminator</td>
<td>Blocking settable 1–40 Hz</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Release settable 1–30 Hz</td>
<td></td>
</tr>
<tr>
<td>*Debounce filter</td>
<td>Settable 1–20 ms</td>
<td></td>
</tr>
<tr>
<td>Binary input operate time</td>
<td>3 ms</td>
<td>-</td>
</tr>
<tr>
<td>(Debounce filter set to 0 ms)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: For compliance with surge immunity a debounce filter time setting of 5 ms is required.

- Maximum 176 binary input channels may be activated simultaneously with influencing factors within nominal range.
- The stated operate time for functions include the operating time for the binary inputs and outputs.

#### Table 15. BIM - Binary input module with enhanced pulse counting capabilities

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Rated value</th>
<th>Nominal range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binary inputs</td>
<td>16</td>
<td>-</td>
</tr>
<tr>
<td>DC voltage, RL</td>
<td>24/30 V, 48/60 V, 110/125 V, 220/250 V</td>
<td>RL ±20%</td>
</tr>
<tr>
<td>Power consumption</td>
<td>24/30 V, 50 mA</td>
<td>max. 0.05 W/input</td>
</tr>
<tr>
<td></td>
<td>48/60 V, 50 mA</td>
<td>max. 0.1 W/input</td>
</tr>
<tr>
<td></td>
<td>110/125 V, 50 mA</td>
<td>max. 0.2 W/input</td>
</tr>
<tr>
<td></td>
<td>220/250 V, 110 mA</td>
<td>max. 0.5 W/input</td>
</tr>
<tr>
<td>Counter input frequency</td>
<td>10 pulses/s max</td>
<td>-</td>
</tr>
<tr>
<td>Balanced counter input frequency</td>
<td>40 pulses/s max</td>
<td>-</td>
</tr>
<tr>
<td>Oscillating signal discriminator</td>
<td>Blocking settable 1–40 Hz</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Release settable 1–30 Hz</td>
<td></td>
</tr>
<tr>
<td>*Debounce filter</td>
<td>Settable 1–20 ms</td>
<td></td>
</tr>
<tr>
<td>Binary input operate time</td>
<td>3 ms</td>
<td>-</td>
</tr>
<tr>
<td>(Debounce filter set to 0 ms)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: For compliance with surge immunity a debounce filter time setting of 5 ms is required.*
Maximum 176 binary input channels may be activated simultaneously with influencing factors within nominal range.

The stated operate time for functions include the operating time for the binary inputs and outputs.

Table 16. IOM - Binary input/output module

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Rated value</th>
<th>Nominal range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binary inputs</td>
<td>8</td>
<td>-</td>
</tr>
<tr>
<td>DC voltage, RL</td>
<td>24/30 V</td>
<td>RL ±20%</td>
</tr>
<tr>
<td></td>
<td>48/60 V</td>
<td>RL ±20%</td>
</tr>
<tr>
<td></td>
<td>110/125 V</td>
<td>RL ±20%</td>
</tr>
<tr>
<td></td>
<td>220/250 V</td>
<td>RL ±20%</td>
</tr>
<tr>
<td>Power consumption</td>
<td>max. 0.05 W/input</td>
<td>-</td>
</tr>
<tr>
<td>24/30 V, 50 mA</td>
<td>max. 0.1 W/input</td>
<td></td>
</tr>
<tr>
<td>48/60 V, 50 mA</td>
<td>max. 0.2 W/input</td>
<td></td>
</tr>
<tr>
<td>110/125 V, 50 mA</td>
<td>max. 0.4 W/input</td>
<td></td>
</tr>
<tr>
<td>220/250 V, 50 mA</td>
<td>max. 0.5 W/input</td>
<td></td>
</tr>
<tr>
<td>220/250 V, 110 mA</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Counter input frequency</td>
<td>10 pulses/s max</td>
<td></td>
</tr>
<tr>
<td>Oscillating signal discriminator</td>
<td>Blocking settable 1-40 Hz</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Release settable 1-30 Hz</td>
<td></td>
</tr>
<tr>
<td>*Debounce filter</td>
<td>Settable 1-20 ms</td>
<td></td>
</tr>
<tr>
<td>Binary input operate time</td>
<td>3 ms</td>
<td>-</td>
</tr>
<tr>
<td>(Debounce filter set to 0 ms)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Note: For compliance with surge immunity a debounce filter time setting of 5 ms is required.
Maximum 176 binary input channels may be activated simultaneously with influencing factors within nominal range. The stated operate time for functions include the operating time for the binary inputs and outputs.

Table 17. IOM - Binary input/output module contact data (reference standard: IEC 61810-2)

<table>
<thead>
<tr>
<th>Function or quantity</th>
<th>Trip and signal relays</th>
<th>Fast signal relays (parallel reed relay)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binary outputs</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Max system voltage</td>
<td>250 V AC, DC</td>
<td>250 V DC</td>
</tr>
<tr>
<td>Min load voltage</td>
<td>24VDC</td>
<td>—</td>
</tr>
<tr>
<td>Test voltage across open contact, 1 min</td>
<td>1000 V rms</td>
<td>800 V DC</td>
</tr>
<tr>
<td>Current carrying capacity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per relay, continuous</td>
<td>8 A</td>
<td>8 A</td>
</tr>
<tr>
<td>Per relay, 1 s</td>
<td>10 A</td>
<td>10 A</td>
</tr>
<tr>
<td>Per process connector pin, continuous</td>
<td>12 A</td>
<td>12 A</td>
</tr>
<tr>
<td>Making capacity at inductive load with L/R &gt; 10 ms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.2 s</td>
<td>30 A</td>
<td>0.4 A</td>
</tr>
<tr>
<td>1.0 s</td>
<td>10 A</td>
<td>0.4 A</td>
</tr>
<tr>
<td>Making capacity at resistive load</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.2 s</td>
<td>30 A</td>
<td>220–250 V/0.4 A</td>
</tr>
<tr>
<td>1.0 s</td>
<td>10 A</td>
<td>110–125 V/0.4 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>48–60 V/0.2 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24–30 V/0.1 A</td>
</tr>
<tr>
<td>Breaking capacity for AC, cos φ &gt; 0.4</td>
<td>250 V/8.0 A</td>
<td>250 V/8.0 A</td>
</tr>
<tr>
<td>Breaking capacity for DC with L/R &lt; 40 ms</td>
<td>48 V/1 A</td>
<td>48 V/1 A</td>
</tr>
<tr>
<td></td>
<td>110 V/0.4 A</td>
<td>110 V/0.4 A</td>
</tr>
<tr>
<td></td>
<td>125 V/0.35 A</td>
<td>125 V/0.35 A</td>
</tr>
<tr>
<td></td>
<td>220 V/0.2 A</td>
<td>220 V/0.2 A</td>
</tr>
<tr>
<td></td>
<td>250 V/0.15 A</td>
<td>250 V/0.15 A</td>
</tr>
<tr>
<td>Maximum capacitive load</td>
<td>-</td>
<td>10 nF</td>
</tr>
<tr>
<td>Max operations with load</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>Max operations with no load</td>
<td>10000</td>
<td></td>
</tr>
<tr>
<td>Operating time</td>
<td>&lt; 6 ms</td>
<td>&lt;= 1 ms</td>
</tr>
</tbody>
</table>
Maximum 72 outputs may be activated simultaneously with influencing factors within nominal range. After 6 ms an additional 24 outputs may be activated. The activation time for the 96 outputs must not exceed 200 ms. 48 outputs can be activated during 1 s. Continued activation is possible with respect to current consumption but after 5 minutes the temperature rise will adversely affect the hardware life. Maximum two relays per BOM/IOM/SOM should be activated continuously due to power dissipation.

The stated operate time for functions include the operating time for the binary inputs and outputs.

Table 18. IOM with MOV and IOM 220/250 V, 110mA - contact data (reference standard: IEC 61810-2)

<table>
<thead>
<tr>
<th>Function or quantity</th>
<th>Trip and Signal relays</th>
<th>Fast signal relays (parallel reed relay)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binary outputs</td>
<td>IOM: 10</td>
<td>IOM: 2</td>
</tr>
<tr>
<td>Max system voltage</td>
<td>250 V AC, DC</td>
<td>250 V DC</td>
</tr>
<tr>
<td>Min load voltage</td>
<td>24VDC</td>
<td>-</td>
</tr>
<tr>
<td>Test voltage across open contact, 1 min</td>
<td>250 V rms</td>
<td>250 V rms</td>
</tr>
<tr>
<td>Current carrying capacity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per relay, continuous</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per relay, 1 s</td>
<td>8 A</td>
<td>8 A</td>
</tr>
<tr>
<td>Per process connector pin, continuous</td>
<td>10 A</td>
<td>10 A</td>
</tr>
<tr>
<td></td>
<td>12 A</td>
<td>12 A</td>
</tr>
<tr>
<td>Making capacity at inductive load with L/R &gt; 10 ms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.2 s</td>
<td>30 A</td>
<td>0.4 A</td>
</tr>
<tr>
<td>1.0 s</td>
<td>10 A</td>
<td>0.4 A</td>
</tr>
<tr>
<td>Making capacity at resistive load</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.2 s</td>
<td>30 A</td>
<td>220–250 V/0.4 A</td>
</tr>
<tr>
<td>1.0 s</td>
<td>10 A</td>
<td>110–125 V/0.4 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>48–60 V/0.2 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24–30 V/0.1 A</td>
</tr>
<tr>
<td>Making capacity for AC, cos Φ &gt; 0.4</td>
<td>250 V/8.0 A</td>
<td>250 V/8.0 A</td>
</tr>
<tr>
<td>Making capacity for DC with L/R &lt; 40 ms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>48 V/1 A</td>
<td></td>
<td>48 V/1 A</td>
</tr>
<tr>
<td>110 V/0.4 A</td>
<td></td>
<td>110 V/0.4 A</td>
</tr>
<tr>
<td>220 V/0.2 A</td>
<td></td>
<td>220 V/0.2 A</td>
</tr>
<tr>
<td>250 V/0.15 A</td>
<td></td>
<td>250 V/0.15 A</td>
</tr>
<tr>
<td>Maximum capacitive load</td>
<td>-</td>
<td>10 nF</td>
</tr>
<tr>
<td>Max operations with load</td>
<td>1000</td>
<td>-</td>
</tr>
<tr>
<td>Max operations with no load</td>
<td>10000</td>
<td>-</td>
</tr>
<tr>
<td>Operating time</td>
<td>&lt; 6 ms</td>
<td>&lt;= 1 ms</td>
</tr>
</tbody>
</table>
Maximum 72 outputs may be activated simultaneously with influencing factors within nominal range. After 6 ms an additional 24 outputs may be activated. The activation time for the 96 outputs must not exceed 200 ms. 48 outputs can be activated during 1 s. Continued activation is possible with respect to current consumption but after 5 minutes the temperature rise will adversely affect the hardware life. Maximum two relays per BOM/IOM/SOM should be activated continuously due to power dissipation.

The stated operate time for functions include the operating time for the binary inputs and outputs.

<table>
<thead>
<tr>
<th>Function of quantity</th>
<th>Static binary output trip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated voltage</td>
<td>48-60 VDC</td>
</tr>
<tr>
<td>Number of outputs</td>
<td>6</td>
</tr>
<tr>
<td>Impedance open state</td>
<td>~300 kΩ</td>
</tr>
<tr>
<td>Test voltage across open contact, 1 min</td>
<td>No galvanic separation</td>
</tr>
<tr>
<td>Current carrying capacity:</td>
<td></td>
</tr>
<tr>
<td>Continuous</td>
<td>5 A</td>
</tr>
<tr>
<td>1.0 s</td>
<td>10 A</td>
</tr>
<tr>
<td>Making capacity at capacitive load with the maximum capacitance of 0.2 μF:</td>
<td></td>
</tr>
<tr>
<td>0.2 s</td>
<td>30 A</td>
</tr>
<tr>
<td>1.0 s</td>
<td>10 A</td>
</tr>
<tr>
<td>Breaking capacity for DC with L/R ≤ 40 ms</td>
<td>48 V/1 A</td>
</tr>
<tr>
<td></td>
<td>60 V/0.75 A</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating time</td>
<td>&lt; 1 ms</td>
</tr>
</tbody>
</table>
Table 20. SOM - Static Output module data (reference standard: IEC 61810-2): Electromechanical relay outputs

<table>
<thead>
<tr>
<th>Function of quantity</th>
<th>Trip and signal relays</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max system voltage</td>
<td>250 V AC/DC</td>
</tr>
<tr>
<td>Min load voltage</td>
<td>24VDC</td>
</tr>
<tr>
<td>Number of outputs</td>
<td>6</td>
</tr>
<tr>
<td>Test voltage across open contact, 1 min</td>
<td>1000 V rms</td>
</tr>
<tr>
<td>Current carrying capacity:</td>
<td></td>
</tr>
<tr>
<td>Continuous</td>
<td>8 A</td>
</tr>
<tr>
<td>1.0 s</td>
<td>10 A</td>
</tr>
<tr>
<td>Max operations with load</td>
<td>1000</td>
</tr>
<tr>
<td>Max operations with no load</td>
<td>10000</td>
</tr>
<tr>
<td>Making capacity at capacitive load with the maximum capacitance of 0.2 μF:</td>
<td></td>
</tr>
<tr>
<td>0.2 s</td>
<td>30 A</td>
</tr>
<tr>
<td>1.0 s</td>
<td>10 A</td>
</tr>
<tr>
<td>Breaking capacity for DC with L/R ≤ 40 ms</td>
<td>48 V/1 A</td>
</tr>
<tr>
<td></td>
<td>110 V/0.4 A</td>
</tr>
<tr>
<td></td>
<td>125 V/0.35 A</td>
</tr>
<tr>
<td></td>
<td>220 V/0.2 A</td>
</tr>
<tr>
<td></td>
<td>250 V/0.15 A</td>
</tr>
<tr>
<td>Operating time</td>
<td>&lt; 6 ms</td>
</tr>
</tbody>
</table>
The stated operate time for functions include the operating time for the binary inputs and outputs.

### Table 21. BOM - Binary output module contact data (reference standard: IEC 61810-2)

<table>
<thead>
<tr>
<th>Function or quantity</th>
<th>Trip and Signal relays</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binary outputs</td>
<td>24</td>
</tr>
<tr>
<td>Max system voltage</td>
<td>250 V AC, DC</td>
</tr>
<tr>
<td>Min load voltage</td>
<td>24VDC</td>
</tr>
<tr>
<td>Test voltage across open contact, 1 min</td>
<td>1000 V rms</td>
</tr>
<tr>
<td>Current carrying capacity</td>
<td></td>
</tr>
<tr>
<td>Per relay, continuous</td>
<td>8 A</td>
</tr>
<tr>
<td>Per relay, 1 s</td>
<td>10 A</td>
</tr>
<tr>
<td>Per process connector pin, continuous</td>
<td>12 A</td>
</tr>
<tr>
<td>Max operations with load</td>
<td>1000</td>
</tr>
<tr>
<td>Max operations with no load</td>
<td>10000</td>
</tr>
<tr>
<td>Making capacity at inductive load with L/R &gt; 10 ms</td>
<td>30 A</td>
</tr>
<tr>
<td>0.2 s</td>
<td></td>
</tr>
<tr>
<td>1.0 s</td>
<td></td>
</tr>
<tr>
<td>Breaking capacity for AC, cos ϕ &gt; 0.4</td>
<td>250 V/8.0 A</td>
</tr>
<tr>
<td>Breaking capacity for DC with L/R &lt; 40 ms</td>
<td>48 V/1 A</td>
</tr>
<tr>
<td></td>
<td>110 V/0.4 A</td>
</tr>
<tr>
<td></td>
<td>125 V/0.35 A</td>
</tr>
<tr>
<td></td>
<td>220 V/0.2 A</td>
</tr>
<tr>
<td>Operating time</td>
<td>&lt; 6 ms</td>
</tr>
</tbody>
</table>

The stated operate time for functions include the operating time for the binary inputs and outputs.

### Influencing factors

### Table 22. Temperature and humidity influence

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Reference value</th>
<th>Nominal range</th>
<th>Influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient temperature, operate value</td>
<td>+20±5°C</td>
<td>-25°C to +55°C</td>
<td>0.02%/°C</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>45-75%</td>
<td>10-90%</td>
<td>-</td>
</tr>
<tr>
<td>Operative range</td>
<td>0-95%</td>
<td>0-95%</td>
<td>-</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>-</td>
<td>-40°C to +70°C</td>
<td>-</td>
</tr>
</tbody>
</table>
Table 23. Auxiliary DC supply voltage influence on functionality during operation

<table>
<thead>
<tr>
<th>Dependence on</th>
<th>Reference value</th>
<th>Within nominal range</th>
<th>Influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ripple, in DC auxiliary voltage Operative range</td>
<td>max. 2%</td>
<td>15% of EL</td>
<td>0.01%/%</td>
</tr>
<tr>
<td></td>
<td>Full wave rectified</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auxiliary voltage dependence, operate value</td>
<td>±20% of EL</td>
<td></td>
<td>0.01%/%</td>
</tr>
<tr>
<td>Interrupted auxiliary DC voltage</td>
<td>24-60 V DC ± 20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>100-250 V DC ±20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0–50 ms</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0–∞ s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restart time</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 24. Frequency influence (reference standard: IEC 60255–1)

<table>
<thead>
<tr>
<th>Dependence on</th>
<th>Within nominal range</th>
<th>Influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency dependence, operate value</td>
<td>f_r ±2.5 Hz for 50 Hz</td>
<td>±1.0%/Hz</td>
</tr>
<tr>
<td></td>
<td>f_r ±3.0 Hz for 60 Hz</td>
<td></td>
</tr>
<tr>
<td>Frequency dependence for distance protection operate value</td>
<td>f_r ±2.5 Hz for 50 Hz</td>
<td>±2.0%/Hz</td>
</tr>
<tr>
<td></td>
<td>f_r ±3.0 Hz for 60 Hz</td>
<td></td>
</tr>
<tr>
<td>Harmonic frequency dependence (20% content)</td>
<td>2nd, 3rd and 5th harmonic of f_r</td>
<td>±2.0%</td>
</tr>
<tr>
<td>Harmonic frequency dependence for distance protection (10% content)</td>
<td>2nd, 3rd and 5th harmonic of f_r</td>
<td>±10.0%</td>
</tr>
<tr>
<td>Harmonic frequency dependence for high impedance differential protection (10% content)</td>
<td>2nd, 3rd and 5th harmonic of f_r</td>
<td>±10.0%</td>
</tr>
<tr>
<td>Harmonic frequency dependence for overcurrent protection</td>
<td>2nd, 3rd and 5th harmonic of f_r</td>
<td>±3.0%</td>
</tr>
</tbody>
</table>

Type tests according to standards
### Table 25. Electromagnetic compatibility

<table>
<thead>
<tr>
<th>Test</th>
<th>Type test values</th>
<th>Reference standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 MHz burst disturbance</td>
<td>2.5 kV</td>
<td>IEC 60255-26</td>
</tr>
<tr>
<td>100 kHz slow damped oscillatory wave immunity test</td>
<td>2.5 kV</td>
<td>IEC 61000-4-18, Level 3</td>
</tr>
<tr>
<td>Ring wave immunity test, 100 kHz</td>
<td>2-4 kV</td>
<td>IEC 61000-4-12, Level 4</td>
</tr>
<tr>
<td>Electrostatic discharge Direct application</td>
<td>15 kV air discharge</td>
<td>IEC 60255-26</td>
</tr>
<tr>
<td>Direct application</td>
<td>8 kV contact discharge</td>
<td>IEC 61000-4-2, Level 4</td>
</tr>
<tr>
<td>Indirect application</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrostatic discharge Direct application</td>
<td>15 kV air discharge</td>
<td>IEEE/ANSI C37.90.3</td>
</tr>
<tr>
<td>Direct application</td>
<td>8 kV contact discharge</td>
<td></td>
</tr>
<tr>
<td>Indirect application</td>
<td>8 kV contact discharge</td>
<td></td>
</tr>
<tr>
<td>Fast transient disturbance</td>
<td>4 kV</td>
<td>IEC 60255-26, Zone A</td>
</tr>
<tr>
<td></td>
<td>2 kV, SFP galvanic RJ45</td>
<td>IEC 60255-26, Zone B</td>
</tr>
<tr>
<td></td>
<td>2 kV, MiM mA-inputs</td>
<td></td>
</tr>
<tr>
<td>Surge immunity test</td>
<td>2-4 kV, 1.2/50μs high energy</td>
<td>IEC 60255-26, Zone A</td>
</tr>
<tr>
<td></td>
<td>1-2 kV, BOM and IRF outputs</td>
<td>IEC 60255-26, Zone A</td>
</tr>
<tr>
<td>Power frequency immunity test</td>
<td>150-300 V, 50 Hz</td>
<td>IEC 60255-26, Zone A</td>
</tr>
<tr>
<td>Conducted common mode immunity test</td>
<td>30-3 V, 15-150 Hz</td>
<td>IEC 61000-4-16, Level 4</td>
</tr>
<tr>
<td>Power frequency magnetic field test</td>
<td>1000 A/m, 3 s</td>
<td>IEC 61000-4-8, Level 5</td>
</tr>
<tr>
<td></td>
<td>100 A/m, cont.</td>
<td></td>
</tr>
<tr>
<td>Pulse magnetic field immunity test</td>
<td>1000 A/m</td>
<td>IEC 61000–4–9, Level 5</td>
</tr>
<tr>
<td>Damped oscillatory magnetic field test</td>
<td>100 A/m</td>
<td>IEC 61000-4-10, Level 5</td>
</tr>
<tr>
<td>Radiated electromagnetic field disturbance</td>
<td>20 V/m</td>
<td>IEC 60255-26</td>
</tr>
<tr>
<td></td>
<td>80-1000 MHz</td>
<td>IEEE/ANSI C37.90.2</td>
</tr>
<tr>
<td></td>
<td>1.4-2.7 GHz</td>
<td>EN 50121-5</td>
</tr>
<tr>
<td></td>
<td>10 V/m, 2.7-6.0 GHz</td>
<td></td>
</tr>
<tr>
<td>Radiated emission</td>
<td>30-6000 MHz</td>
<td>IEC 60255-26</td>
</tr>
<tr>
<td></td>
<td>30-8500 MHz</td>
<td>IEEE/ANSI C63.4, FCC</td>
</tr>
<tr>
<td>Conducted emission</td>
<td>0.15-30 MHz</td>
<td>IEC 60255-26</td>
</tr>
</tbody>
</table>

### Table 26. Insulation

<table>
<thead>
<tr>
<th>Test</th>
<th>Type test values</th>
<th>Reference standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dielectric test</td>
<td>2.0 kV AC, 1 min.</td>
<td>IEC 60255-27</td>
</tr>
<tr>
<td></td>
<td>1.0 kV AC, 1 min.:</td>
<td>ANSI C37.90</td>
</tr>
<tr>
<td></td>
<td>-SFP galvanic RJ45</td>
<td>IEEE 802.3-2015, Environment A</td>
</tr>
<tr>
<td></td>
<td>-X.21-LDCM</td>
<td></td>
</tr>
<tr>
<td>Impulse voltage test</td>
<td>5 kV, 1.2/50μs, 0.5 J</td>
<td>IEC 60255-27</td>
</tr>
<tr>
<td></td>
<td>1 kV, 1.2/50 μs 0.5 J</td>
<td>ANSI C37.90</td>
</tr>
<tr>
<td></td>
<td>-SFP galvanic RJ45</td>
<td>IEEE 802.3-2015, Environment A</td>
</tr>
<tr>
<td></td>
<td>-X.21-LDCM</td>
<td></td>
</tr>
<tr>
<td>Insulation resistance</td>
<td>&gt; 100 MΩ at 500 VDC</td>
<td></td>
</tr>
</tbody>
</table>
### Table 27. Environmental tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Type test value</th>
<th>Reference standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold operation test</td>
<td>Test Ad for 16 h at -25°C</td>
<td>IEC 60068-2-1</td>
</tr>
<tr>
<td>Cold storage test</td>
<td>Test Ab for 16 h at -40°C</td>
<td>IEC 60068-2-1</td>
</tr>
<tr>
<td>Dry heat operation test</td>
<td>Test Bd for 16 h at +70°C</td>
<td>IEC 60068-2-2</td>
</tr>
<tr>
<td>Dry heat storage test</td>
<td>Test Bb for 16 h at +85°C</td>
<td>IEC 60068-2-2</td>
</tr>
<tr>
<td>Change of temperature test</td>
<td>Test Nb for 5 cycles at -25°C to +70°C</td>
<td>IEC 60068-2-14</td>
</tr>
<tr>
<td>Damp heat test, steady state</td>
<td>Test Ca for 10 days at +40°C and humidity 93%</td>
<td>IEC 60068-2-78</td>
</tr>
<tr>
<td>Damp heat test, cyclic</td>
<td>Test Db for 6 cycles at +25 to +55°C and humidity 93 to 95% (1 cycle = 24 hours)</td>
<td>IEC 60068-2-30</td>
</tr>
</tbody>
</table>

### Table 28. CE compliance

<table>
<thead>
<tr>
<th>Test</th>
<th>According to</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electromagnetic compatibility (EMC)</td>
<td>EN 60255–26</td>
</tr>
<tr>
<td>Low voltage (LVD)</td>
<td>EN 60255–27</td>
</tr>
</tbody>
</table>

### Table 29. Mechanical tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Type test values</th>
<th>Reference standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vibration response test</td>
<td>Class II: Rack mount</td>
<td>IEC 60255-21-1</td>
</tr>
<tr>
<td></td>
<td>Class I: Flush and wall mount</td>
<td></td>
</tr>
<tr>
<td>Vibration endurance test</td>
<td>Class I: Rack, flush and wall mount</td>
<td>IEC 60255-21-1</td>
</tr>
<tr>
<td>Shock response test</td>
<td>Class I: Rack, flush and wall mount</td>
<td>IEC 60255-21-2</td>
</tr>
<tr>
<td>Shock withstand test</td>
<td>Class I: Rack, flush and wall mount</td>
<td>IEC 60255-21-2</td>
</tr>
<tr>
<td>Bump test</td>
<td>Class I: Rack, flush and wall mount</td>
<td>IEC 60255-21-2</td>
</tr>
<tr>
<td>Seismic test</td>
<td>Class II: Rack mount</td>
<td>IEC 60255-21-3</td>
</tr>
<tr>
<td></td>
<td>Class I: Flush and wall mount</td>
<td></td>
</tr>
</tbody>
</table>
## Injection equipment

### Table 30. Electromagnetic compatibility tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Type test values</th>
<th>Reference standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 MHz burst disturbance</td>
<td>2.5 kV</td>
<td>IEC 60255-26</td>
</tr>
<tr>
<td>100 kHz slow damped oscillatory wave immunity test</td>
<td>2.5 kV</td>
<td>IEC 61000-4-18, Class III</td>
</tr>
<tr>
<td>Electrostatic discharge</td>
<td>15 kV air discharge</td>
<td>IEC 60255-26</td>
</tr>
<tr>
<td>Direct application</td>
<td>8 kV contact discharge</td>
<td>IEC 61000-4-2, Class IV</td>
</tr>
<tr>
<td>Indirect application</td>
<td>8 kV contact discharge</td>
<td></td>
</tr>
<tr>
<td>Electrostatic discharge</td>
<td>15 kV air discharge</td>
<td>IEEE/ANSI C37.90.3</td>
</tr>
<tr>
<td>Direct application</td>
<td>8 kV contact discharge</td>
<td></td>
</tr>
<tr>
<td>Indirect application</td>
<td>8 kV contact discharge</td>
<td></td>
</tr>
<tr>
<td>Fast transient disturbance test</td>
<td>4 kV</td>
<td>IEC 60255-26, Zone A</td>
</tr>
<tr>
<td>Surge immunity test</td>
<td>1-2 kV, and 2-4 kV, 1.2/50 µs High energy</td>
<td>IEC 60255-26, Zone A</td>
</tr>
<tr>
<td>Power frequency immunity test</td>
<td>150-300 V, 50 Hz</td>
<td>IEC 60255-26, Zone A</td>
</tr>
<tr>
<td>Power frequency magnetic field test</td>
<td>1000 A/m, 3 s</td>
<td>IEC 61000-4-8</td>
</tr>
<tr>
<td>100 A/m, cont.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radiated electromagnetic field disturbance test</td>
<td>20 V/m, 80-1000 MHz 1.4-2.7 GHz</td>
<td>IEC 60255-26</td>
</tr>
<tr>
<td>Radiated electromagnetic field disturbance test</td>
<td>20 V/m, 80-1000 MHz</td>
<td>IEEE/ANSI C37.90.2</td>
</tr>
<tr>
<td>Conducted electromagnetic field disturbance test</td>
<td>10 V, 0.15-80 MHz</td>
<td>IEC 60255-26</td>
</tr>
<tr>
<td>Voltage dips and short interruptions</td>
<td>Dips: 40% /200 ms 70% /500 ms Interruptions: 0-50 ms: No restart 0... = s: Correct behaviour at power down</td>
<td>IEC 60255-26</td>
</tr>
<tr>
<td>Radiated emission</td>
<td>30-1000 MHz</td>
<td>IEC 60255-26</td>
</tr>
<tr>
<td>Conducted emission</td>
<td>0.15-30 MHz</td>
<td>IEC 60255-26</td>
</tr>
</tbody>
</table>

### Table 31. Insulation tests, REX060, REX062 and REG670

<table>
<thead>
<tr>
<th>Test</th>
<th>Type test values</th>
<th>Reference standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dielectric test</td>
<td>2.0 kV AC, 1 min</td>
<td>IEC 60255-27</td>
</tr>
<tr>
<td>Impulse voltage test</td>
<td>5.0 kV, 1.2/50 µs, 0.5 J</td>
<td>IEC 60255-27</td>
</tr>
<tr>
<td>Insulation resistance</td>
<td>&gt;100 MΩ at 500V DC</td>
<td>IEC 60255-27</td>
</tr>
</tbody>
</table>
### Table 32. Insulation tests, REX061

<table>
<thead>
<tr>
<th>Test</th>
<th>Type test values</th>
<th>Reference standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dielectric test</td>
<td>7.48 kV DC, 1 min (connections to rotor)</td>
<td>IEEE 421.3</td>
</tr>
<tr>
<td></td>
<td>2.8 kV DC, 1 min</td>
<td>IEC 60255-27</td>
</tr>
<tr>
<td>Impulse voltage test</td>
<td>12.0 kV, 1.2/50 µs, 0.5 J (connections to rotor)</td>
<td>IEC 60664-1</td>
</tr>
<tr>
<td></td>
<td>5.0 kV, 1.2/50 µs, 0.5 J</td>
<td>IEC 60255-27</td>
</tr>
<tr>
<td>Insulation resistance</td>
<td>&gt;100 MΩ at 500V DC</td>
<td>IEC 60255-27</td>
</tr>
</tbody>
</table>

### Table 33. Mechanical tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Type test value</th>
<th>Reference standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vibration response test</td>
<td>Class 2</td>
<td>IEC 60255-21-1</td>
</tr>
<tr>
<td>Vibration endurance test</td>
<td>Class 1</td>
<td>IEC 60255-21-1</td>
</tr>
<tr>
<td></td>
<td>Class 2</td>
<td></td>
</tr>
<tr>
<td>Shock response test</td>
<td>Class 1</td>
<td>IEC 60255-21-2</td>
</tr>
<tr>
<td></td>
<td>Class 2</td>
<td></td>
</tr>
<tr>
<td>Shock withstand test</td>
<td>Class 1</td>
<td>IEC 60255-21-2</td>
</tr>
<tr>
<td></td>
<td>Class 2</td>
<td></td>
</tr>
<tr>
<td>Bump test</td>
<td>Class 1</td>
<td>IEC 60255-21-2</td>
</tr>
<tr>
<td></td>
<td>Class 2</td>
<td></td>
</tr>
<tr>
<td>Seismic test</td>
<td>Class 2</td>
<td>IEC 60255-21-3</td>
</tr>
<tr>
<td></td>
<td>Class 2 extended</td>
<td></td>
</tr>
</tbody>
</table>

