Voltage Relay
REU610

# Contents

**Copyrights** .................................................................................................................. 5

1. **Introduction** ............................................................................................................. 7  
   1.1. This manual ........................................................................................................... 7  
   1.2. Use of symbols ..................................................................................................... 7  
   1.3. Intended audience ............................................................................................... 7  
   1.4. Product documentation ....................................................................................... 8  
   1.5. Document conventions ....................................................................................... 8  
   1.6. Document revisions ............................................................................................. 9  

2. **Safety information** .................................................................................................. 11  

3. **Product overview** .................................................................................................... 13  
   3.1. Use of the relay .................................................................................................. 13  
   3.2. Features ............................................................................................................... 13  

4. **Application** .............................................................................................................. 15  
   4.1. Requirements ...................................................................................................... 15  
   4.2. Configuration ...................................................................................................... 15  

5. **Technical description** .............................................................................................. 17  
   5.1. Functional description ......................................................................................... 17  
      5.1.1. Product functions ......................................................................................... 17  
      5.1.1.1. Protection functions ................................................................................. 17  
      5.1.1.2. Inputs ........................................................................................................ 17  
      5.1.1.3. Outputs ..................................................................................................... 18  
      5.1.1.4. Disturbance recorder ................................................................................ 18  
      5.1.1.5. Front panel ............................................................................................... 18  
      5.1.1.6. Non-volatile memory ................................................................................ 19  
      5.1.1.7. Self-supervision ....................................................................................... 19  
      5.1.1.8. Time synchronization ............................................................................... 20  
      5.1.2. Measurements .............................................................................................. 21  
      5.1.3. Configuration .............................................................................................. 22  
      5.1.4. Protection ...................................................................................................... 24  
      5.1.4.1. Block diagram .......................................................................................... 24  
      5.1.4.2. Overvoltage protection .......................................................................... 24  
      5.1.4.3. Undervoltage protection ......................................................................... 26  
      5.1.4.4. Residual overvoltage protection .............................................................. 29  
      5.1.4.5. Circuit-breaker failure protection ............................................................ 30  
      5.1.4.6. Inverse definite minimum time characteristics ........................................ 31  
      5.1.4.7. Settings ..................................................................................................... 37  
      5.1.4.8. Technical data on protection functions ..................................................... 47  
      5.1.5. Trip-circuit supervision ................................................................................. 49
5.1.6. Trip lockout function ................................... 50
5.1.7. Trip counters for circuit-breaker condition
monitoring .................................................. 51
5.1.8. Target LEDs and operation target messages .... 51
5.1.9. Demand values ........................................ 52
5.1.10. Commissioning tests ............................... 52
5.1.11. Disturbance recorder ............................... 53
  5.1.11.1. Function........................................ 53
  5.1.11.2. Disturbance recorder data................. 53
  5.1.11.3. Control and target of disturbance
            recorder status.............................. 54
  5.1.11.4. Triggering................................... 55
  5.1.11.5. Settings and unloading................... 55
  5.1.11.6. Event code of the disturbance
            recorder....................................... 55
5.1.12. Recorded data of the last events.............. 55
5.1.13. Communication ports ............................. 57
5.1.14. IEC 60870-5-103 remote communication
        protocol........................................... 58
5.1.15. Modbus remote communication protocol .... 61
  5.1.15.1. Profile of Modbus .......................... 62
5.1.16. DNP 3.0 remote communication protocol .... 74
  5.1.16.1. Protocol parameters....................... 74
  5.1.16.2. DNP 3.0 point list ........................ 74
  5.1.16.3. DNP 3.0 device profile ................... 77
  5.1.16.4. Specific DNP features.................... 83
5.1.17. SPA bus communication protocol parameters ... 86
  5.1.17.1. Event codes ................................ 99
5.1.18. Self-supervision (IRF) system .................. 103
5.1.19. Relay parameterization ........................ 105
5.2. Design description ................................ 105
  5.2.1. Input/output connections ................. 105
  5.2.2. Serial communication connections .......... 111
  5.2.3. Technical data ................................ 117
6. Ordering information ................................ 123
7. Check lists .......................................... 125
8. Abbreviations ......................................... 131
Copyrights

The information in this document is subject to change without notice and should not be construed as a commitment by ABB Oy. ABB Oy assumes no responsibility for any errors that may appear in this document.

In no event shall ABB Oy be liable for direct, indirect, special, incidental or consequential damages of any nature or kind arising from the use of this document, nor shall ABB Oy be liable for incidental or consequential damages arising from the use of any software or hardware described in this document.

This document and parts thereof must not be reproduced or copied without written permission from ABB Oy, and the contents thereof must not be imparted to a third party nor used for any unauthorized purpose.

The software or hardware described in this document is furnished under a license and may be used, copied or disclosed only in accordance with the terms of such license.

© Copyright 2011 ABB Oy

All rights reserved.

Trademarks

ABB is a registered trademark of ABB Group. All other brand or product names mentioned in this document may be trademarks or registered trademarks of their respective holders.

Warranty

Please inquire about the terms of warranty from your nearest ABB representative.
1. Introduction

1.1. This manual

This manual provides thorough information on the voltage relay REU610 and its applications, focusing on giving a technical description of the relay.

Refer to the Operator’s Manual for instructions on how to use the human-machine interface (HMI) of the relay, also known as the man-machine interface (MMI), and to the Installation Manual for installation of the relay.

1.2. Use of symbols

This publication includes the following icons that point out safety-related conditions or other important information:

- The electrical warning icon indicates the presence of a hazard which could result in electrical shock.

- The warning icon indicates the presence of a hazard which could result in personal injury.

- The caution icon indicates important information or warning related to the concept discussed in the text. It might indicate the presence of a hazard which could result in corruption of software or damage to equipment or property.

- The information icon alerts the reader to relevant facts and conditions.

- The tip icon indicates advice on, for example, how to design your project or how to use a certain function.

Although warning hazards are related to personal injury, it should be understood that operation of damaged equipment could, under certain operational conditions, result in degraded process performance leading to personal injury or death. Therefore, comply fully with all warning and caution notices.

1.3. Intended audience

This manual is intended for operators and engineers to support normal use of as well as configuration of the product.
1.4. Product documentation

In addition to the relay and this manual, the delivery contains the following relay-specific documentation:

<table>
<thead>
<tr>
<th>Table 1.4.-1</th>
<th>REU610 product documentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Document ID</td>
</tr>
<tr>
<td>Certificate of verification</td>
<td>1MRS081662</td>
</tr>
<tr>
<td>Installation Manual</td>
<td>1MRS752265-MUM</td>
</tr>
<tr>
<td>Operator’s Manual</td>
<td>1MRS755971</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 1.4.-2</th>
<th>Other reference documentation for REU610</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Document ID</td>
</tr>
</tbody>
</table>

1.5. Document conventions

The following conventions are used for the presentation of material:

- Push button navigation in the human-machine interface (HMI) menu structure is presented by using the push button icons, for example:

  To navigate between the options, use ⬆ and ⬇.

- HMI menu paths are presented as follows:

  Use the arrow buttons to select \CONFIGURATION\COMMUNICATION\SPA SETTINGS\PASSWORD SPA.

- Parameter names, menu names, relay target messages and relay's HMI views are shown in a Courier font, for example:

  Use the arrow buttons to monitor other measured values in the menus DEMAND VALUES and HISTORY DATA.

- HMI messages are shown inside quotation marks when it is good to point out them for the user, for example:

  When you store a new password, the relay confirms the storage by flashing “– – –” once on the display.
### 1.6. Document revisions

<table>
<thead>
<tr>
<th>Version</th>
<th>IED Revision</th>
<th>Date</th>
<th>History</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A</td>
<td>01.02.2006</td>
<td>Document created</td>
</tr>
<tr>
<td>B</td>
<td>C</td>
<td>01.10.2007</td>
<td>Content updated</td>
</tr>
<tr>
<td>C</td>
<td>C</td>
<td>12.12.2007</td>
<td>Added information related to ordering parts and accessories.</td>
</tr>
<tr>
<td>D</td>
<td>C</td>
<td>22.05.2009</td>
<td>Content updated</td>
</tr>
<tr>
<td>E</td>
<td>C</td>
<td>18.11.2011</td>
<td>Language sets updated.</td>
</tr>
</tbody>
</table>
2. **Safety information**

Dangerous voltages can occur on the connectors, even though the auxiliary voltage has been disconnected.

Non-observance can result in death, personal injury or substantial property damage.

Only a competent electrician is allowed to carry out the electrical installation.

National and local electrical safety regulations must always be followed.

The frame of the device has to be carefully grounded.

When the plug-in unit has been detached from the case, do not touch the inside of the case. The relay case internals may contain high voltage potential and touching these may cause personal injury.

The device contains components which are sensitive to electrostatic discharge. Unnecessary touching of electronic components must therefore be avoided.

Breaking the sealing tape on the upper handle of the device will result in loss of guarantee and proper operation will no longer be insured.
3. Product overview

3.1. Use of the relay

The voltage relay REU610 is a versatile multifunction protection relay mainly designed for overvoltage and undervoltage protection and for supervision of medium voltage distribution networks. The relay can also be used for protecting generators, motors and transformers.

The relay is based on a microprocessor environment. A self-supervision system continuously monitors the operation of the relay.

The HMI includes a liquid crystal display (LCD) which makes the local use of the relay safe and easy.

Local control of the relay via serial communication can be carried out with a computer connected to the front communication port. Remote control can be carried out via the rear connector connected to the control and monitoring system through the serial communication bus.

3.2. Features

- Overvoltage protection with definite-time or IDMT characteristic, low-set element
- Overvoltage protection with definite-time or IDMT characteristic, high-set element
  - Based on phase-to-phase voltage measurement or negative phase-sequence (NPS) voltage
- Undervoltage protection with definite-time or IDMT characteristic, low-set element
  - Can also be used as alarm element
- Undervoltage protection with definite-time or IDMT characteristic, high-set element
  - Based on phase-to-phase voltage measurement or positive phase-sequence (PPS) voltage
- Residual overvoltage protection with definite-time characteristic, low-set element
- Residual overvoltage protection with definite-time characteristic, high-set element
- Circuit-breaker failure protection
- Trip counters for circuit-breaker condition monitoring
- Trip-circuit supervision with possibility to route the warning signal to a non-trip output
- Trip lockout function
- Four accurate voltage inputs
  - User-selectable rated voltage 100/110/115/120 V
  - User-selectable rated frequency 50/60 Hz
• Three normally open trip contacts
• Two change-over (form c) non-trip contacts and three additional change-over (form c) non-trip contacts on the optional I/O module
• Output contact functions freely configurable for wanted operation
• Two galvanically isolated digital inputs and three additional galvanically isolated digital inputs on the optional I/O module
• Disturbance recorder:
  • Recording time up to 80 seconds
  • Triggering by one or several internal or digital input signals
  • Records four analog channels and up to eight user-selectable digital channels
  • Adjustable sampling rate
• Non-volatile memory for:
  • Up to 100 event codes with time stamp
  • Setting values
  • Disturbance recorder data
  • Recorded data of the five last events with time stamp
  • Number of pickups for protection elements
  • Operation target messages and LEDs showing the status at the moment of power failure
• HMI with an alphanumeric LCD and navigation buttons
  • Eight programmable LEDs
• Multi-language support
• User-selectable password protection for the HMI
• Display of primary voltage values
• All settings can be modified with a PC
• Optical front communication connection: wirelessly or via cable
• Optional rear communication module with plastic fibre-optic, combined fibre-optic (plastic and glass) or RS-485 connection for system communication using the SPA-bus, IEC 60870-5-103 or Modbus (RTU and ASCII) communication protocol
• Optional DNP 3.0 rear communication module with RS-485 connection for system communication using the DNP 3.0 communication protocol
• Battery back-up for real-time clock
• Time synchronization via a digital input
• Battery charge supervision
• Continuous self-supervision of electronics and software
  • At an internal relay fault, all protection elements and outputs are locked
• Detachable plug-in unit
4. Application

REU610 is a versatile multifunction voltage relay which is used in general voltage supervision applications. It complements the range of feeder protection relay REF610 and motor protection relay REM610 in industrial outgoing feeder and motor feeder applications. The relay can also be used as back-up protection for industrial as well as utility applications.

The large number of integrated protection functions, including two overvoltage protection elements, two undervoltage protection elements and two residual overvoltage protection elements, makes the relay a complete protection against various voltage fault conditions.

The large number of digital inputs and output contacts allows a wide range of applications.

4.1. Requirements

To secure correct and safe operation of the relay, preventive maintenance is recommended to be performed every five years when the relay is operating under the specified conditions; see Table 4.1.-1 and Section 5.2.3. Technical data.

When being used for real-time clock or recorded data functions, the battery should be changed every five years.

<table>
<thead>
<tr>
<th>Table 4.1.-1</th>
<th>Environmental conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended temperature range (continuous)</td>
<td>-10...+55°C</td>
</tr>
<tr>
<td>Limit temperature range (short-term)</td>
<td>-40...+70°C</td>
</tr>
<tr>
<td>Temperature influence on the operation accuracy of the voltage relay within the specified service temperature range</td>
<td>0.1%/°C</td>
</tr>
<tr>
<td>Transport and storage temperature range</td>
<td>-40...+85°C</td>
</tr>
</tbody>
</table>

4.2. Configuration

The appropriate configuration of the output contact matrix enables the use of the signals from the protection elements as contact functions. The pickup signals can be used for blocking co-operating protection relays and signalling.

The Fig. 4.2.-1 represents the relay with trip lockout function and external reset switch.
Fig. 4.2-1 Connection diagram
5. Technical description

5.1. Functional description

5.1.1. Product functions

5.1.1.1. Protection functions

Table 5.1.1.1.-1  IEC symbols and IEEE device numbers

<table>
<thead>
<tr>
<th>Function description</th>
<th>IEC symbol</th>
<th>IEEE device number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overvoltage protection, low-set element</td>
<td>U&gt;</td>
<td>59P-1</td>
</tr>
<tr>
<td>Overvoltage protection, high-set element</td>
<td>U&gt;&gt;</td>
<td>59P-2</td>
</tr>
<tr>
<td>Negative phase-sequence overvoltage protection</td>
<td>U2&gt;</td>
<td>47</td>
</tr>
<tr>
<td>Undervoltage protection, low-set element</td>
<td>U&lt;</td>
<td>27P-1</td>
</tr>
<tr>
<td>Undervoltage protection, high-set element</td>
<td>U&lt;&lt;</td>
<td>27P-2</td>
</tr>
<tr>
<td>Positive phase-sequence undervoltage protection</td>
<td>U1&lt;</td>
<td>27D</td>
</tr>
<tr>
<td>Residual overvoltage protection, low-set element</td>
<td>U0&gt;</td>
<td>59N-1</td>
</tr>
<tr>
<td>Residual overvoltage protection, high-set element</td>
<td>U0&gt;&gt;</td>
<td>59N-2</td>
</tr>
<tr>
<td>Circuit-breaker failure protection</td>
<td>CBFP</td>
<td>CBFAIL</td>
</tr>
<tr>
<td>Lockout relay</td>
<td></td>
<td>86</td>
</tr>
</tbody>
</table>

For protection function descriptions, refer to Section 5.1.4. Protection.

5.1.1.2. Inputs

The relay is provided with four energizing inputs, two digital inputs and three optional digital inputs controlled by an external voltage. Three of the energizing inputs are for the phase-to-phase voltages and one for the residual voltage.

The relay is mainly designed to measure phase-to-phase voltages, but it can be used for measuring phase-to-ground voltages as well. However, the relay does not convert the voltage from phase-to-ground voltage to phase-to-phase voltage.

The functions of the digital inputs are determined with the SGB switches. For details, refer to Section 5.2.1. Input/output connections and Table 5.1.4.7.-7, Table 5.2.1.-1 and Table 5.2.1.-5.
5.1.1.3. Outputs

The relay is provided with:

- Three trip output contacts PO1, PO2 and PO3
- Two non-trip output contacts SO1 and SO2
- Three optional non-trip output contacts SO3, SO4 and SO5

Switchgroups SGR1...8 are used for routing internal signals from the protection elements and the external trip signal to the wanted non-trip or trip output contact. The minimum pulse length can be configured to be 40 or 80 ms and the trip output contacts can be configured to be latched.

5.1.1.4. Disturbance recorder

The relay includes an internal disturbance recorder which records the instantaneous measured values or the RMS curves of the measured signals, and up to eight user-selectable digital signals: the digital input signals and the internal signals from the protection elements. Any digital signal can be set to trigger the recorder on either the falling or rising edge.

5.1.1.5. Front panel

The front panel of the relay contains:

- Alphanumeric 2 × 16 characters’ LCD with backlight and automatic contrast control
- Threetarget LEDs (green, yellow, red) with fixed functionality
- Eight programmable target LEDs (red)
- HMI push-button section with four arrow buttons and buttons for clear/cancel and enter, used in navigating in the menu structure and in adjusting setting values
- Optically isolated serial communication port with a target LED.

There are two levels of HMI passwords; main HMI setting password for all settings and HMI communication password for communication settings only.

The HMI passwords can be set to protect all user-changeable values from being changed by an unauthorized person. Both the HMI setting password and the HMI communication password remain inactive and are not required for altering parameter values until the default HMI password is replaced.

Entering the HMI setting or communication password successfully can be selected to generate an event code. This feature can be used to indicate interaction activities via the local HMI.

For further information on the HMI, refer to the Operator’s Manual.
5.1.1.6. Non-volatile memory

The relay can be configured to store various data in a non-volatile memory, which retains its data also in case of loss of auxiliary voltage (provided that the battery has been inserted and is charged). Operation target messages and LEDs, disturbance recorder data, event codes and recorded data can all be configured to be stored in the non-volatile memory whereas setting values and trip counters are always stored in the EEPROM. The EEPROM does not require battery backup.

5.1.1.7. Self-supervision

The self-supervision system of the relay manages run-time fault situations and informs the user about an existing fault. There are two types of fault targets; internal relay fault (IRF) targets and warnings. Internal relay faults prevent relay operation. Warnings are less severe faults and continued relay operation with full or reduced functionality is allowed.

Internal relay fault (IRF)

When the self-supervision system detects a permanent internal relay fault, the green target LED starts to flash. At the same time, the IRF contact (also referred to as the IRF relay), which is normally picked up, drops off. The text INTERNAL FAULT and a fault code appear on the display.

![INTERNAL FAULT
FAULT CODE :30](image)

Fig. 5.1.1.7.-1 Permanent IRF

Warning

In case of a less severe fault (warning), the relay continues to operate except for those protection functions possibly affected by the fault. At this type of fault, the green target LED remains lit as during normal operation, but the text WARNING with a fault code or a text message indicating the fault type appears on the LCD. In case of a warning due to an external fault in the trip circuit detected by the trip-circuit supervision, SO2 is activated (if SGF1/8=1).
For fault codes, refer to 5.1.18. Self-supervision (IRF) system

5.1.1.8. Time synchronization

Time synchronization of the relay’s real-time clock can be realized in two different ways: via serial communication using a communication protocol or via a digital input.

When time synchronization is realized via serial communication, the time is written directly to the relay’s real-time clock.

Any digital input can be configured for time synchronization and used for either minute-pulse or second-pulse synchronization. The synchronization pulse is automatically selected and depends on the time range within which the pulse occurs. Two detected pulses within acceptable time range are required before the relay activates pulse synchronization. Respectively, if the synchronization pulses disappear, the relay takes time that corresponds to the time range of four pulses before de-activating pulse synchronization. The time must be set once, either via serial communication or manually via the HMI.

When the time is set via serial communication and minute-pulse synchronization is used, only year-month-day-hour-minute is written to the relay’s real-time clock, and when second-pulse synchronization is used, only year-month-day-hour-minute-second is written. The relay’s real-time clock will be rounded to the nearest whole second or minute, depending on whether second- or minute-pulse synchronization is used. When the time is set via the HMI, the entire time is written to the relay’s real-time clock.
If the synchronization pulse differs more than ±0.05 seconds for second-pulse or ±2 seconds for minute-pulse synchronization from the relay’s real-time clock, the synchronization pulse is rejected.

Time synchronization is always triggered on the rising edge of the digital input signal. The time is adjusted by accelerating or decelerating the relay's clock. By this way the clock neither stops nor makes sudden jumps during the time adjustment. The typical accuracy achievable with time synchronization via a digital input is ±2.5 milliseconds for second-pulse and ±5 milliseconds for minute-pulse synchronization.

The pulse length of the digital input signal does not affect time synchronization.

If time synchronization messages are received from a communication protocol as well, they have to be synchronized within ±0.5 minutes at minute-pulse or ±0.5 seconds at second-pulse synchronization. Otherwise the time difference may appear as rounding errors. If it is possible that the synchronization messages from the communication protocol are delayed more than 0.5 seconds, minute-pulse synchronization must be used.

When the minute-pulse synchronization is active and long time format is sent via a communication protocol, the protocol's second and millisecond part is ignored. The protocol's minute part is rounded to the nearest minute. Short time format is ignored altogether.

When the second-pulse synchronization is active and long or short time format is sent via a communication protocol, the protocol's millisecond part is ignored. The protocol's second-part is rounded to the nearest second.

5.1.2. Measurements

The table below presents the measured values which can be accessed through the HMI.

<table>
<thead>
<tr>
<th>Target</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>U_{ab}</td>
<td>Measured phase-to-phase voltage</td>
</tr>
<tr>
<td>U_{bc}</td>
<td>U_{bc}</td>
</tr>
<tr>
<td>U_{ca}</td>
<td>U_{ca}</td>
</tr>
<tr>
<td>U_n</td>
<td>Measured residual voltage U_n</td>
</tr>
<tr>
<td>U_1</td>
<td>Positive phase-sequence voltage</td>
</tr>
<tr>
<td>U_2</td>
<td>Negative phase-sequence voltage</td>
</tr>
</tbody>
</table>
### Target Description

<table>
<thead>
<tr>
<th>Target</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 minute</td>
<td>The average voltage of the three phase-to-phase voltages during one minute</td>
</tr>
<tr>
<td>n minute</td>
<td>The average voltage of the three phase-to-phase voltages during the specified time range</td>
</tr>
<tr>
<td>Max</td>
<td>The maximum of one-minute average voltage of the n minute</td>
</tr>
<tr>
<td>$U_{\text{max}}$</td>
<td>The maximum voltage of the three phase-to-phase voltages since the last reset (with timestamp)</td>
</tr>
<tr>
<td>$U_{\text{min}}$</td>
<td>The minimum voltage of the three phase-to-phase voltages since the last reset (with timestamp)</td>
</tr>
</tbody>
</table>

### 5.1.3. Configuration

The Fig. 5.1.3.-1 illustrates how the internal and digital input signals can be configured to obtain the required protection functionality.
Fig. 5.1.3.-1 Signal diagram
The functions of the relay are selected with the switches of switchgroups SGF, SGB, SGR and SGL. The checksums of the switchgroups are found under SETTINGS in the HMI menu. The functions of the switches are explained in detail in the corresponding SG_ tables.

5.1.4. Protection

5.1.4.1. Block diagram

The dashed line indicates optional functionality.

1) Clear targets by the digital input signal
2) Clear targets and unlatch output contacts by the digital input signal
3) Reset targets and memorized values; unlatch output contacts by the digital input signal

Fig. 5.1.4.1.-1 Block diagram

5.1.4.2. Overvoltage protection

The overvoltage protection can be based on either conventional voltage measurement or calculated negative phase-sequence voltage.

The low-set overvoltage element 59P-1 is based on conventional voltage measurement.
The high-set overvoltage element 59P-2 can be set to be based on either
- Conventional voltage measurement (59P-2 mode selected), or
- Calculated negative phase-sequence voltage (47 mode selected).

The selection between these modes is made either by using HMI or parameter S7, the default setting being conventional measurement. Element 27D (PPS) and 47 (NPS) cannot be used at the same time.

Element 59P-2 can be set out of operation in SGF3/1. This state is indicated by dashes on the LCD and by “999” when the set pickup value is read via serial communication.

💡 It is possible to block the tripping of an overvoltage element by applying a digital input signal to the relay.

**Overvoltage protection based on conventional voltage measurement**

Both the low-set and the high-set overvoltage element can independently be set to pickup and trip when one of the three voltages or all the voltages rise above the set start value. By default, both elements operate when one of the three voltages rise above the set pickup value. The selection is made in SGF4/5 and SGF4/6.

When the phase-to-phase voltage values exceed the set pickup value of the low-set element 59P-1, the element generates a pickup signal after a ~ 60 ms’ pickup time. When the set operate time at definite-time characteristic or the calculated operate time at IDMT characteristic elapses, the element generates a trip signal.

Element 59P-1 has a settable resetting time (both at definite-time and IDMT characteristics), 59P-1 RESET, for reset coordination with existing electromechanical relays or for reducing fault clearance times of recurring, transient faults. If element 59P-1 has picked up and the phase-to-phase voltages fall below the set pickup value of the element, the pickup of the element remains active for the set resetting time. If the phase-to-phase voltages exceed the set pickup value again while the timer is running, the timer is cleared and the pickup of the element remains active.

Consequently, the set resetting time ensures that when the element picks up because of voltage spikes, it is not immediately reset. If element 59P-1 has already tripped, the element is reset in 70 ms after the phase-to-phase voltages have fallen below 0.5 times the set pickup value of the element. However, if element 59P-1 has already tripped and the phase-to-phase voltages have fallen below the set pickup value of the element, but not below 0.5 times the set pickup value, the element is reset when the set resetting time is expired.

When the conventional protection mode is selected and the phase-to-phase voltages exceed the set pickup value of the high-set element, 59P-2, the element generates a pickup signal after a ~ 50 ms’ pickup time. When the set operate time at definite-
time characteristic or the calculated operate time at IDMT characteristic elapses, the element generates a trip signal. The element is reset in 70 ms after the phase-to-phase voltages have fallen below the set pickup value of the element.

The conventional overvoltage elements have a settable drop-off/pick-up ratio, which is adjustable between 0.95...0.99, the default being 0.97.

The settable drop-off/pick-up ratio enables the voltage protection to satisfactorily work with a voltage regulator, for instance, such as a tap changer. The tap changer step is often 1.67%, which is less than the drop-off/pick-up ratio of voltage relays. This can cause a situation where the voltage protection remains active even though the tap changer already has changed the voltage.

**Overvoltage protection based on negative phase-sequence voltage**

When the calculated negative phase-sequence voltage value \( U_2 \) exceeds the set pickup value of the element 47, the element generates a pickup signal after a 50 ms' pickup time. When the set operate time at definite-time characteristics or the calculated operate time at IDMT characteristics elapses, the element generates a trip signal. The element is reset in 70 ms after the calculated negative phase-sequence voltage value has fallen below the set pickup value of the element.

The negative phase-sequence voltage is calculated as follows:

\[
U_2 = \frac{U_{ab} + a^2 \times U_{bc} + a \times U_{ca}}{3}
\]  

\( a = 1 \angle 120^\circ \)

\( a^2 = 1 \angle -120^\circ \)

The negative phase-sequence value is scaled to the amplitude of the measured voltage. On a network with a reverse phase order, the calculated negative phase-sequence value has the same amplitude as the measured voltage signal.

Element 47 can be set to be blocked when one of the measured phase-to-phase voltages falls below 0.15 \( \times U_n \) (VT). The selection is made in SGF4.

Element 47 has a fixed drop-off/pick-up ratio of 0.96.

**5.1.4.3. Undervoltage protection**

The undervoltage protection can be based on either conventional voltage measurement or the calculated positive phase-sequence voltage.

The low-set undervoltage element 27P-1 is based on conventional voltage measurement. The low-set element can also be used for alarm purposes.
The high-set undervoltage element 27P-2 can be set to be based on either:

- Conventional voltage measurement (27P-2 mode selected) or
- Calculated positive phase-sequence voltage (27D mode selected).

The selection between these modes is made either by using HMI or parameter S7, the default setting being conventional measurement. Element 27D (PPS) and 47 (NPS) cannot be used at the same time.

The undervoltage elements can be set to be blocked when one of the measured voltages fall below 0.15 × Uₙ (VT). The blocked element is reset after the set resetting time. This feature can be used to avoid unnecessary pickups and trips during, for example, an auto-reclose sequence. In addition, the tripping of element 27P-1 can be set to be blocked by the element 27P-2 pickup. The selection is made in SGF4.

Element 27P-2 or 27D can be set out of operation in SGF3/2. This state is indicated by dashes on the LCD and by 999 when the set pickup value is read via serial communication.

It is possible to block the tripping of an undervoltage element by applying a digital input signal to the relay.

### Undervoltage protection based on conventional voltage measurement

Both the low-set and the high-set undervoltage element can independently be set to pickup and trip when one of the three voltages or all the voltages fall below the set pickup value. By default, the low-set undervoltage element operates when one of the three voltages fall below the set pickup value and the high-set undervoltage element operates when all the voltages fall below the set pickup value. The selection is made in SGF4/7 and SGF4/8.

When the phase-to-phase voltage values fall below the set pickup value of the low-set element, 27P-1, the element generates a pickup signal after a ~ 80 ms’ pickup time. When the set operate time at definite-time characteristic or the calculated operate time at IDMT characteristic elapses, the element generates a trip signal.

Element 27P-1 has a settable resetting time (both at definite-time and IDMT characteristics), 27P-1 RESET, for reset coordination with existing electromechanical relays or for reducing fault clearance times of recurring, transient faults. If element 27P-1 has picked up and the phase-to-phase voltages exceed the set pickup value of the element, the pickup of the element remains active for the set resetting time. If the phase-to-phase voltages fall below the set pickup value again while the timer is running, the timer is cleared and the pickup of the element remains active.
Consequently, the set resetting time ensures that when the element picks up because of voltage drops, it is not immediately reset. If element 27P-1 has already tripped, the element is reset in 70 ms after the phase-to-phase voltages have fallen below $0.15 \times U_\text{n} \ (VT)$. However, if element 27P-1 has already tripped and the phase-to-phase voltages have exceeded the set pickup value of the element, the element is reset when the set resetting time has expired.

Element 27P-1 tripping can be set to be blocked by the pickup of element 27P-2 or 27D.

Element 27P-1 can also be configured to be used for alarm purposes. When a trip signal is generated for alarm purposes, the Start/Alarm target LED is lit and the fault is indicated as an alarm instead of a trip.

When element 27P-1 is configured to be used for alarm purposes:

- Pickup signal of element is not generated
- Trip signal of element is generated, but it is indicated as an alarm
- Element cannot be used for triggering CBFAIL
- Number of pickups is increased instead of number of trips

When the conventional protection mode is selected and the voltages fall below the set pickup value of the high-set element, 27P-2, the element generates a pickup signal after a ~ 50 ms’ pickup time. When the set operate time at definite-time characteristic or the calculated operate time at IDMT characteristic elapses, the element generates a trip signal. The element is reset in 70 ms after the phase-to-phase voltages have exceeded the set pickup value of the element.

The undervoltage elements have a settable drop-off/pick-up ratio, which is adjustable between 1.01...1.05, the default being 1.03.

**Undervoltage protection based on positive phase-sequence voltage**

The undervoltage protection based on calculated positive phase-sequence voltage can be applied to disconnecting a smaller power plant from the outside network, for instance in situations where there is a fault in the network which can be critical for the power plant, such as a short circuit either at the transmission or distribution network level.

A situation of this kind can be critical for different reasons. The power plant can be left to feed an isolated network due to a trip caused by a fault. In this case, there is a risk that the isolated network, which is in asynchronous state compared to the rest of the network, is reconnected to the network as a result of an autoreclosure, for instance. In addition, the power plant can also fall into an asynchronous state in a fault situation. These critical situations can be prevented by disconnecting the power plant from the network fast enough by tripping the connecting circuit breaker.
The benefit of this function is that the voltage value measured during or after a network fault is a good measure of how critical the fault is for a smaller power plant. When the positive phase-sequence voltage value falls below the critical limit, the power plant has to be disconnected from the network.

REU610 measuring the positive phase-sequence voltage complements other methods used to disconnect smaller power plants. The application of these methods is based on frequency and voltage measurement. The undervoltage protection based on calculated positive phase-sequence voltage requires that the relay is in three-phase use.

When the calculated positive phase-sequence voltage value \( U_1 \) falls below the set pickup value of the element 27D, the element generates a pickup signal after a \( \sim 50 \) ms’ pickup time. When the set operate time at definite-time characteristic or the calculated operate time at IDMT characteristic elapses, the element generates a trip signal. The element is reset in 70 ms after the calculated positive phase-sequence voltage value has exceeded the set pickup value of the element.

The positive phase-sequence voltage is calculated as follows:

\[
U_1 = \frac{U_{ab} + a \times U_{bc} + a^2 \times U_{ca}}{3}
\]  

\( a = 1 \angle 120^\circ \)
\( a^2 = 1 \angle -120^\circ \)

On a symmetrical network, this formula scales the positive phase-sequence value to the same amplitude as the measured voltage signal.

Element 27P-2 can be set to be blocked when the measured voltage values fall below \( 0.15 \times U_n \) (VT). In addition, the tripping of element 27P-1 can be set to be blocked by element 27P-2 pickup. The selection is made in SGF4.

Element 27D has a fixed drop-off/pick-up ratio of 1.04.

5.1.4.4. Residual overvoltage protection

The residual overvoltage protection detects residual voltages caused by ground faults.

When the residual voltage exceeds the set pickup value of the low-set element 59N-1, the element generates a pickup signal after a \( \sim 70 \) ms’ pickup time. When the set operate time elapses, the element generates a trip signal.

Element 59N-1 has a settable resetting time 59N-1 RESET for reset coordination with existing electromechanical relays or for reducing fault clearance times of recurring, transient faults. If element 59N-1 has picked up and the residual voltage falls below the set pickup value of the element, the pickup of the element remains
active for the set resetting time. If the residual voltage exceeds the set pickup value again while the timer is running, the timer is cleared and the pickup of the element remains active.

Consequently, the set resetting time ensures that when the element picks up because of voltage spikes, it is not immediately reset. If element 59N-1 has already tripped, the element is reset in 50 ms after the residual voltage falls below 0.5 times the set pickup value of the element. However, if element 59N-1 has already tripped and the residual voltage has fallen below the set pickup value of the element, but not below 0.5 times the set pickup value, the element is reset after the set resetting time (59N-1 RESET) has expired.

When the residual voltage exceeds the set pickup value of the high-set element 59N-2, the element generates a pickup signal after a ~ 60 ms’ pickup time. When the set operate time has elapsed, the element generates a trip signal.

If element 59N-2 has picked up and the residual voltage falls below the set pickup value of the element, the pickup of the element remains active for 100 ms. If the residual voltage exceeds the set pickup value again while the timer is running, the timer is cleared and the pickup of the element remains active. If element 59N-2 has already tripped, the element is reset in 50 ms after the residual voltage falls below 0.5 times the set pickup value of the element. However, if element 59N-2 has already tripped and the residual voltage has fallen below the set pickup value of the element, but not below 0.5 times the set pickup value, the element is reset after the 100 ms’ resetting time has expired.

Elements 59N-1 can be set out of operation in SGF3/3 and element 59N-2 can be set out of operation in SGF3/4. This state is indicated by dashes on the LCD and by 999 when the set pickup value is read via serial communication.

It is possible to block the tripping of a residual overvoltage element by applying a digital input signal to the relay.

5.1.4.5. Circuit-breaker failure protection

The circuit-breaker failure protection (CBFAIL) detects situations where the trip remains active although the circuit breaker should have operated.

The CBFAIL unit generates a trip signal via output PO2 when the set operate time of CBFAIL expires.

The CBFAIL can be triggered internally via protection functions. All the signals, except external trip, routed to output PO1 trigger the CBFAIL. If the fault situation is not cleared when the set operate time has elapsed, the CBFAIL generates a trip signal via output PO2.
The CBFAIL can also be selected to be triggered externally by applying a digital input signal to the relay, if the maximum of all three phase-to-phase voltages is above $0.15 \times U_n$ (VT). If the fault situation is not cleared when the set operate time has elapsed, the CBFAIL generates a trip signal via output PO2.

Internal triggering is selected by activating the CBFAIL in SGF1/6 and external triggering by activating the CBFAIL in SGB1...5/7.

Normally, the CBFAIL controls the upstream circuit breaker. However, it can also be used for tripping via redundant trip circuits of the same circuit breaker.

### 5.1.4.6. Inverse definite minimum time characteristics

Each of the overvoltage and undervoltage elements can be given either a definite-time or an inverse definite minimum time (IDMT) characteristic. The following setting parameters determine the operation mode of the overvoltage and undervoltage protection elements:

<table>
<thead>
<tr>
<th>Protection element</th>
<th>Parameter</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>59P-1</td>
<td>S3</td>
<td>0 = definite time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 = curve A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 = curve B</td>
</tr>
<tr>
<td>59P-2/47</td>
<td>S11</td>
<td>0 = definite time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 = curve A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 = curve B</td>
</tr>
<tr>
<td>27P-1</td>
<td>S15</td>
<td>0 = definite time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 = curve C</td>
</tr>
<tr>
<td>27P-2/27D</td>
<td>S22</td>
<td>0 = definite time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 = curve C</td>
</tr>
</tbody>
</table>

At IDMT characteristic, the operate time of the element is dependent on the voltage value: the greater the deviation from the setting value, the shorter the operate time. Three time/voltage curve groups are available: A, B and C.

An overvoltage element picks up when the measured voltage exceeds the setting value of the element. An undervoltage element picks up when the measured voltage drops below the setting value of the element. However, the IDMT calculation does not pickup until the deviation between the measured voltage and the setting value exceeds 3 percent. The operate time accuracy stated in technical data applies when the deviation is 10 percent or higher.

**Characteristics of the overvoltage elements**

The IDMT characteristic curve groups A and B are designed for overvoltage elements 59P-1 and 59P-2/47. Elements 59P-1 and 59P-2/47 can be configured to use different characteristics. The relationship between time and voltage at IDMT characteristic can be expressed as follows:
The A- and B-type characteristics are illustrated in Fig. 5.1.4.6.-1 and Fig. 5.1.4.6.-2.

If the ratio between the voltage and the set value is higher than 1.6, the operate time is the same as when the ratio is 1.6.

**Characteristic of the undervoltage elements**

The IDMT characteristic curve group C is designed for undervoltage elements 27P-1 and 27P-2/27D. Elements 27P-1 and 27P-2/27D can be configured to use different characteristics. The relationship between time and voltage at IDMT characteristic can be expressed as follows:

\[
t[s] = \frac{TD \times 480}{\left(32 \times \frac{U - 59P}{59P} - 0.5\right)^p} + 0.05
\]

\[(3)\]

\[
t = \text{operate time}
\]

\[
TD = \text{time dial 59P-1 TD or 59P-2 TD}
\]

\[
U = \text{measured voltage}
\]

\[
59P = \text{set pickup value 59P-1 or 59P-2/47}
\]

\[
p = \text{constant (see Table 5.1.4.6.-2)}
\]

The C-type characteristic is illustrated in Fig. 5.1.4.6.-3.