### Table 34. Environmental tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Type test value</th>
<th>Reference standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold test operation storage</td>
<td>16 h at -25°C</td>
<td>IEC 60068-2-1</td>
</tr>
<tr>
<td></td>
<td>16 h at -40°C</td>
<td></td>
</tr>
<tr>
<td>Dry heat test operation storage</td>
<td>16 h at +70°C</td>
<td>IEC 60068-2-2</td>
</tr>
<tr>
<td></td>
<td>16 h at +85°C</td>
<td></td>
</tr>
<tr>
<td>Damp heat test steady state</td>
<td>240 h at +40°C, humidity 93%</td>
<td>IEC 60068-2-78</td>
</tr>
<tr>
<td></td>
<td>6 cycles at +25 to +55°C, humidity 93-95%</td>
<td></td>
</tr>
<tr>
<td>Cyclic</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

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### Table 35. Auxiliary DC supply voltage influence

<table>
<thead>
<tr>
<th>Test</th>
<th>Type test values</th>
<th>Influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auxiliary voltage dependence, operate value</td>
<td>±20% of EL</td>
<td>0.01%/%</td>
</tr>
<tr>
<td>Ripple in DC auxiliary voltage, operate value</td>
<td>15% of EL</td>
<td>0.01%/%</td>
</tr>
</tbody>
</table>

### Table 36. Temperature influence

<table>
<thead>
<tr>
<th>Test</th>
<th>Type test values</th>
<th>Influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient temperature, operate value</td>
<td>-25°C to +55°C</td>
<td>0.02%/°C</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>-40°C to +85°C</td>
<td>-</td>
</tr>
</tbody>
</table>

### Table 37. Degree of protection

<table>
<thead>
<tr>
<th>Description</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>REX060</td>
<td></td>
</tr>
<tr>
<td>Front</td>
<td>IP40</td>
</tr>
<tr>
<td>Panel mounted, front</td>
<td>IP54</td>
</tr>
<tr>
<td>Rear, sides, top, bottom and connection terminals</td>
<td>IP20</td>
</tr>
<tr>
<td>REX061 and REX062</td>
<td></td>
</tr>
<tr>
<td>Top</td>
<td>IP41</td>
</tr>
<tr>
<td>Front, rear, sides and bottom</td>
<td>IP20</td>
</tr>
</tbody>
</table>
## Differential protection

Table 38. Generator differential protection GENPDIF

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unrestrained differential current limit</td>
<td>(1-50)p.u. of I_{Base}</td>
<td>±1.0% of set value</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&gt; 95%</td>
<td></td>
</tr>
<tr>
<td>Minimum pickup</td>
<td>(0.05–1.00)p.u. of I_{Base}</td>
<td>±1.0% of I_r</td>
</tr>
<tr>
<td>Negative sequence current level</td>
<td>(0.02–0.20)p.u. of I_{Base}</td>
<td>±1.0% of I_r</td>
</tr>
<tr>
<td>Operate time at 0 to 2 x I_{dMin} restrained function</td>
<td>Min. = 25 ms Max. = 35 ms</td>
<td>-</td>
</tr>
<tr>
<td>Reset time at 2 x I_{dMin} to 0 restrained function</td>
<td>Min. = 10 ms Max. = 25 ms</td>
<td>-</td>
</tr>
<tr>
<td>Operate time at 0 to 5 x I_{dUnre} unrestrained function</td>
<td>Min. = 5 ms Max. = 15 ms</td>
<td>-</td>
</tr>
<tr>
<td>Reset time at 5 x I_{dUnre} to 0 unrestrained function</td>
<td>Min. = 15 ms Max. = 30 ms</td>
<td>-</td>
</tr>
<tr>
<td>Critical impulse time, unrestrained function</td>
<td>2 ms typically at 0 to 5 x I_{dUnre}</td>
<td>-</td>
</tr>
<tr>
<td>Impulse margin time unrestrained function</td>
<td>10 ms typically</td>
<td>-</td>
</tr>
<tr>
<td>Operate time at 0 to 5 x I_{MinNegSeq} Negative sequence unrestrained function</td>
<td>Min. = 25 ms Max. = 35 ms</td>
<td>-</td>
</tr>
<tr>
<td>Reset time at 5 x I_{MinNegSeq} to 0 Negative sequence unrestrained function</td>
<td>Min. = 30 ms Max. = 45 ms</td>
<td>-</td>
</tr>
<tr>
<td>Function</td>
<td>Range or value</td>
<td>Accuracy</td>
</tr>
<tr>
<td>-------------------------------------------------</td>
<td>---------------------------------------------------------------</td>
<td>---------------------------------------</td>
</tr>
<tr>
<td>Operating characteristic</td>
<td>Adaptable</td>
<td>±1.0% of Ir at I ≤ Ir</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±1.0% of I at I &gt; Ir</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&gt; 90%</td>
<td>-</td>
</tr>
<tr>
<td>Unrestrained differential current limit</td>
<td>(100-5000)% of I\text{Base} on high voltage winding</td>
<td>±1.0% of set value</td>
</tr>
<tr>
<td>Minimum pickup</td>
<td>(10-60)% of I\text{Base}</td>
<td>±1.0% of Ir</td>
</tr>
<tr>
<td>Second harmonic blocking</td>
<td>(5.0-100.0)% of fundamental differential current</td>
<td>±1.0% of I</td>
</tr>
<tr>
<td></td>
<td>Note: fundamental magnitude = 100% of I\text{r}</td>
<td></td>
</tr>
<tr>
<td>Fifth harmonic blocking</td>
<td>(5.0-100.0)% of fundamental differential current</td>
<td>±15.0% of I</td>
</tr>
<tr>
<td></td>
<td>Note: fundamental magnitude = 100% of I\text{r}</td>
<td></td>
</tr>
<tr>
<td>Connection type for each of the windings</td>
<td>Y or D</td>
<td>-</td>
</tr>
<tr>
<td>Phase displacement between high voltage winding</td>
<td>0–11</td>
<td>-</td>
</tr>
<tr>
<td>W1 and each of the windings, W2 and W3. Hour notation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Operate time at 0 to 10 x I\text{dMin},</td>
<td>Min. = 25 ms</td>
<td>-</td>
</tr>
<tr>
<td>restrained function</td>
<td>Max. = 35 ms</td>
<td></td>
</tr>
<tr>
<td>*Reset time at 10 x I\text{dMin} to 0,</td>
<td>Min. = 5 ms</td>
<td>-</td>
</tr>
<tr>
<td>restrained function</td>
<td>Max. = 15 ms</td>
<td></td>
</tr>
<tr>
<td>*Operate time at 0 to 10 x I\text{dunre},</td>
<td>Min. = 5 ms</td>
<td>-</td>
</tr>
<tr>
<td>unrestrained function</td>
<td>Max. = 15 ms</td>
<td></td>
</tr>
<tr>
<td>*Reset time at 10 x I\text{dunre} to 0,</td>
<td>Min. = 15 ms</td>
<td>-</td>
</tr>
<tr>
<td>unrestrained function</td>
<td>Max. = 35 ms</td>
<td></td>
</tr>
<tr>
<td>**Operate time, unrestrained negative sequence</td>
<td>Min. = 10 ms</td>
<td>-</td>
</tr>
<tr>
<td>function</td>
<td>Max. = 20 ms</td>
<td></td>
</tr>
<tr>
<td>**Reset time, unrestrained negative sequence</td>
<td>Min. = 10 ms</td>
<td>-</td>
</tr>
<tr>
<td>function</td>
<td>Max. = 30 ms</td>
<td></td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>2 ms typically at 0 to 5 x I\text{dMin}</td>
<td>-</td>
</tr>
</tbody>
</table>

*Note: Data obtained with single three-phase input current group. The operate and reset times for T2WPDIF/T3WPDIF are valid for an static output from SOM.

**Note: Data obtained with two three-phase input current groups. The rated symmetrical currents are applied on both sides as pre- and after-fault currents. The fault is performed by increasing one phase current to double on one side and decreasing same phase current to zero on the other side.
<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating characteristic</td>
<td>Adaptable</td>
<td>±1.0% of ( I_r ) at ( I \leq I_r )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±1.0% of ( I ) at ( I &gt; I_r )</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&gt; 95%</td>
<td>-</td>
</tr>
<tr>
<td>Minimum pickup, ( I_{dMin} )</td>
<td>(4.0-100.0)% of ( I_{Base} )</td>
<td>±1.0% of ( I )</td>
</tr>
<tr>
<td>Directional characteristic</td>
<td>Fixed 180 degrees or ±60 to ±90</td>
<td>±2.0 degrees</td>
</tr>
<tr>
<td>degrees</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operate time, trip at 0 to 10 x ( I_{dMin} )</td>
<td>Min. = 15 ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max. = 30 ms</td>
<td></td>
</tr>
<tr>
<td>Reset time, trip at 10 x ( I_{dMin} ) to 0</td>
<td>Min. = 15 ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max. = 30 ms</td>
<td></td>
</tr>
<tr>
<td>Second harmonic blocking</td>
<td>40.0% of fundamental</td>
<td>±1.0% of ( I )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate voltage</td>
<td>((10-900)\ V ) ( \frac{I}{U/R} )</td>
<td>±1.0% of ( I ) at ( I \leq I_r )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±1.0% of ( I ) at ( I &gt; I_r )</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&gt;95% at ((30-900)\ V )</td>
<td>-</td>
</tr>
<tr>
<td>Maximum continuous power</td>
<td>( U&gt;Trip^2/SeriesResistor \leq 200 ) W</td>
<td>-</td>
</tr>
<tr>
<td>Operate time at 0 to 10 x ( U_d )</td>
<td>Min. = 5 ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max. = 15 ms</td>
<td></td>
</tr>
<tr>
<td>Reset time at 10 x ( U_d ) to 0</td>
<td>Min. = 75 ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max. = 95 ms</td>
<td></td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>2 ms typically at 0 to 10 x ( U_d )</td>
<td>-</td>
</tr>
<tr>
<td>Operate time at 0 to 2 x ( U_d )</td>
<td>Min. = 25 ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max. = 35 ms</td>
<td></td>
</tr>
<tr>
<td>Reset time at 2 x ( U_d ) to 0</td>
<td>Min. = 50 ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max. = 70 ms</td>
<td></td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>15 ms typically at 0 to 2 x ( U_d )</td>
<td>-</td>
</tr>
</tbody>
</table>
### Impedance protection

**Table 42. Full-scheme distance protection, Mho characteristic ZMHPDIS**

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of zones, Ph-E</td>
<td>Max 4 with selectable direction</td>
<td></td>
</tr>
<tr>
<td>Minimum operate current</td>
<td>(10–30)% of IBase</td>
<td></td>
</tr>
<tr>
<td>Positive sequence impedance, Ph-E loop</td>
<td>(0.005–3000.000) Ω/phase</td>
<td>±2.0% static accuracy</td>
</tr>
<tr>
<td>Conditions:</td>
<td>Voltage range: (0.1-1.1) x U&lt;sub&gt;r&lt;/sub&gt;</td>
<td></td>
</tr>
<tr>
<td>Positive sequence impedance angle, Ph-E loop</td>
<td>(10–90) degrees</td>
<td></td>
</tr>
<tr>
<td>Reverse reach, Ph-E loop (Magnitude)</td>
<td>(0.005–3000.000) Ω/phase</td>
<td></td>
</tr>
<tr>
<td>Magnitude of earth return compensation factor KN</td>
<td>(0.00–3.00)</td>
<td></td>
</tr>
<tr>
<td>Angle for earth compensation factor KN</td>
<td>(-180–180) degrees</td>
<td></td>
</tr>
<tr>
<td>Dynamic overreach</td>
<td>&lt;5% at 85 degrees measured with CVT’s and 0.5&lt;SIR&lt;30</td>
<td></td>
</tr>
<tr>
<td>Definite time delay Ph-Ph and Ph-E operation</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±60 ms whichever is greater</td>
</tr>
<tr>
<td>Operate time</td>
<td>22 ms typically</td>
<td>IEC 60255-121</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>105% typically</td>
<td>-</td>
</tr>
<tr>
<td>Reset time at 0.5 x Zreach to 1.5 x Zreach</td>
<td>Min. = 30 ms Max. = 50 ms</td>
<td>-</td>
</tr>
</tbody>
</table>
Table 43. High speed distance protection ZMFPDIS, ZMFCPDIS

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of zones</td>
<td>3 selectable directions, 3 fixed directions</td>
<td></td>
</tr>
<tr>
<td>Minimum operate current, Ph-Ph and Ph-E</td>
<td>(5-6000)% of IBase</td>
<td>±1.0% of Ii</td>
</tr>
<tr>
<td>Positive sequence reactance reach, Ph-E and Ph-Ph loop</td>
<td>(0.01 - 3000.00) ohm/p</td>
<td>Pseudo continuous ramp: ±2.0% of set value Conditions: Voltage range: (1.0-1.1) x Ui, Current range: (0.5-30) x Ii, Angle: At 0 degrees and 85 degrees IEC 60255-121 points A,B,C,D,E</td>
</tr>
<tr>
<td>Positive sequence resistance reach, Ph-E and Ph-Ph loop</td>
<td>(0.00 - 1000.00) ohm/p</td>
<td></td>
</tr>
<tr>
<td>Zero sequence reactance reach</td>
<td>(0.01 - 9000.00) ohm/p</td>
<td></td>
</tr>
<tr>
<td>Zero sequence resistive reach</td>
<td>(0.00 - 3000.00) ohm/p</td>
<td></td>
</tr>
<tr>
<td>Fault resistance reach, Ph-E and Ph-Ph</td>
<td>(0.01 - 9000.00) ohm/I</td>
<td></td>
</tr>
<tr>
<td>Dynamic overreach</td>
<td>&lt; 5% at 85 degrees measured with CVTs and 0.5 &lt; SIR &lt; 30, IEC 60255-121</td>
<td>-</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>105% typically</td>
<td>-</td>
</tr>
<tr>
<td>Directional blinders</td>
<td>Forward: -15 – 120 degrees Reverse: 165 – -60 degrees</td>
<td>Pseudo continuous ramp: ±2.0 degrees, IEC 60255-121</td>
</tr>
<tr>
<td>Resistance determining the load impedance area - forward</td>
<td>(0.01 - 5000.00) ohm/p</td>
<td>Pseudo continuous ramp: ±2.0% of set value Conditions: Tested at ArgLd = 30 degrees</td>
</tr>
<tr>
<td>Angle determining the load impedance area</td>
<td>5 - 70 degrees</td>
<td>Pseudo continuous ramp: ±2.0 degrees Conditions: Tested at RLdFw = 20 ohm/p</td>
</tr>
<tr>
<td>Definite time delay to trip, Ph-E and Ph-Ph operation</td>
<td>(0.000-60.000) s</td>
<td>±0.2% of set value or ±35 ms whichever is greater</td>
</tr>
<tr>
<td>Operate time</td>
<td>16 ms typically, IEC 60255-121</td>
<td></td>
</tr>
<tr>
<td>Reset time at 0.1 to 2 x Zreach</td>
<td>Min. = 20 ms Max. = 35 ms</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 44. Pole slip protection PSPPPAM

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impedance reach</td>
<td>(0.00 - 1000.00)% of Zbase</td>
<td>±2.0% of U/I</td>
</tr>
<tr>
<td>Zone 1 and Zone 2 trip counters</td>
<td>(1 - 20)</td>
<td>-</td>
</tr>
</tbody>
</table>
### Table 45. Out-of-step protection OOSPPAM

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impedance reach</td>
<td>(0.00 - 1000.00)% of Zbase</td>
<td>±2.0% of (U_r/(V/3 \cdot I_r))</td>
</tr>
<tr>
<td>Rotor start angle</td>
<td>(90.0 - 130.0) degrees</td>
<td>±5.0 degrees</td>
</tr>
<tr>
<td>Rotor trip angle</td>
<td>(15.0 - 90.0) degrees</td>
<td>±5.0 degrees</td>
</tr>
<tr>
<td>Zone 1 and Zone 2 trip counters</td>
<td>(1 - 20)</td>
<td>-</td>
</tr>
</tbody>
</table>

### Table 46. Loss of excitation LEXPDIS

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>X offset of Mho top point for zone 1 and zone 2</td>
<td>(–100.0–100.0)% of Z(_{Base})</td>
<td>±2.0% of (U_r/(V/3 \cdot I_r))</td>
</tr>
<tr>
<td>Diameter of Mho circle for zone 1 and zone 2</td>
<td>(30.0–300.0)% of Z(_{Base})</td>
<td>±2.0% of (U_r/(V/3 \cdot I_r))</td>
</tr>
<tr>
<td>Independent time delay for zone 1 when impedance jumps from the outside the set circle to the center of the set circle</td>
<td>(0.00-60.00) s</td>
<td>±0.2% or ±60 ms whichever is greater</td>
</tr>
<tr>
<td>Independent time delay for zone 2 when impedance jumps from the outside the set circle to the center of the set circle</td>
<td>(0.00-60.00) s</td>
<td>±0.2% or ±60 ms whichever is greater</td>
</tr>
<tr>
<td>Operate time, start when impedance jumps from the outside the set circle to the center of the set circle</td>
<td>Min. = 35 ms Max. = 50 ms</td>
<td>-</td>
</tr>
</tbody>
</table>

### Table 47. ROTIPHIZ technical data

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fault resistance sensitivity</td>
<td>Can be reached at steady state operating condition of the machine</td>
<td>500 kΩ</td>
</tr>
<tr>
<td></td>
<td>Typically</td>
<td>20 - 50 kΩ</td>
</tr>
<tr>
<td>Injection frequency</td>
<td>(75.000 - 250.000) Hz</td>
<td>±0.1 Hz</td>
</tr>
<tr>
<td>Trip limit of fault resistance</td>
<td>(100 - 100000)Ω</td>
<td>5% of 1 kΩ at (R_f \leq 1) kΩ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5% of set value at 1 kΩ &lt; (R_f \leq 20) kΩ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10% of set value at (R_f &gt; 20) kΩ</td>
</tr>
<tr>
<td>Alarm limit of fault resistance</td>
<td>(100 - 1000000)Ω</td>
<td>5% of 1 kΩ at (R_f \leq 1) kΩ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5% of 10 kΩ at 1 kΩ &lt; (R_f \leq 20) kΩ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10% of set value at 20 kΩ &lt; (R_f \leq 200) kΩ</td>
</tr>
<tr>
<td>Operate time, start at (R_f \sim 0) Ω and filter length = 1 s</td>
<td>1.00 s typically</td>
<td>-</td>
</tr>
<tr>
<td>Operate time, trip at (R_f \sim 0) Ω and filter length = 1 s</td>
<td>3.00 s typically</td>
<td>-</td>
</tr>
<tr>
<td>Alarm time delay at (R_f \sim 0) Ω and filter length = 1 s</td>
<td>(0.00 - 600.00) s</td>
<td>±0.2% or ±2.00 s whichever is greater</td>
</tr>
</tbody>
</table>
### Table 48. STTIPHIZ technical data

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fault resistance sensitivity</td>
<td>Can be reached at steady state operating condition of the machine</td>
<td>50 kΩ</td>
</tr>
<tr>
<td></td>
<td>Typically</td>
<td>10 kΩ</td>
</tr>
<tr>
<td>Injection frequency</td>
<td>(50.000 - 250.000) Hz</td>
<td>±0.1 Hz</td>
</tr>
<tr>
<td>Injection voltage</td>
<td>240 V</td>
<td></td>
</tr>
<tr>
<td>Trip limit of fault resistance</td>
<td>(100 - 10000)Ω</td>
<td>±5% of 1 kΩ at R ≤ 1 kΩ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±10% of set value at R &gt; 1 kΩ</td>
</tr>
<tr>
<td>Alarm limit of fault resistance</td>
<td>(100 - 100000)Ω</td>
<td>±5% of 1 kΩ at R ≤ 1 kΩ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±10% of 10 kΩ at 1 kΩ &lt; R ≤ 10 kΩ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±50% of set value at R &gt; 10 kΩ</td>
</tr>
<tr>
<td>Operate time, start at R_f ~ 0Ω and filter length = 1 s</td>
<td>1.00 s typically</td>
<td></td>
</tr>
<tr>
<td>Operate time, trip at R_f ~ 0Ω and filter length = 1 s</td>
<td>3.00 s typically</td>
<td></td>
</tr>
<tr>
<td>Alarm time delay at R_f ~ 0Ω and filter length = 1 s</td>
<td>(0.00 - 600.00) s</td>
<td>±0.2% or ± 2.00 s whichever is greater</td>
</tr>
</tbody>
</table>

### Table 49. Underimpedance protection for generators and transformers ZGVPDIS

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of zones</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Forward reach</td>
<td>(3.0 - 200.0)% of Z_r where Z_r = U_base/√3 * I_base</td>
<td>±5.0% of set impedance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Conditions: Voltage range: (0.1 - 1.1) x U_r, Current range: (0.5 - 30) x I_r</td>
</tr>
<tr>
<td>Reverse reach</td>
<td>(3.0 - 200.0)% of Z_r where Z_r = U_base/√3 * I_base</td>
<td>±5.0% of set impedance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Conditions: Voltage range: (0.1 - 1.1) x U_r, Current range: (0.5 - 30) x I_r</td>
</tr>
<tr>
<td>Impedance angle</td>
<td>(5 - 90) degrees</td>
<td></td>
</tr>
<tr>
<td>Reset ratio</td>
<td>105% typically</td>
<td></td>
</tr>
<tr>
<td>Start time at 1.2 x set impedance to 0.8 x set impedance</td>
<td>Min. = 15 ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max. = 35 ms</td>
<td></td>
</tr>
<tr>
<td>Independent time delay to operate at 1.2 x set impedance to 0.8 x set impedance</td>
<td>(0.000 – 60.000) s</td>
<td>±0.2% or ±40 ms whichever is greater</td>
</tr>
</tbody>
</table>
Wide area measurement system

Table 50. Protocol reporting via IEEE 1344 and C37.118 PMUREPORT

<table>
<thead>
<tr>
<th>Influencing quantity</th>
<th>Range</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal frequency</td>
<td>± 0.1 x f₀</td>
<td>≤ 1.0% TVE</td>
</tr>
<tr>
<td>Signal magnitude:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage phasor</td>
<td>(0.1–1.2) x U₀</td>
<td></td>
</tr>
<tr>
<td>Current phasor</td>
<td>(0.5–2.0) x I₀</td>
<td></td>
</tr>
<tr>
<td>Phase angle</td>
<td>± 180°</td>
<td></td>
</tr>
<tr>
<td>Harmonic distortion</td>
<td>10% from 2nd – 50th</td>
<td></td>
</tr>
<tr>
<td>Interfering signal:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnitude</td>
<td>10% of fundamental signal</td>
<td></td>
</tr>
<tr>
<td>Minimum frequency</td>
<td>0.1 x f₀</td>
<td></td>
</tr>
<tr>
<td>Maximum frequency</td>
<td>1000 Hz</td>
<td></td>
</tr>
</tbody>
</table>
## Current protection

### Table 51. Instantaneous phase overcurrent protection PHPIOC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate current</td>
<td>(5-2500)% of IBase</td>
<td>±1.0% of (I_o) at (I \leq I_o)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±1.0% of (I_o) at (I &gt; I_o)</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&gt; 95% at (50–2500)% of IBase</td>
<td>-</td>
</tr>
<tr>
<td>Operate time at 0 to 2 (I_{set})</td>
<td>Min. = 15 ms</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Max. = 25 ms</td>
<td>-</td>
</tr>
<tr>
<td>Reset time at 2 (I_{set}) to 0</td>
<td>Min. = 15 ms</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Max. = 25 ms</td>
<td>-</td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>10 ms typically at 0 to 2 (I_{set})</td>
<td>-</td>
</tr>
<tr>
<td>Operate time at 0 to 10 (I_{set})</td>
<td>Min. = 5 ms</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Max. = 15 ms</td>
<td>-</td>
</tr>
<tr>
<td>Reset time at 10 (I_{set}) to 0</td>
<td>Min. = 25 ms</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Max. = 40 ms</td>
<td>-</td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>2 ms typically at 0 to 10 (I_{set})</td>
<td>-</td>
</tr>
<tr>
<td>Dynamic overreach</td>
<td>&lt; 5% at (t = 100) ms</td>
<td>-</td>
</tr>
<tr>
<td>Function</td>
<td>Range or value</td>
<td>Accuracy</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>--------------------------------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Operate current, step 1-4</td>
<td>(5-2500)% of $I_{\text{Base}}$</td>
<td>±1.0% of $I_r$ at $I \leq I_r$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±1.0% of $I$ at $I &gt; I_r$</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&gt; 95% at (50–2500)% of $I_{\text{Base}}$</td>
<td>-</td>
</tr>
<tr>
<td>Minimum operate current, step 1-4</td>
<td>(1-10000)% of $I_{\text{Base}}$</td>
<td>±1.0% of $I_r$ at $I \leq I_r$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±1.0% of $I$ at $I &gt; I_r$</td>
</tr>
<tr>
<td>Relay characteristic angle (RCA)</td>
<td>(40.0–65.0) degrees</td>
<td>±2.0 degrees</td>
</tr>
<tr>
<td>Relay operating angle (ROA)</td>
<td>(40.0–89.0) degrees</td>
<td>±2.0 degrees</td>
</tr>
<tr>
<td>Second harmonic blocking</td>
<td>(5–100)% of fundamental</td>
<td>±2.0% of $I$</td>
</tr>
<tr>
<td>Independent time delay at 0 to 2 x $I_{\text{set}}$, step 1-4</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±35 ms whichever is greater</td>
</tr>
<tr>
<td>Minimum operate time for inverse curves , step 1-4</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±35 ms whichever is greater</td>
</tr>
<tr>
<td>Inverse time characteristics, see table 179, table 180 and table 181</td>
<td>16 curve types</td>
<td>See table 179, table 180 and table 181</td>
</tr>
<tr>
<td>Operate time, start non-directional at 0 to 2 x $I_{\text{set}}$</td>
<td>Min. = 15 ms</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Max. = 30 ms</td>
<td>-</td>
</tr>
<tr>
<td>Reset time, start non-directional at 2 x $I_{\text{set}}$ to 0</td>
<td>Min. = 15 ms</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Max. = 30 ms</td>
<td>-</td>
</tr>
<tr>
<td>Operate time, start non-directional at 0 to 10 x $I_{\text{set}}$</td>
<td>Min. = 5 ms</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Max. = 20 ms</td>
<td>-</td>
</tr>
<tr>
<td>Reset time, start non-directional at 10 x $I_{\text{set}}$ to 0</td>
<td>Min. = 20 ms</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Max. = 35 ms</td>
<td>-</td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>10 ms typically at 0 to 2 x $I_{\text{set}}$</td>
<td>-</td>
</tr>
<tr>
<td>Impulse margin time</td>
<td>15 ms typically</td>
<td>-</td>
</tr>
<tr>
<td>Operate frequency, directional overcurrent</td>
<td>38-83 Hz</td>
<td>-</td>
</tr>
<tr>
<td>Operate frequency, non-directional overcurrent</td>
<td>10-90 Hz</td>
<td>-</td>
</tr>
</tbody>
</table>
### Table 53. Instantaneous residual overcurrent protection EFPIOC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate current</td>
<td>(5-2500)% of I_{Base}</td>
<td>±1.0% of I, at I ≤ I_r</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±1.0% of I at I &gt; I_r</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&gt; 95% at (50–2500)% of I_{Base}</td>
<td>-</td>
</tr>
<tr>
<td>Operate time at 0 to 2 x I_{set}</td>
<td>Min. = 15 ms Max. = 25 ms</td>
<td>-</td>
</tr>
<tr>
<td>Reset time at 2 x I_{set} to 0</td>
<td>Min. = 15 ms Max. = 25 ms</td>
<td>-</td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>10 ms typically at 0 to 2 x I_{set}</td>
<td>-</td>
</tr>
<tr>
<td>Operate time at 0 to 10 x I_{set}</td>
<td>Min. = 5 ms Max. = 15 ms</td>
<td>-</td>
</tr>
<tr>
<td>Reset time at 10 x I_{set} to 0</td>
<td>Min. = 25 ms Max. = 35 ms</td>
<td>-</td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>2 ms typically at 0 to 10 x I_{set}</td>
<td>-</td>
</tr>
<tr>
<td>Dynamic overreach</td>
<td>&lt; 5% at t = 100 ms</td>
<td>-</td>
</tr>
</tbody>
</table>
Table 54. Directional residual overcurrent protection, four steps EF4PTOC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate current, step 1-4</td>
<td>(1-2500)% of IBase</td>
<td>±1.0% of I, at I ≤ I&lt;sub&gt;r&lt;/sub&gt;, ±1.0% of I at I &gt; I&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&gt; 95% at (10-2500)% of IBase</td>
<td>-</td>
</tr>
<tr>
<td>Relay characteristic angle (RCA)</td>
<td>(-180 to 180) degrees</td>
<td>±2.0 degrees</td>
</tr>
<tr>
<td>Operate current for directional release</td>
<td>(1-100)% of IBase</td>
<td>For RCA ±60 degrees: ±2.5% of I, at I ≤ I&lt;sub&gt;r&lt;/sub&gt;, ±2.5% of I at I &gt; I&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td>Independent time delay at 0 to 2 x I&lt;sub&gt;set&lt;/sub&gt;, step 1-4</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±35 ms whichever is greater</td>
</tr>
<tr>
<td>Minimum operate time for inverse curves, step 1-4</td>
<td>(0.000 - 60.000) s</td>
<td>±0.2% or ±35 ms whichever is greater</td>
</tr>
<tr>
<td>Inverse time characteristics, see Table 179, Table 180 and Table 181</td>
<td>16 curve types</td>
<td>See Table 179, Table 180 and Table 181</td>
</tr>
<tr>
<td>Second harmonic blocking</td>
<td>(5-100)% of fundamental</td>
<td>±2.0% of I&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td>Minimum polarizing voltage</td>
<td>(1-100)% of UBase</td>
<td>±0.5% of U&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td>Minimum polarizing current</td>
<td>(2-100)% of IBase</td>
<td>±1.0% of I&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td>Real part of source Z used for current polarization</td>
<td>(0.50-1000.00) Ω/phase</td>
<td>-</td>
</tr>
<tr>
<td>Imaginary part of source Z used for current polarization</td>
<td>(0.50–3000.00) Ω/phase</td>
<td>-</td>
</tr>
<tr>
<td>*Operate time, start non-directional at 0 to 2 x I&lt;sub&gt;set&lt;/sub&gt;</td>
<td>Min. = 15 ms Max. = 30 ms</td>
<td>-</td>
</tr>
<tr>
<td>*Reset time, start non-directional at 2 x I&lt;sub&gt;set&lt;/sub&gt; to 0</td>
<td>Min. = 15 ms Max. = 30 ms</td>
<td>-</td>
</tr>
<tr>
<td>*Operate time, start non-directional at 0 to 10 x I&lt;sub&gt;set&lt;/sub&gt;</td>
<td>Min. = 5 ms Max. = 20 ms</td>
<td>-</td>
</tr>
<tr>
<td>*Reset time, start non-directional at 10 x I&lt;sub&gt;set&lt;/sub&gt; to 0</td>
<td>Min. = 20 ms Max. = 35 ms</td>
<td>-</td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>10 ms typically at 0 to 2 x I&lt;sub&gt;set&lt;/sub&gt;</td>
<td>-</td>
</tr>
<tr>
<td>Impulse margin time</td>
<td>15 ms typically</td>
<td>-</td>
</tr>
</tbody>
</table>