If the ratio between the voltage and the set value is lower than 0.3, the operate time is the same as when the ratio is 0.3.
### Table 5.1.4.6.-2 Values of constant p

<table>
<thead>
<tr>
<th>Time/voltage characteristic</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>p</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>
Fig. 5.1.4.6.-1 Characteristics of type A
Fig. 5.1.4.6.-2  Characteristics of type B
Fig. 5.1.4.6.-3 Characteristics of type C
5.1.4.7. Settings

There are two alternative setting groups available, setting groups 1 and 2. Either of these setting groups can be used as the actual settings, one at a time. Both groups have their related registers. By switching between the setting groups, a whole group of settings can be changed at the same time. This can be done in any of the following ways:

- Via the HMI
- Entering SPA parameter \( V150 \) via serial communication
- Via a digital input

Switching between setting groups via a digital input has a higher priority than via the HMI or with the parameter \( V150 \).

The setting values can be altered via the HMI or with a PC provided with Relay Setting Tool.

Before the relay is connected to a system it must be assured that the relay has been given the correct settings. If there is any doubt, the setting values should be read with the relay trip circuits disconnected or tested with current injection; refer to Chapter 7. Check lists for additional information.

<table>
<thead>
<tr>
<th>Setting</th>
<th>Description</th>
<th>Setting range</th>
<th>Default setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>59P-1</td>
<td>Pickup value of element 59P-1</td>
<td>0.60…1.40 × ( U_i ) (VT)</td>
<td>1.2</td>
</tr>
<tr>
<td>59P-1 TDLY</td>
<td>Operate time of element 59P-1</td>
<td>0.06…600 s</td>
<td>0.06</td>
</tr>
<tr>
<td>59P-1 MODE</td>
<td>Operation mode setting for 59P-1</td>
<td>0 = definite time, 1 = curve A, 2 = curve B</td>
<td>0</td>
</tr>
<tr>
<td>59P-1 TD</td>
<td>IDMT time dial 59P-1 TD</td>
<td>0.05…2.00</td>
<td>0.05</td>
</tr>
<tr>
<td>59P-1 RSET</td>
<td>Resetting time of element 59P-1</td>
<td>0.07…60.0 s</td>
<td>0.07</td>
</tr>
<tr>
<td>59P-1 D/P</td>
<td>Drop-off/pick-up ratio of element 59P-1</td>
<td>0.95…0.99</td>
<td>0.97</td>
</tr>
<tr>
<td>U1/U2 MODE</td>
<td>( U_1/U_2 ) mode setting of elements 59P-2 and 27P-2</td>
<td>0 = 59P-2 and 27P-2, 1 = 59P-2 and 27D, 2 = 47 and 27P-2</td>
<td>0</td>
</tr>
<tr>
<td>59P-2</td>
<td>Pickup value of element 59P-2</td>
<td>0.80…1.60 × ( U_i ) (VT)</td>
<td>1.2</td>
</tr>
<tr>
<td>47</td>
<td>Pickup value of element 47</td>
<td>0.05…1.00 × ( U_i ) (VT)</td>
<td>0.05</td>
</tr>
<tr>
<td>59P-2 TDLY</td>
<td>Operate time of element 59P-2</td>
<td>0.05…600 s</td>
<td>0.05</td>
</tr>
<tr>
<td>59P-2/U2 MODE</td>
<td>Operation mode setting for 59P-2/U2</td>
<td>0 = definite time, 1 = curve A, 2 = curve B</td>
<td>0</td>
</tr>
<tr>
<td>59P-2 TD</td>
<td>IDMT time dial 59P-2 TD</td>
<td>0.05…2.00</td>
<td>0.05</td>
</tr>
<tr>
<td>27P-1</td>
<td>Pickup value of element 27P-1</td>
<td>0.20…1.20 × ( U_i ) (VT)</td>
<td>0.2</td>
</tr>
<tr>
<td>27P-1 TDLY</td>
<td>Operate time of element 27P-1</td>
<td>0.10…600 s</td>
<td>0.1</td>
</tr>
<tr>
<td>27P-1 MODE</td>
<td>Operation mode setting for 27P-1</td>
<td>0 = definite time, 1 = curve C</td>
<td>0</td>
</tr>
<tr>
<td>27P-1 TD</td>
<td>IDMT time dial 27P-1 TD</td>
<td>0.10…2.00</td>
<td>0.1</td>
</tr>
<tr>
<td>Setting</td>
<td>Description</td>
<td>Setting range</td>
<td>Default setting</td>
</tr>
<tr>
<td>------------</td>
<td>--------------------------------------------------</td>
<td>------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>27P-1 RSET</td>
<td>Resetting time of element 27P-1</td>
<td>0.07...60.0 s</td>
<td>0.07</td>
</tr>
<tr>
<td>27P-1 D/P</td>
<td>Drop-off/pick-up ratio of element 27P-1</td>
<td>1.01...1.05</td>
<td>1.03</td>
</tr>
<tr>
<td>27P-2</td>
<td>Pickup value of element 27P-2</td>
<td>0.20...1.20 × Un (VT)</td>
<td>0.2</td>
</tr>
<tr>
<td>27D</td>
<td>Pickup value of element 27D</td>
<td>0.20...1.20 × Un (VT)</td>
<td>0.3</td>
</tr>
<tr>
<td>27P-2 TDLY</td>
<td>Operate time of element 27P-2</td>
<td>0.10...600 s</td>
<td>0.1</td>
</tr>
<tr>
<td>27P-2/U₁ MODE</td>
<td>Operation mode setting for 27P-2/U₁</td>
<td>0 = definite time 1 = curve C</td>
<td>0</td>
</tr>
<tr>
<td>27P-2 TD</td>
<td>IΔMT time dial 27P-2 TD</td>
<td>0.10...2.00</td>
<td>0.1</td>
</tr>
<tr>
<td>59N-1</td>
<td>Pickup value of element 59N-1</td>
<td>2.0...80.0% Un (VT)</td>
<td>2.0</td>
</tr>
<tr>
<td>59N-1 TDLY</td>
<td>Operate time of element 59N-1</td>
<td>0.10...600 s</td>
<td>0.1</td>
</tr>
<tr>
<td>59N-1 RSET</td>
<td>Resetting time of element 59N-1</td>
<td>0.07...60.0 s</td>
<td>0.07</td>
</tr>
<tr>
<td>59N-2</td>
<td>Pickup value of element 59N-2</td>
<td>2.0...80.0% Un (VT)</td>
<td>2.0</td>
</tr>
<tr>
<td>59N-2 TDLY</td>
<td>Operate time of element 59N-2</td>
<td>0.10...600 s</td>
<td>0.1</td>
</tr>
<tr>
<td>Trip fail</td>
<td>Operate time of CBFAIL</td>
<td>0.10...60.0 s</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Switchgroups and parameter masks

The settings can be altered and the functions of the relay selected in the SG_ selector switchgroups. The switchgroups are software based and thus not physical switches to be found in the hardware of the relay.

A checksum is used for verifying that the switches have been properly set. The Fig. 5.1.4.7.-1 shows an example of manual checksum calculation.
Fig. 5.1.4.7.-1 Example of calculating the checksum of a SG_ selector switchgroup

When the checksum, calculated according to the example above, equals the checksum of the switchgroup, the switches in the switchgroup are properly set.

The factory default settings of the switches and the corresponding checksums are presented in the following tables.

**SGF1...SGF5**

Switchgroups SGF1...SGF5 are used for configuring the wanted function as follows:
**Table 5.1.4.7.-2  SGF1**

<table>
<thead>
<tr>
<th>Switch</th>
<th>Function</th>
<th>Default setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>SGF1/1</td>
<td>Selection of the latching feature for PO1</td>
<td>0</td>
</tr>
<tr>
<td>SGF1/2</td>
<td>Selection of the latching feature for PO2</td>
<td>0</td>
</tr>
<tr>
<td>SGF1/3</td>
<td>Selection of the latching feature for PO3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>- When the switch is in position 0 and the measuring signal which caused the trip falls below the set pickup value, the output contact returns to its initial state.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- When the switch is in position 1, the output contact remains active although the measuring signal which caused the trip falls below the set pickup value.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A latched output contact can be unlatched either via the HMI, a digital input or the serial bus.</td>
<td></td>
</tr>
<tr>
<td>SGF1/4</td>
<td>Minimum pulse length for SO1 and SO2 and optional SO3, SO4 and SO5</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>- 0 = 80 ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 1 = 40 ms</td>
<td></td>
</tr>
<tr>
<td>SGF1/5</td>
<td>Minimum pulse length for PO1, PO2 and PO3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>- 0 = 80 ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 1 = 40 ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The latching feature being selected for PO1, PO2 and PO3 overrides this function.</td>
<td></td>
</tr>
<tr>
<td>SGF1/6</td>
<td>CBFAIL</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>- 0 = CBFAIL is not in use</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 1 = the signal to PO1 pickups a timer which generates a delayed signal to PO2, provided that the fault is not cleared before the CBFAIL operate time has elapsed</td>
<td></td>
</tr>
<tr>
<td>SGF1/7</td>
<td>Trip lockout function</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>- 0 = the trip lockout function is not in use. PO3 works as a normal power output relay.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 1 = the trip lockout function is in use. PO3 is dedicated to this function.</td>
<td></td>
</tr>
<tr>
<td>SGF1/8</td>
<td>External fault warning</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>- When the switch is in position 1, the warning signal from the trip-circuit supervision is routed to SO2.</td>
<td></td>
</tr>
</tbody>
</table>

**Table 5.1.4.7.-3  SGF2**

<table>
<thead>
<tr>
<th>Switch</th>
<th>Function</th>
<th>Default setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>SGF2/1</td>
<td>Operation mode of the pickup target of element 59P-1 (^{a)})</td>
<td>0</td>
</tr>
<tr>
<td>SGF2/2</td>
<td>Operation mode of the trip target of element 59P-1</td>
<td>1</td>
</tr>
<tr>
<td>SGF2/3</td>
<td>Operation mode of the pickup target of element 59P-2 or 47 (^{a)})</td>
<td>0</td>
</tr>
<tr>
<td>SGF2/4</td>
<td>Operation mode of the trip target of element 59P-2 or 47</td>
<td>1</td>
</tr>
<tr>
<td>SGF2/5</td>
<td>Operation mode of the pickup target of element 27P-1 (^{a)})</td>
<td>0</td>
</tr>
<tr>
<td>SGF2/6</td>
<td>Operation mode of the trip target of element 27P-1</td>
<td>1</td>
</tr>
<tr>
<td>SGF2/7</td>
<td>Operation mode of the pickup target of element 27P-2 or 27D (^{a)})</td>
<td>0</td>
</tr>
<tr>
<td>SGF2/8</td>
<td>Operation mode of the trip target of element 27P-2 or 27D</td>
<td>1</td>
</tr>
<tr>
<td>SGF2/9</td>
<td>Operation mode of the pickup target of element 59N-1 (^{a)})</td>
<td>0</td>
</tr>
<tr>
<td>SGF2/10</td>
<td>Operation mode of the trip target of element 59N-1</td>
<td>1</td>
</tr>
<tr>
<td>SGF2/11</td>
<td>Operation mode of the pickup target of element 59N-2 (^{a)})</td>
<td>0</td>
</tr>
<tr>
<td>SGF2/12</td>
<td>Operation mode of the trip target of element 59N-2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>- 0 = the trip target is automatically cleared after the fault has disappeared.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 1 = latching. The trip target remains active although the fault has disappeared.</td>
<td></td>
</tr>
</tbody>
</table>

\(^{a)}\)
When the switch is on, the phase(s) that caused the pickup are shown on LCD.

### Table 5.1.4.7.-4 SGF3

<table>
<thead>
<tr>
<th>Switch</th>
<th>Function</th>
<th>Default setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>SGF3/1</td>
<td>Disabling of element 59P-2 or 47</td>
<td>0</td>
</tr>
<tr>
<td>SGF3/2</td>
<td>Disabling of element 27P-2 or 27D</td>
<td>0</td>
</tr>
<tr>
<td>SGF3/3</td>
<td>Disabling of element 59N-1</td>
<td>0</td>
</tr>
<tr>
<td>SGF3/4</td>
<td>Disable of element 59N-2</td>
<td>0</td>
</tr>
</tbody>
</table>

* When the switch is in position 1, the element is disabled.

### Table 5.1.4.7.-5 SGF4

<table>
<thead>
<tr>
<th>Switch</th>
<th>Function</th>
<th>Default setting</th>
</tr>
</thead>
</table>
| SGF4/1 | Selecting single-phase or three-phase use  
  * 0 = three-phase use  
  * 1 = single-phase use a) | 0 |
|          | When single-phase use is selected, the measured voltage has to be connected to inputs X2.1-1 and X2.1-2. Additionally, the \( U_1/U_2 \) mode setting \( S7 \) is overridden and the negative phase-sequence protection mode and positive phase-sequence protection mode are not in use. | |
| SGF4/2 | Internal blocking of pickup and trip of element 27P-1 when one of the measured phase-to-phase voltages fall below 0.15 \( \times U_n \) (VT)  
  * 0 = internal blocking of pickup and trip of element 27P-1  
  * 1 = no internal blocking of pickup and trip of element 27P-1 | 0 |
| SGF4/3 | Internal blocking of pickup and trip of element 27P-2 or 27D when one of the measured phase-to-phase voltages falls below 0.15 \( \times U_n \) (VT)  
  * 0 = internal blocking of pickup and trip of element 27P-2 or 27D  
  * 1 = no internal blocking of pickup and trip of element 27P-2 or 27D | 0 |
| SGF4/4 | Blocking of element 27P-1 tripping by the pickup of element 27P-2 or 27D  
  * 0 = tripping of element 27P-1 is not blocked  
  * 1 = tripping of element 27P-1 is blocked | 0 |
| SGF4/5 | Pickup and trip criteria for element 59P-1 a)  
  * 0 = element operates when one of the phase-to-phase voltages rise above the set pickup value.  
  * 1 = element operates when all the phase-to-phase voltages rise above the set pickup value | 0 |
| SGF4/6 | Pickup and trip criteria for element 59P-2 a)  
  * 0 = element operates when one of the phase-to-phase voltages rise above the set pickup value.  
  * 1 = element operates when all the phase-to-phase voltages rise above the set pickup value.  

This switch has no effect if the element 59P-2 is based on negative phase-sequence calculation. | 0 |
| SGF4/7 | Pickup and trip criteria for element 27P-1 a)  
  * 0 = element operates when one of the phase-to-phase voltages falls below the set pickup value.  
  * 1 = element operates when all the phase-to-phase voltages fall below the set value. | 0 |
### Switch Function Default setting

<table>
<thead>
<tr>
<th>Switch</th>
<th>Function</th>
<th>Default setting</th>
</tr>
</thead>
</table>
| SGF4/8 | Pickup and trip criteria for element 27P-2:  
  - 0 = element operates when one of the phase-to-phase voltages falls below the set pickup value.  
  - 1 = element operates when all the phase-to-phase voltages fall below the set value.  
  This switch has no effect if element 27P-2 is based on positive-phase-sequence calculation. | 1 |
| SGF4/9 | 27P-1 Alarm mode selection  
  - 0 = normal operation of element 27P-1, used for tripping purposes  
  - 1 = element 27P-1 operates as 27P-1 Alarm.  
  The alarm signal is routed to element 27P-1 trip in relay matrix, and the pickup signal of element 27P-1 is disabled. When the alarm signal is active, the pickup LED is lit. | 0 |
| SGF4/10 | Internal blocking of pickup and trip of element 47 when one of the measured phase-to-phase voltages falls below $0.15 \times U_n$ (VT).  
  - 0 = internal blocking of pickup and trip of element 47  
  - 1 = no internal blocking of pickup and trip of element 47 | 0 |

---

**Table 5.1.4.7.-6 SGF5**

<table>
<thead>
<tr>
<th>Switch</th>
<th>Function</th>
<th>Default setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>SGF5/1</td>
<td>Selection of the latching feature for programmable LED1</td>
<td>0</td>
</tr>
<tr>
<td>SGF5/2</td>
<td>Selection of the latching feature for programmable LED2</td>
<td>0</td>
</tr>
<tr>
<td>SGF5/3</td>
<td>Selection of the latching feature for programmable LED3</td>
<td>0</td>
</tr>
<tr>
<td>SGF5/4</td>
<td>Selection of the latching feature for programmable LED4</td>
<td>0</td>
</tr>
<tr>
<td>SGF5/5</td>
<td>Selection of the latching feature for programmable LED5</td>
<td>0</td>
</tr>
<tr>
<td>SGF5/6</td>
<td>Selection of the latching feature for programmable LED6</td>
<td>0</td>
</tr>
<tr>
<td>SGF5/7</td>
<td>Selection of the latching feature for programmable LED7</td>
<td>0</td>
</tr>
</tbody>
</table>
| SGF5/8 | Selection of the latching feature for programmable LED8  
  - When the switch is in position 0 and the signal routed to the LED is reset, the programmable LED is cleared.  
  - When the switch is in position 1, the programmable LED remains lit although the signal routed to the LED is reset.  
  A latched programmable LED can be cleared either via the HMI, a digital input or the serial bus. | 0 |

---

**SGB1...SGB5**

The DI1 signal is routed to the functions below with the switches of switchgroup SGB1, the DI2 signal with those of SGB2, and so forth.
<table>
<thead>
<tr>
<th>Switch</th>
<th>Function</th>
<th>Default setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>SGB1...5/1</td>
<td>• 0 = targets are not cleared by the digital input signal</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>• 1 = targets are cleared by the digital input signal</td>
<td></td>
</tr>
<tr>
<td>SGB1...5/2</td>
<td>• 0 = targets are not cleared and latched output contacts are not unlatched by the digital input signal</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>• 1 = targets are cleared and latched output contacts are unlatched by the digital input signal</td>
<td></td>
</tr>
<tr>
<td>SGB1...5/3</td>
<td>• 0 = targets and memorized values are not cleared and latched output contacts are not unlatched by the digital input signal</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>• 1 = targets and memorized values are cleared and latched output contacts are unlatched by the digital input signal</td>
<td></td>
</tr>
<tr>
<td>SGB1...5/4</td>
<td>Switching between setting groups 1 and 2 by using the digital input</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>• 0 = the setting group cannot be changed using the digital input</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 1 = the setting group is changed by using the digital input. When the digital input is energized, setting group 2 is activated, if not, setting group 1 is activated.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>When SGB1...5/4 is set to 1, it is important that the switch has the same setting in both setting groups.</td>
<td></td>
</tr>
<tr>
<td>SGB1...5/5</td>
<td>Time synchronization by the digital input signal</td>
<td>0</td>
</tr>
<tr>
<td>SGB1...5/6</td>
<td>External tripping by the digital input signal</td>
<td>0</td>
</tr>
<tr>
<td>SGB1...5/7</td>
<td>External triggering of the CBFAIL by the digital input signal</td>
<td>0</td>
</tr>
<tr>
<td>SGB1...5/8</td>
<td>External triggering of the trip lockout by the digital input signal</td>
<td>0</td>
</tr>
<tr>
<td>SGB1...5/9</td>
<td>Resetting of the trip lockout by the digital input signal</td>
<td>0</td>
</tr>
<tr>
<td>SGB1...5/10</td>
<td>Blocking of tripping of element 59P-1 by the digital input signal</td>
<td>0</td>
</tr>
<tr>
<td>SGB1...5/11</td>
<td>Blocking of tripping of element 59P-2 or 47 by the digital input signal</td>
<td>0</td>
</tr>
<tr>
<td>SGB1...5/12</td>
<td>Blocking of tripping of element 27P-1 by the digital input signal</td>
<td>0</td>
</tr>
<tr>
<td>SGB1...5/13</td>
<td>Blocking of tripping of element 27P-2 or 27D by the digital input signal</td>
<td>0</td>
</tr>
<tr>
<td>SGB1...5/14</td>
<td>Blocking of tripping of element 59N-1 by the digital input signal</td>
<td>0</td>
</tr>
<tr>
<td>SGB1...5/15</td>
<td>Blocking of tripping of element 59N-2 by the digital input signal</td>
<td>0</td>
</tr>
<tr>
<td>ΣSGB1...5</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

**SGR1...SGR8**

The pickup, trip and alarm signals from the protection elements and the external trip signal are routed to the output contacts with the switches of switchgroups SGR1...SGR8.

The signals are routed to PO1...PO3 with the switches of switchgroup SGR1...SGR3 and to SO1...SO5 with those of SGR4...SGR8.

The matrix below can be of help when making the wanted selections. The pickup, trip and alarm signals from the protection elements, the signals from the auto-reclose function and the external trip signal are combined with the output contacts by encircling the wanted intersection point. Each intersection point is marked with a switch number, and the corresponding weighting factor of the switch is shown to the right in the matrix. The switchgroup checksum is obtained by vertically adding the weighting factors of all the selected switches of the switchgroup.
The trip lockout signal is always routed to PO3.

The trip signal from CBFAIL is always routed to PO2.

The external fault warning is always routed to SO2.

---

**Fig. 5.1.4.7.-2 Output signal matrix**

a) When element 27P-1 is used for alarm purposes (SGF4/9 = 1), only trip is generated.
Table 5.1.4.7.-8  SGR1...SGR8

<table>
<thead>
<tr>
<th>Switch</th>
<th>Function</th>
<th>Default setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>SGR1...8/1</td>
<td>Pickup signal from element 59P-1</td>
<td>SGR1...SGR3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SGR4...SGR5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SGR6...SGR8</td>
</tr>
<tr>
<td>SGR1...8/2</td>
<td>Trip signal from element 59P-1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>SGR1...8/3</td>
<td>Pickup signal from element 59P-2 or 47</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>SGR1...8/4</td>
<td>Trip signal from element 59P-2 or 47</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>SGR1...8/5</td>
<td>Pickup signal from element 27P-1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>SGR1...8/6</td>
<td>Trip signal from element 27P-1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>SGR1...8/7</td>
<td>Pickup signal from element 27P-2 or 27D</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>SGR1...8/8</td>
<td>Trip signal from element 27P-2 or 27D</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>SGR1...8/9</td>
<td>Pickup signal from element 59N-1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>SGR1...8/10</td>
<td>Trip signal from element 59N-1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>SGR1...8/11</td>
<td>Pickup signal from element 59N-2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>SGR1...8/12</td>
<td>Trip signal from element 59N-2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>SGR1...8/13</td>
<td>External trip signal</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>ΣSGR1...8</td>
<td></td>
<td>2730</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1365</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

a) If the optional I/O module has not been installed, dashes are shown on the LCD and “9999” when the parameter is read via the SPA bus.

SGL1...SGL8

The signals are routed to LED1 with the switches of switchgroup SGL1, to LED2 with those of SGL2, and so forth.

Table 5.1.4.7.-9  SGL1...SGL8

<table>
<thead>
<tr>
<th>Switch</th>
<th>Function</th>
<th>Default setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>SGL1...8/1</td>
<td>Trip signal from element 59P-1</td>
<td>0</td>
</tr>
<tr>
<td>SGL1...8/2</td>
<td>Trip signal from element 59P-2 or 47</td>
<td>0</td>
</tr>
<tr>
<td>SGL1...8/3</td>
<td>Trip signal from element 27P-1</td>
<td>0</td>
</tr>
<tr>
<td>SGL1...8/4</td>
<td>Trip signal from element 27P-2 or 27D</td>
<td>0</td>
</tr>
<tr>
<td>SGL1...8/5</td>
<td>Trip signal from element 59N-1</td>
<td>0</td>
</tr>
<tr>
<td>SGL1...8/6</td>
<td>Trip signal from element 59N-2</td>
<td>0</td>
</tr>
<tr>
<td>SGL1...8/7</td>
<td>Trip lockout signal</td>
<td>0</td>
</tr>
<tr>
<td>SGL1...8/8</td>
<td>DI1 signal</td>
<td>0</td>
</tr>
<tr>
<td>SGL1...8/9</td>
<td>DI2 signal</td>
<td>0</td>
</tr>
<tr>
<td>SGL1...8/10</td>
<td>DI3 signal</td>
<td>0</td>
</tr>
<tr>
<td>SGL1...8/11</td>
<td>DI4 signal</td>
<td>0</td>
</tr>
<tr>
<td>SGL1...8/12</td>
<td>DI5 signal</td>
<td>0</td>
</tr>
<tr>
<td>SGL1...8/13</td>
<td>CB Fail trip</td>
<td>0</td>
</tr>
<tr>
<td>SGL1...8/14</td>
<td>DR triggered</td>
<td>0</td>
</tr>
<tr>
<td>ΣSGL1...SGL8</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>
New trip target timer

The new trip target timer can be configured to allow a second trip target on the LCD. When several protection elements trip, the first trip target is displayed until the time, as specified by the NEW TRIP IND. setting value, has expired. After this, a new trip target can displace the old one. The basic protection functions are not affected by the NEW TRIP IND. setting.

Table 5.1.4.7.-10  New trip target timer

<table>
<thead>
<tr>
<th>Setting</th>
<th>Description</th>
<th>Setting range</th>
<th>Default setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>New trip target</td>
<td>New trip target timer in minutes</td>
<td>0...998</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>No new trip target allowed until the</td>
<td>999</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>previous one has been manually cleared.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Non-volatile memory settings

Non-volatile memory is backed up by a battery; the battery must be inserted and charged.

The table below presents data which can be configured to be stored in the non-volatile memory. All of the functions mentioned below can be selected separately with switches 1...5 either via the HMI or the SPA bus.

Table 5.1.4.7.-11  Memory settings

<table>
<thead>
<tr>
<th>Setting</th>
<th>Switch</th>
<th>Function</th>
<th>Default setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-volatile memory settings</td>
<td>1</td>
<td>0 = operation target messages and LEDs are cleared&lt;br&gt;1 = operation target messages and LEDs are retained</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1 = disturbance recorder data is retained&lt;sup&gt;a)&lt;/sup&gt;</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>1 = event codes are retained&lt;sup&gt;b)&lt;/sup&gt;</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>1 = recorded data and information on the number of pickups of the protection elements are retained</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>1 = the real-time clock is running also during loss of auxiliary voltage&lt;sup&gt;c)&lt;/sup&gt;</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Σ</td>
<td></td>
<td>31</td>
</tr>
</tbody>
</table>

<sup>a)</sup> The prerequisite is that the battery has been inserted and is charged.

When all switches are set to zero, the battery supervision is disabled.
## 5.1.4.8. Technical data on protection functions

### Table 5.1.4.8.-1 Overvoltage protection, elements 59P-1, 59P-2 and 47

<table>
<thead>
<tr>
<th>Feature</th>
<th>Element 59P-1</th>
<th>Element 59P-2</th>
<th>Element 47</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set pickup value 59P-1, 59P-2 and 47:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- at definite-time characteristic</td>
<td>0.60...1.40 × (U_n) (VT)</td>
<td>0.80...1.60 × (U_n) (VT)</td>
<td>0.05...1.00 × (U_n) (VT)</td>
</tr>
<tr>
<td>- at IDMT characteristic</td>
<td>0.60...1.25 × (U_n) (VT) (^{a)}</td>
<td>0.80...1.25 × (U_n) (VT) (^{a)}</td>
<td>0.05...1.00 × (U_n) (VT)</td>
</tr>
<tr>
<td>Pickup time, typical</td>
<td>60 ms</td>
<td>50 ms</td>
<td>50 ms</td>
</tr>
<tr>
<td>Time/voltage characteristic:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- definite-time operate time, 59P-1</td>
<td>0.06...600 s</td>
<td>0.05...600 s</td>
<td>0.05...600 s</td>
</tr>
<tr>
<td>- IDMT</td>
<td>curve A</td>
<td>curve A</td>
<td>curve A</td>
</tr>
<tr>
<td>- time dial, 59P-1 TD, 59P-2 TD</td>
<td>0.05...2.00</td>
<td>0.05...2.00</td>
<td>0.05...2.00</td>
</tr>
<tr>
<td>Resetting time, typical/maximum</td>
<td>70/80 ms(^{b)}</td>
<td>70/80 ms</td>
<td>70/80 ms</td>
</tr>
<tr>
<td>Retardation time, typical</td>
<td>30 ms</td>
<td>30 ms</td>
<td>50 ms</td>
</tr>
<tr>
<td>Set resetting time, 59P-1 RESET</td>
<td>0.07...60.0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Drop-off/pick-up ratio, 59P-1 D/P</td>
<td>0.95...0.99</td>
<td>0.95...0.99</td>
<td>0.96</td>
</tr>
<tr>
<td>Operate time accuracy:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- at definite-time characteristic</td>
<td>±2% of the set operate time or ±25 ms</td>
<td>±2% of the set operate time or ±25 ms</td>
<td>±2% of the set operate time or ±25 ms</td>
</tr>
<tr>
<td>- at IDMT characteristic</td>
<td>±25 ms + the accuracy appearing when the measured voltage varies ±3%</td>
<td>±25 ms + the accuracy appearing when the measured voltage varies ±3%</td>
<td>±25 ms + the accuracy appearing when the measured voltage varies ±3%</td>
</tr>
<tr>
<td>Operation accuracy</td>
<td>±1.5% of the set pickup value</td>
<td>±1.5% of the set pickup value</td>
<td>-</td>
</tr>
<tr>
<td>-0.05...0.15 × (U_n) (VT)</td>
<td>-</td>
<td>-</td>
<td>±10% of the set pickup value</td>
</tr>
<tr>
<td>-0.15...1.00 × (U_n) (VT)</td>
<td>-</td>
<td>-</td>
<td>±5% of the set pickup value</td>
</tr>
</tbody>
</table>

\(^{a)} Because of the maximum measured voltage (2 × \(U_n\) (VT)), the setting value 1.25 is used for the IDMT calculation if the set value is greater than 1.25. This makes the operate time faster than the theoretical IDMT curve. However, the element always picks up according to the set value.

\(^{b)} Resetting time of the trip signal.

### Table 5.1.4.8.-2 Undervoltage protection, elements 27P-1, 27P-2 and 27D

<table>
<thead>
<tr>
<th>Feature</th>
<th>Element 27P-1</th>
<th>Element 27P-2</th>
<th>Element 27D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set pickup value 27P-1, 27P-2 and 27D:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- at definite-time characteristic</td>
<td>0.20...1.20 × (U_n) (VT)</td>
<td>0.20...1.20 × (U_n) (VT)</td>
<td>0.20...1.20 × (U_n) (VT)</td>
</tr>
<tr>
<td>- at IDMT characteristic</td>
<td>0.20...1.20 × (U_n) (VT)</td>
<td>0.20...1.20 × (U_n) (VT)</td>
<td>0.20...1.20 × (U_n) (VT)</td>
</tr>
<tr>
<td>Pickup time, typical</td>
<td>80 ms</td>
<td>50 ms</td>
<td>50 ms</td>
</tr>
</tbody>
</table>
### Table 5.1.4.8.-3 Residual overvoltage protection, elements 59N-1 and 59N-2

<table>
<thead>
<tr>
<th>Feature</th>
<th>Element 59N-1</th>
<th>Element 59N-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set pickup value 59N-1 and 59N-2:</td>
<td>2.0...80% U_n (VT)</td>
<td>2.0...80% U_n (VT)</td>
</tr>
<tr>
<td>Pickup time, typical</td>
<td>70 ms</td>
<td>60 ms</td>
</tr>
<tr>
<td>Time/voltage characteristic:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-at definite-time operate time, 59N-1 TDLY, 59N-2 TDLY</td>
<td>0.10...600 s</td>
<td>0.10...600 s</td>
</tr>
<tr>
<td>Resetting time, typical/maximum</td>
<td>30/50 ms&lt;sup&gt;a)&lt;/sup&gt;</td>
<td>30/50 ms&lt;sup&gt;a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Retardation time, typical</td>
<td>30 ms</td>
<td>30 ms</td>
</tr>
<tr>
<td>Set resetting time, 59N-1 RESET</td>
<td>0.07...60.0 ms</td>
<td>100 ms</td>
</tr>
<tr>
<td>Operate time accuracy:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-at definite-time characteristic</td>
<td>±2% of the set operate time or ±25 ms</td>
<td>±2% of the set operate time or ±25 ms</td>
</tr>
<tr>
<td>Operation accuracy</td>
<td>±1.5% of the set pickup value</td>
<td>±1.5% of the set pickup value</td>
</tr>
</tbody>
</table>

<sup>a)</sup> Resetting time of the trip signal.

---

### Table 5.1.4.8.-3 Residual overvoltage protection, elements 27P-1, 27P-2, and 27D

<table>
<thead>
<tr>
<th>Feature</th>
<th>Element 27P-1</th>
<th>Element 27P-2</th>
<th>Element 27D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time/voltage characteristic:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-at definite operate time, 27P-1 TDLY and 27P-2 TDLY</td>
<td>0.10...600 s</td>
<td>0.10...600 s</td>
<td>0.10...600 s</td>
</tr>
<tr>
<td>-IDMT time dial 27P-1 TD and 27P-2 TD</td>
<td>0.10...2.00 s</td>
<td>0.10...2.00 s</td>
<td>0.10...2.00 s</td>
</tr>
<tr>
<td>Resetting time, typical/maximum</td>
<td>70/80 ms&lt;sup&gt;b)&lt;/sup&gt;</td>
<td>70/80 ms</td>
<td>70/80 ms</td>
</tr>
<tr>
<td>Retardation time, typical</td>
<td>30 ms</td>
<td>30 ms</td>
<td>50 ms</td>
</tr>
<tr>
<td>Set resetting time, 27P-1 RESET</td>
<td>0.07...60.0 s</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Drop-off/pick-up ratio, 27P-1 D/P</td>
<td>1.01...1.05</td>
<td>1.01...1.05</td>
<td>1.04</td>
</tr>
<tr>
<td>Operate time accuracy:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-at definite-time characteristic</td>
<td>±2% of the set operate time or ±25 ms</td>
<td>±2% of the set operate time or ±25 ms</td>
<td>±2% of the set operate time or ±25 ms</td>
</tr>
<tr>
<td>Operation accuracy</td>
<td>±1.5% of the set pickup value</td>
<td>±1.5% of the set pickup value</td>
<td>±5% of the set pickup value</td>
</tr>
</tbody>
</table>

<sup>b)</sup> Resetting time of the trip signal.

---

### Feature Element 27P-1 Element 27P-2 Element 27D

| Time/voltage characteristic: | | | |
| -at definite operate time, 27P-1 TDLY and 27P-2 TDLY | 0.10...600 s | 0.10...600 s | 0.10...600 s |
| -IDMT time dial 27P-1 TD and 27P-2 TD | 0.10...2.00 s | 0.10...2.00 s | 0.10...2.00 s |
| Resetting time, typical/maximum | 70/80 ms<sup>b)</sup> | 70/80 ms | 70/80 ms |
| Retardation time, typical | 30 ms | 30 ms | 50 ms |
| Set resetting time, 27P-1 RESET | 0.07...60.0 s | - | - |
| Drop-off/pick-up ratio, 27P-1 D/P | 1.01...1.05 | 1.01...1.05 | 1.04 |
| Operate time accuracy: | | | |
| -at definite-time characteristic | ±2% of the set operate time or ±25 ms | ±2% of the set operate time or ±25 ms | ±2% of the set operate time or ±25 ms |
| Operation accuracy | ±1.5% of the set pickup value | ±1.5% of the set pickup value | ±5% of the set pickup value |

<sup>b)</sup> Resetting time of the trip signal.
### Table 5.1.4.8.-4 CBFAIL

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set operate time</td>
<td>0.10...60.0 s</td>
</tr>
<tr>
<td>Phase-to-phase voltage threshold for external triggering of the CBFAIL:</td>
<td>0.15/0.10 × Uₙ (VT)</td>
</tr>
</tbody>
</table>

### 5.1.5. Trip-circuit supervision

The trip-circuit supervision (TCS) detects open circuits, both when the circuit breaker is open and closed, and trip-circuit supply failure.

The trip-circuit supervision is based on a constant current injection principle: by applying operating voltage for the circuit breaker, a constant current is forced to flow through the external trip circuit. If the resistance of the trip circuit exceeds a certain limit, due to oxidation or a bad contact, for instance, the trip-circuit supervision is activated and a warning appears on the LCD together with a fault code. The warning signal from the trip-circuit supervision can also be routed to SO2 by setting switch SGF1/8 to 1.

Under normal operating conditions, the applied external voltage is divided between the relay’s internal circuit and the external trip circuit so that at least 20 V remains over the relay’s internal circuit. If the external trip circuit’s resistance is too high or the internal circuit’s too low, due to welded relay contacts, for instance, the voltage over the relay’s internal circuit falls below 20 V (15...20 V), which activates the trip-circuit supervision.

The operation condition is:

\[
U_c - (R_{ext} + R_{int} + R_s) \times I_{tc} \geq 20 \text{ V AC/DC}
\]  

\(U_c\) = operating voltage over the supervised trip circuit  
\(I_{tc}\) = current flowing through the trip circuit, \(\sim 1.5\) mA  
\(R_{ext}\) = external shunt resistor  
\(R_{int}\) = internal shunt resistor, 1 kΩ  
\(R_s\) = trip coil resistance

The external shunt resistor is used to enable trip-circuit supervision also when the circuit breaker is open.

The resistance of the external shunt resistor is to be calculated so that it does not cause malfunction of the trip-circuit supervision or affect the operation of the trip coil. Too high resistance causes too high voltage drop, which in turn results in the operation conditions not being fulfilled, whereas too low resistance may cause faulty operation of the trip coil.

The following values are recommended for the external resistor, \(R_{ext}\):
Table 5.1.5.-1 Recommended values for $R_{ext}$

<table>
<thead>
<tr>
<th>Operating voltage, $U_c$</th>
<th>Shunt resistor $R_{ext}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>48 V DC</td>
<td>1.2 kΩ, 5 W</td>
</tr>
<tr>
<td>60 V DC</td>
<td>5.6 kΩ, 5 W</td>
</tr>
<tr>
<td>110 V DC</td>
<td>22 kΩ, 5 W</td>
</tr>
<tr>
<td>220 V DC</td>
<td>33 kΩ, 5 W</td>
</tr>
</tbody>
</table>

The circuit breaker is to be provided with two external contacts, one opening and one closing contact. The closing contact is to be connected in parallel with the external shunt resistor, which enables trip-circuit supervision when the circuit breaker is closed. The opening contact, on the contrary, is to be connected in series with the external shunt resistor, which enables trip-circuit supervision when the circuit breaker is open; see Fig. 5.1.5.-1.

Trip-circuit supervision can be selected either via the HMI or with SPA parameter V113.