*Note: Operate time and reset time are only valid if harmonic blocking is turned off for a step.
Table 55. Four step directional negative phase sequence overcurrent protection NS4PTOC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate current, step 1 - 4</td>
<td>(1-2500)% of $I_{Base}$</td>
<td>±1.0% of $I$ at $I \leq I_{r}$,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±1.0% of $I$ at $I &gt; I_{r}$</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&gt; 95% at (10-2500)% of $I_{Base}$</td>
<td>-</td>
</tr>
<tr>
<td>Independent time delay at 0 to 2 x $I_{set}$, step 1 - 4</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±35 ms whichever is greater</td>
</tr>
<tr>
<td>Minimum operate time for inverse curves, step 1 - 4</td>
<td>(0.000 - 60.000) s</td>
<td>±0.2% or ±35 ms whichever is greater</td>
</tr>
<tr>
<td>Inverse time characteristics, see table 179, table 180 and table 181</td>
<td>16 curve types</td>
<td>See table 179, table 180 and table 181</td>
</tr>
<tr>
<td>Minimum operate current, step 1 - 4</td>
<td>(1.00 - 10000.00)% of $I_{Base}$</td>
<td>±1.0% of $I$ at $I \leq I_{r}$,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±1.0% of $I$ at $I &gt; I_{r}$</td>
</tr>
<tr>
<td>Relay characteristic angle (RCA)</td>
<td>(-180 to 180) degrees</td>
<td>±2.0 degrees</td>
</tr>
<tr>
<td>Operate current for directional release</td>
<td>(1–100)% of $I_{Base}$</td>
<td>For RCA ±60 degrees:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±2.5% of $I$ at $I \leq I_{r}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±2.5% of $I$ at $I &gt; I_{r}$</td>
</tr>
<tr>
<td>Minimum polarizing voltage</td>
<td>(1–100)% of $U_{Base}$</td>
<td>±0.5% of $U_r$</td>
</tr>
<tr>
<td>Real part of negative sequence source impedance used for current polarization</td>
<td>(0.50-1000.00) $\Omega$/phase</td>
<td>-</td>
</tr>
<tr>
<td>Imaginary part of negative sequence source impedance used for current polarization</td>
<td>(0.50–3000.00) $\Omega$/phase</td>
<td>-</td>
</tr>
<tr>
<td>Operate time, start non-directional at 0 to 2 x $I_{set}$</td>
<td>Min. = 15 ms</td>
<td>Min. = 15 ms</td>
</tr>
<tr>
<td></td>
<td>Max. = 30 ms</td>
<td>Max. = 30 ms</td>
</tr>
<tr>
<td>Reset time, start non-directional at 2 x $I_{set}$ to 0</td>
<td>Min. = 15 ms</td>
<td>Min. = 15 ms</td>
</tr>
<tr>
<td></td>
<td>Max. = 30 ms</td>
<td>Max. = 30 ms</td>
</tr>
<tr>
<td>Operate time, start non-directional at 0 to 10 x $I_{set}$</td>
<td>Min. = 5 ms</td>
<td>Min. = 5 ms</td>
</tr>
<tr>
<td></td>
<td>Max. = 20 ms</td>
<td>Max. = 20 ms</td>
</tr>
<tr>
<td>Reset time, start non-directional at 10 x $I_{set}$ to 0</td>
<td>Min. = 20 ms</td>
<td>Min. = 20 ms</td>
</tr>
<tr>
<td></td>
<td>Max. = 35 ms</td>
<td>Max. = 35 ms</td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>10 ms typically at 0 to 2 x $I_{set}$</td>
<td>-</td>
</tr>
<tr>
<td>Impulse margin time</td>
<td>15 ms typically</td>
<td>-</td>
</tr>
<tr>
<td>Transient overreach</td>
<td>&lt;10% at $\tau = 100$ ms</td>
<td>-</td>
</tr>
</tbody>
</table>
Table 56. Sensitive directional residual overcurrent and power protection SDEPSDE

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate level for $3I_0 \cdot \cos \phi$ directional residual overcurrent</td>
<td>$(0.25-200.00)%$ of $I_{\text{Base}}$</td>
<td>$\pm 1.0%$ of $I$, at $I \leq I_r$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\pm 1.0%$ of $I$ at $I &gt; I_r$</td>
</tr>
<tr>
<td>Operate level for $-3I_0 \cdot 3U_0 \cdot \cos \phi$ directional residual power</td>
<td>$(0.25-200.00)%$ of $S_{\text{Base}}$</td>
<td>$\pm 1.0%$ of $S_r$ at $S \leq S_r$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\pm 1.0%$ of $S$ at $S &gt; S_r$</td>
</tr>
<tr>
<td>Operate level for $3I_0$ and $\phi$ residual overcurrent</td>
<td>$(0.25-200.00)%$ of $I_{\text{Base}}$</td>
<td>$\pm 1.0%$ of $I$, at $I \leq I_r$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\pm 1.0%$ of $I$ at $I &gt; I_r$</td>
</tr>
<tr>
<td>Operate level for non-directional overcurrent</td>
<td>$(1.00-400.00)%$ of $I_{\text{Base}}$</td>
<td>$\pm 1.0%$ of $I$, at $I \leq I_r$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\pm 1.0%$ of $I$ at $I &gt; I_r$</td>
</tr>
<tr>
<td>Operate level for non-directional residual overvoltage</td>
<td>$(1.00-200.00)%$ of $U_{\text{Base}}$</td>
<td>$\pm 0.5%$ of $U_r$, at $U \leq U_r$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\pm 0.5%$ of $U$ at $U &gt; U_r$</td>
</tr>
<tr>
<td>Residual release current for all directional modes</td>
<td>$(0.25-200.00)%$ of $I_{\text{Base}}$</td>
<td>$\pm 1.0%$ of $I$, at $I \leq I_r$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\pm 1.0%$ of $I$ at $I &gt; I_r$</td>
</tr>
<tr>
<td>Residual release voltage for all directional modes</td>
<td>$(1.00-300.00)%$ of $U_{\text{Base}}$</td>
<td>$\pm 0.5%$ of $U$, at $U \leq U_r$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\pm 0.5%$ of $U$ at $U &gt; U_r$</td>
</tr>
<tr>
<td>Operate time for non-directional residual overcurrent at 0 to 2 x $I_{\text{set}}$</td>
<td>Min. = 40 ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max. = 65 ms</td>
<td></td>
</tr>
<tr>
<td>Reset time for non-directional residual overcurrent at 2 x $I_{\text{set}}$ to 0</td>
<td>Min. = 40 ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max. = 65 ms</td>
<td></td>
</tr>
<tr>
<td>Operate time for directional residual overcurrent at 0 to 2 x $I_{\text{set}}$</td>
<td>Min. = 110 ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max. = 160 ms</td>
<td></td>
</tr>
<tr>
<td>Reset time for directional residual overcurrent at 2 x $I_{\text{set}}$ to 0</td>
<td>Min. = 20 ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max. = 60 ms</td>
<td></td>
</tr>
<tr>
<td>Independent time delay for non-directional residual overvoltage at 0.8 x $U_{\text{set}}$ to 1.2 x $U_{\text{set}}$</td>
<td>$(0.000 – 60.000)\text{s}$</td>
<td>$\pm 0.2%$ or $\pm 75\text{ ms}$ whichever is greater</td>
</tr>
<tr>
<td>Independent time delay for non-directional residual overcurrent at 0 to 2 x $I_{\text{set}}$</td>
<td>$(0.000 – 60.000)\text{s}$</td>
<td>$\pm 0.2%$ or $\pm 75\text{ ms}$ whichever is greater</td>
</tr>
<tr>
<td>Independent time delay for directional residual overcurrent at 0 to 2 x $I_{\text{set}}$</td>
<td>$(0.000 – 60.000)\text{s}$</td>
<td>$\pm 0.2%$ or $\pm 170\text{ ms}$ whichever is greater</td>
</tr>
<tr>
<td>Inverse characteristics, see table 182, Table 183 and Table 184</td>
<td>16 curve types</td>
<td>See Table 182, Table 183 and Table 184</td>
</tr>
<tr>
<td>Relay characteristic angle (RCADir)</td>
<td>(-179 to 180) degrees</td>
<td>$\pm 2.0$ degrees</td>
</tr>
<tr>
<td>Relay operate angle (ROADir)</td>
<td>(0 to 90) degrees</td>
<td>$\pm 2.0$ degrees</td>
</tr>
</tbody>
</table>
Table 57. Thermal overload protection, two time constants TRPTTR

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base current 1 and 2</td>
<td>(30–250)% of /Base</td>
<td>±1.0% of /r</td>
</tr>
<tr>
<td>Operate time:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( t = \tau \cdot \ln \left( \frac{I_p^2 - I_{tr}^2}{I_{tr}^2 - I_{trip}^2} \right) )</td>
<td>Time constant ( \tau = (0.10\text{–}500.00) ) minutes</td>
<td>±5.0% or ±200 ms whichever is greater</td>
</tr>
<tr>
<td>( I = ) actual measured current</td>
<td>( I_p = ) load current before overload occurs</td>
<td></td>
</tr>
<tr>
<td>( I_{tr} = ) steady state operate current in % of /Base</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operate time:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alarm level 1 and 2</td>
<td>(50–99)% of heat content</td>
<td>±2.0% of heat content trip</td>
</tr>
<tr>
<td>Operate current</td>
<td>(50–250)% of /Base</td>
<td>±1.0% of /r</td>
</tr>
<tr>
<td>Reset level temperature</td>
<td>(10–95)% of heat content</td>
<td>±2.0% of heat content trip</td>
</tr>
</tbody>
</table>

Table 58. Breaker failure protection CCRBRF

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate phase current</td>
<td>(5-200)% of /Base</td>
<td>±1.0% of /r at ( I \leq I_r )</td>
</tr>
<tr>
<td>Reset ratio, phase current</td>
<td>&gt; 95%</td>
<td></td>
</tr>
<tr>
<td>Operate residual current</td>
<td>(2-200)% of /Base</td>
<td>±1.0% of /r at ( I \leq I_r )</td>
</tr>
<tr>
<td>Reset ratio, residual current</td>
<td>&gt; 95%</td>
<td></td>
</tr>
<tr>
<td>Phase current level for blocking of contact function</td>
<td>(5-200)% of /Base</td>
<td>±1.0% of /r at ( I \leq I_r )</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&gt; 95%</td>
<td></td>
</tr>
<tr>
<td>Operate time for current detection</td>
<td>10 ms typically</td>
<td></td>
</tr>
<tr>
<td>Reset time for current detection</td>
<td>10 ms maximum *</td>
<td></td>
</tr>
<tr>
<td>Time delay for retrip at 0 to 2 ( x ) ( I_{set} )</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±15 ms whichever is greater</td>
</tr>
<tr>
<td>Time delay for backup trip at 0 to 2 ( x ) ( I_{set} )</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±15 ms whichever is greater</td>
</tr>
<tr>
<td>Time delay for backup trip at multi-phase start at 0 to 2 ( x ) ( I_{set} )</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±20 ms whichever is greater</td>
</tr>
<tr>
<td>Additional time delay for a second backup trip at 0 to 2 ( x ) ( I_{set} )</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±20 ms whichever is greater</td>
</tr>
<tr>
<td>Time delay for alarm for faulty circuit breaker</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±15 ms whichever is greater</td>
</tr>
<tr>
<td>Minimum trip pulse duration</td>
<td>(0.010-60.000) s</td>
<td>±0.2% or ±5 ms whichever is greater</td>
</tr>
</tbody>
</table>

* Valid for product version 2.2.3 or later
### Table 59. Pole discordance protection CCPDSC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate current</td>
<td>(0–100)% of IBase</td>
<td>±1.0% of I&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td>Independent time delay between trip condition and trip signal</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ± 30 ms whichever is greater</td>
</tr>
</tbody>
</table>

### Table 60. Directional underpower protection GUPPDUP

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power level for Step 1 and Step 2</td>
<td>(0.0–500.0)% of SBase</td>
<td>±1.0% of S&lt;sub&gt;r&lt;/sub&gt; at S ≤ S&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±1.0% of S at S &gt; S&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>where S&lt;sub&gt;r&lt;/sub&gt; = 1.732 · U&lt;sub&gt;r&lt;/sub&gt; · I&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td>Characteristic angle for Step 1 and Step 2</td>
<td>(-180.0–180.0) degrees</td>
<td>±2.0 degrees</td>
</tr>
<tr>
<td>Independent time delay to operate for Step 1 and Step 2 at 2 x S&lt;sub&gt;r&lt;/sub&gt; to 0.5 x S&lt;sub&gt;r&lt;/sub&gt; and k=0.000</td>
<td>(0.01-60000.00) s</td>
<td>±0.2% or ±40 ms whichever is greater</td>
</tr>
</tbody>
</table>

### Table 61. Directional overpower protection GOPPDOP

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power level for Step 1 and Step 2</td>
<td>(0.0–500.0)% of SBase</td>
<td>±1.0% of S&lt;sub&gt;r&lt;/sub&gt; at S ≤ S&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±1.0% of S at S &gt; S&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Start value P=0.5% of S&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pickup accuracy of ±0.20% of S&lt;sub&gt;r&lt;/sub&gt; (*)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Start value P=0.2% of S&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pickup accuracy of ±0.15% of S&lt;sub&gt;r&lt;/sub&gt; (*)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>where S&lt;sub&gt;r&lt;/sub&gt; = 1.732 · U&lt;sub&gt;r&lt;/sub&gt; · I&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td>Characteristic angle for Step 1 and Step 2</td>
<td>(-180.0–180.0) degrees</td>
<td>±2.0 degrees</td>
</tr>
<tr>
<td>Operate time, start at 0.5 x S&lt;sub&gt;r&lt;/sub&gt; to 2 x S&lt;sub&gt;r&lt;/sub&gt; and k=0.000</td>
<td>Min. =10 ms</td>
<td>Max. = 25 ms</td>
</tr>
<tr>
<td>Reset time, start at 2 x S&lt;sub&gt;r&lt;/sub&gt; to 0.5 x S&lt;sub&gt;r&lt;/sub&gt; and k=0.000</td>
<td>Min. = 35 ms</td>
<td>Max. = 55 ms</td>
</tr>
<tr>
<td>Independent time delay to operate for Step 1 and Step 2 at 0.5 x S&lt;sub&gt;r&lt;/sub&gt; to 2 x S&lt;sub&gt;r&lt;/sub&gt; and k=0.000</td>
<td>(0.01-60000.00) s</td>
<td>±0.2% or ±40 ms whichever is greater</td>
</tr>
</tbody>
</table>

*) To achieve this accuracy for reverse power protection it is also recommended to apply settings k=0.990 and Mode=PosSeq. These settings will help to minimize the overall measurement error ensuring the best accuracy for this application.
Table 62. Negative sequence time overcurrent protection for machines NS2PTOC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate current, step 1 - 2</td>
<td>(3-500)% of (I_{\text{Base}})</td>
<td>±1.0% of (I_r) at (I \leq I_r), ±1.0% of (I) at (I &gt; I_r)</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&gt;95%</td>
<td>-</td>
</tr>
</tbody>
</table>
| Operate time, start at 0 to \(2 \times I_{\text{set}}\) | Min. = 15 ms  
Max. = 30 ms | - |
| Reset time, start at \(2 \times I_{\text{set}}\) to 0 | Min. = 15 ms  
Max. = 30 ms | - |
| Operate time, start at 0 to \(10 \times I_{\text{set}}\) | Min. = 5 ms  
Max. = 20 ms | - |
| Reset time, start at \(10 \times I_{\text{set}}\) to 0 | Min. = 20 ms  
Max. = 35 ms | - |
| Time characteristics | Definite or Inverse | - |
| Inverse time characteristic, step 1 - 2 | \(I^2 t = K\)  
\(K = 1.0 - 99.0\) | ±2.0% or ±140 ms whichever is greater |
| Reset time, inverse characteristic, step 1 - 2 | Reset Multiplier = 0.01-20.00 | ±5.0% or ±140 ms whichever is greater |
| Minimum operate time for inverse time characteristic, step 1 - 2 | (0.000-60.000) s | ±0.2% or ±35 ms whichever is greater |
| Maximum trip delay at 0.5 \(\times I_{\text{set}}\) to \(2 \times I_{\text{set}}\), step 1 - 2 | (0.00-6000.00) s | ±0.2% or ±35 ms whichever is greater |
| Independent time delay at 0.5 \(\times I_{\text{set}}\) to \(2 \times I_{\text{set}}\), step 1 - 2 | (0.00-6000.00) s | ±0.2% or ±35 ms whichever is greater |
| Independent time delay for Alarm at 0.5 \(\times I_{\text{set}}\) to \(2 \times I_{\text{set}}\) | (0.00-6000.00) s | ±0.2% or ±35 ms whichever is greater |
### Table 63. Accidental energizing protection for synchronous generator AEGPVOC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate value, overcurrent</td>
<td>(5–900)% of IBase</td>
<td>±1.0% of I at I ≤ I&lt;sub&gt;r&lt;/sub&gt;, ±1.0% of I at I &gt; I&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td>Reset ratio, overcurrent</td>
<td>&gt;95% at (20–900)% of IBase</td>
<td>-</td>
</tr>
<tr>
<td>Transient overreach, overcurrent function</td>
<td>&lt;10% at τ = 100 ms</td>
<td>-</td>
</tr>
<tr>
<td>Critical impulse time, overcurrent</td>
<td>10 ms typically at 0 to 2 x I&lt;sub&gt;set&lt;/sub&gt;</td>
<td>-</td>
</tr>
<tr>
<td>Impulse margin time, overcurrent</td>
<td>15 ms typically</td>
<td>-</td>
</tr>
<tr>
<td>Operate value, undervoltage</td>
<td>(2–150)% of UBase</td>
<td>±0.5% of U at U ≤ U&lt;sub&gt;r&lt;/sub&gt;, ±0.5% of U at U &gt; U&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td>Critical impulse time, undervoltage</td>
<td>10 ms typically at 2 x U&lt;sub&gt;set&lt;/sub&gt; to 0</td>
<td>-</td>
</tr>
<tr>
<td>Impulse margin time, undervoltage</td>
<td>15 ms typically</td>
<td>-</td>
</tr>
<tr>
<td>Operate value, overvoltage</td>
<td>(2–200)% of UBase</td>
<td>±0.5% of U at U ≤ U&lt;sub&gt;r&lt;/sub&gt;, ±0.5% of U at U &gt; U&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td>Definite time delay, overcurrent, at 0 to 2 x I&lt;sub&gt;set&lt;/sub&gt;</td>
<td>(0.000–60.000) s</td>
<td>±0.2% or ±135 ms whichever is greater</td>
</tr>
<tr>
<td>Definite time delay, undervoltage, at 1.2 x U&lt;sub&gt;set&lt;/sub&gt; to 0.8 x U&lt;sub&gt;set&lt;/sub&gt;</td>
<td>(0.000–60.000) s</td>
<td>±0.2% or ±135 ms whichever is greater</td>
</tr>
<tr>
<td>Definite time delay, overvoltage, at 0.8 x U&lt;sub&gt;set&lt;/sub&gt; to 1.2 x U&lt;sub&gt;set&lt;/sub&gt;</td>
<td>(0.000–60.000) s</td>
<td>±0.2% or ±135 ms whichever is greater</td>
</tr>
</tbody>
</table>

### Table 64. Generator stator overload protection GSPTTR

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current start level for overload protection</td>
<td>(105.0–900.0)% of IBase</td>
<td>±1.0% of I at I ≤ I&lt;sub&gt;r&lt;/sub&gt;, ±1.0% of I at I &gt; I&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&gt;95%</td>
<td>-</td>
</tr>
<tr>
<td>Start time at 0 to 2 x I&lt;sub&gt;set&lt;/sub&gt;</td>
<td>Min. = 50 ms</td>
<td>Max. = 170 ms</td>
</tr>
<tr>
<td>Thermal time characteristic</td>
<td>According to IEEE Std C50.13–2005</td>
<td>±1.5% or ±1200 ms whichever is greater</td>
</tr>
<tr>
<td>Minimum operate time for thermal characteristic</td>
<td>(1.0–120.0) s</td>
<td>±1.5% or ±1200 ms whichever is greater</td>
</tr>
<tr>
<td>Maximum operate time for thermal characteristic</td>
<td>(100.0–2000.0) s</td>
<td>±1.5% or ±1200 ms whichever is greater</td>
</tr>
<tr>
<td>Function</td>
<td>Range or value</td>
<td>Accuracy</td>
</tr>
<tr>
<td>----------------------------------------------------</td>
<td>-------------------------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>Overcurrent start level for overload protection</td>
<td>(105.0–900.0)% of IBase</td>
<td>±1.0% of I, at I ≤ I,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±1.0% of I, at I &gt; I,</td>
</tr>
<tr>
<td>Reset ratio, overcurrent</td>
<td>&gt;95%</td>
<td>—</td>
</tr>
<tr>
<td>Start time, overcurrent at 0 to 2 x (I_{set})</td>
<td>Min = 50 ms</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Max = 170 ms</td>
<td>—</td>
</tr>
<tr>
<td>Thermal time characteristic</td>
<td>According to IEEE Std C50.13–2005</td>
<td>±1.5% or ±200 ms whichever is greater</td>
</tr>
<tr>
<td>Minimum operate time for thermal characteristic</td>
<td>(1.0–120.0) s</td>
<td>±1.5% or ±200 ms whichever is greater</td>
</tr>
<tr>
<td>Maximum operate time for thermal characteristic</td>
<td>(100.0–2000.0) s</td>
<td>±1.5% or ±200 ms whichever is greater</td>
</tr>
<tr>
<td>Undercurrent start level</td>
<td>(5.0–500.0)% of IBase</td>
<td>±1.0% of I, at I ≤ I,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±1.0% of I, at I &gt; I,</td>
</tr>
<tr>
<td>Start time, undercurrent at 2 x (I_{set}) to 0</td>
<td>Min = 15 ms</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Max = 30 ms</td>
<td>—</td>
</tr>
<tr>
<td>Independent time delay for undercurrent function at 2 x (I_{set}) to 0</td>
<td>(0.0–600.0) s</td>
<td>±0.2% or ±45 ms whichever is greater</td>
</tr>
</tbody>
</table>
Table 66. Voltage-restrained time overcurrent protection VRPVOC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
</table>
| Start overcurrent               | (2.0 - 5000.0)% of I_base           | ±1.0% of I, at I ≤ I_r  
|                                 |                                     | ±1.0% of I at I > I_r                                                   |
| Reset ratio, overcurrent        | > 95%                               | -                                                                        |
| Operate time, start overcurrent | at 0 to 2 x I_set                   | Min. = 15 ms  
|                                 |                                     | Max. = 30 ms                                                           |
| Reset time, start overcurrent   | at 2 x I_set to 0                   | Min. = 15 ms  
|                                 |                                     | Max. = 30 ms                                                           |
| Operate time, start overcurrent | at 0 to 10 x I_set                  | Min. = 5 ms  
|                                 |                                     | Max. = 20 ms                                                           |
| Reset time, start overcurrent   | at 10 x I_set to 0                  | Min. = 20 ms  
|                                 |                                     | Max. = 35 ms                                                           |
| Independent time delay to operate at 0 to 2 x I_set | (0.00 - 6000.00) s | ±0.2% or ±35 ms whichever is greater                                     |
| Inverse time characteristics,   | 13 curve types                      | See tables 179 and 180                                                  |
|                                 |                                     |                                                                          |
| Minimum operate time for inverse time characteristics | (0.00 - 60.00) s | ±0.2% or ±35 ms whichever is greater                                     |
| High voltage limit, voltage     | (30.0 - 100.0)% of U_base           | ±1.0% of U_r                                                            |
| dependent operation             |                                     |                                                                          |
| Start undervoltage              | (2.0 - 100.0)% of U_base            | ±0.5% of U_r                                                            |
| Reset ratio, undervoltage       | < 105%                              | -                                                                        |
| Operate time start undervoltage | at 2 x U_set to 0                   | Min. = 15 ms  
|                                 |                                     | Max. = 30 ms                                                           |
| Reset time start undervoltage   | at 0 to 2 x U_set                   | Min. = 15 ms  
|                                 |                                     | Max. = 30 ms                                                           |
| Independent time delay to operate, | undervoltage at 2 x U_set to 0     | (0.00 - 6000.00) s  
|                                 |                                     | ±10.2% or ±35 ms whichever is greater                                   |
| Internal low voltage blocking   | (0.0 - 5.0)% of U_base              | ±0.25% of U_r                                                            |
| Overcurrent:                    |                                     |                                                                          |
| Critical impulse time           | 10 ms typically at 0 to 2 x I_set   |                                                                          |
| Impulse margin time             | 15 ms typically                      |                                                                          |
| Undervoltage:                   |                                     |                                                                          |
| Critical impulse time           | 10 ms typically at 2 x U_set to 0   |                                                                          |
| Impulse margin time             | 15 ms typically                      |                                                                          |
Voltage protection

Table 67. Two step undervoltage protection UV2PTUV

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate voltage, low and high step</td>
<td>(1.0–100.0)% of UBase</td>
<td>±0.5% of U&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td>Absolute hysteresis</td>
<td>(0.0–50.0)% of UBase</td>
<td>±0.5% of U&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td>Internal blocking level, step 1 and step 2</td>
<td>(1–50)% of UBase</td>
<td>±0.5% of U&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td>Inverse time characteristics for step 1 and step 2</td>
<td>-</td>
<td>See table 188</td>
</tr>
<tr>
<td>Definite time delay, step 1 at 1.2 x U&lt;sub&gt;set&lt;/sub&gt; to 0</td>
<td>(0.00-6000.00) s</td>
<td>±0.2% or ±40ms whichever is greater</td>
</tr>
<tr>
<td>Definite time delay, step 2 at 1.2 x U&lt;sub&gt;set&lt;/sub&gt; to 0</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±40ms whichever is greater</td>
</tr>
<tr>
<td>Minimum operate time, inverse characteristics</td>
<td>(0.000-60.000) s</td>
<td>±0.5% or ±40ms whichever is greater</td>
</tr>
<tr>
<td>Operate time, start at 2 x U&lt;sub&gt;set&lt;/sub&gt; to 0</td>
<td>Min. = 15 ms</td>
<td>-</td>
</tr>
<tr>
<td>Reset time, start at 0 to 2 x U&lt;sub&gt;set&lt;/sub&gt;</td>
<td>Min. = 15 ms</td>
<td>-</td>
</tr>
<tr>
<td>Operate time, start at 1.2 x U&lt;sub&gt;set&lt;/sub&gt; to 0</td>
<td>Min. = 5 ms</td>
<td>-</td>
</tr>
<tr>
<td>Reset time, start at 0 to 1.2 x U&lt;sub&gt;set&lt;/sub&gt;</td>
<td>Min. = 15 ms</td>
<td>-</td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>5 ms typically at 1.2 x U&lt;sub&gt;set&lt;/sub&gt; to 0</td>
<td>-</td>
</tr>
<tr>
<td>Impulse margin time</td>
<td>15 ms typically</td>
<td>-</td>
</tr>
</tbody>
</table>
Table 68. Two step overvoltage protection OV2PTOV

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
</table>
| Operate voltage, step 1 and 2                | (1.0-200.0)% of $U_{Base}$ | ±0.5% of $U_r$ at $U \leq U_r$  
|                                               |                        | ±0.5% of $U$ at $U > U_r$                   |
| Absolute hysteresis                          | (0.0–50.0)% of $U_{Base}$ | ±0.5% of $U_r$ at $U \leq U_r$  
|                                               |                        | ±0.5% of $U$ at $U > U_r$                   |
| Inverse time characteristics for steps 1 and 2 | -                      | See table 187                                 |
| Definite time delay, low step (step 1) at 0 to 1.2 x $U_{set}$ | (0.00 - 6000.00) s     | ±0.2% or ±45 ms whichever is greater         |
| Definite time delay, high step (step 2) at 0 to 1.2 x $U_{set}$ | (0.000-60.000) s       | ±0.2% or ±45 ms whichever is greater         |
| Minimum operate time, Inverse characteristics | (0.000-60.000) s       | ±0.2% or ±45 ms whichever is greater         |
| Operate time, start at 0 to 2 x $U_{set}$    | Min. = 15 ms           | -                                            |
|                                               | Max. = 30 ms           |                                               |
| Reset time, start at 2 x $U_{set}$ to 0      | Min. = 15 ms           | -                                            |
|                                               | Max. = 30 ms           |                                               |
| Operate time, start at 0 to 1.2 x $U_{set}$  | Min. = 20 ms           | -                                            |
|                                               | Max. = 35 ms           |                                               |
| Reset time, start at 1.2 x $U_{set}$ to 0    | Min. = 5 ms            | -                                            |
|                                               | Max. = 25 ms           |                                               |
| Critical impulse time                         | 10 ms typically at 0 to 2 x $U_{set}$ | -                                           |
| Impulse margin time                           | 15 ms typically        | -                                            |
Table 69. Two step residual overvoltage protection ROV2PTOV

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate voltage, step 1 - step 2</td>
<td>(1.0-200.0)% of U\textsubscript{Base}</td>
<td>± 0.5% of U\textsubscript{r} at U ≤ U\textsubscript{r}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>± 0.5% of U at U &gt; U\textsubscript{r}</td>
</tr>
<tr>
<td>Absolute hysteresis</td>
<td>(0.0–50.0)% of U\textsubscript{Base}</td>
<td>± 0.5% of U\textsubscript{r} at U ≤ U\textsubscript{r}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>± 0.5% of U at U &gt; U\textsubscript{r}</td>
</tr>
<tr>
<td>Inverse time characteristics for low and high step, see table 189</td>
<td>-</td>
<td>See table 189</td>
</tr>
<tr>
<td>Definite time delay low step (step 1) at 0 to 1.2 x U\textsubscript{set}</td>
<td>(0.00–6000.00) s</td>
<td>± 0.2% or ± 45 ms whichever is greater</td>
</tr>
<tr>
<td>Definite time delay high step (step 2) at 0 to 1.2 x U\textsubscript{set}</td>
<td>(0.000–60.000) s</td>
<td>± 0.2% or ± 45 ms whichever is greater</td>
</tr>
<tr>
<td>Minimum operate time</td>
<td>(0.000-60.000) s</td>
<td>± 0.2% or ± 45 ms whichever is greater</td>
</tr>
<tr>
<td>Operate time, start at 0 to 2 x U\textsubscript{set}</td>
<td>Min. = 15 ms</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Max. = 30 ms</td>
<td>-</td>
</tr>
<tr>
<td>Reset time, start at 2 x U\textsubscript{set} to 0</td>
<td>Min. = 15 ms</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Max. = 30 ms</td>
<td>-</td>
</tr>
<tr>
<td>Operate time, start at 0 to 1.2 x U\textsubscript{set}</td>
<td>Min. = 20 ms</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Max. = 35 ms</td>
<td>-</td>
</tr>
<tr>
<td>Reset time, start at 1.2 x U\textsubscript{set} to 0</td>
<td>Min. = 5 ms</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Max. = 25 ms</td>
<td>-</td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>10 ms typically at 0 to 2 x U\textsubscript{set}</td>
<td>-</td>
</tr>
<tr>
<td>Impulse margin time</td>
<td>15 ms typically</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 70. Overexcitation protection OEXPVPH

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate value, start</td>
<td>(100–180)% of (U\textsubscript{Base}/f\textsubscript{rated})</td>
<td>±0.5% of U</td>
</tr>
<tr>
<td>Operate value, alarm</td>
<td>(50–120)% of start level</td>
<td>±0.5% of U\textsubscript{r} at U ≤ U\textsubscript{r}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.5% of U at U &gt; U\textsubscript{r}</td>
</tr>
<tr>
<td>Operate value, high level</td>
<td>(100–200)% of (U\textsubscript{Base}/f\textsubscript{rated})</td>
<td>±0.5% of U</td>
</tr>
<tr>
<td>Curve type</td>
<td>IEEE or customer defined</td>
<td>±5.0 % or ±45 ms, whichever is greater</td>
</tr>
<tr>
<td></td>
<td>( t = \frac{(0.18 \times k)}{(M-1)} )</td>
<td>(Equation 2)</td>
</tr>
<tr>
<td></td>
<td>where M = (E/f)/(Ur/fr)</td>
<td></td>
</tr>
<tr>
<td>Minimum time delay for inverse function</td>
<td>(0.000–60.000) s</td>
<td>±1.0% or ±45 ms, whichever is greater</td>
</tr>
<tr>
<td>Maximum time delay for inverse function</td>
<td>(0.00–9000.00) s</td>
<td>±1.0% or ±45 ms, whichever is greater</td>
</tr>
<tr>
<td>Alarm time delay</td>
<td>(0.00–9000.00) s</td>
<td>±1.0% or ±45 ms, whichever is greater</td>
</tr>
</tbody>
</table>
### Table 71. Voltage differential protection VDCPTOV

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage difference for alarm and trip</td>
<td>(2.0–100.0) % of $U_{Base}$</td>
<td>±0.5% of $U_r$</td>
</tr>
<tr>
<td>Under voltage level</td>
<td>(1.0–100.0) % of $U_{Base}$</td>
<td>±0.5% of $U_r$</td>
</tr>
<tr>
<td>Independent time delay for voltage differential alarm at 0.8 x $U_{DAalarm}$ to 1.2 x $U_{DAalarm}$</td>
<td>(0.000–60.000) s</td>
<td>±0.2% or ±40 ms whichever is greater</td>
</tr>
<tr>
<td>Independent time delay for voltage differential trip at 0.8 x $U_{DTrip}$ to 1.2 x $U_{DTrip}$</td>
<td>(0.000–60.000) s</td>
<td>±0.2% or ±40 ms whichever is greater</td>
</tr>
<tr>
<td>Independent time delay for voltage differential reset at 1.2 x $U_{DTrip}$ to 0.8 x $U_{DTrip}$</td>
<td>(0.000–60.000) s</td>
<td>±0.2% or ±40 ms whichever is greater</td>
</tr>
</tbody>
</table>