![Fig. 5.1.5.-1 Connecting the trip-circuit supervision using two external contacts and the external resistor in the trip circuit](image)

5.1.6. Trip lockout function

The trip lockout function is used to prevent accidental closing of the circuit breaker after a trip. The trip lockout function must be locally reset with a separate reset command before the circuit breaker can be closed again. This function is useful when the trip output contact of the relay is latched or the open circuit of the circuit breaker remains activated.
The trip lockout function is selected in SGF1. When selected, PO3 is dedicated to this function. As long as no trip occurs, PO3 is closed.

Every signal which has been routed to PO3 via the output signal matrix activates the trip lockout function and opens the contacts of PO3. When the contacts have opened, they are locked into the open state.

The trip lockout function can also be activated externally, via a digital input. The trip lockout function can be reset via a digital input, the HMI or SPA parameter V103, but not before the signal which activated the function has been reset.

In case of loss of auxiliary power when the trip lockout function is in use, the contacts of PO3 return to the same state as before the loss, provided that the battery has been inserted and is charged. If no battery has been inserted, the trip lockout function is activated and the contacts of PO3 remain open when the auxiliary power is switched on again.

5.1.7. Trip counters for circuit-breaker condition monitoring

The trip counters for circuit-breaker condition monitoring provide history data, which can be used for circuit-breaker service scheduling. With this information, the service cycle can be estimated for the future.

The monitoring function consists of four counters, which count the number of trip signals generated to the circuit breaker by the relay. Every time an element generates a trip signal, the corresponding counter value is increased by one. The number of trips is stored in the non-volatile EEPROM memory.

There are separate counters for the different protection elements. The overvoltage elements (59P-1, 59P-2 and 47), undervoltage elements (27P-1, 27P-2 and 27D) and residual overvoltage elements (59N-1 and 59N-2) have a common trip counter each, whereas there is an own trip counter for the external trip.

The counters can be read via the HMI or SPA parameters V9...V12 and cleared via SPA parameter V166. When a counter reaches its maximum value, it rolls over.

In case several elements trip during the same fault sequence, only the counter of the element which tripped first is increased by one.

5.1.8. Target LEDs and operation target messages

The operation of the relay can be monitored via the HMI by means of LED targets and text messages on the LCD. On the front panel of the relay there are three target LEDs with fixed functionality:

- Green target LED (ready)
- Yellow target LED (pickup/alarm)
- Red target LED (trip)
In addition, there are eight programmable LEDs and an target LED for front communication. Refer to the Operator’s Manual for a more thorough presentation.

The target messages on the LCD have a certain priority order. If different types of targets are activated simultaneously, the message with the highest priority appears on the LCD.

The priority order of the operation target messages:
1. CBFAIL
2. Trip
3. Pickup/Alarm

5.1.9. Demand values

The relay provides three different kinds of demand values.

The first value shows the average voltage of all three phase-to-phase voltages measured during one minute. The value is updated once a minute.

The second value shows the average voltage during an adjustable time range, ranging from 0 to 999 minutes, with an accuracy of one minute. This value is updated at the expiration of each time range.

The third value shows the highest one-minute average voltage value measured during the previous time range. However, if the time range is set to zero, only the one-minute and the maximum average voltage value is shown. The maximum value is the highest one-minute mean value since the last reset.

The demand voltage values can be set to zero through serial communication using SPA parameter \textit{V102}. The average voltage values are also reset if SPA parameter \textit{V105} is changed or the relay is reset.

5.1.10. Commissioning tests

The following two product functions can be used during the commissioning of the relay: function test and digital input test.

The function test is used for testing the configuration as well as the connections from the relay. By selecting this test, the internal signals from the protection elements, the motor start-up signal, the external trip signal and the IRF function can be activated one by one. Provided that the signals have been set to be routed to the output contacts (PO1...PO3 and SO1...SO5) with the switches of SGR1...SGR8, the output contacts are activated and their corresponding event codes are generated when the test is run. However, activation of the internal signals from the protection elements, the external trip signal and the IRF function do not generate an event code.

The digital input test is used for testing the connections to the relay. The state of the digital inputs can be monitored via the HMI.
Refer to the Operator’s Manual for instructions on how to perform the tests.

5.1.11. Disturbance recorder

5.1.11.1. Function

The relay features an integrated disturbance recorder which continuously captures the curve forms of the voltages as well as the status of both internal signals and the external digital input signals and stores these in the memory.

Triggering of the recorder generates an event code. After the recorder has been triggered, it continues to record data for a pre-defined post-triggering time. An asterisk is shown on the LCD on completion of the recording. The status of the recording can also be viewed using SPA parameter V246.

As soon as the recorder has been triggered and the recording has finished, the recording can be uploaded and analyzed by means of a PC provided with a special program.

5.1.11.2. Disturbance recorder data

One recording contains data from the four analog channels and up to eight digital channels. The analog channels, whose data is stored either as RMS curves or as instantaneous measured values, are the voltages measured by the relay. The digital channels, referred to as digital signals, are pickup and trip signals from the protection elements and the digital input signals linked to the relay.

The user can select up to eight digital signals to be recorded. If more than eight signals are selected, the first eight signals are stored, beginning with the internal signals followed by the digital input signals.

The digital signals to be stored are selected with parameters V238 and V243; see Table 5.1.17.-5 and Table 5.1.17.-6.

The recording length varies according to the selected sampling frequency. The RMS curve is recorded by selecting the sampling frequency to be the same as the nominal frequency of the relay. The sampling frequency is selected with SPA parameter M15; see the table below for details.

<table>
<thead>
<tr>
<th>Nominal frequency Hz</th>
<th>Sampling frequency Hz</th>
<th>Cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>800</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>400</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>50^a)</td>
<td>4000</td>
</tr>
<tr>
<td>60</td>
<td>960</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>480</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>60^a)</td>
<td>4000</td>
</tr>
</tbody>
</table>

Table 5.1.11.2.-1 Sampling frequency
Changing the setting values of parameters M15, V238 and V243 is allowed only when the recorder is not triggered.

The post-triggering recording length defines the time during which the recorder continues to store data after it has been triggered. The length can be changed with SPA parameter V240. If the post-triggering recording length is defined to be the same as the total recording length, no data stored prior to the triggering is retained in the memory. By the time the post-triggering recording finishes, a complete recording is created.

Triggering of the recorder immediately after it has been cleared or the auxiliary voltage connected may result in a shortened total recording length. Disconnection of the auxiliary voltage after the recorder has been triggered, but before the recording has finished, on the other hand, may result in a shortened post-triggering recording length. This, however, does not affect the total recording length.

At a power reset, triggered recorder data is retained in the memory provided that it has been defined non-volatile.

### 5.1.11.3. Control and target of disturbance recorder status

It is possible to control and monitor the recording status of the disturbance recorder by writing to and reading SPA parameters M1, M2 and V246. Reading SPA parameter V246 returns either the value 0 or 1, indicating whether the recorder has not been triggered or triggered and ready to be uploaded. Event code E31 is generated the moment the disturbance recorder is triggered. If the recorder is ready to be uploaded, this is also indicated by an asterisk shown in the lower right-hand corner of the LCD when it is in the idle mode. Target can also be routed to programmable LEDs.

Writing the value 1 to SPA parameter M2 clears the recorder memory and enables the triggering of the recorder. Recorder data can be cleared by performing a master reset, that is, clearing targets and memorized values and unlatching output contacts.

Writing the value 2 to SPA parameter V246 restarts the unloading process by setting the time stamp and the first data ready to be read.
5.1.11.4. **Triggering**

The user can select one or several internal or external digital input signals to trigger the disturbance recorder, either on the rising or falling edge of the signal(s). Triggering on the rising edge means that the post-triggering recording sequence starts when the signal is activated. Correspondingly, triggering on the falling edge means that the post-triggering recording sequence starts when the active signal is reset.

The trigger signal(s) and the edge are selected with SPA parameters V236...V237 and V241...V242; see Table 5.1.17.-5 and Table 5.1.17.-6. The recorder can also be triggered manually with SPA parameter M1.

Triggering of the disturbance recorder is only possible if the recorder is not already triggered.

5.1.11.5. **Settings and unloading**

The setting parameters for the disturbance recorder are V parameters V236...V238, V240...V243 and V246, and M parameters M15, M18, M20 and M80...M83.

Unloading correct information from the recorder requires that M80 and M83 have been set. Unloading is done by using a PC application. The uploaded recorder data is stored in separate files defined by the comtrade® format.

5.1.11.6. **Event code of the disturbance recorder**

The disturbance recorder generates an event code on triggering (E31) and clearing (E32) the recorder. The event mask is determined using SPA parameter V155.

5.1.12. **Recorded data of the last events**

The relay records up to five events. This enables the user to analyze the last five fault conditions in the electrical power network. Each event includes the measured voltages, pickup durations and time stamp, for instance. Additionally, information on the number of pickups of the elements and trips is provided.

Recorded data is non-volatile by default, provided that the battery has been inserted and is charged. A master reset, that is, clearing of targets and memorized values and unlatching of output contacts, erases the contents of the stored events and the number of pickups of the elements.

The number of trips is stored in the non-volatile memory (EEPROM) and is thereby not cleared when performing a master reset. The number of trips can be erased by entering the value 1 into parameter V166.
The relay collects data during fault conditions. When all pickup signals have been reset or an element trips, the collected data and time stamp is stored as EVENT1 and the previously stored events move one step forward. When a sixth event is stored, the oldest event is cleared.

### Table 5.1.12.-1 Recorded data

<table>
<thead>
<tr>
<th>REGISTER</th>
<th>Data description</th>
</tr>
</thead>
</table>
| EVENT1  | - Phase-to-phase voltage $U_{ab}$ measured at a time of trip as a multiple of the rated voltage, $U_n$ (VT). The same applies to phase-to-phase voltages $U_{bc}$ and $U_{ca}$.
- Residual voltage $U_r$ measured at a time of trip as a percentage of the rated voltage $U_n$ (VT).
- Maximum voltage value of the phase-to-phase voltages during the last fault conditions in the network, measured as a multiple of the rated voltage $U_n$ (VT).
- Minimum voltage value of the phase-to-phase voltages during the last fault conditions in the network, measured as a multiple of the rated voltage $U_n$ (VT).
- Maximum voltage value of the negative phase-sequence voltage during the last fault conditions in the network, measured as a multiple of the rated voltage $U_n$ (VT). If element 59P-2 is not based on negative phase-sequence voltage $U_2$, dashes are shown on the LCD and "999" when read via serial communication.
- Minimum voltage value of the positive phase-sequence voltage during the last fault conditions in the network, measured as a multiple of the rated voltage $U_n$ (VT). If element 27P-2 is not based on positive phase-sequence voltage $U_1$, dashes are shown on the LCD and "999" when read via serial communication.
- Maximum voltage value of the residual voltage $U_r$ during the last fault conditions in the network, measured as a percentage of the rated voltage $U_n$ (VT).
- Duration of the last pickup of elements 59P-1, 59P-2/47, 27P-1, 27P-2/27D, 59N-1, 59N-2 and of the external trip, shown as a percentage of the set operate time, or of the calculated operate time at IDMT characteristic. A value other than zero indicates that the corresponding element has picked up whereas a value which is 100% of the set or calculated operate time indicates that the operate time of the element has elapsed, that is, the element has tripped. If the operate time of a element has elapsed but the element is blocked, the value is 99% of the set or calculated operate time.
- Time stamp for the event. The time when the collected data was stored. The time stamp is displayed in two registers, one including the date expressed as yy-mm-dd, and the other including the time expressed as HH.MM;SS.sss. |
| EVENT2  | Same as EVENT 1. |
| EVENT3  | Same as EVENT 1. |
| EVENT4  | Same as EVENT 1. |
| EVENT5  | Same as EVENT 1. |

### Number of pickups

The number of times each protection element 59P-1, 59P-2/47, 27P-1, 27P-2/27D, 59N-1, 59N-2 has picked up, counting up to 999.

### Number of trips

- Overvoltage element 59P-1, 59P-2 and 47
- Undervoltage elements 27P-1, 27P-2 and 27D
- Residual overvoltage elements 59N-1 and 29N-2
- External trip
  When the counters reach their maximum values (65535), they roll over.
5.1.13. Communication ports

The relay is provided with an optical communication port (infrared) on the front panel. Rear communication is optional and requires a communication module, which can be provided with either a plastic fibre-optic, combined fibre-optic (plastic and glass) or RS-485 connection. The relay is connected to an automation system via the rear connection. The optional rear communication module allows the use of either the SPA bus, IEC 60870-5-103 or Modbus communication protocol.

For connection to the DNP 3.0 communication system, the relay can be provided with an optional DNP 3.0 rear communication module with RS-485 connection. For further information on optional rear communication module connections, refer to Section 5.2.2. Serial communication connections.

![Communication port](image)

**Fig. 5.1.13.-1 Communication port**

1) Front connection for local communication

The relay is connected to a PC used for local parameterization via the infrared port on the front panel. The front connection allows the use of the SPA bus protocol only.

The optical front connection galvanically isolates the PC from the relay. The front connection can be used in two different ways: wirelessly using a PC compatible to the IrDA®, Standard specifications or using a specific front communication cable (refer to Section 6. Ordering information). The cable is connected to the serial RS-232 port of the PC. The optical element of the cable is powered by RS-232 control signals. The cable has a fixed baud rate of 9.6 kbps.

The following serial communication parameters are to be set for RS-232:

- Number of data bits: 7
- Number of stop bits: 1
- Parity: even
- Baud rate: 9.6 kbps

Relay data such as events, setting values and all input data and memorized values can be read via the front communication port.
When setting values are altered via the front communication port, the relay checks
that the entered parameter values are within the permitted setting range. If an entered
value is too high or too low, the setting value remains unchanged.

The relay has a counter which can be accessed via CONFIGURATION
\COMMUNICATION in the HMI menu. The counter value is set to zero when the
relay receives a valid message.

5.1.14. IEC 60870-5-103 remote communication protocol

The relay supports the IEC 60870-5-103 remote communication protocol in the
unbalanced transmission mode. The IEC 60870-5-103 protocol is used to transfer
measurand and status data from the slave to the master. However, the IEC 60870-5-
103 protocol cannot be used to transfer disturbance recorder data.

The IEC 60870-5-103 protocol can be used only through the rear connection of the
relay on the optional communication module. Connecting the relay to a fibre-optic
communication bus requires a fibre-optic communication module. The line-idle
state of the fibre-optic communication module can be selected either via the HMI or
the SPA bus. According to the IEC 60870-5-103 standard, the line-idle state is “light
on”. To ensure communication, the line-idle state should be the same for both the
master and the slave device. The connection topology can be selected to be either
loop or star, the default being loop, and either via the HMI or the SPA bus. The
selected line-idle state and connection topology apply irrespective of which rear
communication protocol is active.

The relay uses the SPA bus protocol as default when the optional communication
module is in use. The protocol selection is memorized and is therefore always
activated when the rear connection is in use. The baud rate can be selected either via
the HMI or the SPA bus. According to the IEC 60870-5-103 standard, the baud rate
is 9.6 kbps. When the IEC 60870-5-103 protocol is active, event masks are not in
use. Consequently, all events in the selected configuration set are included in the
event reporting.

The relay is provided with two different selectable configuration sets, of which
configuration set 1 is used by default.

Configuration set 1 is intended to be used when the optional I/O module is not
installed. Configuration set 2 includes additional information, for example output
contact events 6...8 (SO3...SO5) and digital input events 3...5 (DI3...DI5), provided
that the optional I/O module is installed.

Function type and information number are mapped into configuration sets according
to the IEC 60870-5-103 standard to the extent that these have been defined by the
standard. If not defined by the standard, the type of function and/or the information
number are/is mapped into a private range.

The tables below indicate the information mapping of the corresponding
configuration sets. The column GI indicates whether the status of the specified
information object is transmitted within the general interrogation cycle. The relative
time in messages with the type identification 2 is calculated as a time difference between the occurred event and the event specified in the column Relative time. The measurand multiplied by the normalize factor is proportional to the rated value. Therefore, the maximum value of each measurand is the normalize factor multiplied by the rated value.

Table 5.1.14.-1 Information mapping of configuration set 1 and 2

<table>
<thead>
<tr>
<th>Event reason</th>
<th>Event code</th>
<th>Configuration set 1</th>
<th>Configuration set 2</th>
<th>Function type</th>
<th>Information number</th>
<th>GI</th>
<th>Relative time</th>
<th>Type identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disturbance recorder Triggered/Cleared</td>
<td>0E31/0E32</td>
<td>X</td>
<td>X</td>
<td>178</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>HMI Setting password Opened/Closed</td>
<td>0E33/0E34</td>
<td>X</td>
<td>X</td>
<td>178</td>
<td>101</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>HMI Communication password Opened/Closed</td>
<td>0E35/0E36</td>
<td>X</td>
<td>X</td>
<td>178</td>
<td>102</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>59P-1 Pickup/Reset</td>
<td>1E1/1E2</td>
<td>X</td>
<td>X</td>
<td>165</td>
<td>84</td>
<td>X</td>
<td>1E1</td>
<td>2</td>
</tr>
<tr>
<td>59P-1 Trip/Reset</td>
<td>1E3/1E4</td>
<td>X</td>
<td>X</td>
<td>165</td>
<td>90</td>
<td>-</td>
<td>1E1</td>
<td>2</td>
</tr>
<tr>
<td>59P-2 or 47 Pickup/Reset</td>
<td>1E5/1E6</td>
<td>X</td>
<td>X</td>
<td>165</td>
<td>94</td>
<td>X</td>
<td>1E5</td>
<td>2</td>
</tr>
<tr>
<td>59P-2 or 47 Trip/Reset</td>
<td>1E7/1E8</td>
<td>X</td>
<td>X</td>
<td>165</td>
<td>91</td>
<td>-</td>
<td>1E5</td>
<td>2</td>
</tr>
<tr>
<td>27P-1 Pickup/Reset</td>
<td>1E9/1E10</td>
<td>X</td>
<td>X</td>
<td>166</td>
<td>84</td>
<td>X</td>
<td>1E9</td>
<td>2</td>
</tr>
<tr>
<td>27P-1 Trip/Reset</td>
<td>1E11/1E12</td>
<td>X</td>
<td>X</td>
<td>166</td>
<td>90</td>
<td>-</td>
<td>1E9</td>
<td>2</td>
</tr>
<tr>
<td>27P-2 or 27D Pickup/Reset</td>
<td>1E13/1E14</td>
<td>X</td>
<td>X</td>
<td>166</td>
<td>94</td>
<td>X</td>
<td>1E13</td>
<td>2</td>
</tr>
<tr>
<td>27P-2 or 27D Trip/Reset</td>
<td>1E15/1E16</td>
<td>X</td>
<td>X</td>
<td>166</td>
<td>91</td>
<td>-</td>
<td>1E13</td>
<td>2</td>
</tr>
<tr>
<td>59N-1 Pickup/Reset</td>
<td>1E17/1E18</td>
<td>X</td>
<td>X</td>
<td>170</td>
<td>84</td>
<td>X</td>
<td>1E17</td>
<td>2</td>
</tr>
<tr>
<td>59N-1 Trip/Reset</td>
<td>1E19/1E20</td>
<td>X</td>
<td>X</td>
<td>170</td>
<td>90</td>
<td>-</td>
<td>1E17</td>
<td>2</td>
</tr>
<tr>
<td>59N-2 Pickup/Reset</td>
<td>1E21/1E22</td>
<td>X</td>
<td>X</td>
<td>170</td>
<td>94</td>
<td>X</td>
<td>1E21</td>
<td>2</td>
</tr>
<tr>
<td>59N-2 Trip/Reset</td>
<td>1E23/1E24</td>
<td>X</td>
<td>X</td>
<td>170</td>
<td>91</td>
<td>-</td>
<td>1E21</td>
<td>2</td>
</tr>
<tr>
<td>Trip Lockout/Reset</td>
<td>1E25/1E26</td>
<td>X</td>
<td>X</td>
<td>10</td>
<td>223</td>
<td>X</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>External Trip/Reset</td>
<td>1E27/1E28</td>
<td>X</td>
<td>X</td>
<td>10</td>
<td>222</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>CBFAIL Activated/Reset</td>
<td>1E29/1E30</td>
<td>X</td>
<td>X</td>
<td>160</td>
<td>85</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
</tbody>
</table>
### Event reason