### Table 72. 100% Stator E/F 3rd harmonic STEFPHIZ

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamental frequency level UN (95% Stator EF)</td>
<td>(1.0–50.0)% of $U_{Base}$</td>
<td>±0.25% of $U_r$</td>
</tr>
<tr>
<td>Third harmonic differential level</td>
<td>(0.5–10.0)% of $U_{Base}$</td>
<td>±0.25% of $U_r$</td>
</tr>
<tr>
<td>Third harmonic differential block level</td>
<td>(0.1–10.0)% of $U_{Base}$</td>
<td>±0.25% of $U_r$</td>
</tr>
<tr>
<td>Independent time delay to operate for fundamental UN &gt; protection at 0 to 1.2 x $U_{UNFund}&gt;$</td>
<td>(0.020–60.000) s</td>
<td>±0.2% or ±40 ms whichever is greater</td>
</tr>
<tr>
<td>Independent time delay to operate for 3rd harm-based protection at 0 to 5 x $U_{3rdH&lt;}$</td>
<td>(0.020–60.000) s</td>
<td>±0.2% or ±40 ms whichever is greater</td>
</tr>
<tr>
<td>Filter characteristic:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fundamental</td>
<td>Reject third harmonic by 1–40</td>
<td></td>
</tr>
<tr>
<td>Third harmonic</td>
<td>Reject fundamental harmonic by 1–40</td>
<td></td>
</tr>
</tbody>
</table>

Generator protection REG670

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Frequency protection

Table 73. Underfrequency protection SAPTUF

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate value, start function, at symmetrical three phase voltage</td>
<td>(35.00-75.00) Hz</td>
<td>±2.0 mHz</td>
</tr>
<tr>
<td>Operate time, start at ( f_{set} + 0.02 ) Hz to ( f_{set} - 0.02 ) Hz</td>
<td>( fn = 50 ) Hz</td>
<td>Min. = 80 ms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Max. = 95 ms</td>
</tr>
<tr>
<td></td>
<td>( fn = 60 ) Hz</td>
<td>Min. = 65 ms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Max. = 80 ms</td>
</tr>
<tr>
<td>Reset time, start at ( f_{set} - 0.02 ) Hz to ( f_{set} + 0.02 ) Hz</td>
<td>Min. = 15 ms</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Max. = 30 ms</td>
<td>-</td>
</tr>
<tr>
<td>Operate time, definite time function at ( f_{set} + 0.02 ) Hz to ( f_{set} - 0.02 ) Hz</td>
<td>(0.000-60.000)s</td>
<td>±0.2% or ±100 ms whichever is greater</td>
</tr>
<tr>
<td>Reset time, definite time function at ( f_{set} - 0.02 ) Hz to ( f_{set} + 0.02 ) Hz</td>
<td>(0.000-60.000)s</td>
<td>±0.2% or ±120 ms whichever is greater</td>
</tr>
<tr>
<td>Voltage dependent time delay</td>
<td>Settings:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( UNom = (50-150)% ) of ( U_{base} )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( U_{Min} = (50-150)% ) of ( U_{base} )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exponent = 0.0 - 5.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( t_{Max} = (0.010-60.000) ) s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( t_{Min} = (0.010-60.000) ) s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>±1.0% or ±100 ms whichever is greater</td>
<td></td>
</tr>
</tbody>
</table>

\[
U = U_{\text{measured}} = \left[ \frac{U - U_{\text{Min}}}{UNom - U_{\text{Min}}} \right]^{t_{\text{exp}}} - (t_{\text{Max}} - t_{\text{Min}}) + t_{\text{Min}}
\]

(Equation 3)

Table 74. Overfrequency protection SAPTOF

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate value, start function at symmetrical three-phase voltage</td>
<td>(35.00-90.00) Hz</td>
<td>±2.0 mHz</td>
</tr>
<tr>
<td>Operate time, start at ( f_{set} - 0.02 ) Hz to ( f_{set} + 0.02 ) Hz</td>
<td>( fn = 50 ) Hz</td>
<td>Min. = 80 ms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Max. = 95 ms</td>
</tr>
<tr>
<td></td>
<td>( fn = 60 ) Hz</td>
<td>Min. = 65 ms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Max. = 80 ms</td>
</tr>
<tr>
<td>Reset time, start at ( f_{set} + 0.02 ) Hz to ( f_{set} - 0.02 ) Hz</td>
<td>Min. = 15 ms</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Max. = 30 ms</td>
<td>-</td>
</tr>
<tr>
<td>Operate time, definite time function at ( f_{set} - 0.02 ) Hz to ( f_{set} + 0.02 ) Hz</td>
<td>(0.000-60.000)s</td>
<td>±0.2% or ±100 ms whichever is greater</td>
</tr>
<tr>
<td>Reset time, definite time function at ( f_{set} + 0.02 ) Hz to ( f_{set} - 0.02 ) Hz</td>
<td>(0.000-60.000)s</td>
<td>±0.2% or ±120 ms whichever is greater</td>
</tr>
</tbody>
</table>
### Table 75. Rate-of-change of frequency protection SAPFRC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate value, start function</td>
<td>(-10.00-10.00) Hz/s</td>
<td>±10.0 mHz/s</td>
</tr>
<tr>
<td>Operate value, restore enable frequency</td>
<td>(45.00-65.00) Hz</td>
<td>±2.0 mHz</td>
</tr>
<tr>
<td>Definite restore time delay</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±100 ms whichever is greater</td>
</tr>
<tr>
<td>Definite time delay for frequency gradient trip</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±120 ms whichever is greater</td>
</tr>
<tr>
<td>Definite reset time delay</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±250 ms whichever is greater</td>
</tr>
</tbody>
</table>

### Table 76. Frequency accumulation protection FTAQFVR

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate value, frequency high limit level at symmetrical three phase voltage</td>
<td>(35.00 – 90.00) Hz</td>
<td>±2.0 mHz</td>
</tr>
<tr>
<td>Operate value, frequency low limit level at symmetrical three phase voltage</td>
<td>(30.00 – 85.00) Hz</td>
<td>±2.0 mHz</td>
</tr>
<tr>
<td>Operate value, voltage high and low limit for voltage band limit check</td>
<td>(0.0 – 200.0)% of UBase</td>
<td>±0.5% of U, at U ≤ U&lt;sub&gt;r&lt;/sub&gt;, ±0.5% of U at U &gt; U&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td>Operate value, current start level</td>
<td>(5.0 – 100.0)% of IBase</td>
<td>±1.0% of I&lt;sub&gt;r&lt;/sub&gt; or 0.01 A at I&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td>Independent time delay for the continuous time limit at f&lt;sub&gt;set&lt;/sub&gt;+0.02 Hz to f&lt;sub&gt;set&lt;/sub&gt;-0.02 Hz</td>
<td>(0.0 – 6000.0) s</td>
<td>±0.2% or ±250 ms whichever is greater</td>
</tr>
<tr>
<td>Independent time delay for the accumulation time limit at f&lt;sub&gt;set&lt;/sub&gt;+0.02 Hz to f&lt;sub&gt;set&lt;/sub&gt;-0.02 Hz</td>
<td>(10.0 – 90000.0) s</td>
<td>±0.2% or ±250 ms whichever is greater</td>
</tr>
</tbody>
</table>
## Multipurpose protection

Table 77. General current and voltage protection CVGAPC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measuring current input</td>
<td>phase1, phase2, phase3, PosSeq, -NegSeq, -3*ZeroSeq, MaxPh, MinPh, UnbalancePh, phase1-phase2, phase2-phase3, phase3-phase1, MaxPh-Ph, MinPh-Ph, UnbalancePh-Ph</td>
<td>-</td>
</tr>
<tr>
<td>Measuring voltage input</td>
<td>phase1, phase2, phase3, PosSeq, -NegSeq, -3*ZeroSeq, MaxPh, MinPh, UnbalancePh, phase1-phase2, phase2-phase3, phase3-phase1, MaxPh-Ph, MinPh-Ph, UnbalancePh-Ph</td>
<td>-</td>
</tr>
<tr>
<td>Start overcurrent, step 1 - 2</td>
<td>(2 - 5000)% of IBase</td>
<td>±1.0% of I, at I ≤ I&lt;sub&gt;r&lt;/sub&gt;, ±1.0% of I at I &gt; I&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td>Start undercurrent, step 1 - 2</td>
<td>(2 - 150)% of IBase</td>
<td>±1.0% of I, at I ≤ I&lt;sub&gt;r&lt;/sub&gt;, ±1.0% of I at I &gt; I&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td>Independent time delay, overcurrent at 0 to 2 x I&lt;sub&gt;set&lt;/sub&gt;, step 1 - 2</td>
<td>(0.00 - 6000.00) s</td>
<td>±0.2% or ±35 ms whichever is greater</td>
</tr>
<tr>
<td>Independent time delay, undercurrent at 2 x I&lt;sub&gt;set&lt;/sub&gt; to 0, step 1 - 2</td>
<td>(0.00 - 6000.00) s</td>
<td>±0.2% or ±35 ms whichever is greater</td>
</tr>
<tr>
<td>Overcurrent (non-directional):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start time at 0 to 2 x I&lt;sub&gt;set&lt;/sub&gt;</td>
<td>Min. = 15 ms&lt;br&gt;Max. = 30 ms</td>
<td>-</td>
</tr>
<tr>
<td>Reset time at 2 x I&lt;sub&gt;set&lt;/sub&gt; to 0</td>
<td>Min. = 15 ms&lt;br&gt;Max. = 30 ms</td>
<td>-</td>
</tr>
<tr>
<td>Start time at 0 to 10 x I&lt;sub&gt;set&lt;/sub&gt;</td>
<td>Min. = 5 ms&lt;br&gt;Max. = 20 ms</td>
<td>-</td>
</tr>
<tr>
<td>Reset time at 10 x I&lt;sub&gt;set&lt;/sub&gt; to 0</td>
<td>Min. = 20 ms&lt;br&gt;Max. = 35 ms</td>
<td>-</td>
</tr>
<tr>
<td>Undercurrent:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start time at 2 x I&lt;sub&gt;set&lt;/sub&gt; to 0</td>
<td>Min. = 15 ms&lt;br&gt;Max. = 30 ms</td>
<td>-</td>
</tr>
<tr>
<td>Reset time at 0 to 2 x I&lt;sub&gt;set&lt;/sub&gt;</td>
<td>Min. = 15 ms&lt;br&gt;Max. = 30 ms</td>
<td>-</td>
</tr>
<tr>
<td>Overcurrent:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inverse time characteristics, see table 179, 180 and table 181</td>
<td>16 curve types</td>
<td>See table 179, 180 and table 181</td>
</tr>
<tr>
<td>Minimum operate time for inverse curves, step 1 - 2</td>
<td>(0.00 - 6000.00) s</td>
<td>±0.2% or ±35 ms whichever is greater</td>
</tr>
<tr>
<td>Voltage level where voltage memory takes over</td>
<td>(0.0 - 5.0)% of UBase</td>
<td>±0.5% of U&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td>Start overvoltage, step 1 - 2</td>
<td>(2.0 - 200.0)% of UBase</td>
<td>±0.5% of U&lt;sub&gt;r&lt;/sub&gt; at U ≤ U&lt;sub&gt;r&lt;/sub&gt;, ±0.5% of U at U &gt; U&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td>Function</td>
<td>Range or value</td>
<td>Accuracy</td>
</tr>
<tr>
<td>----------</td>
<td>---------------</td>
<td>----------</td>
</tr>
<tr>
<td>Start undervoltage, step 1 - 2</td>
<td>(2.0 - 150.0)% of UBase</td>
<td>±0.5% of U, at U ≤ U, ±0.5% of U at U &gt; U,</td>
</tr>
<tr>
<td>Independent time delay, overvoltage at 0.8 x U&lt;sub&gt;set&lt;/sub&gt; to 1.2 x U&lt;sub&gt;set&lt;/sub&gt;, step 1 - 2</td>
<td>(0.00 - 6000.00) s</td>
<td>±0.2% or ±35 ms whichever is greater</td>
</tr>
<tr>
<td>Independent time delay, undervoltage at 1.2 x U&lt;sub&gt;set&lt;/sub&gt; to 0.8 x U&lt;sub&gt;set&lt;/sub&gt;, step 1 - 2</td>
<td>(0.00 - 6000.00) s</td>
<td>±0.2% or ±35 ms whichever is greater</td>
</tr>
<tr>
<td>Overvoltage:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start time at 0.8 x U&lt;sub&gt;set&lt;/sub&gt; to 1.2 x U&lt;sub&gt;set&lt;/sub&gt;</td>
<td>Min. = 15 ms Max. = 30 ms</td>
<td>-</td>
</tr>
<tr>
<td>Reset time at 1.2 x U&lt;sub&gt;set&lt;/sub&gt; to 0.8 x U&lt;sub&gt;set&lt;/sub&gt;</td>
<td>Min. = 15 ms Max. = 30 ms</td>
<td>-</td>
</tr>
<tr>
<td>Undervoltage:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start time at 1.2 x U&lt;sub&gt;set&lt;/sub&gt; to 0.8 x U&lt;sub&gt;set&lt;/sub&gt;</td>
<td>Min. = 15 ms Max. = 30 ms</td>
<td>-</td>
</tr>
<tr>
<td>Reset time at 1.2 x U&lt;sub&gt;set&lt;/sub&gt; to 0.8 x U&lt;sub&gt;set&lt;/sub&gt;</td>
<td>Min. = 15 ms Max. = 30 ms</td>
<td>-</td>
</tr>
<tr>
<td>Overvoltage:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inverse time characteristics, see table 187</td>
<td>4 curve types</td>
<td>See table 187</td>
</tr>
<tr>
<td>Undervoltage:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inverse time characteristics, see table 188</td>
<td>3 curve types</td>
<td>See table 188</td>
</tr>
<tr>
<td>High and low voltage limit, voltage dependent operation, step 1 - 2</td>
<td>(1.0 - 200.0)% of UBase</td>
<td>±1.0% of U, at U ≤ U, ±1.0% of U at U &gt; U,</td>
</tr>
<tr>
<td>Directional function</td>
<td>Settable: NonDir, forward and reverse</td>
<td>-</td>
</tr>
<tr>
<td>Relay characteristic angle</td>
<td>(-180 to +180) degrees</td>
<td>±2.0 degrees</td>
</tr>
<tr>
<td>Relay operate angle</td>
<td>(1 to 90) degrees</td>
<td>±2.0 degrees</td>
</tr>
<tr>
<td>Reset ratio, overcurrent</td>
<td>&gt; 95%</td>
<td>-</td>
</tr>
<tr>
<td>Reset ratio, undercurrent</td>
<td>&lt; 105%</td>
<td>-</td>
</tr>
<tr>
<td>Reset ratio, overvoltage</td>
<td>&gt; 95%</td>
<td>-</td>
</tr>
<tr>
<td>Reset ratio, undervoltage</td>
<td>&lt; 105%</td>
<td>-</td>
</tr>
<tr>
<td>Operate frequency</td>
<td>10-90 Hz</td>
<td>-</td>
</tr>
<tr>
<td>Overcurrent:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>10 ms typically at 0 to 2 x I&lt;sub&gt;set&lt;/sub&gt;</td>
<td>-</td>
</tr>
<tr>
<td>Impulse margin time</td>
<td>15 ms typically</td>
<td>-</td>
</tr>
<tr>
<td>Undercurrent:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>10 ms typically at 2 x I&lt;sub&gt;set&lt;/sub&gt; to 0</td>
<td>-</td>
</tr>
<tr>
<td>Impulse margin time</td>
<td>15 ms typically</td>
<td>-</td>
</tr>
<tr>
<td>Overvoltage:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>10 ms typically at 0.8 x U&lt;sub&gt;set&lt;/sub&gt; to 1.2 x U&lt;sub&gt;set&lt;/sub&gt;</td>
<td>-</td>
</tr>
</tbody>
</table>
### Table 77. General current and voltage protection CVGAPC, continued

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impulse margin time</td>
<td>15 ms typically</td>
<td>-</td>
</tr>
<tr>
<td>Undervoltage:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>10 ms typically at 1.2 x (U_{\text{set}}) to 0.8 x (U_{\text{set}})</td>
<td>-</td>
</tr>
<tr>
<td>Impulse margin time</td>
<td>15 ms typically</td>
<td>-</td>
</tr>
</tbody>
</table>

### Table 78. Rotor earth fault protection based on General current and voltage protection (CVGAPC) and RXTTE4

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>For machines with:</td>
<td></td>
</tr>
<tr>
<td>• rated field voltage up to 350 V DC</td>
<td>350 V DC</td>
</tr>
<tr>
<td>• static exciter with rated supply voltage up to 700 V 50/60 Hz</td>
<td>700 V 50/60 Hz</td>
</tr>
<tr>
<td>Supply voltage 120 or 230 V</td>
<td>50/60 Hz</td>
</tr>
<tr>
<td>Operate earth fault resistance value</td>
<td>Approx. 1–20 kΩ</td>
</tr>
<tr>
<td>Influence of harmonics in the DC field voltage</td>
<td>Negligible influence of 50 V, 150 Hz or 50 V, 300 Hz</td>
</tr>
<tr>
<td>Permitted leakage capacitance</td>
<td>(1–5) μF</td>
</tr>
<tr>
<td>Permitted shaft earthing resistance</td>
<td>Maximum 200 Ω</td>
</tr>
<tr>
<td>Protective resistor</td>
<td>220 Ω, 100 W, plate (the height is 160 mm (6.2 inches) and width 135 mm (5.31 inches))</td>
</tr>
</tbody>
</table>
## Secondary system supervision

### Table 79. Current circuit supervision CCSSPVC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
</table>
| Operate current           | (10-200)% of IBase | ±10.0% of I at I ≤ I<sub>r</sub>,  
|                           |                | ±10.0% of I at I > I<sub>r</sub>,           |
| Reset ratio, Operate current | >90%            |                                               |
| Block current             | (20-500)% of IBase | ±5.0% of I at I ≤ I<sub>r</sub>,  
|                           |                | ±5.0% of I at I > I<sub>r</sub>,           |
| Reset ratio, Block current | >90% at (50-500)% of IBase |                                               |

### Table 80. Fuse failure supervision FUFSVPC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate voltage, zero sequence</td>
<td>(1-100)% of UBase</td>
<td>±0.5% of U&lt;sub&gt;r&lt;/sub&gt;,</td>
</tr>
<tr>
<td>Operate current, zero sequence</td>
<td>(1–100)% of IBase</td>
<td>±0.5% of I&lt;sub&gt;r&lt;/sub&gt;,</td>
</tr>
<tr>
<td>Operate voltage, negative sequence</td>
<td>(1-100)% of UBase</td>
<td>±0.5% of U&lt;sub&gt;r&lt;/sub&gt;,</td>
</tr>
<tr>
<td>Operate current, negative sequence</td>
<td>(1–100)% of IBase</td>
<td>±0.5% of I&lt;sub&gt;r&lt;/sub&gt;,</td>
</tr>
<tr>
<td>Operate voltage change level</td>
<td>(1-100)% of UBase</td>
<td>±10.0% of U&lt;sub&gt;r&lt;/sub&gt;,</td>
</tr>
<tr>
<td>Operate current change level</td>
<td>(1–100)% of IBase</td>
<td>±10.0% of I&lt;sub&gt;r&lt;/sub&gt;,</td>
</tr>
<tr>
<td>Operate phase voltage</td>
<td>(1-100)% of UBase</td>
<td>±0.5% of U&lt;sub&gt;r&lt;/sub&gt;,</td>
</tr>
<tr>
<td>Operate phase current</td>
<td>(1–100)% of IBase</td>
<td>±0.5% of I&lt;sub&gt;r&lt;/sub&gt;,</td>
</tr>
<tr>
<td>Operate phase dead line voltage</td>
<td>(1-100)% of UBase</td>
<td>±0.5% of U&lt;sub&gt;r&lt;/sub&gt;,</td>
</tr>
<tr>
<td>Operate phase dead line current</td>
<td>(1–100)% of IBase</td>
<td>±0.5% of I&lt;sub&gt;r&lt;/sub&gt;,</td>
</tr>
</tbody>
</table>
| Operate time, start, 1 ph, at 1 x U<sub>r</sub> to 0 | Min. = 10 ms  
Max. = 25 ms | -            |
| Reset time, start, 1 ph, at 0 to 1 x U<sub>r</sub> | Min. = 15 ms  
Max. = 30 ms | -            |
### Table 81. Fuse failure supervision VDSPVC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate value, block of main fuse failure</td>
<td>(10.0-80.0)% of UBase</td>
<td>±0.5% of Ur</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&lt;110%</td>
<td></td>
</tr>
<tr>
<td>Operate time, block of main fuse failure at 1 x Ur to 0</td>
<td>Min. = 5 ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max. = 15 ms</td>
<td></td>
</tr>
<tr>
<td>Reset time, block of main fuse failure at 0 to 1 x Ur</td>
<td>Min. = 15 ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max. = 30 ms</td>
<td></td>
</tr>
<tr>
<td>Operate value, alarm for pilot fuse failure</td>
<td>(10.0-80.0)% of UBase</td>
<td>±0.5% of Ur</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&lt;110%</td>
<td></td>
</tr>
<tr>
<td>Operate time, alarm for pilot fuse failure at 1 x Ur to 0</td>
<td>Min. = 5 ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max. = 15 ms</td>
<td></td>
</tr>
<tr>
<td>Reset time, alarm for pilot fuse failure at 0 to 1 x Ur</td>
<td>Min. = 15 ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max. = 30 ms</td>
<td></td>
</tr>
</tbody>
</table>

### Table 82. Voltage based delta supervision DELVSPVC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Voltage</td>
<td>(5.0 - 50.0)% of UBase</td>
<td>±0.5% of Ur at U ≤ Ur</td>
</tr>
</tbody>
</table>
| DelU>                                        | (2.0 - 500.0)% of UBase | Instantaneous 1 cycle & Instantaneous 2 cycle mode: ±20% of Ur at U ≤ Ur  
|                                               |                | ±20% of U at U > UrRMS & DFT Mag mode:±10% of Ur at U ≤ Ur±10% of U at U > Ur |
| DelUAng>                                     | (2.0 - 40.0) degrees | ±2.0 degrees                                       |
| Operate time for change at Ur to (Ur + 2 x DelU>) at Ur to (Ur + 5 x DelU>) | Instantaneous 1 cycle & Instantaneous 2 cycle mode - <20msRMS & DFT Mag mode - <30ms |
| Operate time for jump from Zero degrees to 'AngStVal' + 2 degrees | Vector shift mode - <60ms |                                                      |

### Table 83. Current based delta supervision DELISPVC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum current</td>
<td>(5.0 - 50.0)% of IBase</td>
<td>±1.0% of Ir at I ≤ Ir±1.0% of I at I &gt; Ir</td>
</tr>
<tr>
<td>Dell&gt;</td>
<td>(10.0 - 500.0)% of IBase</td>
<td>Instantaneous 1 cycle &amp; Instantaneous 2 cycle mode: ±20% of Ir at I ≤ Ir±20% of I at I &gt; IrRMS &amp; DFT Mag mode:±10% of Ir at I ≤ Ir±10% of I at I &gt; Ir</td>
</tr>
<tr>
<td>Second harmonic blocking</td>
<td>(5.0 - 100.0)% of fundamental</td>
<td>±2.0% of Ir</td>
</tr>
<tr>
<td>Third harmonic restraining</td>
<td>(5.0 - 100.0)% of fundamental</td>
<td>±2.0% of Ir</td>
</tr>
<tr>
<td>Operate time for change at Ir to (Ir + 2 x Dell&gt;) at Ir to (Ir + 5 x Dell&gt;)</td>
<td>Instantaneous 1 cycle &amp; Instantaneous 2 cycle mode - &lt;20msRMS &amp; DFT Mag mode - &lt;30ms</td>
<td></td>
</tr>
</tbody>
</table>

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## Control

### Table 84. Synchronizing, synchrocheck and energizing check SESRSYN

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase shift, $\phi_{line} - \phi_{bus}$</td>
<td>(-180 to 180) degrees</td>
<td>-</td>
</tr>
<tr>
<td>Voltage high limit for synchronizing and synchrocheck</td>
<td>(50.0-120.0)% of UBase</td>
<td>±0.5% of $U_r$ at $U \leq U_r$</td>
</tr>
<tr>
<td>Reset ratio, synchrocheck</td>
<td>&gt; 95%</td>
<td>-</td>
</tr>
<tr>
<td>Frequency difference limit between bus and line for synchrocheck</td>
<td>(0.003-1.000) Hz</td>
<td>±2.5 mHz</td>
</tr>
<tr>
<td>Phase angle difference limit between bus and line for synchrocheck</td>
<td>(5.0-90.0) degrees</td>
<td>±2.0 degrees</td>
</tr>
<tr>
<td>Voltage difference limit between bus and line for synchronizing and synchrocheck</td>
<td>(0.02-0.5) p.u</td>
<td>±0.5% of $U_r$</td>
</tr>
<tr>
<td>Time delay output for synchrocheck when angle difference between bus and line jumps from “PhaseDiff” + 2 degrees to “PhaseDiff” - 2 degrees</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±35 ms whichever is greater</td>
</tr>
<tr>
<td>Frequency difference minimum limit for synchronizing</td>
<td>(0.003-0.250) Hz</td>
<td>±2.5 mHz</td>
</tr>
<tr>
<td>Frequency difference maximum limit for synchronizing</td>
<td>(0.050-1.000) Hz</td>
<td>±2.5 mHz</td>
</tr>
<tr>
<td>Maximum closing angle between bus and line for synchronizing</td>
<td>(15-30) degrees</td>
<td>±2.0 degrees</td>
</tr>
<tr>
<td>Breaker closing pulse duration</td>
<td>(0.050-1.000) s</td>
<td>±0.2% or ±15 ms whichever is greater</td>
</tr>
<tr>
<td>tMaxSynch, which resets synchronizing function if no close has been made before set time</td>
<td>(0.000-6000.00) s</td>
<td>±0.2% or ±35 ms whichever is greater</td>
</tr>
<tr>
<td>Minimum time to accept synchronizing conditions</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±35 ms whichever is greater</td>
</tr>
<tr>
<td>Voltage high limit for energizing check</td>
<td>(50.0-120.0)% of UBase</td>
<td>±0.5% of $U_r$ at $U \leq U_r$</td>
</tr>
<tr>
<td>Reset ratio, voltage high limit</td>
<td>&gt; 95%</td>
<td>-</td>
</tr>
<tr>
<td>Voltage low limit for energizing check</td>
<td>(10.0-80.0)% of UBase</td>
<td>±0.5% of $U_r$</td>
</tr>
<tr>
<td>Reset ratio, voltage low limit</td>
<td>&lt; 105%</td>
<td>-</td>
</tr>
<tr>
<td>Maximum voltage for energizing</td>
<td>(50.0-180.0)% of UBase</td>
<td>±0.5% of $U_r$ at $U \leq U_r$</td>
</tr>
<tr>
<td>Time delay for energizing check when voltage jumps from 0 to 90% of Urated</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±100 ms whichever is greater</td>
</tr>
<tr>
<td>Operate time for synchrocheck function when angle difference between bus and line jumps from “PhaseDiff” + 2 degrees to “PhaseDiff” - 2 degrees</td>
<td>Min. = 15 ms Max. = 30 ms</td>
<td>-</td>
</tr>
<tr>
<td>Operate time for energizing function when voltage jumps from 0 to 90% of Urated</td>
<td>Min. = 70 ms Max. = 90 ms</td>
<td>-</td>
</tr>
</tbody>
</table>
Table 85. Tap changer control TCMYLTC/TCLYLTC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tap position for lowest and highest voltage</td>
<td>(1–63)</td>
<td>-</td>
</tr>
<tr>
<td>mA for lowest and highest voltage tap position</td>
<td>(0.000–25.000) mA</td>
<td>-</td>
</tr>
<tr>
<td>Type of code conversion</td>
<td>BIN, BCD, GRAY, SINGLE, mA</td>
<td>-</td>
</tr>
<tr>
<td>Time after position change before the value is accepted (t_{Stable})</td>
<td>(1–60) s</td>
<td>±0.2% or ±200 ms whichever is greater</td>
</tr>
<tr>
<td>Tap changer constant time-out</td>
<td>(1–120) s</td>
<td>±0.2% or ±200 ms whichever is greater</td>
</tr>
<tr>
<td>Raise/lower command output pulse duration</td>
<td>(0.5–10.0) s</td>
<td>±0.2% or ±200 ms whichever is greater</td>
</tr>
</tbody>
</table>
## Logic

### Table 86. Tripping logic common 3-phase output SMPPTRC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trip action</td>
<td>3-ph, 1/3-ph, 1/2/3-ph</td>
<td>-</td>
</tr>
<tr>
<td>Minimum trip pulse length</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±15 ms whichever is greater</td>
</tr>
<tr>
<td>3-pole trip delay</td>
<td>(0.020-0.500) s</td>
<td>±0.2% or ±15 ms whichever is greater</td>
</tr>
<tr>
<td>Evolving fault delay</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±15 ms whichever is greater</td>
</tr>
</tbody>
</table>

### Table 87. Number of SMAGAPC instances

<table>
<thead>
<tr>
<th>Function</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 ms</td>
</tr>
<tr>
<td>SMAGAPC</td>
<td>12</td>
</tr>
</tbody>
</table>

### Table 88. Number of STARTCOMB instances

<table>
<thead>
<tr>
<th>Function</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 ms</td>
</tr>
<tr>
<td>STARTCOMB</td>
<td>32</td>
</tr>
</tbody>
</table>

### Table 89. Number of TMAGAPC instances

<table>
<thead>
<tr>
<th>Function</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 ms</td>
</tr>
<tr>
<td>TMAGAPC</td>
<td>6</td>
</tr>
</tbody>
</table>

### Table 90. Number of ALMCALH instances

<table>
<thead>
<tr>
<th>Function</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 ms</td>
</tr>
<tr>
<td>ALMCALH</td>
<td>-</td>
</tr>
</tbody>
</table>

### Table 91. Number of WRNCALH instances

<table>
<thead>
<tr>
<th>Function</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 ms</td>
</tr>
<tr>
<td>WRNCALH</td>
<td>-</td>
</tr>
</tbody>
</table>

### Table 92. Number of INDCALH instances

<table>
<thead>
<tr>
<th>Function</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 ms</td>
</tr>
<tr>
<td>INDCALH</td>
<td>-</td>
</tr>
</tbody>
</table>
### Table 93. Number of AND instances

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 ms</td>
</tr>
<tr>
<td>AND</td>
<td>60</td>
</tr>
</tbody>
</table>

### Table 94. Number of GATE instances

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 ms</td>
</tr>
<tr>
<td>GATE</td>
<td>10</td>
</tr>
</tbody>
</table>

### Table 95. Number of INV instances

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 ms</td>
</tr>
<tr>
<td>INV</td>
<td>90</td>
</tr>
</tbody>
</table>

### Table 96. Number of LLD instances

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 ms</td>
</tr>
<tr>
<td>LLD</td>
<td>10</td>
</tr>
</tbody>
</table>

### Table 97. Number of OR instances

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 ms</td>
</tr>
<tr>
<td>OR</td>
<td>78</td>
</tr>
</tbody>
</table>

### Table 98. Number of PULSETIMER instances

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
<th>Range or Value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 ms</td>
<td>8 ms</td>
<td>100 ms</td>
</tr>
<tr>
<td>PULSETIMER</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
</tbody>
</table>

### Table 99. Number of RSMEMORY instances

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 ms</td>
</tr>
<tr>
<td>RSMEMORY</td>
<td>10</td>
</tr>
</tbody>
</table>

### Table 100. Number of SRMEMORY instances

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 ms</td>
</tr>
<tr>
<td>SRMEMORY</td>
<td>10</td>
</tr>
</tbody>
</table>
Table 101. Number of TIMERSET instances

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
<th>Range or Value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 ms</td>
<td>8 ms</td>
<td>100 ms</td>
</tr>
<tr>
<td>TIMERSET</td>
<td>15</td>
<td>15</td>
<td>30</td>
</tr>
</tbody>
</table>

Table 102. Number of XOR instances

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 ms</td>
</tr>
<tr>
<td>XOR</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 103. Number of ANDQT instances

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 ms</td>
</tr>
<tr>
<td>ANDQT</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 104. Number of INDCOMBSPQT instances

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 ms</td>
</tr>
<tr>
<td>INDCOMBSPQT</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 105. Number of INDEXTSPQT instances

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 ms</td>
</tr>
<tr>
<td>INDEXTSPQT</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 106. Number of INVALIDQT instances

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 ms</td>
</tr>
<tr>
<td>INVALIDQT</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 107. Number of INVERTERQT instances

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 ms</td>
</tr>
<tr>
<td>INVERTERQT</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 108. Number of ORQT instances

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 ms</td>
</tr>
<tr>
<td>ORQT</td>
<td>-</td>
</tr>
</tbody>
</table>
### Table 109. Number of PULSETIMERQT instances

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
<th>Range or Value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>PULSETIMERQT</td>
<td>3 ms, 8 ms, 100 ms</td>
<td>(0.000–90000.000) s</td>
<td>±0.5% ±10 ms</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
<th>Range or Value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>PULSETIMERQT</td>
<td>3 ms, 8 ms, 100 ms</td>
<td>(0.000–90000.000) s</td>
<td>±0.5% ±10 ms</td>
</tr>
</tbody>
</table>

### Table 110. Number of RSMEMORYQT instances

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSMEMORYQT</td>
<td>3 ms, 8 ms, 100 ms</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSMEMORYQT</td>
<td>3 ms, 8 ms, 100 ms</td>
</tr>
</tbody>
</table>

### Table 111. Number of SRMEMORYQT instances

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRMEMORYQT</td>
<td>3 ms, 8 ms, 100 ms</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRMEMORYQT</td>
<td>3 ms, 8 ms, 100 ms</td>
</tr>
</tbody>
</table>

### Table 112. Number of TIMERSETQT instances

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
<th>Range or Value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIMERSETQT</td>
<td>3 ms, 8 ms, 100 ms</td>
<td>(0.000–90000.000) s</td>
<td>±0.5% ±10 ms</td>
</tr>
</tbody>
</table>

### Table 113. Number of XORQT instances

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td>XORQT</td>
<td>3 ms, 8 ms, 100 ms</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td>XORQT</td>
<td>3 ms, 8 ms, 100 ms</td>
</tr>
</tbody>
</table>
Table 114. Number of instances in the extension logic package

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 ms</td>
</tr>
<tr>
<td>SLGAPC</td>
<td>10</td>
</tr>
<tr>
<td>VSGAPC</td>
<td>10</td>
</tr>
<tr>
<td>AND</td>
<td>80</td>
</tr>
<tr>
<td>OR</td>
<td>80</td>
</tr>
<tr>
<td>PULSETIMER</td>
<td>20</td>
</tr>
<tr>
<td>GATE</td>
<td>—</td>
</tr>
<tr>
<td>TIMERSET</td>
<td>34</td>
</tr>
<tr>
<td>XOR</td>
<td>10</td>
</tr>
<tr>
<td>LLD</td>
<td>—</td>
</tr>
<tr>
<td>SRMEMORY</td>
<td>10</td>
</tr>
<tr>
<td>INV</td>
<td>80</td>
</tr>
<tr>
<td>RSMEMORY</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 115. Number of B16I instances

<table>
<thead>
<tr>
<th>Function</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 ms</td>
</tr>
<tr>
<td>B16I</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 116. Number of BTIGAPC instances

<table>
<thead>
<tr>
<th>Function</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td>BTIGAPC</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 117. Number of IB16 instances

<table>
<thead>
<tr>
<th>Function</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td>IB16</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 118. Number of ITBGAPC instances

<table>
<thead>
<tr>
<th>Function</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITBGAPC</td>
<td>4</td>
</tr>
</tbody>
</table>
### Table 119. Integrator TIGAPC

<table>
<thead>
<tr>
<th>Function</th>
<th>Cycle time (ms)</th>
<th>Range of value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time integration continuous active</td>
<td>3</td>
<td>0-999999.99 s</td>
<td>±0.2% or ±20 ms whichever is greater</td>
</tr>
<tr>
<td>Time integration continuous active</td>
<td>8</td>
<td>0-999999.99 s</td>
<td>± 0.2% or ±50 ms whichever is greater</td>
</tr>
</tbody>
</table>

### Table 119. Integrator TIGAPC, continued

<table>
<thead>
<tr>
<th>Function</th>
<th>Cycle time (ms)</th>
<th>Range of value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time integration continuous active</td>
<td>100</td>
<td>0-999999.99 s</td>
<td>±0.2% or ±250 ms whichever is greater</td>
</tr>
</tbody>
</table>

### Table 120. Number of TIGAPC instances

<table>
<thead>
<tr>
<th>Function</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIGAPC</td>
<td>3 ms</td>
</tr>
</tbody>
</table>

### Table 121. Elapsed time integrator with limit transgression and overflow supervision TEIGAPC

<table>
<thead>
<tr>
<th>Function</th>
<th>Cycle time (ms)</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elapsed time integration</td>
<td>3</td>
<td>0 ~ 999999.9 s</td>
<td>±0.2% or ±20 ms whichever is greater</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>0 ~ 999999.9 s</td>
<td>±0.2% or ±100 ms whichever is greater</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>0 ~ 999999.9 s</td>
<td>±0.2% or ±250 ms whichever is greater</td>
</tr>
</tbody>
</table>

### Table 122. Number of TEIGAPC instances

<table>
<thead>
<tr>
<th>Function</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEIGAPC</td>
<td>4</td>
</tr>
</tbody>
</table>

### Table 123. Number of INTCOMP instances

<table>
<thead>
<tr>
<th>Function</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTCOMP</td>
<td>10</td>
</tr>
</tbody>
</table>

### Table 124. Number of REALCOMP instances

<table>
<thead>
<tr>
<th>Function</th>
<th>Quantity with cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td>REALCOMP</td>
<td>10</td>
</tr>
</tbody>
</table>
## Monitoring

Table 125. Power system measurement CVMMXN

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>(0.95-1.05) x f</td>
<td>±2.0 mHz</td>
</tr>
<tr>
<td>Voltage</td>
<td>(10 to 300) V</td>
<td>±0.3% of U at U ≤ 50 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.2% of U at U &gt; 50 V</td>
</tr>
<tr>
<td>Current</td>
<td>(0.1-4.0) x I</td>
<td>±0.8% of I at 0.1 x I &lt; I &lt; 0.2 x I</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.5% of I at 0.2 x I &lt; I &lt; 0.5 x I</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.2% of I at 0.5 x I &lt; I &lt; 4.0 x I</td>
</tr>
<tr>
<td>Active power, P</td>
<td>(10 to 300) V</td>
<td>±0.5% of S, at S ≤ 0.5 x S</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.5% of S, at S &gt; 0.5 x S</td>
</tr>
<tr>
<td></td>
<td>(100 to 220) V</td>
<td>±0.2% of P</td>
</tr>
<tr>
<td></td>
<td>(0.5-2.0) x I</td>
<td>cos φ &gt; 0.7</td>
</tr>
<tr>
<td>Reactive power, Q</td>
<td>(10 to 300) V</td>
<td>±0.5% of S, at S ≤ 0.5 x S</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.5% of S, at S &gt; 0.5 x S</td>
</tr>
<tr>
<td></td>
<td>(100 to 220) V</td>
<td>±0.2% of Q</td>
</tr>
<tr>
<td></td>
<td>(0.5-2.0) x I</td>
<td>cos φ &lt; 0.7</td>
</tr>
<tr>
<td>Apparent power, S</td>
<td>(10 to 300) V</td>
<td>±0.5% of S, at S ≤ 0.5 x S</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.5% of S, at S &gt; 0.5 x S</td>
</tr>
<tr>
<td></td>
<td>(100 to 220) V</td>
<td>±0.2% of S</td>
</tr>
<tr>
<td></td>
<td>(0.5-2.0) x I</td>
<td>cos φ &lt; 0.7</td>
</tr>
<tr>
<td>Power factor, cos (φ)</td>
<td>(10 to 300) V</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td></td>
<td>(0.1-4.0) x I</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(100 to 220) V</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>(0.5-2.0) x I</td>
<td></td>
</tr>
</tbody>
</table>

Table 126. Current measurement CMMXU

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current at symmetrical load</td>
<td>(0.1-4.0) x I</td>
<td>±0.3% of I, at I ≤ 0.5 x I</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.3% of I, at I &gt; 0.5 x I</td>
</tr>
<tr>
<td>Phase angle at symmetrical</td>
<td>(0.1-4.0) x I</td>
<td>±1.0 degrees at 0.1 x I &lt; I ≤ 0.5 x I</td>
</tr>
<tr>
<td>load</td>
<td></td>
<td>±0.5 degrees at 0.5 x I &lt; I ≤ 4.0 x I</td>
</tr>
</tbody>
</table>

Table 127. Voltage measurement phase-phase VMMXU

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>(10 to 300) V</td>
<td>±0.5% of U at U ≤ 50 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.2% of U at U &gt; 50 V</td>
</tr>
<tr>
<td>Phase angle</td>
<td>(10 to 300) V</td>
<td>±0.5 degrees at U ≤ 50 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.2 degrees at U &gt; 50 V</td>
</tr>
</tbody>
</table>
Table 128. Voltage measurement phase-earth VNMMXU

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>(5 to 175) V</td>
<td>±0.5% of U at U ≤ 50 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.2% of U at U &gt; 50 V</td>
</tr>
<tr>
<td>Phase angle</td>
<td>(5 to 175) V</td>
<td>±0.5 degrees at U ≤ 50 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.2 degrees at U &gt; 50 V</td>
</tr>
</tbody>
</table>

Table 129. Current sequence measurement CMSQI

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current positive sequence, $I_1$</td>
<td>$(0.1–4.0) \times I_r$</td>
<td>±0.3% of $I_r$ at $I \leq 0.5 \times I_r$</td>
</tr>
<tr>
<td>Three phase settings</td>
<td></td>
<td>±0.3% of $I$ at $I &gt; 0.5 \times I_r$</td>
</tr>
<tr>
<td>Current zero sequence, $3I_0$</td>
<td>$(0.1–1.0) \times I_r$</td>
<td>±0.3% of $I_r$ at $I \leq 0.5 \times I_r$</td>
</tr>
<tr>
<td>Three phase settings</td>
<td></td>
<td>±0.3% of $I$ at $I &gt; 0.5 \times I_r$</td>
</tr>
<tr>
<td>Current negative sequence, $I_2$</td>
<td>$(0.1–1.0) \times I_r$</td>
<td>±0.3% of $I_r$ at $I \leq 0.5 \times I_r$</td>
</tr>
<tr>
<td>Three phase settings</td>
<td></td>
<td>±0.3% of $I$ at $I &gt; 0.5 \times I_r$</td>
</tr>
<tr>
<td>Phase angle</td>
<td>$(0.1–4.0) \times I_r$</td>
<td>±1.0 degrees at $0.1 \times I_r &lt; I \leq 0.5 \times I_r$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.5 degrees at $0.5 \times I_r &lt; I \leq 4.0 \times I_r$</td>
</tr>
</tbody>
</table>

Table 130. Voltage sequence measurement VMSQI

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage positive sequence, $U_1$</td>
<td>(10 to 300) V</td>
<td>±0.5% of U at U ≤ 50 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.2% of U at U &gt; 50 V</td>
</tr>
<tr>
<td>Voltage zero sequence, $3U_0$</td>
<td>(10 to 300) V</td>
<td>±0.5% of U at U ≤ 50 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.2% of U at U &gt; 50 V</td>
</tr>
<tr>
<td>Voltage negative sequence, $U_2$</td>
<td>(10 to 300) V</td>
<td>±0.5% of U at U ≤ 50 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.2% of U at U &gt; 50 V</td>
</tr>
<tr>
<td>Phase angle</td>
<td>(10 to 300) V</td>
<td>±0.5 degrees at U ≤ 50 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±0.2 degrees at U &gt; 50 V</td>
</tr>
</tbody>
</table>

Table 131. Supervision of mA input signals

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>mA measuring function</td>
<td>±5, ±10, ±20 mA</td>
<td>±0.1 % of set value ±0.005 mA</td>
</tr>
<tr>
<td>Max current of transducer to input</td>
<td>-20.00 to +20.00 mA</td>
<td></td>
</tr>
<tr>
<td>Min current of transducer to input</td>
<td>-20.00 to +20.00 mA</td>
<td></td>
</tr>
<tr>
<td>Alarm level for input</td>
<td>-20.00 to +20.00 mA</td>
<td></td>
</tr>
<tr>
<td>Warning level for input</td>
<td>-20.00 to +20.00 mA</td>
<td></td>
</tr>
<tr>
<td>Alarm hysteresis for input</td>
<td>(0.0-20.0) mA</td>
<td></td>
</tr>
</tbody>
</table>
### Table 132. Disturbance report DRPRDRE

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-fault time</td>
<td>(0.05–9.90) s</td>
<td></td>
</tr>
<tr>
<td>Post-fault time</td>
<td>(0.1–10.0) s</td>
<td></td>
</tr>
<tr>
<td>Limit time</td>
<td>(0.5–10.0) s</td>
<td></td>
</tr>
<tr>
<td>Maximum number of recordings</td>
<td>100, first in - first out</td>
<td></td>
</tr>
<tr>
<td>Time tagging resolution</td>
<td>1 ms</td>
<td>See table 174</td>
</tr>
<tr>
<td>Maximum number of analog inputs</td>
<td>30 + 10 (external + internally derived)</td>
<td></td>
</tr>
<tr>
<td>Maximum number of binary inputs</td>
<td>352</td>
<td></td>
</tr>
<tr>
<td>Maximum number of phasors in the Trip Value recorder per recording</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Maximum number of indications in a disturbance report</td>
<td>352</td>
<td></td>
</tr>
<tr>
<td>Maximum number of events in the Event recording per recording</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>Maximum number of events in the Event list</td>
<td>1000, first in - first out</td>
<td></td>
</tr>
<tr>
<td>Maximum total recording time (3.4 s recording time and maximum number of channels, typical value)</td>
<td>340 seconds (100 recordings) at 50 Hz, 280 seconds (80 recordings) at 60 Hz</td>
<td></td>
</tr>
<tr>
<td>Sampling rate</td>
<td>1 kHz at 50 Hz</td>
<td></td>
</tr>
<tr>
<td>Recording bandwidth</td>
<td>(5–300) Hz</td>
<td></td>
</tr>
</tbody>
</table>

### Table 133. Insulation supervision for gas medium function SSIMG

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure alarm level</td>
<td>1.00-100.00</td>
<td>±10.0% of set value</td>
</tr>
<tr>
<td>Pressure lockout level</td>
<td>1.00-100.00</td>
<td>±10.0% of set value</td>
</tr>
<tr>
<td>Temperature alarm level</td>
<td>-40.00-200.00</td>
<td>±2.5% of set value</td>
</tr>
<tr>
<td>Temperature lockout level</td>
<td>-40.00-200.00</td>
<td>±2.5% of set value</td>
</tr>
<tr>
<td>Time delay for pressure alarm</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±250ms whichever is greater</td>
</tr>
<tr>
<td>Reset time delay for pressure alarm</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±250ms whichever is greater</td>
</tr>
<tr>
<td>Time delay for pressure lockout</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±250ms whichever is greater</td>
</tr>
<tr>
<td>Time delay for temperature alarm</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±250ms whichever is greater</td>
</tr>
<tr>
<td>Reset time delay for temperature alarm</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±250ms whichever is greater</td>
</tr>
<tr>
<td>Time delay for temperature lockout</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±250ms whichever is greater</td>
</tr>
</tbody>
</table>
### Table 134. Insulation supervision for liquid medium function SSIML

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil alarm level</td>
<td>1.00-100.00</td>
<td>±10.0% of set value</td>
</tr>
<tr>
<td>Oil lockout level</td>
<td>1.00-100.00</td>
<td>±10.0% of set value</td>
</tr>
<tr>
<td>Temperature alarm level</td>
<td>-40.00-200.00</td>
<td>±2.5% of set value</td>
</tr>
<tr>
<td>Temperature lockout level</td>
<td>-40.00-200.00</td>
<td>±2.5% of set value</td>
</tr>
<tr>
<td>Time delay for oil alarm</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±250ms whichever is greater</td>
</tr>
<tr>
<td>Reset time delay for oil alarm</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±250ms whichever is greater</td>
</tr>
<tr>
<td>Time delay for oil lockout</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±250ms whichever is greater</td>
</tr>
<tr>
<td>Time delay for temperature alarm</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±250ms whichever is greater</td>
</tr>
<tr>
<td>Reset time delay for temperature alarm</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±250ms whichever is greater</td>
</tr>
<tr>
<td>Time delay for temperature lockout</td>
<td>(0.000-60.000) s</td>
<td>±0.2% or ±250ms whichever is greater</td>
</tr>
</tbody>
</table>

### Table 135. Circuit breaker condition monitoring SSCBR

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alarm level for open and close travel time</td>
<td>(0 – 200) ms</td>
<td>±3 ms</td>
</tr>
<tr>
<td>Alarm level for number of operations</td>
<td>(0 – 9999)</td>
<td></td>
</tr>
<tr>
<td>Independent time delay for spring charging time alarm</td>
<td>(0.00 – 60.00) s</td>
<td>±0.2% or ±30 ms whichever is greater</td>
</tr>
<tr>
<td>Independent time delay for gas pressure alarm</td>
<td>(0.00 – 60.00) s</td>
<td>±0.2% or ±30 ms whichever is greater</td>
</tr>
<tr>
<td>Independent time delay for gas pressure lockout</td>
<td>(0.00 – 60.00) s</td>
<td>±0.2% or ±30 ms whichever is greater</td>
</tr>
<tr>
<td>CB Contact Travel Time, opening and closing</td>
<td></td>
<td>±3 ms</td>
</tr>
<tr>
<td>Remaining Life of CB</td>
<td></td>
<td>±2 operations</td>
</tr>
<tr>
<td>Accumulated Energy</td>
<td></td>
<td>±1.0% or ±0.5 whichever is greater</td>
</tr>
</tbody>
</table>

### Table 136. Transformer loss of life LOLSPTTR

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service value, hot spot temperature</td>
<td></td>
<td>±2.0% of expected value</td>
</tr>
<tr>
<td>Service value, top oil temperature</td>
<td></td>
<td>±2.0% of expected value</td>
</tr>
<tr>
<td>Service value, loss of life</td>
<td></td>
<td>±2.0% of expected value</td>
</tr>
<tr>
<td>Operate level, Warning level 1 and 2</td>
<td>(50 - 700)°C/°F of hot spot temperature</td>
<td>±2.0% of hot spot temperature</td>
</tr>
<tr>
<td>Operate time, Warning level 1 and 2</td>
<td>(50 - 700)°C/°F of hot spot temperature</td>
<td>±200 ms typically</td>
</tr>
<tr>
<td>Operate time, definite time function (ALARMX)</td>
<td>(0.0 - 6000.0) s</td>
<td>±250 ms typically</td>
</tr>
</tbody>
</table>
### Table 137. Event list

<table>
<thead>
<tr>
<th>Function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffer capacity</td>
<td>Maximum number of events in the list</td>
</tr>
<tr>
<td>Resolution</td>
<td>1 ms</td>
</tr>
<tr>
<td>Accuracy</td>
<td>Depending on time synchronizing</td>
</tr>
</tbody>
</table>

### Table 138. Indications

<table>
<thead>
<tr>
<th>Function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffer capacity</td>
<td>Maximum number of indications presented for single disturbance</td>
</tr>
<tr>
<td>Maximum number of recorded disturbances</td>
<td>100</td>
</tr>
</tbody>
</table>

### Table 139. Event recorder

<table>
<thead>
<tr>
<th>Function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffer capacity</td>
<td>Maximum number of events in disturbance report</td>
</tr>
<tr>
<td>Maximum number of disturbance reports</td>
<td>100</td>
</tr>
<tr>
<td>Resolution</td>
<td>1 ms</td>
</tr>
<tr>
<td>Accuracy</td>
<td>Depending on time synchronizing</td>
</tr>
</tbody>
</table>

### Table 140. Trip value recorder

<table>
<thead>
<tr>
<th>Function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffer capacity</td>
<td>Maximum number of analog inputs</td>
</tr>
<tr>
<td>Maximum number of disturbance reports</td>
<td>100</td>
</tr>
</tbody>
</table>

### Table 141. Disturbance recorder

<table>
<thead>
<tr>
<th>Function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffer capacity</td>
<td>Maximum number of analog inputs</td>
</tr>
<tr>
<td>Maximum number of binary inputs</td>
<td>352</td>
</tr>
<tr>
<td>Maximum number of disturbance reports</td>
<td>100</td>
</tr>
<tr>
<td>Maximum total recording time (3.4 s recording time and maximum number of channels, typical value)</td>
<td>340 seconds (100 recordings) at 50 Hz</td>
</tr>
</tbody>
</table>

### Table 142. Event counter with limit supervision L4UFCNT

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Counter value</td>
<td>0-65535</td>
<td>-</td>
</tr>
<tr>
<td>Max. count up speed</td>
<td>30 pulses/s (50% duty cycle)</td>
<td>-</td>
</tr>
</tbody>
</table>
Table 143. Running hour-meter TEILGAPC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time limit for alarm supervision, tAlarm</td>
<td>(0 - 99999.9) hours</td>
<td>±0.1% of set value</td>
</tr>
<tr>
<td>Time limit for warning supervision, tWarning</td>
<td>(0 - 99999.9) hours</td>
<td>±0.1% of set value</td>
</tr>
<tr>
<td>Time limit for overflow supervision</td>
<td>Fixed to 99999.9 hours</td>
<td>±0.1%</td>
</tr>
</tbody>
</table>

Table 144. Through fault monitoring PTRSTHR

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate current</td>
<td>(50-1000)% of IBase</td>
<td>±1.0% of $I_r$ at $I \leq I_r$</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&gt; 95% at (50-1000)% of IBase</td>
<td>–</td>
</tr>
</tbody>
</table>

Table 145. Current harmonic monitoring CHMMHAI (50/60 Hz)

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Harmonic</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2nd order to 5th order (0.1 - 0.5) X Ir</td>
<td>± 2 mHz</td>
</tr>
<tr>
<td>Frequency</td>
<td>(0.95 - 1.05) X fr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>True RMS</td>
<td>(0.1 to 1) X Ir</td>
<td>None</td>
<td>± 0.5%</td>
</tr>
<tr>
<td></td>
<td>1 X Ir</td>
<td></td>
<td>± 2%</td>
</tr>
<tr>
<td>Fundamental</td>
<td>(0.1 to 1) X Ir</td>
<td>2nd order to 5th order (0.1 - 0.5) X Ir</td>
<td>± 0.5%</td>
</tr>
<tr>
<td></td>
<td>1 X Ir</td>
<td>None</td>
<td>± 2%</td>
</tr>
<tr>
<td>Crest Factor</td>
<td>(0.1 to 1) X Ir</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harmonic Amplitude</td>
<td>(0.1 to 1) X Ir</td>
<td>2nd order to 5th order (0.1 - 0.5) X Ir</td>
<td>± 5%</td>
</tr>
<tr>
<td>Total Demand Distortion (TDD)</td>
<td>(0.1 to 1) X Ir</td>
<td>2nd order to 5th order (0.1 - 0.5) X Ir</td>
<td>± 6%</td>
</tr>
<tr>
<td>Total Harmonic Distortion (ITHD)</td>
<td>(0.1 to 1) X Ir</td>
<td>2nd order to 5th order (0.1 - 0.5) X Ir</td>
<td>± 6%</td>
</tr>
<tr>
<td>Function</td>
<td>Range or value</td>
<td>Accuracy</td>
<td></td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------</td>
<td>-----------</td>
<td></td>
</tr>
<tr>
<td><strong>Fundamental</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>(0.95 - 1.05) X fr</td>
<td>2nd order to 5th order (0.1 - 0.5) X V</td>
<td>± 2 mHz</td>
</tr>
<tr>
<td>True RMS</td>
<td>(10 to 150) V</td>
<td>None</td>
<td>± 0.5%</td>
</tr>
<tr>
<td></td>
<td>(10 to 150) V</td>
<td>2nd order to 5th order (0.1 - 0.5) X V</td>
<td>± 2%</td>
</tr>
<tr>
<td><strong>Harmonic</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fundamental</td>
<td>(10 to 150) V</td>
<td>None</td>
<td>± 0.5%</td>
</tr>
<tr>
<td></td>
<td>(10 to 150) V</td>
<td>2nd order to 5th order (0.1 - 0.5) X V</td>
<td>± 0.5%</td>
</tr>
<tr>
<td>Crest Factor</td>
<td>(10 to 150) V</td>
<td>None</td>
<td>± 2%</td>
</tr>
<tr>
<td>Harmonic Amplitude</td>
<td>(10 to 150) V</td>
<td>2nd order to 5th order (0.1 - 0.5) X V</td>
<td>± 4%</td>
</tr>
<tr>
<td>Total Harmonic Distortion (VTHD)</td>
<td>(10 to 150) V</td>
<td>2nd order to 5th order (0.1 - 0.5) X V</td>
<td>± 4%</td>
</tr>
</tbody>
</table>
### Metering

Table 147. Pulse-counter logic PCFCNT

<table>
<thead>
<tr>
<th>Function</th>
<th>Setting range</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input frequency</td>
<td>See Binary Input Module (BIM)</td>
<td>-</td>
</tr>
<tr>
<td>Cycle time for report of</td>
<td>(1–3600) s</td>
<td>-</td>
</tr>
<tr>
<td>counter value</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 148. Function for energy calculation and demand handling ETPMMTR

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy metering</td>
<td>kWh Export/Import, kvarh</td>
<td>Input from MMXU. No extra error at steady load</td>
</tr>
<tr>
<td></td>
<td>Export/Import</td>
<td></td>
</tr>
</tbody>
</table>
### Station communication

Table 149. Communication protocols

<table>
<thead>
<tr>
<th>Function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protocol</td>
<td>IEC 61850-8-1</td>
</tr>
<tr>
<td>Communication speed for the IEDs</td>
<td>100BASE-FX</td>
</tr>
<tr>
<td>Protocol</td>
<td>IEC 60870–5–103</td>
</tr>
<tr>
<td>Communication speed for the IEDs</td>
<td>9600 or 19200 Bd</td>
</tr>
<tr>
<td>Protocol</td>
<td>DNP3.0</td>
</tr>
<tr>
<td>Communication speed for the IEDs</td>
<td>300–115200 Bd</td>
</tr>
<tr>
<td>Protocol</td>
<td>TCP/IP, Ethernet</td>
</tr>
<tr>
<td>Communication speed for the IEDs</td>
<td>100 Mbit/s</td>
</tr>
<tr>
<td>Protocol</td>
<td>LON</td>
</tr>
<tr>
<td>Communication speed for the IEDs</td>
<td>1.25 Mbit/s</td>
</tr>
<tr>
<td>Protocol</td>
<td>SPA</td>
</tr>
<tr>
<td>Communication speed for the IEDs</td>
<td>300–38400 Bd</td>
</tr>
</tbody>
</table>

Table 150. IEC 61850-9-2 communication protocol

<table>
<thead>
<tr>
<th>Function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protocol</td>
<td>IEC 61850-9-2</td>
</tr>
<tr>
<td>Communication speed for the IEDs</td>
<td>100BASE-FX</td>
</tr>
</tbody>
</table>

Table 151. LON communication protocol

<table>
<thead>
<tr>
<th>Function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protocol</td>
<td>LON</td>
</tr>
<tr>
<td>Communication speed</td>
<td>1.25 Mbit/s</td>
</tr>
</tbody>
</table>

Table 152. SPA communication protocol

<table>
<thead>
<tr>
<th>Function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protocol</td>
<td>SPA</td>
</tr>
<tr>
<td>Communication speed</td>
<td>300, 1200, 2400, 4800, 9600, 19200 or 38400 Bd</td>
</tr>
<tr>
<td>Slave number</td>
<td>1 to 899</td>
</tr>
</tbody>
</table>

Table 153. IEC 60870-5-103 communication protocol

<table>
<thead>
<tr>
<th>Function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protocol</td>
<td>IEC 60870-5-103</td>
</tr>
<tr>
<td>Communication speed</td>
<td>9600, 19200 Bd</td>
</tr>
</tbody>
</table>
### Table 154. SLM – LON port

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optical connector</td>
<td>Glass fiber: type ST</td>
</tr>
<tr>
<td></td>
<td>Plastic fiber: type HFBR snap-in</td>
</tr>
<tr>
<td>Fiber, optical budget</td>
<td>Glass fiber: 11 dB (1000m/3000 ft typically *)</td>
</tr>
<tr>
<td></td>
<td>Plastic fiber: 7 dB (10m/35ft typically *)</td>
</tr>
<tr>
<td>Fiber diameter</td>
<td>Glass fiber: 62.5/125 μm</td>
</tr>
<tr>
<td></td>
<td>Plastic fiber: 1 mm</td>
</tr>
</tbody>
</table>

*) depending on optical budget calculation

### Table 155. SLM – SPA/IEC 60870-5-103/DNP3 port

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optical connector</td>
<td>Glass fiber: type ST</td>
</tr>
<tr>
<td></td>
<td>Plastic fiber: type HFBR snap-in</td>
</tr>
<tr>
<td>Fiber, optical budget</td>
<td>Glass fiber: 11 dB (1000m/3000 ft typically *)</td>
</tr>
<tr>
<td></td>
<td>Plastic fiber: 7 dB (25m/80ft typically *)</td>
</tr>
<tr>
<td>Fiber diameter</td>
<td>Glass fiber: 62.5/125 μm</td>
</tr>
<tr>
<td></td>
<td>Plastic fiber: 1 mm</td>
</tr>
</tbody>
</table>

*) depending on optical budget calculation

### Table 156. Galvanic RS485 communication module

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication speed</td>
<td>2400–19200 bauds</td>
</tr>
<tr>
<td>External connectors</td>
<td>RS-485 6-pole connector</td>
</tr>
<tr>
<td></td>
<td>Soft ground 2-pole connector</td>
</tr>
</tbody>
</table>

### Table 157. SFP - Optical ethernet port

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Rated value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of channels</td>
<td>Up to 6 single or 3 redundant or a combination of single and redundant links for communication using any protocol</td>
</tr>
<tr>
<td>Standard</td>
<td>IEEE 802.3u 100BASE-FX</td>
</tr>
<tr>
<td>Type of fiber</td>
<td>62.5/125 μm multimode fiber</td>
</tr>
<tr>
<td>Wave length</td>
<td>1310 nm, Class 1 laser safety</td>
</tr>
<tr>
<td>Optical connector</td>
<td>Type LC</td>
</tr>
<tr>
<td>Communication speed</td>
<td>Fast Ethernet 100 Mbit/s</td>
</tr>
</tbody>
</table>
### Table 158. SFP - Galvanic RJ45

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Rated value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of channels</td>
<td>Up to 6 single or 3 redundant or a combination of single and redundant links for communication using any protocol</td>
</tr>
<tr>
<td>Standard</td>
<td>IEEE 802.3u 100BASE-TX</td>
</tr>
<tr>
<td>Type of cable</td>
<td>Cat5e FTP</td>
</tr>
<tr>
<td>Connector</td>
<td>Type RJ45</td>
</tr>
<tr>
<td>Communication Speed</td>
<td>Fast Ethernet 100 Mbit/s</td>
</tr>
</tbody>
</table>

### Table 159. Ethernet redundancy protocols, IEC 62439-3

<table>
<thead>
<tr>
<th>Function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protocol</td>
<td>IEC 62439-3 Ed.1 Parallel Redundancy Protocol (PRP-0)</td>
</tr>
<tr>
<td>Communication speed</td>
<td>100Base-FX</td>
</tr>
<tr>
<td>Protocol</td>
<td>IEC 62439-3 Ed.2 Parallel Redundancy Protocol (PRP-1)</td>
</tr>
<tr>
<td>Communication speed</td>
<td>100Base-FX</td>
</tr>
<tr>
<td>Protocol</td>
<td>IEC 62439-3 Ed.2 High-availability Seamless Redundancy (HSR)</td>
</tr>
<tr>
<td>Communication speed</td>
<td>100Base-FX</td>
</tr>
<tr>
<td>Connectors</td>
<td>Optical, type LC</td>
</tr>
</tbody>
</table>
## Remote communication

Table 160. Line data communication module

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of LDCM</strong></td>
<td>Short range (SR)</td>
</tr>
<tr>
<td>Type of fiber</td>
<td>Multi-mode fiber glass 62.5/125 µm</td>
</tr>
<tr>
<td>Peak Emission Wave length</td>
<td>Nominal</td>
</tr>
<tr>
<td>Nominal</td>
<td>820 nm</td>
</tr>
<tr>
<td>Maximum</td>
<td>865 nm</td>
</tr>
<tr>
<td>Minimum</td>
<td>792 nm</td>
</tr>
<tr>
<td>Optical budget</td>
<td>Multi-mode fiber glass 62.5/125 µm</td>
</tr>
<tr>
<td>Multi-mode fiber glass 50/125 µm</td>
<td>11.5 dB (typical distance about 2 km/1 mile *)</td>
</tr>
<tr>
<td>Optical connector</td>
<td>Type ST</td>
</tr>
<tr>
<td>Protocol</td>
<td>C37.94</td>
</tr>
<tr>
<td>Data transmission</td>
<td>Synchronous</td>
</tr>
<tr>
<td>Transmission rate / Data rate</td>
<td>2 Mbit/s / 64 kbit/s</td>
</tr>
<tr>
<td>Clock source</td>
<td>Internal or derived from received signal</td>
</tr>
</tbody>
</table>

*) depending on optical budget calculation
**) C37.94 originally defined just for multi-mode; using same header, configuration and data format as C37.94

Table 161. Galvanic X.21 line data communication module (X.21-LDCM)

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connector, X.21</td>
<td>Micro D-sub, 15-pole male, 1.27 mm (0.050&quot;) pitch</td>
</tr>
<tr>
<td>Connector, ground selection</td>
<td>2 pole screw terminal</td>
</tr>
<tr>
<td>Standard</td>
<td>CCITT X21</td>
</tr>
<tr>
<td>Communication speed</td>
<td>64 kbit/s</td>
</tr>
<tr>
<td>Insulation</td>
<td>1 kV</td>
</tr>
<tr>
<td>Maximum cable length</td>
<td>10 m</td>
</tr>
</tbody>
</table>
Hardware

IED

Table 162. Case

<table>
<thead>
<tr>
<th>Material</th>
<th>Steel sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front plate</td>
<td>Stainless steel with cut-out for HMI</td>
</tr>
<tr>
<td>Surface treatment</td>
<td>Aluzink preplated steel</td>
</tr>
<tr>
<td>Finish</td>
<td>Light grey (RAL 7035)</td>
</tr>
</tbody>
</table>

Table 163. Water and dust protection level according to IEC 60529

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Front</td>
<td>IP40 (IP54 with sealing strip)</td>
</tr>
<tr>
<td>Sides, top and bottom</td>
<td>IP40</td>
</tr>
<tr>
<td>Rear side</td>
<td>IP20 with screw compression type</td>
</tr>
<tr>
<td></td>
<td>IP10 with ring lug terminals</td>
</tr>
</tbody>
</table>

Table 164. Weight

<table>
<thead>
<tr>
<th>Case size</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>6U, 1/2 x 19”</td>
<td>≤ 7.5 kg/16 lb</td>
</tr>
<tr>
<td>6U, 3/4 x 19”</td>
<td>≤ 15 kg/33 lb</td>
</tr>
<tr>
<td>6U, 1/1 x 19”</td>
<td>≤ 15 kg/33 lb</td>
</tr>
</tbody>
</table>

Electrical safety

Table 165. Electrical safety according to IEC 60255-27

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment class</td>
<td>I (protective earthed)</td>
</tr>
<tr>
<td>Overvoltage category</td>
<td>III</td>
</tr>
<tr>
<td>Pollution degree</td>
<td>2 (normally only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is to be expected)</td>
</tr>
</tbody>
</table>

Connection system

Table 166. CT and VT circuit connectors

<table>
<thead>
<tr>
<th>Connector type</th>
<th>Rated voltage and current</th>
<th>Maximum conductor area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screw compression type</td>
<td>250 V AC, 20 A</td>
<td>4 mm² (AWG12)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 × 2.5 mm² (2 x AWG14)</td>
</tr>
<tr>
<td>Terminal blocks suitable for ring lug terminals</td>
<td>250 V AC, 20 A</td>
<td>4 mm² (AWG12)</td>
</tr>
</tbody>
</table>

Table 167. Auxiliary power supply and binary I/O connectors

<table>
<thead>
<tr>
<th>Connector type</th>
<th>Rated voltage</th>
<th>Maximum conductor area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screw compression type</td>
<td>250 V AC</td>
<td>2.5 mm² (AWG14)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 × 1 mm² (2 x AWG18)</td>
</tr>
<tr>
<td>Terminal blocks suitable for ring lug terminals</td>
<td>300 V AC</td>
<td>3 mm² (AWG14)</td>
</tr>
</tbody>
</table>
Because of limitations of space, when ring lug terminal is ordered for Binary I/O connections, one blank slot is necessary between two adjacent I/O modules. Please refer to the ordering particulars for details.