<table>
<thead>
<tr>
<th>Event reason</th>
<th>Event code</th>
<th>Configuration set 1</th>
<th>Function type</th>
<th>Information number</th>
<th>GI</th>
<th>Relative time</th>
<th>Type identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO1 Activated/Reset</td>
<td>2E1/2E2</td>
<td>X</td>
<td>X</td>
<td>251</td>
<td>27</td>
<td>X</td>
<td>- 1</td>
</tr>
<tr>
<td>PO2 Activated/Reset</td>
<td>2E3/2E4</td>
<td>X</td>
<td>X</td>
<td>251</td>
<td>28</td>
<td>X</td>
<td>- 1</td>
</tr>
<tr>
<td>PO3 Activated/Reset</td>
<td>2E5/2E6</td>
<td>X</td>
<td>X</td>
<td>251</td>
<td>29</td>
<td>X</td>
<td>- 1</td>
</tr>
<tr>
<td>SO1 Activated/Reset</td>
<td>2E7/2E8</td>
<td>X</td>
<td>X</td>
<td>251</td>
<td>30</td>
<td>X</td>
<td>- 1</td>
</tr>
<tr>
<td>SO2 Activated/Reset</td>
<td>2E9/2E10</td>
<td>X</td>
<td>X</td>
<td>251</td>
<td>31</td>
<td>X</td>
<td>- 1</td>
</tr>
<tr>
<td>SO3 Activated/Reset</td>
<td>2E11/2E12</td>
<td>-</td>
<td>X</td>
<td>251</td>
<td>32</td>
<td>X</td>
<td>- 1</td>
</tr>
<tr>
<td>SO4 Activated/Reset</td>
<td>2E13/2E14</td>
<td>-</td>
<td>X</td>
<td>251</td>
<td>33</td>
<td>X</td>
<td>- 1</td>
</tr>
<tr>
<td>SO5 Activated/Reset</td>
<td>2E15/2E16</td>
<td>-</td>
<td>X</td>
<td>251</td>
<td>34</td>
<td>X</td>
<td>- 1</td>
</tr>
<tr>
<td>DI1 Activated/Deactivated</td>
<td>2E17/2E18</td>
<td>X</td>
<td>X</td>
<td>249</td>
<td>231</td>
<td>X</td>
<td>- 1</td>
</tr>
<tr>
<td>DI2 Activated/Deactivated</td>
<td>2E19/2E20</td>
<td>X</td>
<td>X</td>
<td>249</td>
<td>232</td>
<td>X</td>
<td>- 1</td>
</tr>
<tr>
<td>DI3 Activated/Deactivated</td>
<td>2E21/2E22</td>
<td>-</td>
<td>X</td>
<td>249</td>
<td>233</td>
<td>X</td>
<td>- 1</td>
</tr>
<tr>
<td>DI4 Activated/Deactivated</td>
<td>2E23/2E24</td>
<td>-</td>
<td>X</td>
<td>249</td>
<td>234</td>
<td>X</td>
<td>- 1</td>
</tr>
<tr>
<td>DI5 Activated/Deactivated</td>
<td>2E25/2E26</td>
<td>-</td>
<td>X</td>
<td>249</td>
<td>235</td>
<td>X</td>
<td>- 1</td>
</tr>
</tbody>
</table>

### Table 5.1.14.-2 Information mapping of configuration set 1 and 2

<table>
<thead>
<tr>
<th>Measurand</th>
<th>Normalize factor</th>
<th>Rated value</th>
<th>Configuration set 1</th>
<th>Configuration set 2</th>
<th>Function type</th>
<th>Information number</th>
<th>Type identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage U_{ab}</td>
<td>2.40</td>
<td>U_{i} (VT)</td>
<td>X</td>
<td>X</td>
<td>135</td>
<td>143</td>
<td>9</td>
</tr>
<tr>
<td>Voltage U_{bc}</td>
<td>2.40</td>
<td>U_{i} (VT)</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage U_{ca}</td>
<td>2.40</td>
<td>U_{i} (VT)</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage U_{i}</td>
<td>2.40</td>
<td>U_{i} (VT)</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage U_{1}</td>
<td>2.40</td>
<td>U_{i} (VT)</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage U_{2}</td>
<td>2.40</td>
<td>U_{i} (VT)</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.1.15. Modbus remote communication protocol

The master/slave protocol Modbus was first introduced by Modicon Inc. and is widely accepted as a communication standard for industrial device controllers and PLCs. For the protocol definition, refer to Section 1.4. Product documentation.

The implementation of the Modbus protocol in the relay supports both the RTU and the ASCII link mode. Both the link mode and the line setting parameters are user-configurable. The character codings of the link modes follow the protocol definition. The RTU character format is presented in Table 5.1.15.-1 and the ASCII character format in Table 5.1.15.-2:

**Table 5.1.15.-1 RTU character format**

<table>
<thead>
<tr>
<th>Coding system</th>
<th>8-bit binary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bits per character</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 pickup bit</td>
</tr>
<tr>
<td></td>
<td>8 data bits, the least significant bit is sent first</td>
</tr>
<tr>
<td></td>
<td>1 bit for even/odd parity; no bit if parity is not used</td>
</tr>
<tr>
<td></td>
<td>1 stop bit if parity is used; 2 stop bits if parity is not used</td>
</tr>
</tbody>
</table>

**Table 5.1.15.-2 ASCII character format**

<table>
<thead>
<tr>
<th>Coding system</th>
<th>Two ASCII characters representing a hexadecimal number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bits per character</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 pickup bit</td>
</tr>
<tr>
<td></td>
<td>7 data bits, the least significant bit is sent first</td>
</tr>
<tr>
<td></td>
<td>1 bit for even/odd parity; no bit if parity is not used</td>
</tr>
<tr>
<td></td>
<td>1 stop bit if parity is used; 2 stop bits if parity is not used</td>
</tr>
</tbody>
</table>

The turnaround time (response time) of the relay depends on the amount of data requested in a query. Therefore, the turnaround time can vary between approximately 20 and 100 ms. However, a turnaround timeout no lower than 150 ms is recommended for the Modbus master.

The data address range in the Modbus network follows the protocol definition and starts from 0. Consequently, the data addresses in Table 5.1.15.1.-5...Table 5.1.15.1.-13 are decreased by one when transferred over the network.

The Modbus data type digital input (DI) is commonly also referred to as 1X, coils as 0X, input register (IR) as 3X and holding register (HR) as 4X, of which the former is used here. Thus, HR 123, for instance, can also be referred to as register 400123.
5.1.15.1. Profile of Modbus

The Modbus protocol (ASCII or RTU) is selected via the HMI and can be used only through the rear connection of the relay on the optional communication module. Modbus line settings, that is, parity, CRC byte order and baud rate, can be adjusted either via the HMI or the SPA bus.

The implementation of the Modbus protocol in REU610 supports the following functions:

Table 5.1.15.1.-1 Supported application functions

<table>
<thead>
<tr>
<th>Function code</th>
<th>Function description</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Read coil status</td>
</tr>
<tr>
<td></td>
<td>Reads the status of discrete outputs.</td>
</tr>
<tr>
<td>02</td>
<td>Read digital input status</td>
</tr>
<tr>
<td></td>
<td>Reads the status of discrete inputs.</td>
</tr>
<tr>
<td>03</td>
<td>Read holding registers</td>
</tr>
<tr>
<td></td>
<td>Reads the contents of output registers.</td>
</tr>
<tr>
<td>04</td>
<td>Read input registers</td>
</tr>
<tr>
<td></td>
<td>Reads the contents of input registers.</td>
</tr>
<tr>
<td>05</td>
<td>Force single coil</td>
</tr>
<tr>
<td></td>
<td>Sets the status of a discrete output.</td>
</tr>
<tr>
<td>06</td>
<td>Preset single register</td>
</tr>
<tr>
<td></td>
<td>Sets the value of a holding register.</td>
</tr>
<tr>
<td>08</td>
<td>Diagnostics</td>
</tr>
<tr>
<td></td>
<td>Checks the communication system between the master and the slave.</td>
</tr>
<tr>
<td>15</td>
<td>Force multiple coils</td>
</tr>
<tr>
<td></td>
<td>Sets the status of multiple discrete outputs.</td>
</tr>
<tr>
<td>16</td>
<td>Preset multiple registers</td>
</tr>
<tr>
<td></td>
<td>Sets the value of multiple holding registers.</td>
</tr>
<tr>
<td>23</td>
<td>Read/write holding registers</td>
</tr>
<tr>
<td></td>
<td>Exchanges holding registers in one query.</td>
</tr>
</tbody>
</table>

Table 5.1.15.1.-2 Supported diagnostic subfunctions

<table>
<thead>
<tr>
<th>Code</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>Return query data</td>
<td>The data in the query data field is returned (looped back) in the response. The entire response is to be identical to the query.</td>
</tr>
<tr>
<td>01</td>
<td>Restart communication option</td>
<td>The slave’s peripheral port is initialized and restarted and the communication event counters are cleared. Before this, a normal response will be sent provided that the port is not in the listen only mode. However, if the port is in the listen only mode, no response will be sent.</td>
</tr>
<tr>
<td>04</td>
<td>Force listen only mode</td>
<td>The slave is forced to enter the listen only mode for Modbus communication.</td>
</tr>
<tr>
<td>10</td>
<td>Clear counters and diagnostic register</td>
<td>All counters and the diagnostic register are cleared.</td>
</tr>
<tr>
<td>11</td>
<td>Return bus message count</td>
<td>The number of messages in the communications system detected by the slave since its last restart, clear counters operation or power up is returned in the response.</td>
</tr>
</tbody>
</table>
The Modbus protocol provides the following diagnostic counters:

**Table 5.1.15.1.-3 Diagnostic counters**

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus message count</td>
<td>The number of messages in the communications system detected by the slave since its last pickup, clear counters operation or power up.</td>
</tr>
<tr>
<td>Bus communication error count</td>
<td>The number of CRC or LRC errors encountered by the slave since its last restart, clear counters operation or power up.</td>
</tr>
<tr>
<td>Bus exception error count</td>
<td>The number of Modbus exception responses sent by the slave since its last restart, clear counters operation or power up.</td>
</tr>
<tr>
<td>Slave message count</td>
<td>The number of messages addressed to the slave or broadcast which the slave has processed since its last restart, clear counters operation or power up.</td>
</tr>
</tbody>
</table>

Sending other subfunction codes than those listed above cause an **Illegal data value** response.
Name | Description
--- | ---
Slave no response count | The number of messages addressed to the slave for which a response (neither a normal response nor an exception response) has not been sent since its last restart, clear counters operation or power up.
Slave NACK response count | The number of messages addressed to the slave for which a NACK response has been sent.
Bus character overrun count | The number of messages addressed to the slave for which it has not been able to send a response due to a character overrun since its last restart, clear counters operation or power up.

The following exception codes may be generated by the Modbus protocol:

<table>
<thead>
<tr>
<th>Code</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Illegal function</td>
<td>The slave does not support the requested function.</td>
</tr>
<tr>
<td>02</td>
<td>Illegal data address</td>
<td>The slave does not support the data address or the number of items in the query is incorrect.</td>
</tr>
<tr>
<td>03</td>
<td>Illegal data value</td>
<td>A value contained in the query data field is out of range.</td>
</tr>
<tr>
<td>04</td>
<td>Slave device failure</td>
<td>An unrecoverable error has occurred while the slave was attempting to perform the requested task.</td>
</tr>
</tbody>
</table>

If an Illegal data value exception response is generated when attempting to preset multiple registers, the contents of the register to which an illegal value has been imposed and of the following registers is not changed. Registers which have already been preset are not restored.

**User-defined registers**

Reading of unwanted data in a data block wastes bandwidth and complicates data interpretation. For optimum efficiency in Modbus communication, data has therefore been organized into consecutive blocks. In addition, a set of programmable user-defined registers (UDR) has been defined in the holding register area.

The first sixteen holding registers, that is, HR1...16, are user-defined registers. The UDRs can be linked to any holding register, except for HR721...727, using SPA parameters 504V1...504V16. However, one UDR cannot be linked to another, that is, linking cannot be nested. Each parameter contains the address of the holding register to which the UDR is linked.

If a UDR is linked to a non-existent holding register, reading from the register fails and an Illegal address exception response is sent. Giving the link address the value 0 disables the UDR. If the master reads from a disabled UDR, the value 0 is returned.
The UDRs are mirrored in HR385...400.

Fault records

The data recorded during a fault sequence is called a fault record (FR). The slave stores the five latest fault records. When a sixth record is stored, the oldest record is deleted.

To read a fault record:

1. Write a preset single register command (function 06) to HR601 using a selection code as data value.
2. Read the selected fault record (function 04) from HR601, register count 28.

Selection code 1: the master reads the oldest unread record

Status register 3 (HR403) informs whether there are unread fault records (see Fig. 5.1.15.1.-2). If there is one or several unread fault records, the master can read the contents using selection code 1.

The fault record contains a sequence number which makes it possible for the master to determine whether one or several unread fault records have been deleted due to overflow. The master compares the sequence number to that of the previously read fault record.

The slave keeps track of which fault record is currently the oldest unread. The master can continue reading fault records for as long as Status register 3 indicates that there are unread records.

- Special case 1: If there are no unread fault records, the contents of the last read record is returned. If the buffer is empty, however, the registers contain only zeros. This is the only time when sequence number zero appears.
- Special case 2: If the master tries to read the next unread fault record without entering selection code 1 again, the contents of the last read record will be returned.

Selection code 2: the master reads the oldest stored record

By resetting the read pointer using selection code 2, the master can read the oldest stored fault record. After this, the master can continue reading the following records using selection code 1, irrespective of whether they have been read before.

Resetting the read pointer does not affect the sequence number of the fault record.

A master reset, that is, clearing of targets and memorized values and unlatching of output contacts, clears the fault records, after which the sequence number starts from 1 again.
Event records

Modbus events are derived from SPA events. With a few exceptions, SPA events update binary points in the DI and the packed HR area. Simultaneously, a corresponding Modbus event record is generated. The event record contains the Modbus DI/CO data point address and the value to which the point has changed (0 or 1). SPA events lacking a corresponding DI/CO data point are shown as SPA channel and event code (informative event) in the event record. The maximum capacity of the Modbus event buffer is 99 events. The time stamp of Modbus events is extended to contain complete information, from date to millisecond.

To read an event record:

1. Write a preset single register command (function 06) to HR671 using a selection code as data value.
2. Read the selected fault record (function 04) from HR672, register count 8.

Alternatively, a fault record can be read using one command (function 23) only.

Selection code 1: reading the oldest unread record

Status register 3 (HR403) informs whether there are unread event records (see Fig. 5.1.15.1.-2). If there is one or several unread event records, the master can read the contents using selection code 1.

The event record contains a sequence number which makes it possible for the master to determine whether one or several unread event records have been deleted due to overflow by comparing it to the sequence number of the previously read event record.

The slave keeps track of which event record is currently the oldest unread. The master can continue reading event records for as long as Status register 3 indicates that there are unread records.

- Special case 1: If there are no unread event records, the contents of the last read record is returned. If the buffer is empty, however, the registers contain only zeros. This is the only time when sequence number zero appears.
- Special case 2: If the master tries to read the next unread event record without entering selection code 1 again, the contents of the last read record is returned.

Selection code 2: reading the oldest stored record

By resetting the read pointer using selection code 2, the master can read the oldest stored event record. After this, the master can continue reading the following records using selection code 1, irrespective of whether they have been read before.

Resetting the read pointer does not affect the sequence number of the event record.
Selection code -1...-99

With selection code -1...-99, the master can move backwards from the newest event as many events as defined by the selection code and read that specific event record. After this, the master can continue reading the following records using selection code 1, irrespective of whether they have been read before.

- Special case: If there is not as many events in the buffer as specified by the selection code, the oldest stored event is read.

Selection code 3

The Modbus event buffer is cleared with selection code 3. Clearing the buffer does not require any read operation to follow.

Digital inputs

As the master may not detect the state changes of all digital signals when scanning, an additional change detect (CD) target bit is created for every instantaneous target point; see the example below.

![Diagram of Momentary and Change Detect](image)

Fig. 5.1.15.1.-1  Change detection bit

If the instantaneous value of a target bit has changed two or more times since the master last read it, the CD bit is set to one. When the CD bit has been read, it is set to zero.

The instantaneous and the CD bit of a certain target point always occur as a pair in the Modbus memory map.
Modbus data mapping

There are two types of monitoring data: digital targets and measurands. For convenience and efficiency, the same data can be read from different data areas. Measurands and other 16-bit values can be read either from the IR or HR (read-only) area and digital target values from either the DI or coil (read-only) area. It is also possible to read the status of the DIs as packed 16-bit registers from both the IR and the HR area.

Consequently, all monitoring data can be read as consecutive blocks of data from the IR or HR area.

The register and bit addresses are presented in the tables below. Some register structures are presented in separate sections below.

The HR and IR values are unsigned 16-bit integers unless otherwise specified.

<table>
<thead>
<tr>
<th>Description</th>
<th>HR/IR address (.bit)</th>
<th>DI/Coil bit address</th>
<th>Writeable</th>
<th>Value range</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>UDR 1</td>
<td>1 or 385</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UDR 2</td>
<td>2 or 386</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UDR 3</td>
<td>3 or 387</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UDR 4</td>
<td>4 or 388</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UDR 5</td>
<td>5 or 389</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UDR 6</td>
<td>6 or 390</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UDR 7</td>
<td>7 or 391</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UDR 8</td>
<td>8 or 392</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UDR 9</td>
<td>9 or 393</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UDR 10</td>
<td>10 or 394</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UDR 11</td>
<td>11 or 395</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UDR 12</td>
<td>12 or 396</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UDR 13</td>
<td>13 or 397</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UDR 14</td>
<td>14 or 398</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UDR 15</td>
<td>15 or 399</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UDR 16</td>
<td>16 or 400</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The HR and IR values are unsigned 16-bit integers unless otherwise specified.