Table 168. NUM: Communication ports

<table>
<thead>
<tr>
<th>NUM</th>
<th>4 Ethernet ports</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 Basic, 3 Optional</td>
</tr>
</tbody>
</table>

| Ethernet connection type | SFP Optical LC or Galvanic RJ45 |

| Carrier modules supported | OEM, LDCM |

Table 169. OEM: Number of Ethernet ports

<table>
<thead>
<tr>
<th>OEM</th>
<th>2 Ethernet Ports</th>
</tr>
</thead>
</table>

| Ethernet connection type | SFP Optical LC or Galvanic RJ45 |
### Injection equipment hardware

**Table 170. Injection unit REX060**

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case size</td>
<td>6U, 1/2 19”; 223.7 x 245 x 267 mm (W x D x H)</td>
</tr>
<tr>
<td>Weight</td>
<td>8.0 kg</td>
</tr>
<tr>
<td>Burden, binary inputs</td>
<td>Bi 220 V: burden 0.4 W</td>
</tr>
<tr>
<td></td>
<td>Bi 110 V: burden 0.2 W</td>
</tr>
<tr>
<td></td>
<td>Bi 48 V: burden 0.1 W</td>
</tr>
<tr>
<td>Burden, RIM injection</td>
<td>&lt; 10 VA at 100 V external disturbance</td>
</tr>
<tr>
<td>Burden, SIM injection</td>
<td>&lt; 10 VA at 12 V earth fault voltage</td>
</tr>
<tr>
<td></td>
<td>0 VA at &gt; 10% of maximum earth fault voltage</td>
</tr>
<tr>
<td>Burden, SIM injection with REX062</td>
<td>&lt; 1 VA at 24 V earth fault voltage</td>
</tr>
<tr>
<td>Burden, measuring transformer SIM</td>
<td>&lt; 60 mVA at 24 V; 87 Hz</td>
</tr>
<tr>
<td>Burden, measuring transformer RIM</td>
<td>&lt; 60 mVA at 50 V; 113 Hz</td>
</tr>
<tr>
<td>Installation category</td>
<td>III</td>
</tr>
<tr>
<td>Pollution degree</td>
<td>2</td>
</tr>
</tbody>
</table>

**Table 171. Coupling capacitor unit REX061**

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or values</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>For machines with:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• rated field voltage up to</td>
<td>800 V DC</td>
<td>-</td>
</tr>
<tr>
<td>• static exciter with rated supply voltage up to</td>
<td>1600 V 50/60 Hz</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case size</td>
<td>218 x 150 x 243 mm (W x D x H)</td>
</tr>
<tr>
<td>Weight</td>
<td>4.8 kg</td>
</tr>
<tr>
<td>Assembling</td>
<td>6 x 5 mm screws (3 at bottom and 3 at top)</td>
</tr>
<tr>
<td>Rated rotor injection voltage</td>
<td>250 V</td>
</tr>
<tr>
<td>Burden, static excitation system X1:1 to X1:7</td>
<td>&lt; 0.5 VA at 100 V external disturbance</td>
</tr>
<tr>
<td>Burden, static excitation system X1:1 or X1:7 to 0 V</td>
<td>&lt; 1.0 VA at 100 V external disturbance</td>
</tr>
<tr>
<td>Burden, brushless excitation system X1:1 and X1:7 to 0 V</td>
<td>&lt; 1.5 VA at 100 V external disturbance</td>
</tr>
<tr>
<td>Installation category</td>
<td>III</td>
</tr>
<tr>
<td>Pollution degree</td>
<td>2</td>
</tr>
</tbody>
</table>
Table 172. Shunt resistor unit REX062

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case size</td>
<td>218 x 150 x 243 mm (W x D x H)</td>
</tr>
<tr>
<td>Weight</td>
<td>4.5 kg</td>
</tr>
<tr>
<td>Assembling</td>
<td>6 x 5 mm screws (3 at bottom and 3 at top)</td>
</tr>
<tr>
<td>Rated stator injection voltage</td>
<td>240 V</td>
</tr>
<tr>
<td>Rated stator voltage</td>
<td>240 V</td>
</tr>
<tr>
<td>Burden, injection X1:2 and X1:4</td>
<td>&lt; 25 VA at 12 V earth fault voltage</td>
</tr>
<tr>
<td></td>
<td>&lt; 100 VA at 24 V earth fault voltage</td>
</tr>
<tr>
<td>Installation category</td>
<td>III</td>
</tr>
<tr>
<td>Pollution degree</td>
<td>2</td>
</tr>
</tbody>
</table>
Basic IED functions

Table 173. Self supervision with internal event list

<table>
<thead>
<tr>
<th>Data</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recording manner</td>
<td>Continuous, event controlled</td>
</tr>
<tr>
<td>List size</td>
<td>40 events, first in-first out</td>
</tr>
</tbody>
</table>

Table 174. Time synchronization, time tagging

<table>
<thead>
<tr>
<th>Function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time tagging accuracy of the synchrophasor data</td>
<td>± 1 µs</td>
</tr>
<tr>
<td>Time tagging resolution, events and sampled measurement values</td>
<td>1 ms</td>
</tr>
<tr>
<td>Time tagging error with synchronization once/min (minute pulse synchronization), events and sampled measurement values</td>
<td>± 1.0 ms typically</td>
</tr>
<tr>
<td>Time tagging error with SNTP synchronization, sampled measurement values</td>
<td>± 1.0 ms typically</td>
</tr>
</tbody>
</table>

Table 175. Time synchronization PTP: IEC/IEEE 61850-9-3

<table>
<thead>
<tr>
<th>Supported types of clock</th>
<th>Boundary Clock (BC), Ordinary Clock (OC), Transparent Clock (TC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>According to standard IEC/IEEE 61850-9-3</td>
</tr>
<tr>
<td>Number of nodes</td>
<td>According to standard IEC/IEEE 61850-9-3</td>
</tr>
<tr>
<td>Ports supported</td>
<td>All rear Ethernet ports</td>
</tr>
</tbody>
</table>

Table 176. GPS time synchronization module (GTM)

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receiver</td>
<td>–</td>
<td>±1µs relative UTC</td>
</tr>
<tr>
<td>Time to reliable time reference with antenna in new position or after power loss longer than 1 month</td>
<td>&lt;30 minutes</td>
<td>–</td>
</tr>
<tr>
<td>Time to reliable time reference after a power loss longer than 48 hours</td>
<td>&lt;15 minutes</td>
<td>–</td>
</tr>
<tr>
<td>Time to reliable time reference after a power loss shorter than 48 hours</td>
<td>&lt;5 minutes</td>
<td>–</td>
</tr>
</tbody>
</table>

Table 177. GPS – Antenna and cable

<table>
<thead>
<tr>
<th>Function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max antenna cable attenuation</td>
<td>26 db @ 1.6 GHz</td>
</tr>
<tr>
<td>Antenna cable impedance</td>
<td>50 ohm</td>
</tr>
<tr>
<td>Lightning protection</td>
<td>Must be provided externally</td>
</tr>
<tr>
<td>Antenna cable connector</td>
<td>SMA in receiver end, TNC in antenna end</td>
</tr>
<tr>
<td>Accuracy</td>
<td>±/−1µs</td>
</tr>
<tr>
<td>Quantity</td>
<td>Rated value</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>Number of channels IRIG-B</td>
<td>1</td>
</tr>
<tr>
<td>Number of optical channels</td>
<td>1</td>
</tr>
<tr>
<td>Electrical connector:</td>
<td></td>
</tr>
<tr>
<td>Electrical connector IRIG-B</td>
<td>BNC</td>
</tr>
<tr>
<td>Pulse-width modulated</td>
<td>5 Vpp</td>
</tr>
<tr>
<td>Amplitude modulated</td>
<td></td>
</tr>
<tr>
<td>– low level</td>
<td>1-3 Vpp</td>
</tr>
<tr>
<td>– high level</td>
<td>3 x low level, max 9 Vpp</td>
</tr>
<tr>
<td>Supported formats</td>
<td>IRIG-B 00x, IRIG-B 12x</td>
</tr>
<tr>
<td>Accuracy</td>
<td>+/-10μs for IRIG-B 00x and +/-100μs for IRIG-B 12x</td>
</tr>
<tr>
<td>Input impedance</td>
<td>100 k ohm</td>
</tr>
<tr>
<td>Optical connector:</td>
<td></td>
</tr>
<tr>
<td>Optical connector IRIG-B</td>
<td>Type ST</td>
</tr>
<tr>
<td>Type of fiber</td>
<td>62.5/125 μm multimode fiber</td>
</tr>
<tr>
<td>Supported formats</td>
<td>IRIG-B 00x</td>
</tr>
<tr>
<td>Accuracy</td>
<td>+/-1μs</td>
</tr>
</tbody>
</table>
## Inverse characteristic

Table 179. ANSI Inverse time characteristics

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating characteristic:</td>
<td></td>
<td>ANSI/IEEE C37.112 , ±2.0% or ±40 ms whichever is greater</td>
</tr>
<tr>
<td>$t = \frac{A}{t^k} + B$</td>
<td>$0.05 \leq k \leq 999.00$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$1.5 \times I_{set} \leq I \leq 20 \times I_{set}$</td>
<td></td>
</tr>
<tr>
<td>Reset characteristic:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t = \frac{t_r}{t^k}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I = \frac{I_{measured}}{I_{set}}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ANSI Extremely Inverse</td>
<td>$A=28.2$, $B=0.1217$, $P=2.0$, $t_r=29.1$</td>
<td></td>
</tr>
<tr>
<td>ANSI Very Inverse</td>
<td>$A=19.61$, $B=0.491$, $P=2.0$, $t_r=21.6$</td>
<td></td>
</tr>
<tr>
<td>ANSI Normal Inverse</td>
<td>$A=0.0086$, $B=0.0185$, $P=0.02$, $t_r=0.46$</td>
<td></td>
</tr>
<tr>
<td>ANSI Moderately Inverse</td>
<td>$A=0.0515$, $B=0.1140$, $P=0.02$, $t_r=4.85$</td>
<td></td>
</tr>
<tr>
<td>ANSI Long Time Extremely Inverse</td>
<td>$A=64.07$, $B=0.250$, $P=2.0$, $t_r=30$</td>
<td></td>
</tr>
<tr>
<td>ANSI Long Time Very Inverse</td>
<td>$A=28.55$, $B=0.712$, $P=2.0$, $t_r=13.46$</td>
<td></td>
</tr>
<tr>
<td>ANSI Long Time Inverse</td>
<td>$A=0.086$, $B=0.185$, $P=0.02$, $t_r=4.6$</td>
<td></td>
</tr>
</tbody>
</table>
Table 180. IEC Inverse time characteristics

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating characteristic:</td>
<td>$0.05 \leq k \leq 999.00$</td>
<td>IEC 60255-151, ±2.0% or ±40 ms whichever is greater</td>
</tr>
<tr>
<td></td>
<td>$1.5 \times I_{set} \leq I \leq 20 \times I_{set}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$I = \frac{A}{(I^P - C)} \cdot k$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$I = \frac{P}{I_{measured}}$</td>
<td></td>
</tr>
<tr>
<td>IEC Normal Inverse</td>
<td>$A=0.14$, $P=0.02$</td>
<td></td>
</tr>
<tr>
<td>IEC Very inverse</td>
<td>$A=13.5$, $P=1.0$</td>
<td></td>
</tr>
<tr>
<td>IEC Inverse</td>
<td>$A=0.14$, $P=0.02$</td>
<td></td>
</tr>
<tr>
<td>IEC Extremely inverse</td>
<td>$A=80.0$, $P=2.0$</td>
<td></td>
</tr>
<tr>
<td>IEC Short time inverse</td>
<td>$A=0.05$, $P=0.04$</td>
<td></td>
</tr>
<tr>
<td>IEC Long time inverse</td>
<td>$A=120$, $P=1.0$</td>
<td></td>
</tr>
<tr>
<td>Programmable characteristic</td>
<td>$k = (0.05-999)$ in steps of 0.01</td>
<td></td>
</tr>
<tr>
<td>Operate characteristic:</td>
<td>$A=(0.005-200.000)$ in steps of 0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$B=(0.00-20.00)$ in steps of 0.01</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$C=(0.1-10.0)$ in steps of 0.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$P=(0.005-3.000)$ in steps of 0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$TR=(0.005-100.000)$ in steps of 0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$CR=(0.1-10.0)$ in steps of 0.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$PR=(0.005-3.000)$ in steps of 0.001</td>
<td></td>
</tr>
<tr>
<td>Reset characteristic:</td>
<td>$I = \frac{TR}{(I^P - CR)} \cdot k$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$I = \frac{P}{I_{measured}}$</td>
<td></td>
</tr>
</tbody>
</table>

The parameter setting *Characteristn = Reserved* (where, n = 1 - 4) shall not be used, since this parameter setting is for future use and not implemented yet.
### Table 181. RI and RD type inverse time characteristics

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI type inverse characteristic</td>
<td>( t = \frac{1}{0.339 - 0.236 \cdot \frac{k}{I}} )</td>
<td>( I = \frac{I_{\text{measured}}}{I_{\text{set}}} )</td>
</tr>
<tr>
<td>RD type logarithmic inverse characteristic</td>
<td>( t = 5.8 - \left(1.35 \cdot \ln \left(\frac{I}{k}\right)\right) )</td>
<td>( I = \frac{I_{\text{measured}}}{I_{\text{set}}} )</td>
</tr>
</tbody>
</table>

### Table 182. ANSI Inverse time characteristics for Sensitive directional residual overcurrent and power protection

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating characteristic:</td>
<td>( t = \left(\frac{A}{\left(I^{P} - 1\right)} + B\right)k )</td>
<td>( I = \frac{I_{\text{measured}}}{I_{\text{set}}} )</td>
</tr>
<tr>
<td>Reset characteristic:</td>
<td>( t = \frac{t_r}{\left(\frac{I}{I_{\text{set}}} - 1\right)} )</td>
<td>( I = \frac{I_{\text{measured}}}{I_{\text{set}}} )</td>
</tr>
<tr>
<td>ANSI Extremely Inverse</td>
<td>( A=28.2, B=0.1217, P=2.0, t_r=29.1 )</td>
<td></td>
</tr>
<tr>
<td>ANSI Very Inverse</td>
<td>( A=19.61, B=0.491, P=2.0, t_r=21.6 )</td>
<td></td>
</tr>
<tr>
<td>ANSI Normal Inverse</td>
<td>( A=0.0086, B=0.0185, P=0.02, t_r=0.46 )</td>
<td></td>
</tr>
<tr>
<td>ANSI Moderately Inverse</td>
<td>( A=0.0515, B=0.1140, P=0.02, t_r=4.85 )</td>
<td></td>
</tr>
<tr>
<td>ANSI Long Time Extremely Inverse</td>
<td>( A=64.07, B=0.250, P=2.0, t_r=30 )</td>
<td></td>
</tr>
<tr>
<td>ANSI Long Time Very Inverse</td>
<td>( A=28.55, B=0.712, P=2.0, t_r=13.46 )</td>
<td></td>
</tr>
<tr>
<td>ANSI Long Time Inverse</td>
<td>( A=0.086, B=0.185, P=0.02, t_r=4.6 )</td>
<td></td>
</tr>
</tbody>
</table>
### Table 183. IEC Inverse time characteristics for Sensitive directional residual overcurrent and power protection

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating characteristic:</td>
<td>0.05 ≤ k ≤ 2.00 1.5 x I&lt;sub&gt;set&lt;/sub&gt; ≤ I ≤ 20 x I&lt;sub&gt;set&lt;/sub&gt;</td>
<td>IEC 60255-151, ±5.0% or ±160 ms whichever is greater</td>
</tr>
<tr>
<td>I = ( \frac{A}{\left(1^k - 1\right)} ) 475x721-SMALL V1 EN-US</td>
<td>I&lt;sub&gt;measured&lt;/I&lt;sub&gt;set</td>
<td></td>
</tr>
<tr>
<td>IEC Normal Inverse</td>
<td>A=0.14, P=0.02</td>
<td></td>
</tr>
<tr>
<td>IEC Very inverse</td>
<td>A=13.5, P=1.0</td>
<td></td>
</tr>
<tr>
<td>IEC Inverse</td>
<td>A=0.14, P=0.02</td>
<td></td>
</tr>
<tr>
<td>IEC Extremely inverse</td>
<td>A=80.0, P=2.0</td>
<td></td>
</tr>
<tr>
<td>IEC Short time inverse</td>
<td>A=0.05, P=0.04</td>
<td></td>
</tr>
<tr>
<td>IEC Long time inverse</td>
<td>A=120, P=1.0</td>
<td></td>
</tr>
<tr>
<td>Programmable characteristic</td>
<td>k = (0.05-2.00) in steps of 0.01 475x721-SMALL V1 EN-US</td>
<td></td>
</tr>
<tr>
<td>Operate characteristic:</td>
<td>A=(0.005-200.000) in steps of 0.001 475x721-SMALL V1 EN-US</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B=(0.00-20.00) in steps of 0.01 475x721-SMALL V1 EN-US</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C=(0.1-10.0) in steps of 0.1 475x721-SMALL V1 EN-US</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P=(0.005-3.000) in steps of 0.001 475x721-SMALL V1 EN-US</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TR=(0.005-100.000) in steps of 0.001 475x721-SMALL V1 EN-US</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CR=(0.1-10.0) in steps of 0.1 475x721-SMALL V1 EN-US</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PR=(0.005-3.000) in steps of 0.001 475x721-SMALL V1 EN-US</td>
<td></td>
</tr>
<tr>
<td>I = ( \frac{TR}{\left(I_{set} - CR\right)} ) 475x721-SMALL V1 EN-US</td>
<td>I&lt;sub&gt;measured&lt;/I&lt;sub&gt;set</td>
<td></td>
</tr>
</tbody>
</table>

### Table 184. RI and RD type inverse time characteristics for Sensitive directional residual overcurrent and power protection

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI type inverse characteristic</td>
<td>0.05 ≤ k ≤ 2.00 1.5 x I&lt;sub&gt;set&lt;/sub&gt; ≤ I ≤ 20 x I&lt;sub&gt;set&lt;/sub&gt;</td>
<td>IEC 60255-151, ±5.0% or ±160 ms whichever is greater</td>
</tr>
<tr>
<td>I = ( \frac{1}{0.339 - \frac{0.236}{I}} ) 475x721-SMALL V1 EN-US</td>
<td>I&lt;sub&gt;measured&lt;/I&lt;sub&gt;set</td>
<td></td>
</tr>
<tr>
<td>RD type logarithmic inverse characteristic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I = 5.8 \left(1.35 \cdot \ln \frac{I}{k}\right)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I = I&lt;sub&gt;measured&lt;/I&lt;sub&gt;set</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ABB

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Table 185. ANSI Inverse time characteristics for Voltage restrained time overcurrent protection

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating characteristic:</td>
<td></td>
<td>ANSI/IEEE C37.112 , ±5.0% or ±40 ms whichever is greater</td>
</tr>
<tr>
<td>( t = \left( \frac{A}{(I^r - 1)} + B \right) k )</td>
<td>0.05 ≤ k ≤ 999.00</td>
<td></td>
</tr>
<tr>
<td>Reset characteristic:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( t = \frac{t_f}{(I^r - 1)} k )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( I = \frac{I_{\text{measured}}}{I_{\text{set}}} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ANSI Extremely Inverse</td>
<td></td>
<td>A=28.2, B=0.1217, P=2.0 , tr=29.1</td>
</tr>
<tr>
<td>ANSI Very Inverse</td>
<td></td>
<td>A=19.61, B=0.491, P=2.0 , tr=21.6</td>
</tr>
<tr>
<td>ANSI Normal Inverse</td>
<td></td>
<td>A=0.0086, B=0.0185, P=0.02, tr=0.46</td>
</tr>
<tr>
<td>ANSI Moderately Inverse</td>
<td></td>
<td>A=0.0515, B=0.1140, P=0.02, tr=4.85</td>
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<td></td>
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<td>A=28.55, B=0.712, P=2.0, tr=13.46</td>
</tr>
<tr>
<td>ANSI Long Time Inverse</td>
<td></td>
<td>A=0.086, B=0.185, P=0.02, tr=4.6</td>
</tr>
</tbody>
</table>

Table 186. IEC Inverse time characteristics for Voltage restrained time overcurrent protection

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating characteristic:</td>
<td></td>
<td>IEC 60255-151, ±5.0% or ±40 ms whichever is greater</td>
</tr>
<tr>
<td>( t = \left( \frac{A}{(I^r - 1)} \right) k )</td>
<td>0.05 ≤ k ≤ 999.00</td>
<td></td>
</tr>
<tr>
<td>( I = \frac{I_{\text{measured}}}{I_{\text{set}}} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IEC Normal Inverse</td>
<td></td>
<td>A=0.14, P=0.02</td>
</tr>
<tr>
<td>IEC Very Inverse</td>
<td></td>
<td>A=13.5, P=1.0</td>
</tr>
<tr>
<td>IEC Inverse</td>
<td></td>
<td>A=0.14, P=0.02</td>
</tr>
<tr>
<td>IEC Extremely inverse</td>
<td></td>
<td>A=80.0, P=2.0</td>
</tr>
<tr>
<td>IEC Short time Inverse</td>
<td></td>
<td>A=0.05, P=0.04</td>
</tr>
<tr>
<td>IEC Long time Inverse</td>
<td></td>
<td>A=120, P=1.0</td>
</tr>
</tbody>
</table>
Table 187. Inverse time characteristics for overvoltage protection

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type A curve:</td>
<td>$t = \frac{k}{U - U &gt; \frac{U &gt;}{U &gt;}}$</td>
<td>$k = (0.05-1.10)$ in steps of 0.01 ±5.0% or ±45 ms whichever is greater</td>
</tr>
<tr>
<td></td>
<td>$U &gt; = U_{set}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$U = U_{measured}$</td>
<td></td>
</tr>
<tr>
<td>Type B curve:</td>
<td>$t = \frac{k \cdot 480}{32 \cdot \left(\frac{U - U_n &gt;}{U_n &gt;} - 0.5\right)^3 + 0.035}$</td>
<td>$k = (0.05-1.10)$ in steps of 0.01</td>
</tr>
<tr>
<td>Type C curve:</td>
<td>$t = \frac{k \cdot 480}{32 \cdot \left(\frac{U - U_n &gt;}{U &gt;} - 0.5\right)^3 + 0.035}$</td>
<td>$k = (0.05-1.10)$ in steps of 0.01</td>
</tr>
</tbody>
</table>
| Programmable curve: | $t = \frac{k \cdot A}{(B \cdot \left(\frac{U - U >}{U >} - C\right)^p + D}$ | $k = (0.05-1.10)$ in steps of 0.01  
A = (0.005-200.000) in steps of 0.001  
B = (0.50-100.00) in steps of 0.01  
C = (0.0-1.0) in steps of 0.1  
D = (0.000-60.000) in steps of 0.001  
P = (0.000-3.000) in steps of 0.001 |
### Table 188. Inverse time characteristics for undervoltage protection

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type A curve:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( t = \frac{k}{U \leq -U \quad U &lt;} )</td>
<td>( k = (0.05-1.10) ) in steps of 0.01</td>
<td>±5.0% or ±45 ms whichever is greater</td>
</tr>
<tr>
<td>( U \leq = U_{\text{set}} )</td>
<td>( U = U_{\text{measured}} )</td>
<td></td>
</tr>
<tr>
<td><strong>Type B curve:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( t = \frac{k \cdot 480}{32 \cdot U \leq -U \quad U &lt; -0.5} )</td>
<td>( k = (0.05-1.10) ) in steps of 0.01</td>
<td></td>
</tr>
<tr>
<td>( U \leq = U_{\text{set}} )</td>
<td>( U = U_{\text{measured}} )</td>
<td></td>
</tr>
<tr>
<td><strong>Programmable curve:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( t = \left[ \frac{k \cdot A}{B \cdot U \leq -U \quad U &lt; -C} \right]^P + D )</td>
<td>( k = (0.05-1.10) ) in steps of 0.01</td>
<td></td>
</tr>
<tr>
<td>( A = (0.005-200.000) ) in steps of 0.001</td>
<td>( A = (0.005-200.000) ) in steps of 0.001</td>
<td></td>
</tr>
<tr>
<td>( B = (0.50-100.00) ) in steps of 0.01</td>
<td>( B = (0.50-100.00) ) in steps of 0.01</td>
<td></td>
</tr>
<tr>
<td>( C = (0.0-1.0) ) in steps of 0.1</td>
<td>( C = (0.0-1.0) ) in steps of 0.1</td>
<td></td>
</tr>
<tr>
<td>( D = (0.000-60.000) ) in steps of 0.001</td>
<td>( D = (0.000-60.000) ) in steps of 0.001</td>
<td></td>
</tr>
<tr>
<td>( P = (0.000-3.000) ) in steps of 0.001</td>
<td>( P = (0.000-3.000) ) in steps of 0.001</td>
<td></td>
</tr>
<tr>
<td>( U \leq = U_{\text{set}} )</td>
<td>( U = U_{\text{measured}} )</td>
<td></td>
</tr>
</tbody>
</table>
Table 189. Inverse time characteristics for residual overvoltage protection

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type A curve:</td>
<td>$t = \frac{k}{(U - U &gt;)}$</td>
<td>$k = (0.05-1.10)$ in steps of 0.01 ±5.0% or ±45 ms whichever is greater</td>
</tr>
<tr>
<td></td>
<td>$U &gt; = U_{set}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$U = U_{measured}$</td>
<td></td>
</tr>
<tr>
<td>Type B curve:</td>
<td>$t = \frac{k \cdot 480}{32 \cdot (U - U &gt; - 0.5)^2} + 0.035$</td>
<td>$k = (0.05-1.10)$ in steps of 0.01</td>
</tr>
<tr>
<td>Type C curve:</td>
<td>$t = \frac{k \cdot 480}{32 \cdot (U - U &gt; - 0.5)^{3.0}} + 0.035$</td>
<td>$k = (0.05-1.10)$ in steps of 0.01</td>
</tr>
<tr>
<td>Programmable curve:</td>
<td>$t = \frac{k \cdot A}{(B \cdot (U - U &gt; - C)^p + D}$</td>
<td>$k = (0.05-1.10)$ in steps of 0.01</td>
</tr>
<tr>
<td></td>
<td>$A = (0.005-200.000)$ in steps of 0.001</td>
<td>$A = (0.005-200.000)$ in steps of 0.001</td>
</tr>
<tr>
<td></td>
<td>$B = (0.50-100.00)$ in steps of 0.01</td>
<td>$B = (0.50-100.00)$ in steps of 0.01</td>
</tr>
<tr>
<td></td>
<td>$C = (0.0-1.0)$ in steps of 0.1</td>
<td>$C = (0.0-1.0)$ in steps of 0.1</td>
</tr>
<tr>
<td></td>
<td>$D = (0.000-60.000)$ in steps of 0.001</td>
<td>$D = (0.000-60.000)$ in steps of 0.001</td>
</tr>
<tr>
<td></td>
<td>$P = (0.000-3.000)$ in steps of 0.001</td>
<td>$P = (0.000-3.000)$ in steps of 0.001</td>
</tr>
</tbody>
</table>
25. Ordering for customized IED

Table 190. General guidelines

**Guidelines**

- Carefully read and follow the set of rules to ensure problem-free order management.
- Please refer to the available functions table for included application functions.
- PCM600 can be used to make changes and/or additions to the delivered factory configuration of the pre-configured.

Table 191. Example ordering code

To obtain the complete ordering code, please combine code from the selection tables, as given in the example below.