<table>
<thead>
<tr>
<th>Description</th>
<th>HR/IR address (.bit)</th>
<th>DI/Coil bit address</th>
<th>Writeable</th>
<th>Value range</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status register 1</td>
<td>401</td>
<td></td>
<td></td>
<td>IRF code</td>
<td>See Structure 1</td>
</tr>
<tr>
<td>Status register 2</td>
<td>402</td>
<td></td>
<td></td>
<td>Warning codes</td>
<td>See Structure 1</td>
</tr>
<tr>
<td>Status register 3</td>
<td>403</td>
<td></td>
<td></td>
<td></td>
<td>See Structure 1</td>
</tr>
</tbody>
</table>
### Table 5.1.15.1.-7  Mapping of Modbus data: analog data

<table>
<thead>
<tr>
<th>Description</th>
<th>HR/IR address (.bit)</th>
<th>DI/Coil bit address</th>
<th>Writeable</th>
<th>Value range</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase-to-phase voltage U_{ab}</td>
<td>404</td>
<td></td>
<td></td>
<td>0...200</td>
<td>0...2 × U_n (VT)</td>
</tr>
<tr>
<td>Phase-to-phase voltage U_{bc}</td>
<td>405</td>
<td></td>
<td></td>
<td>0...200</td>
<td>0...2 × U_n (VT)</td>
</tr>
<tr>
<td>Phase-to-phase voltage U_{ca}</td>
<td>406</td>
<td></td>
<td></td>
<td>0...200</td>
<td>0...200% U_n (VT)</td>
</tr>
<tr>
<td>Residual voltage U_n</td>
<td>407</td>
<td></td>
<td></td>
<td>0...200</td>
<td></td>
</tr>
<tr>
<td>Positive phase-sequence voltage</td>
<td>408</td>
<td></td>
<td></td>
<td>0...200</td>
<td></td>
</tr>
<tr>
<td>Negative phase-sequence voltage</td>
<td>409</td>
<td></td>
<td></td>
<td>0...200</td>
<td></td>
</tr>
</tbody>
</table>

### Table 5.1.15.1.-8  Mapping of Modbus data: digital data

<table>
<thead>
<tr>
<th>Description</th>
<th>HR/IR address (.bit)</th>
<th>DI/Coil bit address</th>
<th>Writeable</th>
<th>Value range</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pickup signal from element 59P-1</td>
<td>410.00</td>
<td>1</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>Pickup signal from element 59P-1 CD</td>
<td>410.01</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trip signal from element 59P-1</td>
<td>410.02</td>
<td>3</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>Trip signal from element 59P-1 CD</td>
<td>410.03</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pickup signal from element 59P-2/47</td>
<td>410.04</td>
<td>5</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>Pickup signal from element 59P-2/47 CD</td>
<td>410.05</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trip signal from element 59P-2/47</td>
<td>410.06</td>
<td>7</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>Trip signal from element 59P-2/47 CD</td>
<td>410.07</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pickup signal from element 27P-1</td>
<td>410.08</td>
<td>9</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>Pickup signal from element 27P-1 CD</td>
<td>410.09</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trip signal from element 27P-1</td>
<td>410.10</td>
<td>11</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>Trip signal from element 27P-1 CD</td>
<td>410.11</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pickup signal from element 27P-2/27D</td>
<td>410.12</td>
<td>13</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>Pickup signal from element 27P-2/27D CD</td>
<td>410.13</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trip signal from element 27P-2/27D</td>
<td>410.14</td>
<td>15</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>Trip signal from element 27P-2/27D CD</td>
<td>410.15</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pickup signal from element 59N-1</td>
<td>411.00</td>
<td>17</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>Pickup signal from element 59N-1 CD</td>
<td>411.01</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trip signal from element 59N-1</td>
<td>411.02</td>
<td>19</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>Trip signal from element 59N-1 CD</td>
<td>411.03</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pickup signal from element 59N-2</td>
<td>411.04</td>
<td>21</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>Pickup signal from element 59N-2 CD</td>
<td>411.05</td>
<td>22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trip signal from element 59N-2</td>
<td>411.06</td>
<td>23</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>Trip signal from element 59N-2 CD</td>
<td>411.07</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trip lockout</td>
<td>411.08</td>
<td>25</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>Trip lockout CD</td>
<td>411.09</td>
<td>26</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>External trip</td>
<td>411.10</td>
<td>27</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>External trip CD</td>
<td>411.11</td>
<td>28</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBFAIL</td>
<td>411.12</td>
<td>29</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>CBFAIL CD</td>
<td>411.13</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td>HR/IR address (.bit)</td>
<td>DI/Coil bit address</td>
<td>Writeable</td>
<td>Value range</td>
<td>Comment</td>
</tr>
<tr>
<td>------------------------------</td>
<td>----------------------</td>
<td>---------------------</td>
<td>-----------</td>
<td>-------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>PO1 contact</td>
<td>411.14</td>
<td>31</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>PO1 contact CD</td>
<td>411.15</td>
<td>32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PO2 contact</td>
<td>412.00</td>
<td>33</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>PO2 contact CD</td>
<td>412.01</td>
<td>34</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PO3 contact</td>
<td>412.02</td>
<td>35</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>PO3 contact CD</td>
<td>412.03</td>
<td>36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO1 contact</td>
<td>412.04</td>
<td>37</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>SO1 contact CD</td>
<td>412.05</td>
<td>38</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO2 contact</td>
<td>412.06</td>
<td>39</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>SO2 contact CD</td>
<td>412.07</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO3 contact</td>
<td>412.08</td>
<td>41</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>SO3 contact CD</td>
<td>412.09</td>
<td>42</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO4 contact</td>
<td>412.10</td>
<td>43</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>SO4 contact CD</td>
<td>412.11</td>
<td>44</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO5 contact</td>
<td>412.12</td>
<td>45</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>SO5 contact CD</td>
<td>412.13</td>
<td>46</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DI1</td>
<td>412.14</td>
<td>47</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>DI1 CD</td>
<td>412.15</td>
<td>48</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DI2</td>
<td>413.00</td>
<td>49</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>DI2 CD</td>
<td>413.01</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DI3</td>
<td>413.02</td>
<td>51</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>DI3 CD</td>
<td>413.03</td>
<td>52</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DI4</td>
<td>413.04</td>
<td>53</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>DI4 CD</td>
<td>413.05</td>
<td>54</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DI5</td>
<td>413.06</td>
<td>55</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>DI5 CD</td>
<td>413.07</td>
<td>56</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disturbance recorder</td>
<td>413.08</td>
<td>57</td>
<td>0/1</td>
<td>1 = triggered</td>
<td></td>
</tr>
<tr>
<td>Disturbance recorder CD</td>
<td>413.09</td>
<td>58</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HMI Setting password</td>
<td>413.10</td>
<td>59</td>
<td>0/1</td>
<td>1 = opened 0 = closed</td>
<td></td>
</tr>
<tr>
<td>HMI Setting password CD</td>
<td>413.11</td>
<td>60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IRF</td>
<td>413.12</td>
<td>61</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>IRF CD</td>
<td>413.13</td>
<td>62</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warning</td>
<td>413.14</td>
<td>63</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>Warning CD</td>
<td>413.15</td>
<td>64</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPA event overflow</td>
<td>414.00</td>
<td>65</td>
<td>0/1</td>
<td>1 = activated</td>
<td></td>
</tr>
<tr>
<td>SPA event overflow CD</td>
<td>414.01</td>
<td>66</td>
<td></td>
<td></td>
<td>Only the CD bit is activated in case of overflow.</td>
</tr>
<tr>
<td>HMI Communication password</td>
<td>414.02</td>
<td>67</td>
<td>0/1</td>
<td>1 = opened 0 = closed</td>
<td></td>
</tr>
<tr>
<td>HMI Communication password CD</td>
<td>414.03</td>
<td>68</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 5.1.15.1.-9 Mapping of Modbus data: recorded data

<table>
<thead>
<tr>
<th>Description</th>
<th>HR/IR address (.bit)</th>
<th>DI/Coil bit address</th>
<th>Writeable</th>
<th>Value range</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fault record</td>
<td>601...623</td>
<td></td>
<td></td>
<td></td>
<td>See Structure 2</td>
</tr>
<tr>
<td>Event record</td>
<td>671...679</td>
<td></td>
<td></td>
<td></td>
<td>See Structure 3</td>
</tr>
</tbody>
</table>

### Table 5.1.15.1.-10 Mapping of Modbus data: relay identification

<table>
<thead>
<tr>
<th>Description</th>
<th>HR/IR address (.bit)</th>
<th>DI/Coil bit address</th>
<th>Writeable</th>
<th>Value range</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type designation of the relay</td>
<td>701...708</td>
<td></td>
<td></td>
<td></td>
<td>ASCII chars, 2 chars/register</td>
</tr>
</tbody>
</table>

### Table 5.1.15.1.-11 Mapping of Modbus data: real-time clock

<table>
<thead>
<tr>
<th>Description</th>
<th>HR/IR address (.bit)</th>
<th>DI/Coil bit address</th>
<th>Writeable</th>
<th>Value range</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time reading and setting</td>
<td>721...727</td>
<td></td>
<td>W</td>
<td></td>
<td>See Structure 4</td>
</tr>
</tbody>
</table>

### Table 5.1.15.1.-12 Mapping of Modbus data: additional analog data

<table>
<thead>
<tr>
<th>Description</th>
<th>HR/IR address (.bit)</th>
<th>DI/Coil bit address</th>
<th>Writeable</th>
<th>Value range</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Element which caused the operation</td>
<td>801 HI word</td>
<td></td>
<td></td>
<td>0...65536</td>
<td>See Table 5.1.17.-2</td>
</tr>
<tr>
<td></td>
<td>802 LO word</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operation target code</td>
<td>803</td>
<td></td>
<td></td>
<td>1...14</td>
<td>See Table 5.1.17.-2</td>
</tr>
<tr>
<td>Number of pickups of element 59P-1</td>
<td>804</td>
<td></td>
<td></td>
<td>0...999</td>
<td>Counter</td>
</tr>
<tr>
<td>Number of pickups of element 59P-2/47</td>
<td>805</td>
<td></td>
<td></td>
<td>0...999</td>
<td>Counter</td>
</tr>
<tr>
<td>Number of pickups of element 27P-1</td>
<td>806</td>
<td></td>
<td></td>
<td>0...999</td>
<td>Counter</td>
</tr>
<tr>
<td>Number of pickups of element 27P-2</td>
<td>807</td>
<td></td>
<td></td>
<td>0...999</td>
<td>Counter</td>
</tr>
<tr>
<td>Number of pickups of element 59N-1</td>
<td>808</td>
<td></td>
<td></td>
<td>0...999</td>
<td>Counter</td>
</tr>
<tr>
<td>Number of pickups of element 59N-2</td>
<td>809</td>
<td></td>
<td></td>
<td>0...999</td>
<td>Counter</td>
</tr>
<tr>
<td>Number of trips of element 59P-1 and 59P-2/47</td>
<td>810</td>
<td></td>
<td></td>
<td>0...65535</td>
<td>Counter</td>
</tr>
<tr>
<td>Number of trips of element 27P-1 and 27P-2/27D</td>
<td>811</td>
<td></td>
<td></td>
<td>0...65535</td>
<td>Counter</td>
</tr>
<tr>
<td>Number of trips of element 59N-1 and 59N-2</td>
<td>812</td>
<td></td>
<td></td>
<td>0...65535</td>
<td>Counter</td>
</tr>
<tr>
<td>Number of external trips</td>
<td>813</td>
<td></td>
<td></td>
<td>0...65535</td>
<td>Counter</td>
</tr>
</tbody>
</table>

### Table 5.1.15.1.-13 Mapping of Modbus data: control points

<table>
<thead>
<tr>
<th>Description</th>
<th>HR/IR address (.bit)</th>
<th>DI/Coil bit address</th>
<th>Writeable</th>
<th>Value range</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>LED reset</td>
<td>501</td>
<td></td>
<td>W</td>
<td>1</td>
<td>1 = LED reset(3)</td>
</tr>
</tbody>
</table>

---

(3) Coil area, only writeable.

### Structure 1

The status registers contain information on unread fault and event records, and relay status. The registers are arranged as in Fig. 5.1.15.1.-2 below.
When the value of the FR/ER bit is 1, there is one or several unread fault/event records. If time synchronization is realized via a digital input, either the SP (second-pulse) or MP (minute-pulse) bit will be activated.

Refer to Table 5.1.18.-1 for IRF codes and Table 5.1.18.-2 for warning codes.

**Structure 2**

This structure contains data recorded during a fault sequence. Refer to Fault records earlier in this section for the reading method.

### Table 5.1.15.1.-14 Fault record

<table>
<thead>
<tr>
<th>Address</th>
<th>Signal name</th>
<th>Range</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>601</td>
<td>Latest selection code(^a)</td>
<td>1...2</td>
<td>1 = read oldest unread record&lt;br&gt;2 = read oldest stored record</td>
</tr>
<tr>
<td>602</td>
<td>Sequence number</td>
<td>1...255</td>
<td></td>
</tr>
<tr>
<td>603</td>
<td>Unread records left</td>
<td>0...6</td>
<td></td>
</tr>
<tr>
<td>604</td>
<td>Time stamp of the recorded data, date</td>
<td>0...999</td>
<td>0...999 ms</td>
</tr>
<tr>
<td>605</td>
<td>Time stamp of the recorded data, date and time</td>
<td>0...999</td>
<td>0...999 ms</td>
</tr>
<tr>
<td>606</td>
<td>Time stamp of the recorded data, time</td>
<td>0...999</td>
<td>0...999 ms</td>
</tr>
<tr>
<td>607</td>
<td>Time stamp of the recorded data, time</td>
<td>0...999</td>
<td>0...999 ms</td>
</tr>
<tr>
<td>608</td>
<td>Phase-to-phase voltage U(_{ab})</td>
<td>0...200</td>
<td>0...2 (\times U_n) (VT)</td>
</tr>
<tr>
<td>609</td>
<td>Phase-to-phase voltage U(_{bc})</td>
<td>0...200</td>
<td>0...2 (\times U_n) (VT)</td>
</tr>
<tr>
<td>610</td>
<td>Phase-to-phase voltage U(_{ca})</td>
<td>0...200</td>
<td>0...2 (\times U_n) (VT)</td>
</tr>
<tr>
<td>611</td>
<td>Residual voltage U(_n)</td>
<td>0...200</td>
<td>0...200% (U_n) (VT)</td>
</tr>
<tr>
<td>612</td>
<td>Maximum pickup phase-to-phase voltage</td>
<td>0...200</td>
<td>0...2 (\times U_n) (VT)</td>
</tr>
<tr>
<td>613</td>
<td>Minimum pickup phase-to-phase voltage</td>
<td>0...200</td>
<td>0...2 (\times U_n) (VT)</td>
</tr>
<tr>
<td>614</td>
<td>Maximum pickup negative phase-sequence voltage U(_2)</td>
<td>0...200</td>
<td>0...2 (\times U_n) (VT)(^b)</td>
</tr>
<tr>
<td>615</td>
<td>Minimum pickup positive phase-sequence voltage U(_1)</td>
<td>0...200</td>
<td>0...2 (\times U_n) (VT)(^b)</td>
</tr>
<tr>
<td>616</td>
<td>Maximum residual voltage U(_n)</td>
<td>0...200</td>
<td>0...200% (U_n) (VT)</td>
</tr>
<tr>
<td>617</td>
<td>Pickup duration of element 59P-1</td>
<td>0...100</td>
<td>0...100%</td>
</tr>
<tr>
<td>618</td>
<td>Pickup duration of element 59P-2/47</td>
<td>0...100</td>
<td>0...100%</td>
</tr>
<tr>
<td>619</td>
<td>Pickup duration of element 27P-1</td>
<td>0...100</td>
<td>0...100%</td>
</tr>
<tr>
<td>620</td>
<td>Pickup duration of element 27P-2/27D</td>
<td>0...100</td>
<td>0...100%</td>
</tr>
</tbody>
</table>
### Structure 3

This structure contains Modbus event records. Refer to Event records earlier in this section for the reading method.

#### Table 5.1.15.1.-15 Event record

<table>
<thead>
<tr>
<th>Address</th>
<th>Signal name</th>
<th>Range</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>671</td>
<td>Latest selection code&lt;sup&gt;a)&lt;/sup&gt;</td>
<td>1...3</td>
<td>1 = read oldest unread record</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 = read oldest stored record</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3 = clear Modbus event buffer</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-1...-99 = move to the nth newest record</td>
</tr>
<tr>
<td>672</td>
<td>Sequence number</td>
<td>1...255</td>
<td></td>
</tr>
<tr>
<td>673</td>
<td>Unread records left</td>
<td>0...99</td>
<td></td>
</tr>
<tr>
<td>674</td>
<td>Time stamp of the event, date</td>
<td></td>
<td>2 bytes: YY.MM</td>
</tr>
<tr>
<td>675</td>
<td>Time stamp of the event, date and time</td>
<td></td>
<td>2 bytes: DD.HH</td>
</tr>
<tr>
<td>676</td>
<td>Time stamp of the event, time</td>
<td></td>
<td>2 bytes: MM.SS</td>
</tr>
<tr>
<td>677</td>
<td>Time stamp of the event, time</td>
<td>0...999</td>
<td>0...999 ms</td>
</tr>
<tr>
<td>678</td>
<td>Event data</td>
<td></td>
<td>See Table 5.1.15.1.-16 for Modbus DI-point events and</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Table 5.1.15.1.-17 for informative events</td>
</tr>
</tbody>
</table>

<sup>a)</sup> Readable and writeable register.

#### Table 5.1.15.1.-16 Modbus DI-point event

<table>
<thead>
<tr>
<th>Address</th>
<th>Name</th>
<th>Range</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>678</td>
<td>Modbus DI-point</td>
<td>1...99</td>
<td>MSB = 0</td>
</tr>
<tr>
<td>679</td>
<td>Modbus DI value</td>
<td>0...1</td>
<td></td>
</tr>
</tbody>
</table>

#### Table 5.1.15.1.-17 Informative event

<table>
<thead>
<tr>
<th>Address</th>
<th>Name</th>
<th>Range</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>678</td>
<td>SPA channel</td>
<td>0...3</td>
<td>MSB = 1</td>
</tr>
<tr>
<td>679</td>
<td>SPA event</td>
<td>0...63</td>
<td></td>
</tr>
</tbody>
</table>

### Structure 4

The relay's real-time clock is stored in this structure. It can be updated by presetting the whole register structure in one Modbus transaction.
Table 5.1.15.1.-18 Real-time clock structure

<table>
<thead>
<tr>
<th>Address</th>
<th>Description</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>721</td>
<td>Year</td>
<td>0...99</td>
</tr>
<tr>
<td>722</td>
<td>Month</td>
<td>1...12</td>
</tr>
<tr>
<td>723</td>
<td>Day</td>
<td>1...31</td>
</tr>
<tr>
<td>724</td>
<td>Hour</td>
<td>0...23</td>
</tr>
<tr>
<td>725</td>
<td>Minute</td>
<td>0...59</td>
</tr>
<tr>
<td>726</td>
<td>Second</td>
<td>0...59</td>
</tr>
<tr>
<td>727</td>
<td>Hundredth of a second</td>
<td>0...99</td>
</tr>
</tbody>
</table>

5.1.16. DNP 3.0 remote communication protocol

The DNP 3.0 protocol was developed by Harris Control based on the early versions of the IEC 60870-5 standard telecontrol protocol specifications. Today, the DNP protocol specifications are controlled by the DNP Users Group.

The DNP protocol supports the ISO OSI (Open System Interconnection) based model, which only specifies physical, data link and application layers. This reduced protocol stack is referred to as Enhanced Performance Architecture (EPA). To support advanced RTU functions and messages larger than the maximum frame length as defined in the IEC 60870-1, the DNP 3.0 Data Link is to be used with a transport pseudo-layer. As a minimum, the transport pseudo-layer implements message assembly and disassembly services.

5.1.16.1. Protocol parameters

The DNP parameters can all be adjusted using Relay Setting Tool. For the DNP parameters, refer to Table 5.1.17.-13.

Storing DNP 3.0 parameters

All DNP parameters are stored on the external DNP 3.0 module. After parameterization with Relay Setting Tool, REU610 must be switched to the rear communication mode for at least 10 seconds in order for the DNP parameters to be replicated and stored onto the DNP module. However, this is necessary only if the DNP parameters have been altered.