Example of a complete code: REG670*2.2-F00X0 - A0002262300000002 - B0000040200000001121212 - C4600262200340004440022311 - D2322100 - E66612 - F9 - S6 - G532 - H12000010044 - K00000000 - L1100 - M12042 - P11100000000000001 - B1X0 - AC - B - A3X0 - CD1ARGN11XXXXXX - KKKXXHKKAKGXY

<table>
<thead>
<tr>
<th>Product definition</th>
<th>Differential protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>REG670* 2.2 F00 X0</td>
<td>0 0 0 0 0 0 0 0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Impedance protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>B 0 0 0 0 0 0 0 0 0 0</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Current protection</th>
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</thead>
<tbody>
<tr>
<td>C 00 0 0 0 0 0 0 0</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Voltage protection</th>
<th>Frequency protection</th>
<th>Multipurpose protection</th>
<th>General calculation</th>
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<tbody>
<tr>
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<td>- F</td>
<td>- S</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Secondary system supervision</th>
<th>Control</th>
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<tbody>
<tr>
<td>G 0 0 0 0 0 0 0 0 0 0</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Scheme communication</th>
<th>Logic</th>
<th>Monitoring</th>
<th>Station communication</th>
</tr>
</thead>
<tbody>
<tr>
<td>K 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td>L 00</td>
<td>M 0</td>
<td>P 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Language</th>
<th>Casing and mounting</th>
<th>Power supply</th>
<th>HMI</th>
<th>Analog system</th>
<th>Binary input/output</th>
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</table>

<table>
<thead>
<tr>
<th>Station communication, remote end serial communication and time synchronization</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
</tr>
</tbody>
</table>

Table 192. Product definition

| REG670* | 2.2 | F00 | X0 |

Table 193. Product definition ordering codes

<table>
<thead>
<tr>
<th>Product</th>
<th>REG670*</th>
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</thead>
<tbody>
<tr>
<td>Product version</td>
<td>2.2</td>
</tr>
<tr>
<td>Configuration alternative</td>
<td>REG670 Generator protection</td>
</tr>
<tr>
<td>ACT configuration</td>
<td>No ACT configuration downloaded</td>
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<tr>
<td>Ordering number</td>
<td>REG670 Generator protection</td>
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**Table 194. Differential protection**

<table>
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<th>3</th>
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<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
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<tbody>
<tr>
<td>A</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tbody>
</table>

**Table 195. Differential functions**

<table>
<thead>
<tr>
<th>Function</th>
<th>Function identification</th>
<th>Ordering no</th>
<th>Position</th>
<th>Available qty</th>
<th>Selected qty</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformer differential protection, two winding</td>
<td>T2WPDIF</td>
<td>1MRK005904-FC</td>
<td>4</td>
<td>0-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transformer differential protection, three winding</td>
<td>T3WPDIF</td>
<td>1MRK005904-GB</td>
<td>5</td>
<td>0-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High impedance differential protection, single phase</td>
<td>HZPDIF</td>
<td>1MRK005904-HB</td>
<td>6</td>
<td>0-0-06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generator differential protection</td>
<td>GENPDIF</td>
<td>1MRK005904-KB</td>
<td>7</td>
<td>0-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restricted earth fault protection, low impedance</td>
<td>REFPDIF</td>
<td>1MRK005904-LC</td>
<td>8</td>
<td>0-3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-adaptive differential protection for two-winding power transformers</td>
<td>PSTPDIF</td>
<td>1MRK005905-SA</td>
<td>16</td>
<td>0-2</td>
<td></td>
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</tr>
</tbody>
</table>

**Table 196. Impedance protection**

| Position | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
|----------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| B        | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

**Table 197. Impedance functions**

Note: Only 1 alternative may be selected

<table>
<thead>
<tr>
<th>Function</th>
<th>Function identification</th>
<th>Ordering no</th>
<th>Position</th>
<th>Available qty</th>
<th>Selected qty</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative 3 Distance protection, mho (mho for phase - phase fault and mho in parallel with quad for earth fault)</td>
<td>ZMHPDIS</td>
<td>1MRK005907-FA</td>
<td>6</td>
<td>0-4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full-scheme distance protection, mho characteristic</td>
<td>ZMHPDIS</td>
<td>1MRK005907-FA</td>
<td>6</td>
<td>0-4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Directional impedance element for mho characteristic</td>
<td>ZDMRDIR</td>
<td>1MRK005907-HA</td>
<td>8</td>
<td>0-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative 5 High speed distance protection, quadrilateral and mho</td>
<td>ZMFDPDIS</td>
<td>1MRK005907-SE</td>
<td>14</td>
<td>0-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High speed distance protection, quad and mho characteristic</td>
<td>ZMFDPDIS</td>
<td>1MRK005907-SE</td>
<td>14</td>
<td>0-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative 6 High speed distance protection for series compensated lines, quadrilateral and mho</td>
<td>ZMFPCPDIS</td>
<td>1MRK005907-RE</td>
<td>15</td>
<td>0-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High speed distance protection for series comp. lines, quad and mho chara</td>
<td>ZMFPCPDIS</td>
<td>1MRK005907-RE</td>
<td>15</td>
<td>0-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optional with any alternative</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Poleslip/out-of-step protection</td>
<td>PSPPAM</td>
<td>1MRK005908-CB</td>
<td>21</td>
<td>0-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Out-of-step protection</td>
<td>QOSPPAM</td>
<td>1MRK005908-GA</td>
<td>22</td>
<td>0-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loss of excitation</td>
<td>LEXPDIS</td>
<td>1MRK005908-BB</td>
<td>23</td>
<td>0-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitive rotor earth fault protection, injection based</td>
<td>ROTIPHIZ</td>
<td>1MRK005908-EB</td>
<td>24</td>
<td>0-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% stator earth fault protection, injection based</td>
<td>STITPHIZ</td>
<td>1MRK005908-FB</td>
<td>25</td>
<td>0-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Underimpedance protection for generators and transformers</td>
<td>ZGVPDIS</td>
<td>1MRK005907-TC</td>
<td>26</td>
<td>0-2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 198. Current protection**

| Position | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
|----------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| C        | 0 | 0 | 0 |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
Table 199. Current functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Function identification</th>
<th>Ordering no</th>
<th>Position</th>
<th>Available qty</th>
<th>Selected qty</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instantaneous phase overcurrent protection</td>
<td>PHPIOC</td>
<td>1MRK005910-AD</td>
<td>1</td>
<td>0-4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Directional phase overcurrent, four steps</td>
<td>OC4PTOC</td>
<td>1MRK005910-B</td>
<td>2</td>
<td>0-6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instantaneous residual overcurrent protection</td>
<td>EFPIOC</td>
<td>1MRK005910-DD</td>
<td>4</td>
<td>0-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Directional residual overcurrent, four steps</td>
<td>EF4PTOC</td>
<td>1MRK005910-EE</td>
<td>5</td>
<td>0-6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Four step directional negative phase sequence overcurrent protection</td>
<td>NS4PTOC</td>
<td>1MRK005910-FB</td>
<td>6</td>
<td>0-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitive directional residual overcurrent and power protection</td>
<td>SDEPSDE</td>
<td>1MRK005910-GA</td>
<td>7</td>
<td>0-2</td>
<td></td>
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</tr>
<tr>
<td>Thermal overload protection, two time constants</td>
<td>TRPTTR</td>
<td>1MRK005910-HC</td>
<td>10</td>
<td>0-3</td>
<td></td>
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</tr>
<tr>
<td>Breaker failure protection</td>
<td>CCR8RF</td>
<td>1MRK005910-LC</td>
<td>11</td>
<td>0-4</td>
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<tr>
<td>Pole discordance protection</td>
<td>CCPDSC</td>
<td>1MRK005910-PA</td>
<td>14</td>
<td>0-4</td>
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</tr>
<tr>
<td>Directional underpower protection</td>
<td>GUPPDUP</td>
<td>1MRK005910-RA</td>
<td>15</td>
<td>0-4</td>
<td></td>
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<tr>
<td>Directional overpower protection</td>
<td>GOPPDOP</td>
<td>1MRK005910-TA</td>
<td>16</td>
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<tr>
<td>Negative sequence time overcurrent protection for machines</td>
<td>NS2PTOC</td>
<td>1MRK005910-VA</td>
<td>19</td>
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<tr>
<td>Accidental energizing protection for synchronous generator</td>
<td>AEGPVOC</td>
<td>1MRK005910-WA</td>
<td>20</td>
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</tr>
<tr>
<td>Voltage restrained overcurrent protection</td>
<td>VRPVOC</td>
<td>1MRK005910-XA</td>
<td>21</td>
<td>0-3</td>
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</tr>
<tr>
<td>Stator overload protection</td>
<td>GSPPTTR</td>
<td>1MRK005910-ZB</td>
<td>22</td>
<td>0-1</td>
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<tr>
<td>Rotor overload protection</td>
<td>GRPTTR</td>
<td>1MRK005910-YB</td>
<td>23</td>
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</table>

Table 200. Voltage protection

<table>
<thead>
<tr>
<th>Position</th>
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<th>3</th>
<th>4</th>
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<tbody>
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</tbody>
</table>

Table 201. Voltage functions

<table>
<thead>
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<th>Function</th>
<th>Function identification</th>
<th>Ordering no</th>
<th>Position</th>
<th>Available qty</th>
<th>Selected qty</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two step undervoltage protection</td>
<td>UV2PTUV</td>
<td>1MRK005912-AA</td>
<td>1</td>
<td>0-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two step overvoltage protection</td>
<td>OV2PTOV</td>
<td>1MRK005912-BA</td>
<td>2</td>
<td>0-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two step residual overvoltage protection</td>
<td>RV2PTOV</td>
<td>1MRK005912-CC</td>
<td>3</td>
<td>0-3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overexcitation protection</td>
<td>OEXPVPH</td>
<td>1MRK005912-DA</td>
<td>4</td>
<td>0-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage differential protection</td>
<td>VDCPTOV</td>
<td>1MRK005912-EA</td>
<td>5</td>
<td>0-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% Stator earth fault protection, 3rd harmonic based</td>
<td>STEPHIZ</td>
<td>1MRK005912-FB</td>
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Table 202. Frequency protection

<table>
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<th>3</th>
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<tr>
<td></td>
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</table>

Table 203. Frequency functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Function identification</th>
<th>Ordering no</th>
<th>Position</th>
<th>Available qty</th>
<th>Selected qty</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underfrequency protection</td>
<td>SAPTUF</td>
<td>1MRK005914-AC</td>
<td>1</td>
<td>0-6</td>
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<tr>
<td>Overfrequency protection</td>
<td>SAPTOF</td>
<td>1MRK005914-BB</td>
<td>2</td>
<td>0-6</td>
<td></td>
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</tr>
<tr>
<td>Rate-of-change of frequency protection</td>
<td>SAPFRC</td>
<td>1MRK005914-CB</td>
<td>3</td>
<td>0-6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency time accumulation protection</td>
<td>FTAQFVR</td>
<td>1MRK005914-DB</td>
<td>4</td>
<td>00-12</td>
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Table 204. Multipurpose protection

<table>
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<tbody>
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</table>

Table 205. Multipurpose functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Function identification</th>
<th>Ordering no</th>
<th>Position</th>
<th>Available qty</th>
<th>Selected qty</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>General current and voltage protection</td>
<td>CVGAPC</td>
<td>1MRK005915-AA</td>
<td>1</td>
<td>0-9</td>
<td></td>
<td></td>
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</tbody>
</table>

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### Table 206. General calculation

<table>
<thead>
<tr>
<th>Position</th>
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<tbody>
<tr>
<td>S</td>
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### Table 207. General calculation functions

<table>
<thead>
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<th>Function</th>
<th>Function identification</th>
<th>Ordering no</th>
<th>Position</th>
<th>Available qty</th>
<th>Selected qty</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multipurpose filter</td>
<td>SMAIHPAC</td>
<td>1MRK005915-KB</td>
<td>1</td>
<td>0-6</td>
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</table>

### Table 208. Secondary system supervision

<table>
<thead>
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<th>Position</th>
</tr>
</thead>
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<td>3</td>
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</table>

### Table 209. Secondary system supervision functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Function identification</th>
<th>Ordering no</th>
<th>Position</th>
<th>Available qty</th>
<th>Selected qty</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current circuit supervision</td>
<td>CCSSPVC</td>
<td>1MRK005916-AC</td>
<td>1</td>
<td>0-5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuse failure supervision</td>
<td>FUFSVPC</td>
<td>1MRK005916-BA</td>
<td>2</td>
<td>0-3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuse failure supervision based on voltage difference</td>
<td>VDSPVC</td>
<td>1MRK005916-CA</td>
<td>3</td>
<td>0-2</td>
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</table>

### Table 210. Control

<table>
<thead>
<tr>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
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<tr>
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<td>10</td>
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<td>11</td>
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</table>

### Table 211. Control functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Function identification</th>
<th>Ordering no</th>
<th>Position</th>
<th>Available qty</th>
<th>Selected qty</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synchrocheck, energizing check and synchronizing</td>
<td>SESRSYN</td>
<td>1MRK005917-XD</td>
<td>2</td>
<td>0-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control functionality for up to 6 bays, max 30 objects (6CBs), including interlocking</td>
<td>APC30</td>
<td>1MRK005917-CZ</td>
<td>7</td>
<td>0-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tap changer control and supervision, 6 binary inputs</td>
<td>TCMYLTC</td>
<td>1MRK005917-DB</td>
<td>10</td>
<td>0-4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tap changer control and supervision, 32 binary inputs</td>
<td>TCLYLTC</td>
<td>1MRK005917-EA</td>
<td>11</td>
<td>0-4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 212. Scheme communication

<table>
<thead>
<tr>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
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<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
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<tr>
<td>7</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>K</td>
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</tbody>
</table>

### Table 213. Logic

<table>
<thead>
<tr>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>L</td>
</tr>
</tbody>
</table>

### Table 214. Logic functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Function identification</th>
<th>Ordering no</th>
<th>Position</th>
<th>Available qty</th>
<th>Selected qty</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configurable logic blocks Q/T</td>
<td>1MRK005922-MX</td>
<td>1</td>
<td>0</td>
<td>0-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extension logic package</td>
<td>1MRK005922-DA</td>
<td>2</td>
<td>0</td>
<td>0-1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 215. Monitoring

<table>
<thead>
<tr>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>M</td>
</tr>
</tbody>
</table>

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### Table 216. Monitoring functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Function identification</th>
<th>Ordering no</th>
<th>Position</th>
<th>Available qty</th>
<th>Selected qty</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circuit breaker condition monitoring</td>
<td>SSCBR</td>
<td>1MRK005924-HA</td>
<td>1</td>
<td>00-12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transformer insulation loss of life monitoring</td>
<td>LOLSPTIR</td>
<td>1MRK005924-NB</td>
<td>3</td>
<td>0-4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Through fault monitoring</td>
<td>PTRSTHR</td>
<td>1MRK005924-TA</td>
<td>4</td>
<td>0-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current harmonic monitoring, 3 phase</td>
<td>CHMMHAI</td>
<td>1MRK005924-QA</td>
<td>5</td>
<td>0-3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage harmonic monitoring, 3 phase</td>
<td>VHMMHAI</td>
<td>1MRK005924-SA</td>
<td>6</td>
<td>0-3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 217. Station communication

<table>
<thead>
<tr>
<th>Position</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### Table 218. Station communication functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Function identification</th>
<th>Ordering no</th>
<th>Position</th>
<th>Available qty</th>
<th>Selected qty</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 61850-9-2 Process bus communication, 8 merging units</td>
<td>1MRK005933-HA</td>
<td>1</td>
<td>0-1</td>
<td></td>
<td></td>
<td>PRP and HSR require two SFPs placed in pairs.</td>
</tr>
<tr>
<td>IEC 62439-3 Parallel redundancy protocol</td>
<td>PRP</td>
<td>1MRK005932-FA</td>
<td>2</td>
<td>0-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IEC 62439-3 High-availability seamless redundancy</td>
<td>HSR</td>
<td>1MRK005932-NA</td>
<td>3</td>
<td>0-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synchrophasor report, 16 phasors</td>
<td></td>
<td>1MRK005933-FA</td>
<td>17</td>
<td>0-1</td>
<td></td>
<td>This functionality requires accurate time synchronization, therefore either 'Precision Time Protocol (PTP) Time synch or GTM or IRIG-B will be required.</td>
</tr>
</tbody>
</table>

### Table 219. Language selection

<table>
<thead>
<tr>
<th>Language</th>
<th>Ordering no</th>
<th>Selection</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>First local HMI user dialogue language</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HMI language, English IEC</td>
<td>1MRK002930-AA</td>
<td>B1</td>
<td></td>
</tr>
<tr>
<td>Additional local HMI user dialogue language</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No additional HMI language</td>
<td>1MRK002920-UB</td>
<td>A12</td>
<td>Additional 2nd languages are continuously being added. Please get in touch with local ABB sales contact.</td>
</tr>
<tr>
<td>HMI language, English US</td>
<td></td>
<td>X0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Selected B1</td>
<td></td>
</tr>
</tbody>
</table>

### Table 220. Casing selection

<table>
<thead>
<tr>
<th>Casing</th>
<th>Ordering no</th>
<th>Selection</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2 x 19” rack casing, 1 TRM</td>
<td>1MRK000151-VA</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>3/4 x 19” rack casing, 1 TRM</td>
<td>1MRK000151-VB</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>3/4 x 19” rack casing, 2 TRM</td>
<td>1MRK000151-VE</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>1/1 x 19” rack casing, 1 TRM</td>
<td>1MRK000151-VC</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>1/1 x 19” rack casing, 2 TRM</td>
<td>1MRK000151-VD</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Selected</td>
<td></td>
</tr>
</tbody>
</table>
### Table 221. Mounting selection

<table>
<thead>
<tr>
<th>Mounting details with IP40 of protection from the front</th>
<th>Ordering no</th>
<th>Selection</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>No mounting kit included</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>19&quot; rack mounting kit for 1/2 x 19&quot; case or 2xRHGS6 or RHGS12</td>
<td>1MRK002420-BB</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>19&quot; rack mounting kit for 3/4 x 19&quot; case or 3xRHGS6</td>
<td>1MRK002420-BA</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>19&quot; rack mounting kit for 1/1 x 19&quot; case</td>
<td>1MRK002420-CA</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Wall mounting kit</td>
<td>1MRK002420-DA</td>
<td>D</td>
<td>Wall mounting not recommended with communication modules with fiber connection</td>
</tr>
<tr>
<td>Flush mounting kit</td>
<td>1MRK002420-PA</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>Flush mounting kit + IP54 mounting seal</td>
<td>1MRK002420-NA</td>
<td>F</td>
<td></td>
</tr>
</tbody>
</table>

### Table 222. Power supply module selection

<table>
<thead>
<tr>
<th>Power supply module</th>
<th>Ordering no</th>
<th>Selection</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression terminals</td>
<td>1MRK002960-GA</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Ringlug terminals</td>
<td>1MRK002960-HA</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Power supply module 24-60 VDC</td>
<td>1MRK002239-AB</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Power supply module 90-250 VDC</td>
<td>1MRK002239-BB</td>
<td>B</td>
<td></td>
</tr>
</tbody>
</table>

### Table 223. Human machine interface selection

<table>
<thead>
<tr>
<th>Human machine hardware interface</th>
<th>Case size</th>
<th>Ordering no</th>
<th>Selection</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium size - graphic display, IEC keypad symbols</td>
<td>1/2 x 19&quot;, IEC</td>
<td>1MRK000028-AA</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3/4 x 19&quot;, IEC</td>
<td>1MRK000028-CA</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1/1 x 19&quot;, IEC</td>
<td>1MRK000028-BA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium size - graphic display, ANSI keypad symbols</td>
<td>1/2 x 19&quot;, ANSI</td>
<td>1MRK000028-AB</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3/4 x 19&quot;, ANSI</td>
<td>1MRK000028-CB</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1/1 x 19&quot;, ANSI</td>
<td>1MRK000028-BB</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 224. Analog system selection

<table>
<thead>
<tr>
<th>Analog system</th>
<th>Ordering no</th>
<th>Selection</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>When more than one TRM is selected, the connector type on both TRMs must be the same (A compression or B ring lug).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Slot position (front view/rear view)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Transformer input module included</td>
<td>X0</td>
<td>X0</td>
<td>Only valid if IEC 61850-9-2 Process bus communication is selected.</td>
</tr>
<tr>
<td>TRM 12I 1A, 50/60Hz, compression terminals</td>
<td>1MRK002247-CG</td>
<td>A1</td>
<td></td>
</tr>
<tr>
<td>TRM 12I 5A, 50/60Hz, compression terminals</td>
<td>1MRK002247-CH</td>
<td>A2</td>
<td></td>
</tr>
<tr>
<td>TRM 9I 1A + 3U 110/220V, 50/60Hz, compression terminals</td>
<td>1MRK002247-BG</td>
<td>A3</td>
<td></td>
</tr>
<tr>
<td>TRM 9I 5A + 3U 110/220V, 50/60Hz, compression terminals</td>
<td>1MRK002247-BK</td>
<td>A5</td>
<td></td>
</tr>
<tr>
<td>TRM 6I 1A + 6U 110/220V, 50/60Hz, compression terminals</td>
<td>1MRK002247-AG</td>
<td>A6</td>
<td></td>
</tr>
<tr>
<td>TRM 6I 5A + 6U 110/220V, 50/60Hz, compression terminals</td>
<td>1MRK002247-AH</td>
<td>A7</td>
<td></td>
</tr>
<tr>
<td>TRM 10I 1A + 2U 110/220V, 50/60Hz, compression terminals</td>
<td>1MRK002247-FA</td>
<td>A19</td>
<td></td>
</tr>
<tr>
<td>TRM 10I 5A + 2U 110/220V, 50/60Hz, compression terminals</td>
<td>1MRK002247-FB</td>
<td>A20</td>
<td></td>
</tr>
<tr>
<td>TRM 12I 1A, 50/60Hz, ring lug terminals</td>
<td>1MRK002247-DG</td>
<td>B8</td>
<td>Maximum qty=1</td>
</tr>
<tr>
<td>TRM 12I 5A, 50/60Hz, ring lug terminals</td>
<td>1MRK002247-DD</td>
<td>B9</td>
<td>Maximum qty=1</td>
</tr>
<tr>
<td>TRM 9I 1A + 3U 110/220V, 50/60Hz, ring lug terminals</td>
<td>1MRK002247-EC</td>
<td>B17</td>
<td></td>
</tr>
<tr>
<td>TRM 9I 5A + 3U 110/220V, 50/60Hz, ring lug terminals</td>
<td>1MRK002247-ED</td>
<td>B18</td>
<td></td>
</tr>
<tr>
<td>TRM 6I 1A + 6U 110/220V, 50/60Hz, ring lug terminals</td>
<td>1MRK002247-FD</td>
<td>B20</td>
<td></td>
</tr>
</tbody>
</table>

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Table 225. Maximum quantity of I/O modules, with compression terminals

When ordering I/O modules, observe the maximum quantities according to the tables below.

Note: Standard order of location for I/O modules is BIM-BOM-SOM-IOM-MIM from left to right as seen from the rear side of the IED, but can also be freely placed.

Note: The maximum quantity of I/O modules depends on the type of connection terminals.

<table>
<thead>
<tr>
<th>Case sizes</th>
<th>BIM</th>
<th>IOM</th>
<th>BOM/ SOM</th>
<th>MIM</th>
<th>Maximum in case</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/1 x 19” rack casing, one (1) TRM</td>
<td>14</td>
<td>6</td>
<td>4</td>
<td>4</td>
<td>14 *)</td>
</tr>
<tr>
<td>1/1 x 19” rack casing, two (2) TRM</td>
<td>11</td>
<td>6</td>
<td>4</td>
<td>4</td>
<td>11 *)</td>
</tr>
<tr>
<td>3/4 x 19” rack casing, one (1) TRM</td>
<td>8</td>
<td>6</td>
<td>4</td>
<td>4</td>
<td>8 *)</td>
</tr>
<tr>
<td>3/4 x 19” rack casing, two (2) TRM</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>5 *)</td>
</tr>
<tr>
<td>1/2 x 19” rack casing, one (1) TRM</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

*) including a combination of maximum four modules of type BOM, SOM and MIM

Table 226. Maximum quantity of I/O modules, with ringlug terminals

Note: Only every second slot can be used.

<table>
<thead>
<tr>
<th>Case sizes</th>
<th>BIM</th>
<th>IOM</th>
<th>BOM/ SOM</th>
<th>MIM</th>
<th>Maximum in case</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/1 x 19” rack casing, one (1) TRM</td>
<td>7</td>
<td>6</td>
<td>4</td>
<td>4</td>
<td>7 **) possible locations: P3, P5, P7, P9, P11, P13, P15</td>
</tr>
<tr>
<td>1/1 x 19” rack casing, two (2) TRM</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>5 **) possible locations: P3, P5, P7, P9, P11</td>
</tr>
<tr>
<td>3/4 x 19” rack casing, one (1) TRM</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4 **) possible locations: P3, P5, P7, P9</td>
</tr>
<tr>
<td>3/4 x 19” rack casing, two (2) TRM</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2, possible locations: P3, P5</td>
</tr>
<tr>
<td>1/2 x 19” rack casing, one (1) TRM</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1, possible location: P3</td>
</tr>
</tbody>
</table>

**) including a combination of maximum four modules of type BOM, SOM and MIM
### Table 227. Binary input/output module selection

<table>
<thead>
<tr>
<th>Slot position (front view/rear view)</th>
<th>Ordering no</th>
<th>Selection</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2 case with 1 TRM</td>
<td>P3/X31</td>
<td>P4/X41</td>
<td>These black marks indicate the maximum number of modules per casing type and the slots that can be occupied.</td>
</tr>
<tr>
<td>3/4 case with 1 TRM</td>
<td>P5/X51</td>
<td>P6/X61</td>
<td></td>
</tr>
<tr>
<td>3/4 case with 2 TRM</td>
<td>P7/X71</td>
<td>P8/X81</td>
<td></td>
</tr>
<tr>
<td>1/1 case with 1 TRM</td>
<td>P9/X91</td>
<td>P10/X101</td>
<td></td>
</tr>
<tr>
<td>1/1 case with 2 TRM</td>
<td>P11/X111</td>
<td>P12/X121</td>
<td></td>
</tr>
<tr>
<td>Compression terminals</td>
<td>P13/X131</td>
<td>P14/X141</td>
<td></td>
</tr>
<tr>
<td>Ringlug terminals</td>
<td>P15/X151</td>
<td>P16/X161</td>
<td></td>
</tr>
<tr>
<td>No board in slot</td>
<td></td>
<td></td>
<td>Only every second slot can be used; see Table 226</td>
</tr>
<tr>
<td>Binary output module 24 output relays (BOM)</td>
<td>1MRK000614-AB</td>
<td>A A A A A</td>
<td></td>
</tr>
<tr>
<td>BIM 16 inputs, RL24, 24-30VDC, 50mA</td>
<td>1MRK000508-DD</td>
<td>B1 B1 B1 B1</td>
<td></td>
</tr>
<tr>
<td>BIM 16 inputs, RL48, 48-60VDC, 50mA</td>
<td>1MRK000508-AD</td>
<td>C1 C1 C1 C1</td>
<td></td>
</tr>
<tr>
<td>BIM 16 inputs, RL110, 110-125VDC, 50mA</td>
<td>1MRK000508-BD</td>
<td>D1 D1 D1 D1</td>
<td></td>
</tr>
<tr>
<td>BIM 16 inputs, RL220, 220-250VDC, 50mA</td>
<td>1MRK000508-CB</td>
<td>E1 E1 E1 E1</td>
<td></td>
</tr>
<tr>
<td>BIM 16 inputs, RL220, 220-250VDC, 120mA</td>
<td>1MRK000508-CB</td>
<td>E2 E2 E2 E2</td>
<td></td>
</tr>
<tr>
<td>BIM 16 inputs, RL24, 24-30VDC, 50mA, enhanced pulse counting</td>
<td>1MRK000508-HA</td>
<td>F F F F F F</td>
<td></td>
</tr>
<tr>
<td>BIM 16 inputs, RL48, 48-60VDC, 50mA, enhanced pulse counting</td>
<td>1MRK000508-EA</td>
<td>G G G G G G</td>
<td></td>
</tr>
<tr>
<td>BIM 16 inputs, RL110, 110-125VDC, 50mA, enhanced pulse counting</td>
<td>1MRK000508-FA</td>
<td>H H H H H</td>
<td></td>
</tr>
<tr>
<td>BIM 16 inputs, RL220, 220-250VDC, 50mA, enhanced pulse counting</td>
<td>1MRK000508-GA</td>
<td>K K K K K K</td>
<td></td>
</tr>
<tr>
<td>IOM 8 inputs, 10+2 outputs, RL24, 24-30VDC, 50mA</td>
<td>1MRK000173-GD</td>
<td>L1 L1 L1 L1 L1 L1</td>
<td></td>
</tr>
<tr>
<td>IOM 8 inputs, 10+2 outputs, RL48, 48-60VDC, 50mA</td>
<td>1MRK000173-AE</td>
<td>M1 M1 M1 M1</td>
<td></td>
</tr>
</tbody>
</table>
Table 227. Binary input/output module selection, continued

<table>
<thead>
<tr>
<th>Binary input/ output modules</th>
<th>Ordering no</th>
<th>Selection</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>IOM 8 inputs, 10+2 outputs, RL110, 110-125VDC, 50mA</td>
<td>1MRK000173-BE</td>
<td>N1 N1 N1 N1 N1 N1 N1 N1 N1</td>
<td></td>
</tr>
<tr>
<td>IOM 8 inputs, 10+2 outputs, RL220, 220-250VDC, 50mA</td>
<td>1MRK000173-CE</td>
<td>P1 P1 P1 P1 P1 P1 P1 P1 P1</td>
<td></td>
</tr>
<tr>
<td>IOM 8 inputs 10+2 outputs, RL220, 220-250VDC, 110mA</td>
<td>1MRK000173-CF</td>
<td>P2 P2 P2 P2 P2 P2 P2 P2 P2</td>
<td></td>
</tr>
<tr>
<td>IOM with MOV 8 inputs, 10+2 outputs, RL24, 24-30VDC, 50mA</td>
<td>1MRK000173-GC</td>
<td>U U U U U U U U U</td>
<td></td>
</tr>
<tr>
<td>IOM with MOV 8 inputs, 10+2 outputs, RL48, 48-60VDC, 50mA</td>
<td>1MRK000173-AD</td>
<td>V V V V V V V V V</td>
<td></td>
</tr>
<tr>
<td>IOM with MOV 8 inputs, 10+2 outputs, RL110, 110-125VDC, 50mA</td>
<td>1MRK000173-BD</td>
<td>W W W W W W W W W</td>
<td></td>
</tr>
<tr>
<td>IOM with MOV 8 inputs, 10+2 outputs, RL220, 220-250VDC, 50mA</td>
<td>1MRK000173-CD</td>
<td>Y Y Y Y Y Y Y Y Y</td>
<td></td>
</tr>
<tr>
<td>mA input module MIM 6 channels</td>
<td>1MRK000284-AB</td>
<td>R R R R R R R R R</td>
<td>SOM must not be placed in the following positions: 1/2 case slot P5, 3/4 case 1 TRM slot P10, 3/4 case 2 TRM slot P7, 1/1 case 2 TRM slot P13, 1/1 case, 1 TRM slot P16.</td>
</tr>
<tr>
<td>SOM Static output module, 12 outputs; 6 standard relays + 6 static outputs, 48-60VDC</td>
<td>1MRK002614-BA</td>
<td>T1 T1 T1 T1 T1 T1 T1 T1 T1</td>
<td></td>
</tr>
<tr>
<td>SOM Static output module, 12 outputs; 6 standard relays + 6 static outputs, 110-250VDC</td>
<td>1MRK002614-CA</td>
<td>T2 T2 T2 T2 T2 T2 T2 T2 T2</td>
<td></td>
</tr>
</tbody>
</table>
Table 228. Station communication, remote end serial communication and time synchronization selection

<table>
<thead>
<tr>
<th>Station communication, remote end serial communication and time synchronization</th>
<th>Selection</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slot position (front view/rear view)</td>
<td>Ordering no</td>
<td></td>
</tr>
<tr>
<td>Available slots in 1/2, 3/4 and 1/1 case with 1 TRM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Available slots in 3/4 and 1/1 case with 2 TRM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethernet SFP, optical LC connector</td>
<td>1MRK005500-AA</td>
<td>K</td>
</tr>
<tr>
<td>Serial SPA/LON/DNP/IEC 60870-5-103 plastic interface</td>
<td>1MRK001608-AB</td>
<td></td>
</tr>
<tr>
<td>Serial SPA/LON/DNP/IEC 60870-5-103 plastic/glass interface</td>
<td>1MRK001608-BB</td>
<td></td>
</tr>
<tr>
<td>Serial SPA/LON/DNP/IEC 60870-5-103 glass interface</td>
<td>1MRK001608-CB</td>
<td></td>
</tr>
<tr>
<td>Optical long range LDCM, 1550 nm</td>
<td>1MRK002311-BA</td>
<td>C</td>
</tr>
<tr>
<td>Line data communication, default 64kbps mode</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Allow line data communication in 2Mbps mode</td>
<td>1MRK007002-AA</td>
<td></td>
</tr>
<tr>
<td>GPS time module</td>
<td>1MRK002282-AB</td>
<td>S</td>
</tr>
<tr>
<td>IRIG-B time synchronization module, with PPS</td>
<td>1MRK002305-AA</td>
<td>F</td>
</tr>
</tbody>
</table>

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26. Ordering for pre-configured IED

Guidelines
Carefully read and follow the set of rules to ensure problem-free order management.
Please refer to the available functions table for included application functions.
PCM600 can be used to make changes and/or additions to the delivered factory configuration of the pre-configured.

To obtain the complete ordering code, please combine code from the tables, as given in the example below.
Example code: REG670*2.2-A20X00-A02H39-B1A12-AC-CA-B-A3X0-CDAB1RGN1LXX XXXX-KKXXHKKLAGFSX. Using the code of each position #1-11 specified as REG670*1-2 2-3 3-4 4-5 5-6 6-7 7-8-9 9 9-10 10 10 10-11 11 11 11 11 11 11 11 11 11 11

<table>
<thead>
<tr>
<th>Product version</th>
<th>Configuration alternatives</th>
<th>Software options</th>
</tr>
</thead>
<tbody>
<tr>
<td>#</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>REG670*</td>
<td>2.2</td>
<td>-</td>
</tr>
<tr>
<td>Language</td>
<td>Casing and Mounting</td>
<td>Power supply</td>
</tr>
<tr>
<td>4</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Binary input/output modules
Station communication, remote end serial communication and time synchronization

<table>
<thead>
<tr>
<th>Product version</th>
<th>Configuration alternatives</th>
<th>Ordering no</th>
<th>Software options</th>
</tr>
</thead>
<tbody>
<tr>
<td>#</td>
<td>1</td>
<td>A20</td>
<td></td>
</tr>
<tr>
<td>Generator protection, Generator differential and back-up</td>
<td>1MRK004826-AG</td>
<td>A20</td>
<td></td>
</tr>
<tr>
<td>Generator protection, Generator differential and generator/transformer back-up</td>
<td>1MRK004826-BG</td>
<td>B30</td>
<td></td>
</tr>
<tr>
<td>Generator protection, Generator/transformer differential and back-up</td>
<td>1MRK004826-CG</td>
<td>C30</td>
<td></td>
</tr>
</tbody>
</table>

ACT configuration
ABB standard configuration
Selection for position #2 X00

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<table>
<thead>
<tr>
<th>Software options</th>
<th>Ordering no</th>
<th>#3</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>No option</td>
<td></td>
<td>X00</td>
<td>All fields in the ordering form do not need to be filled in.</td>
</tr>
<tr>
<td>Restricted earth fault protection, low impedance</td>
<td>1MRK004001-AA</td>
<td>A01</td>
<td>A01 only for B30</td>
</tr>
<tr>
<td>High impedance differential protection - 3 blocks</td>
<td>1MRK004001-AB</td>
<td>A02</td>
<td>A02 only for A20</td>
</tr>
<tr>
<td>Transformer differential protection - 2 winding</td>
<td>1MRK004001-AP</td>
<td>A31</td>
<td>A31 only for A20</td>
</tr>
<tr>
<td>Transformer differential protection - 2 and 3 winding</td>
<td>1MRK004001-AR</td>
<td>A33</td>
<td>A33 only for B30</td>
</tr>
<tr>
<td>Out-of-step protection</td>
<td>1MRK004001-BW</td>
<td>B22</td>
<td></td>
</tr>
<tr>
<td>Rotor Fault Detection by Injection</td>
<td>1MRK004001-BV</td>
<td>B31</td>
<td></td>
</tr>
<tr>
<td>Stator Fault Detection by Injection</td>
<td>1MRK004001-BX</td>
<td>B32</td>
<td></td>
</tr>
<tr>
<td>Sensitive directional residual overcurrent and power protection</td>
<td>1MRK004001-CT</td>
<td>C16</td>
<td></td>
</tr>
<tr>
<td>Voltage restrained overcurrent protection</td>
<td>1MRK004001-UN</td>
<td>C36</td>
<td></td>
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<tr>
<td>Rotor overload protection</td>
<td>1MRK004001-UR</td>
<td>C38</td>
<td></td>
</tr>
<tr>
<td>Four step directional negative phase sequence overcurrent protection - 1 block</td>
<td>1MRK004001-UH</td>
<td>C41</td>
<td>C41 only for A20</td>
</tr>
<tr>
<td>Four step directional negative phase sequence overcurrent protection - 2 blocks</td>
<td>1MRK004001-UK</td>
<td>C42</td>
<td>C42 only for B30/C30</td>
</tr>
<tr>
<td>100% Stator E/F 3rd harmonic</td>
<td>1MRK004001-DE</td>
<td>D21</td>
<td>D21 only for A20</td>
</tr>
<tr>
<td>Frequency time accumulation protection</td>
<td>1MRK004001-EC</td>
<td>E03</td>
<td></td>
</tr>
<tr>
<td>Fuse failure supervision based on voltage difference</td>
<td>1MRK004001-HC</td>
<td>G03</td>
<td></td>
</tr>
<tr>
<td>Control functionality for up to 30 objects</td>
<td>1MRK004001-GZ</td>
<td>H39</td>
<td></td>
</tr>
<tr>
<td>Transformer insulation loss of life monitoring</td>
<td>1MRK004001-KM</td>
<td>M21</td>
<td>M21 only for B30/C30</td>
</tr>
<tr>
<td>Through fault monitoring</td>
<td>1MRK004001-KR</td>
<td>M22</td>
<td></td>
</tr>
<tr>
<td>Harmonic monitoring</td>
<td>1MRK004001-KS</td>
<td>M23</td>
<td></td>
</tr>
<tr>
<td>IEC 62439-3 Parallel redundancy protocol</td>
<td>1MRK004001-PP</td>
<td>P23</td>
<td>Options P23 and P24 require two SFPs placed in pairs.</td>
</tr>
<tr>
<td>IEC 62439-3 High-availability seamless redundancy</td>
<td>1MRK004001-PR</td>
<td>P24</td>
<td></td>
</tr>
<tr>
<td>IEC 61850-9-2 Process Bus communication, 8 merging units</td>
<td>1MRK004001-PT</td>
<td>P30</td>
<td></td>
</tr>
<tr>
<td>Synchrophasor report, 16 phasors</td>
<td>1MRK004001-PX</td>
<td>P34</td>
<td>This functionality requires accurate time synchronization, therefore either Precision Time Protocol (PTP) Time synch or GTM or IRIG-B will be required.</td>
</tr>
</tbody>
</table>

**Selection for position #3**

<table>
<thead>
<tr>
<th>Language</th>
<th>Ordering no</th>
<th>#4</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First local HMI user dialogue language</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HMI language, English IEC</td>
<td>1MRK002930-AA</td>
<td>B1</td>
<td></td>
</tr>
<tr>
<td><strong>Additional local HMI user dialogue language</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No additional HMI language</td>
<td></td>
<td>X0</td>
<td></td>
</tr>
<tr>
<td>Additional 2nd languages are continuously being added</td>
<td></td>
<td>A12</td>
<td>Additional 2nd languages are continuously being added. Please get in touch with local ABB sales contact.</td>
</tr>
<tr>
<td>HMI language, English US</td>
<td>1MRK002920-UB</td>
<td>B1</td>
<td></td>
</tr>
</tbody>
</table>

**Selection for position #4**

<table>
<thead>
<tr>
<th>Casing</th>
<th>Ordering no</th>
<th>#5</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2 x 19” rack casing, 1 TRM</td>
<td>1MRK000151-VA</td>
<td>A</td>
<td>Only for A20</td>
</tr>
<tr>
<td>3/4 x 19” rack casing, 2 TRM</td>
<td>1MRK000151-VE</td>
<td>C</td>
<td>Only for B30/C30</td>
</tr>
<tr>
<td>1/1 x 19” rack casing, 2 TRM</td>
<td>1MRK000151-VD</td>
<td>E</td>
<td></td>
</tr>
</tbody>
</table>

**Selection for position #5**
### Mounting details with IP40 of protection from the front

<table>
<thead>
<tr>
<th>Description</th>
<th>Ordering no</th>
<th>#6</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>No mounting kit included</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>19&quot; rack mounting kit for 1/2 x 19&quot; case or 2xRHGS6 or RHGS12</td>
<td>1MRK002420-BB</td>
<td>A</td>
<td>Only for A20</td>
</tr>
<tr>
<td>19&quot; rack mounting kit for 3/4x19&quot; case or 3xRHGS6</td>
<td>1MRK002420-BA</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>19&quot; rack mounting kit for 1/1 x 19&quot; case</td>
<td>1MRK002420-CA</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Wall mounting kit</td>
<td>1MRK002420-DA</td>
<td>D</td>
<td>Wall mounting not recommended with communication modules with fiber connection</td>
</tr>
<tr>
<td>Flush mounting kit</td>
<td>1MRK002420-PA</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>Flush mounting kit + IP54 mounting seal</td>
<td>1MRK002420-NA</td>
<td>F</td>
<td></td>
</tr>
</tbody>
</table>

### Power supply modules

<table>
<thead>
<tr>
<th>Description</th>
<th>Ordering no</th>
<th>#7</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression terminals</td>
<td>1MRK002960-GA</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Ringlug terminals</td>
<td>1MRK002960-HA</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Power supply module, 24-60 VDC</td>
<td>1MRK002239-AB</td>
<td>A</td>
<td>Only for A20</td>
</tr>
<tr>
<td>Power supply module, 90-250 VDC</td>
<td>1MRK002239-BB</td>
<td>B</td>
<td></td>
</tr>
</tbody>
</table>

### Human machine hardware interface

<table>
<thead>
<tr>
<th>Description</th>
<th>Case size</th>
<th>Ordering no</th>
<th>#8</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium size - graphic display, IEC keypad symbols</td>
<td>1/2 x 19&quot;, IEC</td>
<td>1MRK000028-AA</td>
<td>B</td>
<td>Only for A20</td>
</tr>
<tr>
<td></td>
<td>3/4 x 19&quot;, IEC</td>
<td>1MRK000028-CA</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1/1 x 19&quot;, IEC</td>
<td>1MRK000028-BA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium size - graphic display, ANSI keypad symbols</td>
<td>1/2 x 19&quot;, ANSI</td>
<td>1MRK000028-AB</td>
<td>C</td>
<td>Only for A20</td>
</tr>
<tr>
<td></td>
<td>3/4 x 19&quot;, ANSI</td>
<td>1MRK000028-CB</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1/1 x 19&quot;, ANSI</td>
<td>1MRK000028-BB</td>
<td></td>
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</tbody>
</table>

### Analog system

<table>
<thead>
<tr>
<th>Description</th>
<th>Ordering no</th>
<th>#9</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Transformer input module included</td>
<td></td>
<td>X0</td>
<td>X0</td>
</tr>
<tr>
<td>TRM 9I 1A + 3U 110/220V, 50/60Hz, compression terminals</td>
<td>1MRK002247-BG</td>
<td>A3</td>
<td>A3</td>
</tr>
<tr>
<td>TRM 9I 5A + 3U 110/220V, 50/60Hz, compression terminals</td>
<td>1MRK002247-BH</td>
<td>A4</td>
<td>A4</td>
</tr>
<tr>
<td>TRM 5I 1A + 4I 5A + 3U 110/220V, 50/60Hz, compression terminals</td>
<td>1MRK002247-BK</td>
<td>A5</td>
<td>A5</td>
</tr>
<tr>
<td>TRM 6I 1A + 6U 110/220V, 50/60Hz, compression terminals</td>
<td>1MRK002247-AG</td>
<td>A6</td>
<td>A6</td>
</tr>
<tr>
<td>TRM 6I 5A + 6U 110/220V, 50/60Hz, compression terminals</td>
<td>1MRK002247-AH</td>
<td>A7</td>
<td>A7</td>
</tr>
<tr>
<td>TRM 7I 1A + 5U 110/220V, 50/60Hz, compression terminals</td>
<td>1MRK002247-AP</td>
<td>A12</td>
<td>A12</td>
</tr>
<tr>
<td>TRM 7I 5A + 5U 110/220V, 50/60Hz, compression terminals</td>
<td>1MRK002247-AR</td>
<td>A13</td>
<td>A13</td>
</tr>
<tr>
<td>TRM 6I 5A + 1I 1A + 5U 110/220V, 50/60Hz, compression terminals</td>
<td>1MRK002247-AU</td>
<td>A14</td>
<td>A14</td>
</tr>
<tr>
<td>TRM 3I 5A + 4I 1A + 5U 110/220V, 50/60Hz, compression terminals</td>
<td>1MRK002247-AV</td>
<td>A15</td>
<td>A15</td>
</tr>
<tr>
<td>TRM 9I 1A + 3U 110/220V, 50/60Hz, ring lug terminals</td>
<td>1MRK002247-BC</td>
<td>B3</td>
<td>B3</td>
</tr>
<tr>
<td>TRM 9I 5A + 3U 110/220V, 50/60Hz, ring lug terminals</td>
<td>1MRK002247-BD</td>
<td>B4</td>
<td>B4</td>
</tr>
<tr>
<td>TRM 5I 1A + 4I 5A + 3U 110/220V, 50/60Hz, ring lug terminals</td>
<td>1MRK002247-BF</td>
<td>B5</td>
<td>B5</td>
</tr>
<tr>
<td>TRM 6I 1A + 6U 110/220V, 50/60Hz, ring lug terminals</td>
<td>1MRK002247-AC</td>
<td>B6</td>
<td>B6</td>
</tr>
<tr>
<td>TRM 6I 5A + 6U 110/220V, 50/60Hz, ring lug terminals</td>
<td>1MRK002247-AD</td>
<td>B7</td>
<td>B7</td>
</tr>
<tr>
<td>TRM 7I 1A + 5U 110/220V, 50/60Hz, ring lug terminals</td>
<td>1MRK002247-A5</td>
<td>B12</td>
<td>B12</td>
</tr>
<tr>
<td>TRM 7I 5A + 5U 110/220V, 50/60Hz, ring lug terminals</td>
<td>1MRK002247-AT</td>
<td>B13</td>
<td>B13</td>
</tr>
<tr>
<td>TRM 6I 5A + 1I 1A + 5U 110/220V, 50/60Hz, ring lug terminals</td>
<td>1MRK002247-AX</td>
<td>B14</td>
<td>B14</td>
</tr>
<tr>
<td>TRM 3I 5A + 4I 1A + 5U 110/220V, 50/60Hz, ring lug terminals</td>
<td>1MRK002247-AY</td>
<td>B15</td>
<td>B15</td>
</tr>
</tbody>
</table>

**Selection for position #6**
**Binary input/output modules**

For pulse counting, for example kWh metering, the BIM with enhanced pulse counting capabilities must be used.

Note: 1BIM and 1 BOM required in slots P3 and P4.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2 Case with 1 TRM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/4 Case with 2 TRM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1/1 Case with 2 TRM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Compression terminals</th>
<th>1MRK002960-KA</th>
</tr>
</thead>
<tbody>
<tr>
<td>No board in slot</td>
<td>C</td>
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</table>

<table>
<thead>
<tr>
<th>Binary output module 24 output relays (BOM)</th>
<th>1MRK000614-AB</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIME 16 inputs, RL24, 24-30VDC, 50mA</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BIME 16 inputs, RL48, 48-60VDC, 50mA</th>
<th>1MRK000508-DD</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIME 16 inputs, RL110, 110-125VDC, 50mA</td>
<td>1MRK000508-BD</td>
</tr>
<tr>
<td>BIME 16 inputs, RL220, 220-250VDC, 50mA</td>
<td>1MRK000508-CD</td>
</tr>
<tr>
<td>BIME 16 inputs, RL220, 220-250VDC, 120mA</td>
<td>1MRK000508-CE</td>
</tr>
<tr>
<td>BIME 16 inputs, RL24, 24-30VDC, 50mA, enhanced pulse counting</td>
<td>1MRK000508-HA</td>
</tr>
<tr>
<td>BIME 16 inputs, RL48, 48-60VDC, 50mA, enhanced pulse counting</td>
<td>1MRK000508-EA</td>
</tr>
<tr>
<td>BIME 16 inputs, RL110, 110-125VDC, 50mA</td>
<td>1MRK000508-FA</td>
</tr>
<tr>
<td>BIME 16 inputs, RL220, 220-250VDC, 50mA</td>
<td>1MRK000508-GA</td>
</tr>
<tr>
<td>IOM 8 inputs, 10+2 outputs, RL24, 24-30VDC, 50mA</td>
<td>1MRK000173-GD</td>
</tr>
<tr>
<td>IOM 8 inputs, 10+2 outputs, RL48, 48-60VDC, 50mA</td>
<td>1MRK000173-AE</td>
</tr>
<tr>
<td>IOM 8 inputs, 10+2 outputs, RL110, 110-125VDC, 50mA</td>
<td>1MRK000173-BE</td>
</tr>
<tr>
<td>IOM 8 inputs, 10+2 outputs, RL220, 220-250VDC, 50mA</td>
<td>1MRK000173-CE</td>
</tr>
<tr>
<td>IOM 8 inputs, 10+2 outputs, RL220, 220-250VDC, 110mA</td>
<td>1MRK000173-CF</td>
</tr>
<tr>
<td>IOM with MOV 8 inputs, 10+2 outputs, RL24, 24-30VDC, 50mA</td>
<td>1MRK000173-GC</td>
</tr>
<tr>
<td>IOM with MOV 8 inputs, 10+2 outputs, RL48, 48-60VDC, 50mA</td>
<td>1MRK000173-AD</td>
</tr>
<tr>
<td>IOM with MOV 8 inputs, 10+2 outputs, RL110, 110-125VDC, 50mA</td>
<td>1MRK000173-BD</td>
</tr>
<tr>
<td>IOM with MOV 8 inputs, 10+2 outputs, RL220, 220-250VDC, 50mA</td>
<td>1MRK000173-CD</td>
</tr>
<tr>
<td>mA input module MIM 6 channels</td>
<td>1MRK000284-AB</td>
</tr>
<tr>
<td>SOM Static binary output, 12 outputs, 6 standard relays + 6 static outputs, 48-60VDC</td>
<td>1MRK002614-BA</td>
</tr>
<tr>
<td>SOM Static binary output, 12 outputs, 6 standard relays + 6 static outputs, 110-250VDC</td>
<td>1MRK002614-CA</td>
</tr>
</tbody>
</table>

Notes and rules:

- These black marks indicate the maximum number of modules per casing type and the slots that can be occupied.
- For pulse counting, for example kWh metering, the BIM with enhanced pulse counting capabilities must be used.
- Note: 1BIM and 1 BOM required in slots P3 and P4.
- No board in slot
- Maximum 4 (BOM+SOM+MIM) boards.
- Compression terminals
- Binary output module 24 output relays (BOM)
- BIM 16 inputs, RL24, 24-30VDC, 50mA
- BIM 16 inputs, RL48, 48-60VDC, 50mA
- BIM 16 inputs, RL110, 110-125VDC, 50mA
- BIM 16 inputs, RL220, 220-250VDC, 50mA
- IOM 8 inputs, 10+2 outputs, RL24, 24-30VDC, 50mA
- IOM 8 inputs, 10+2 outputs, RL48, 48-60VDC, 50mA
- IOM 8 inputs, 10+2 outputs, RL110, 110-125VDC, 50mA
- IOM 8 inputs, 10+2 outputs, RL220, 220-250VDC, 50mA
- IOM 8 inputs, 10+2 outputs, RL220, 220-250VDC, 110mA
- IOM with MOV 8 inputs, 10+2 outputs, RL24, 24-30VDC, 50mA
- IOM with MOV 8 inputs, 10+2 outputs, RL48, 48-60VDC, 50mA
- IOM with MOV 8 inputs, 10+2 outputs, RL110, 110-125VDC, 50mA
- IOM with MOV 8 inputs, 10+2 outputs, RL220, 220-250VDC, 50mA
- mA input module MIM 6 channels
- SOM Static binary output, 12 outputs, 6 standard relays + 6 static outputs, 48-60VDC
- SOM Static binary output, 12 outputs, 6 standard relays + 6 static outputs, 110-250VDC

**Ordering no**

- 1MRK000614-AB
- 1MRK000508-BD
- 1MRK000508-CD
- 1MRK000508-CE
- 1MRK000508-HA
- 1MRK000508-EA
- 1MRK000508-FA
- 1MRK000508-GA
- 1MRK000173-GD
- 1MRK000173-AE
- 1MRK000173-BE
- 1MRK000173-CE
- 1MRK000173-CF
- 1MRK000173-GC
- 1MRK000173-AD
- 1MRK000173-BD
- 1MRK000173-CD
- 1MRK000284-AB
- 1MRK002614-BA
- 1MRK002614-CA
### Station communication, serial communication and time synchronization

<table>
<thead>
<tr>
<th>Slot position (front view/rear view)</th>
<th>Ordering no</th>
<th>#11</th>
<th>Notes and rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available slots in 1/2 with 1 TRM</td>
<td></td>
<td></td>
<td>The maximum number and type of LDCM modules supported depend on the total amount of I/O and communication modules in the IED.</td>
</tr>
<tr>
<td>No communication board included</td>
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<td></td>
<td>Ethernet SFP, RJ45 connector 1MRK005500-BA</td>
</tr>
<tr>
<td>Ethernet SFP, optical LC connector 1MRK005500-AA</td>
<td>K</td>
<td>K</td>
<td>K</td>
</tr>
<tr>
<td>Ethernet SFP, RJ45 connector 1MRK005500-BA</td>
<td>P</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>Optical Ethernet module 1MRK002266-EA</td>
<td>H</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serial SPA/LON/DNP/IEC 60870-5-103 plastic interface 1MRK001608-AB</td>
<td>L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serial SPA/LON/DNP/IEC 60870-5-103 plastic/glass interface 1MRK001608-BB</td>
<td>M</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serial SPA/LON/DNP/IEC 60870-5-103 glass interface 1MRK001608-CB</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Galvanic RS485 communication module 1MRK002309-AA</td>
<td>G</td>
<td>G</td>
<td>G</td>
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<tr>
<td>Optical short range LDCM 1MRK002212-AB</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Optical medium range, LDCM 1310 nm 1MRK002311-AA</td>
<td>B</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Line data communication, default 64kbps mode</td>
<td>—</td>
<td></td>
<td>Default if no LDCM is selected</td>
</tr>
<tr>
<td>Allow line data communication in 2Mbps mode 1MRK007002-AA</td>
<td>Y</td>
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<td></td>
</tr>
<tr>
<td>GPS time module 1MRK002282-AB</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>IRIG-B Time synchronization module, with PPS 1MRK002305-AA</td>
<td>F</td>
<td>F</td>
<td>F</td>
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</tbody>
</table>

**Selection for position #11**
27. Ordering for Accessories

**Accessories**

**GPS antenna and mounting details**

- GPS antenna, including mounting kits
  - Quantity: 1MRK 001 640-AA
- Cable for antenna, 20 m (Appx. 65 ft)
  - Quantity: 1MRK 001 665-AA
- Cable for antenna, 40 m (Appx. 131 ft)
  - Quantity: 1MRK 001 665-BA

**Interface converter (for remote end data communication)**

- External interface converter from C37.94 (64kbps) to G703
  - Quantity: 1MRK 002 245-AA
- External interface converter from C37.94 (64kbps/2Mbps) to G703.E1
  - Quantity: 1MRK 002 245-BA

**Test switch**

The test system COMBITEST intended for use with the IEDs is described in 1MRK 512 001-BEN and 1MRK 001024-CA. Please refer to the website: [www.abb.com/protection-control](http://www.abb.com/protection-control) for detailed information.

Due to the high flexibility of our product and the wide variety of applications possible the test switches needs to be selected for each specific application.

Select your suitable test switch based on the available contacts arrangements shown in the reference documentation.

However our proposals for suitable variants are:

- Two winding transformer with external neutral on current circuits. Two pcs can be used in applications for three winding transformers in single or multi-breaker arrangement (ordering number RK926 315-BD).
- Three winding transformer with internal neutral on current circuits (ordering number RK926 315-BX).
- The normally open "In test mode" contact 29-30 on the RTXP test switches should be connected to the input of the test function block to allow activation of functions individually during testing.

Test switches type RTXP 24 is ordered separately. Please refer to Section Related documents for references to corresponding documents.

**Protection cover**

- Protective cover for rear side of RHGS6, 6U, 1/4 x 19"
  - Quantity: 1MRK 002 420-AE
- Protective cover for rear side of terminal, 6U, 1/2 x 19"
  - Quantity: 1MRK 002 420-TA
- Protective cover for rear side of terminal, 6U, 3/4 x 19"
  - Quantity: 1MRK 002 420-SA
- Protective cover for rear side of terminal, 6U, 1/1 x 19"
  - Quantity: 1MRK 002 420-RA
### External resistor unit

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>High impedance resistor unit with resistor and voltage dependent resistor 20-100V, 1ph</td>
<td>1 2 3</td>
<td>RK 795 101-MA</td>
</tr>
<tr>
<td>High impedance resistor unit with resistor and voltage dependent resistor 20-100V, 3ph</td>
<td></td>
<td>RK 795 101-MB</td>
</tr>
<tr>
<td>High impedance resistor unit with resistor and voltage dependent resistor 100-400V, 1ph</td>
<td>1 2 3</td>
<td>RK 795 101-CB</td>
</tr>
<tr>
<td>High impedance resistor unit with resistor and voltage dependent resistor 100-400V, 3ph</td>
<td></td>
<td>RK 795 101-DC</td>
</tr>
</tbody>
</table>
Injection equipment

Rule: If injection equipment is ordered, ROTIPHIZ or STTIPHIZ Sensitive rotor earth fault protection, injection based (option B31) or 100% stator earth fault protection, injection based (option B32) is required in the IED.

Injection unit, REX060

The REX060 injection unit requires a connection to a VT across the generator neutral point earthing resistor. The VT must have a rating of at least 100 VA and a rated secondary winding voltage of up to 120 V. It must adhere to IEC 61869-3:2011 section 5.5.301 Rated Output Values and the standard values specified according to burden range II.

Casing

1/2 x 19” rack casing
Backplane module (BPM)

Human machine interface

HMI and logic module (HLM)

Injection modules

Note: One of RIM and SIM have to be selected if REX060 is specified

Rule: Stator injection module (SIM) is required if 100% stator earth fault protection, injection based (option B32)(STTIPHIZ) is selected/active in REG670

Stator injection module (SIM)

If the generator is earthed via a primary resistor connected between the generator neutral point and earth, a VT is placed across the primary resistor. SIM is then connected to the secondary side of the VT. The VT must have a rating of at least 100 VA and a rated secondary winding voltage of up to 120 V. It must adhere to IEC 61869-3:2011 section 5.5.301 Rated Output Values and the standard values specified according to burden range II.

Rule: Rotor injection module (RIM) is required if Sensitive rotor earth fault protection, injection based (option B31) (ROTIPHIZ) is selected/active in REG670

Rotor injection module (RIM)

Power supply module

Rule: One Power supply module must be specified

Power supply module (PSM)

Mounting details with IP40 of protection from the front

19” rack mounting kit
Wall mounting kit for terminal
Flush mounting kit for terminal
Extra IP54 mounting seal + flush mounting kit for terminal

Coupling capacitor unit, REX061

Quantity: 1MRK 002 550-AA

Rule: REX061 requires REX060 and that Rotor injection module (RIM) is selected in REX060 and that Sensitive rotor earth fault protection, injection based (option B31) (ROTIPHIZ) is selected/active in REG670.

Shunt resistor unit, REX062

Quantity: 1MRK 002 555-AA

Rule: REX062 requires REX060 and that Stator injection module (SIM) is selected in REX060 and that 100% stator earth fault protection, injection based (option B32) (STTIPHIZ) is selected/active in REG670.
### Combiflex

**Key switch for settings**

- Key switch for lock-out of settings via LHMI
  - Quantity: 1MRK 000 611-A

*Note: To connect the key switch, leads with 10 A Combiflex socket on one end must be used.*

**Mounting kit**

- Side-by-side mounting kit
  - Quantity: 1MRK 002 420-Z

**Injection unit for Rotor earth fault protection (RXTTE 4)**

*Note: Requires additional COMBIFLEX terminal base RX4, 10A COMBIFLEX sockets and appropriate COMBIFLEX mounting accessories for proper operation*

- Protective resistor on plate
  - Quantity: RK795102-AD

**Configuration and monitoring tools**

- Front connection cable between LHMI and PC
  - Quantity: 1MRK 001 665-CA

- LED Label special paper A4, 1 pc
  - Quantity: 1MRK 002 038-CA

- LED Label special paper Letter, 1 pc
  - Quantity: 1MRK 002 038-DA

**Manuals**

*Note: One (1) IED Connect USB flash drive containing user documentation (Operation manual, Technical manual, Installation manual, Commissioning manual, Application manual and Getting started guide), Connectivity packages and LED label template is always included for each IED.*

- Rule: Specify additional quantity of IED Connect USB flash drive requested.
  - Quantity: 1MRK 002 290-AE
User documentation

*Rule: Specify the number of printed manuals requested*

<table>
<thead>
<tr>
<th>Manual Type</th>
<th>IEC</th>
<th>ANSI</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application manual</td>
<td>1MRK 502 071-UEN</td>
<td>1MRK 502 071-UUS</td>
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<tr>
<td>Technical manual</td>
<td>1MRK 502 072-UEN</td>
<td>1MRK 502 072-UUS</td>
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</tr>
<tr>
<td>Commissioning manual</td>
<td>1MRK 502 073-UEN</td>
<td>1MRK 502 073-UUS</td>
<td></td>
</tr>
<tr>
<td>Communication protocol manual, IEC 61850 Edition 1</td>
<td>1MRK 511 392-UEN</td>
<td></td>
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<tr>
<td>Communication protocol manual, IEC 61850 Edition 2</td>
<td>1MRK 511 393-UEN</td>
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<tr>
<td>Communication protocol manual, IEC 60870-5-103</td>
<td>1MRK 511 394-UEN</td>
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<tr>
<td>Communication protocol manual, LON</td>
<td>1MRK 511 395-UEN</td>
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<tr>
<td>Communication protocol manual, SPA</td>
<td>1MRK 511 396-UEN</td>
<td></td>
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<tr>
<td>Communication protocol manual, DNP</td>
<td>1MRK 511 391-UUS</td>
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<tr>
<td>Point list manual, DNP</td>
<td>1MRK 511 397-UUS</td>
<td></td>
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<tr>
<td>Operation manual</td>
<td>1MRK 500 127-UEN</td>
<td>1MRK 500 127-UUS</td>
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</tr>
<tr>
<td>Installation manual</td>
<td>1MRK 514 026-UEN</td>
<td>1MRK 514 026-UUS</td>
<td></td>
</tr>
<tr>
<td>Engineering manual</td>
<td>1MRK 511 398-UEN</td>
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</tbody>
</table>
Reference information

For our reference and statistics we would be pleased to be provided with the following application data:

Country: 
End user: 
Station name: 
Voltage level: kV
Generator manufacturer: 
Rated power: MVA
Type of prime mover: steam ☐, gas ☐, hydro ☐, pumpstorage ☐, nuclear ☐, other ______________________

Related documents

<table>
<thead>
<tr>
<th>Documents related to REG670</th>
<th>670 series manuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application manual</td>
<td>Operation manual</td>
</tr>
<tr>
<td>Commissioning manual</td>
<td>Engineering manual</td>
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<tr>
<td>Product guide</td>
<td>Installation manual</td>
</tr>
<tr>
<td>Technical manual</td>
<td>Communication protocol manual, DNP3</td>
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<tr>
<td>Type test certificate</td>
<td>Communication protocol manual, IEC 60870-5-103</td>
</tr>
<tr>
<td></td>
<td>Communication protocol manual, IEC 61850 Edition 1</td>
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<td>Communication protocol manual, IEC 61850 Edition 2</td>
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<td>Communication protocol manual, LON</td>
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<td>Communication protocol manual, SPA</td>
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<td></td>
<td>Point list manual, DNP3</td>
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<td>Accessories guide</td>
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<td>Cyber security deployment guideline</td>
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<td>Connection and Installation components</td>
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<td></td>
<td>Test system, COMBITEST</td>
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<td>Application guide, Communication set-up</td>
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