5.1.16.2. DNP 3.0 point list

The DNP data points (binary, analog and counters) of the relay, presented in Table 5.1.16.2.-1...Table 5.1.16.2.-3, are all in use as default.

The default class settings of the DNP points within the different event object groups are:
Binary inputs change events: class 1
Analog inputs change events: class 2
Counter change events: class 3

All static data points belong to class 0.

Unsolicited reporting is enabled for all event objects as default. However, the point-specific enable/disable parameters are meaningless unless unsolicited reporting has been enabled with SPA parameter 503V24.

The pointers to the scaling factors for analog objects are all 0 as default. Consequently, the DNP and Modbus analog values of the relay are identical as default.

All DNP process points can be edited using Relay Setting Tool. Editing features include:
- Re-organizing, adding and removing DNP points
- Assigning event classes to specific DNP points
- DNP point-specific enabling/disabling of unsolicited reporting
- Defining deadbands for event reporting
- Defining scaling factors for analog values

### Table 5.1.6.2-1 Binary data

<table>
<thead>
<tr>
<th>Description</th>
<th>DNP point address</th>
<th>Event class</th>
<th>UR enable</th>
<th>Value range</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pickup signal from element 59P-1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0/1</td>
<td>1 = activated</td>
</tr>
<tr>
<td>Trip signal from element 59P-1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0/1</td>
<td>1 = activated</td>
</tr>
<tr>
<td>Pickup signal from element 59P-2/47</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0/1</td>
<td>1 = activated</td>
</tr>
<tr>
<td>Trip signal from element 59P-2/47</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>0/1</td>
<td>1 = activated</td>
</tr>
<tr>
<td>Pickup signal from 27P-1</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>0/1</td>
<td>1 = activated</td>
</tr>
<tr>
<td>Trip signal from element 27P-1</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>0/1</td>
<td>1 = activated</td>
</tr>
<tr>
<td>Pickup signal from element 27P-2/27D</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>0/1</td>
<td>1 = activated</td>
</tr>
<tr>
<td>Trip signal from element 27P-2/27D</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>0/1</td>
<td>1 = activated</td>
</tr>
<tr>
<td>Pickup signal from element 59N-1</td>
<td>8</td>
<td>1</td>
<td>1</td>
<td>0/1</td>
<td>1 = activated</td>
</tr>
<tr>
<td>Trip signal from element 59N-1</td>
<td>9</td>
<td>1</td>
<td>1</td>
<td>0/1</td>
<td>1 = activated</td>
</tr>
<tr>
<td>Pickup signal from element 59N-2</td>
<td>10</td>
<td>1</td>
<td>1</td>
<td>0/1</td>
<td>1 = activated</td>
</tr>
<tr>
<td>Trip signal from element 59N-2</td>
<td>11</td>
<td>1</td>
<td>1</td>
<td>0/1</td>
<td>1 = activated</td>
</tr>
<tr>
<td>Trip lockout signal</td>
<td>12</td>
<td>1</td>
<td>1</td>
<td>0/1</td>
<td>1 = activated</td>
</tr>
<tr>
<td>External trip signal</td>
<td>13</td>
<td>1</td>
<td>1</td>
<td>0/1</td>
<td>1 = activated</td>
</tr>
<tr>
<td>CBFAIL</td>
<td>14</td>
<td>1</td>
<td>1</td>
<td>0/1</td>
<td>1 = failure</td>
</tr>
<tr>
<td>PO1</td>
<td>15</td>
<td>1</td>
<td>1</td>
<td>0/1</td>
<td>1 = activated</td>
</tr>
<tr>
<td>PO2</td>
<td>16</td>
<td>1</td>
<td>1</td>
<td>0/1</td>
<td>1 = activated</td>
</tr>
<tr>
<td>PO3</td>
<td>17</td>
<td>1</td>
<td>1</td>
<td>0/1</td>
<td>1 = activated</td>
</tr>
<tr>
<td>SO1</td>
<td>18</td>
<td>1</td>
<td>1</td>
<td>0/1</td>
<td>1 = activated</td>
</tr>
<tr>
<td>SO2</td>
<td>19</td>
<td>1</td>
<td>1</td>
<td>0/1</td>
<td>1 = activated</td>
</tr>
<tr>
<td>SO3</td>
<td>20</td>
<td>1</td>
<td>1</td>
<td>0/1</td>
<td>1 = activated</td>
</tr>
<tr>
<td>SO4</td>
<td>21</td>
<td>1</td>
<td>1</td>
<td>0/1</td>
<td>1 = activated</td>
</tr>
</tbody>
</table>
### Table 5.1.16.2.-2 Analog data

<table>
<thead>
<tr>
<th>Description</th>
<th>DNP point address</th>
<th>Event class</th>
<th>UR enable</th>
<th>Deadband</th>
<th>Value range</th>
<th>Internal scaling factor (ix = 0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase-to-phase voltage $U_{ab}$</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0...200</td>
<td>100</td>
</tr>
<tr>
<td>Phase-to-phase voltage $U_{bc}$</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0...200</td>
<td>100</td>
</tr>
<tr>
<td>Phase-to-phase voltage $U_{ca}$</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0...200</td>
<td>100</td>
</tr>
<tr>
<td>Residual voltage $U_n$</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0...200</td>
<td>100</td>
</tr>
<tr>
<td>Positive phase-sequence voltage</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0...200</td>
<td>100</td>
</tr>
<tr>
<td>Negative phase-sequence voltage</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0...200</td>
<td>100</td>
</tr>
</tbody>
</table>

### Table 5.1.16.2.-3 Counters

<table>
<thead>
<tr>
<th>Description</th>
<th>DNP point address</th>
<th>Event class</th>
<th>UR enable</th>
<th>Deadband</th>
<th>Value range</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of pickups of element 59P-1</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0...999</td>
<td></td>
</tr>
<tr>
<td>Number of pickups of element 59P-2/47</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0...999</td>
<td></td>
</tr>
<tr>
<td>Number of pickups of element 27P-1</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0...999</td>
<td></td>
</tr>
<tr>
<td>Number of pickups of element 27P-2/27D</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0...999</td>
<td></td>
</tr>
<tr>
<td>Number of pickups of element 59N-1</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0...999</td>
<td></td>
</tr>
<tr>
<td>Number of pickups of element 59N-2</td>
<td>5</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0...999</td>
<td></td>
</tr>
<tr>
<td>Number of trips of element 59P-1 and 59P-2/47</td>
<td>6</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0...65535</td>
<td></td>
</tr>
<tr>
<td>Number of trips of element 27P-1 and 27P-2/27D</td>
<td>7</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0...65535</td>
<td></td>
</tr>
<tr>
<td>Number of trips of element 59N-1 and 59N-2</td>
<td>8</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0...65535</td>
<td></td>
</tr>
<tr>
<td>Number of external trips</td>
<td>9</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0...65535</td>
<td></td>
</tr>
</tbody>
</table>
## 5.1.16.3. DNP 3.0 device profile

### DNP V3.00

#### DEVICE PROFILE DOCUMENT

Vendor Name: ABB Oy, Distribution Automation, Vaasa, Finland  
Device Name: REU610

<table>
<thead>
<tr>
<th>Highest DNP Level Supported</th>
<th>Device Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>For Requests</td>
<td>l_b</td>
</tr>
<tr>
<td>For Responses</td>
<td>l_b</td>
</tr>
</tbody>
</table>

Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table):

Additions to level 2 are marked as shaded in the implementation table:

<table>
<thead>
<tr>
<th>Maximum Data Link Frame Size (octets)</th>
<th>Maximum Application Fragment Size (octets)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitted</td>
<td>292</td>
</tr>
<tr>
<td>Received</td>
<td>292</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Maximum Data Link Re-tries:</th>
<th>Maximum Application Layer Re-tries:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configurable, range from 0 to 255 with primary data link layer retransmission count</td>
<td>Configurable, range from 0 to 255 with application layer retransmission count</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Requires Data Link Layer Confirmation:</th>
<th>Requires Application Layer Confirmation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configurable, with confirmation type selector, default NO ACK</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Timeouts while waiting for:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Link Confirm</td>
<td>Configurable with primary data link layer timeout, not relevant when NO ACK</td>
</tr>
<tr>
<td>Complete Appl. Fragment</td>
<td>No, multi-fragment application frames not supported</td>
</tr>
<tr>
<td>Application Confirm</td>
<td>Configurable with application layer timeout</td>
</tr>
<tr>
<td>Complete Appl. Response</td>
<td>No, not relevant in slave</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sends/Executes Control Operations</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>WRITE Binary Outputs</td>
<td>Never</td>
</tr>
<tr>
<td>SELECT/OPERATE</td>
<td>Never</td>
</tr>
<tr>
<td>DIRECT OPERATE</td>
<td>Never</td>
</tr>
<tr>
<td>DIRECT OPERATE - NO ACK</td>
<td>Never</td>
</tr>
<tr>
<td>Count</td>
<td>Never</td>
</tr>
<tr>
<td>Code</td>
<td>Never</td>
</tr>
<tr>
<td>Trip/Close</td>
<td>Never</td>
</tr>
<tr>
<td>Pulse On</td>
<td>Never</td>
</tr>
<tr>
<td>Queue</td>
<td>Never</td>
</tr>
<tr>
<td>Clear Queue</td>
<td>Never</td>
</tr>
</tbody>
</table>

**FILL OUT THE FOLLOWING ITEMS FOR SLAVE DEVICES ONLY:**

<table>
<thead>
<tr>
<th>Reports Digital Input Change Events when no specific variation requested</th>
<th>Reports time-tagged Digital Input Change Events when no specific variation requested</th>
</tr>
</thead>
</table>
**Configurable to send both, one or the other** (depends on default variation)

**Configurable, depends on objects basic variation (variation used at initialization)**

**Sends Unsolicited Responses**
- Never
- Only time-tagged
- Only non-time-tagged
- Configurable
- Only certain objects
- Sometimes (attach explanation)

**FUNCTION CODES**

<table>
<thead>
<tr>
<th>Code</th>
<th>Function</th>
<th>Description</th>
<th>Supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Confirm</td>
<td>Message fragment confirmation</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No response</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Read</td>
<td>Request objects from outstation</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Respond with requested objects</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Write</td>
<td>Store specified objects to outstation</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Respond with status of operation</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Select</td>
<td>Select output point of outstation</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Respond with status of control point</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Operate</td>
<td>Set previously selected output</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Respond with status of control point</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Direct operate</td>
<td>Set output directly</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Respond with status of control point</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Direct operate NO ACK</td>
<td>Set output directly</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No response</td>
<td></td>
</tr>
</tbody>
</table>

**FREEZE FUNCTION CODES**

<table>
<thead>
<tr>
<th>Code</th>
<th>Function</th>
<th>Description</th>
<th>Supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Immediate Freeze</td>
<td>Copy specified objects to freeze buffer</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Respond with status of operation</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Immediate Freeze NO ACK</td>
<td>Copy specified objects to freeze buffer</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No response</td>
<td></td>
</tr>
</tbody>
</table>
### Code Function Description Supported

<table>
<thead>
<tr>
<th>Code</th>
<th>Function</th>
<th>Description</th>
<th>Supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Freeze and Clear</td>
<td>Copy specified objects to freeze buffer and clear objects. Respond with status of operation</td>
<td>Yes$^a$</td>
</tr>
<tr>
<td>10</td>
<td>Freeze and Clear NO ACK</td>
<td>Copy specified objects to freeze buffer and clear objects. No response</td>
<td>Yes$^a$</td>
</tr>
<tr>
<td>11</td>
<td>Freeze with time</td>
<td>Copy specified objects to freeze buffer at specified time. Respond with status of operation</td>
<td>No</td>
</tr>
<tr>
<td>12</td>
<td>Freeze with time NO ACK</td>
<td>Copy specified objects to freeze buffer at specified time. No response</td>
<td>No</td>
</tr>
</tbody>
</table>

### Application Control Function Codes

<table>
<thead>
<tr>
<th>Code</th>
<th>Function</th>
<th>Description</th>
<th>Supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Cold Restart</td>
<td>Perform desired reset sequence. Respond with a time object</td>
<td>Yes</td>
</tr>
<tr>
<td>14</td>
<td>Warm Restart</td>
<td>Perform desired partial reset operation. Respond with a time object</td>
<td>Yes</td>
</tr>
<tr>
<td>15</td>
<td>Initialize Data to Defaults</td>
<td>Initialize the specified data to default. Respond with status of operation</td>
<td>No</td>
</tr>
<tr>
<td>16</td>
<td>Initialize Application</td>
<td>Set the specified application ready to be run. Respond with status of operation</td>
<td>No</td>
</tr>
<tr>
<td>17</td>
<td>Start Application</td>
<td>Start the specified application to run. Respond with status of operation</td>
<td>Yes</td>
</tr>
<tr>
<td>18</td>
<td>Stop Application</td>
<td>Stop the specified application to run. Respond with status of operation</td>
<td>Yes</td>
</tr>
</tbody>
</table>

### Configuration Function Codes

<table>
<thead>
<tr>
<th>Code</th>
<th>Function</th>
<th>Description</th>
<th>Supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Save configuration</td>
<td>Save configuration. Respond with status of operation</td>
<td>No</td>
</tr>
<tr>
<td>20</td>
<td>Enable Unsolicited Messages</td>
<td>Enable Unsolicited Messages. Respond with status of operation</td>
<td>Yes</td>
</tr>
<tr>
<td>21</td>
<td>Disable Unsolicited Messages</td>
<td>Disable Unsolicited Messages. Respond with status of operation</td>
<td>Yes</td>
</tr>
<tr>
<td>22</td>
<td>Assign Class</td>
<td>Assign specified objects to a class. Respond with status of operation</td>
<td>Yes</td>
</tr>
</tbody>
</table>

### Time Synchronization Function Codes

<table>
<thead>
<tr>
<th>Code</th>
<th>Function</th>
<th>Description</th>
<th>Supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>Delay Measurement</td>
<td>Perform propagation delay measurement</td>
<td>Yes</td>
</tr>
</tbody>
</table>

### Response Function Codes

<table>
<thead>
<tr>
<th>Code</th>
<th>Function</th>
<th>Description</th>
<th>Supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Confirm</td>
<td>Message fragment confirmation</td>
<td>Yes</td>
</tr>
<tr>
<td>129</td>
<td>Response</td>
<td>Response to request message</td>
<td>Yes</td>
</tr>
<tr>
<td>130</td>
<td>Unsolicited Message</td>
<td>Spontaneous message without request</td>
<td>Yes</td>
</tr>
</tbody>
</table>

$^a$ Counters of the relay cannot be cleared by using the DNP 3.0 protocol.

### Table 5.1.16.3.-2 Supported objects

<table>
<thead>
<tr>
<th>OBJECT</th>
<th>REQUEST (slave must parse)</th>
<th>RESPONSE (master must parse)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Object group</strong></td>
<td><strong>Variation</strong></td>
<td><strong>Description</strong></td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>Binary Input, all variations</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>Binary Input</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>Binary Input with Status</td>
</tr>
<tr>
<td>Object group</td>
<td>Variation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>Binary Input Change, all variation</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>Binary Input Change without Time</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Binary Input Change with Time</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>Binary Input Change with Relative Time</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>Binary Output, all variations</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>Binary Output</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>Binary Output with Status</td>
</tr>
<tr>
<td>12</td>
<td>0</td>
<td>Control Block, all variations</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>Control Relay Output Block</td>
</tr>
<tr>
<td>12</td>
<td>2</td>
<td>Pattern Control Block</td>
</tr>
<tr>
<td>12</td>
<td>3</td>
<td>Pattern Mask</td>
</tr>
<tr>
<td>20</td>
<td>0</td>
<td>Binary Counter, all variations</td>
</tr>
<tr>
<td>20</td>
<td>1</td>
<td>32-Bit Binary Counter</td>
</tr>
<tr>
<td>20</td>
<td>2</td>
<td>16-Bit Binary Counter</td>
</tr>
<tr>
<td>20</td>
<td>3</td>
<td>32-Bit Delta Counter</td>
</tr>
<tr>
<td>20</td>
<td>4</td>
<td>16-Bit Delta Counter</td>
</tr>
<tr>
<td>20</td>
<td>5</td>
<td>32-Bit Binary Counter without Flag</td>
</tr>
<tr>
<td>20</td>
<td>6</td>
<td>16-Bit Binary Counter without Flag</td>
</tr>
<tr>
<td>20</td>
<td>7</td>
<td>32-Bit Delta Counter without Flag</td>
</tr>
<tr>
<td>20</td>
<td>8</td>
<td>16-Bit Delta Counter without Flag</td>
</tr>
<tr>
<td>21</td>
<td>0</td>
<td>Frozen Counter, all variations</td>
</tr>
<tr>
<td>21</td>
<td>1</td>
<td>32-Bit Frozen Counter</td>
</tr>
<tr>
<td>21</td>
<td>2</td>
<td>16-Bit Frozen Counter</td>
</tr>
<tr>
<td>21</td>
<td>3</td>
<td>32-Bit Frozen Delta Counter</td>
</tr>
<tr>
<td>21</td>
<td>4</td>
<td>16-Bit Frozen Delta Counter</td>
</tr>
<tr>
<td>21</td>
<td>5</td>
<td>32-Bit Frozen Counter with Time of Freeze</td>
</tr>
<tr>
<td>21</td>
<td>6</td>
<td>16-Bit Frozen Counter with Time of Freeze</td>
</tr>
<tr>
<td>21</td>
<td>7</td>
<td>32-Bit Frozen Delta Counter with Time of Freeze</td>
</tr>
<tr>
<td>21</td>
<td>8</td>
<td>16-Bit Frozen Delta Counter with Time of Freeze</td>
</tr>
<tr>
<td>21</td>
<td>9</td>
<td>32-Bit Frozen Counter without Flag</td>
</tr>
<tr>
<td>21</td>
<td>10</td>
<td>16-Bit Frozen Counter without Flag</td>
</tr>
<tr>
<td>21</td>
<td>11</td>
<td>32-Bit Frozen Delta Counter without Flag</td>
</tr>
<tr>
<td>Object group</td>
<td>Variation</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------</td>
<td>-----------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>16-Bit Frozen Delta Counter without Flag</td>
</tr>
<tr>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Counter Change Event, all variations</td>
</tr>
<tr>
<td>22</td>
<td>1</td>
<td>32-Bit Counter Change Event without Time</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>16-Bit Counter Change Event without Time</td>
</tr>
<tr>
<td>22</td>
<td>3</td>
<td>32-Bit Delta Counter Change Event without Time</td>
</tr>
<tr>
<td>22</td>
<td>4</td>
<td>16-Bit Delta Counter Change Event without Time</td>
</tr>
<tr>
<td>22</td>
<td>5</td>
<td>32-Bit Counter Change Event with Time</td>
</tr>
<tr>
<td>22</td>
<td>6</td>
<td>16-Bit Counter Change Event with Time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Frozen Counter Event, all variations</td>
</tr>
<tr>
<td>23</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>32-Bit Frozen Counter Event without Time</td>
</tr>
<tr>
<td>23</td>
<td>2</td>
<td>16-Bit Frozen Counter Event without Time</td>
</tr>
<tr>
<td>23</td>
<td>3</td>
<td>32-Bit Frozen Delta Counter Event without Time</td>
</tr>
<tr>
<td>23</td>
<td>4</td>
<td>16-Bit Frozen Delta Counter Event without Time</td>
</tr>
<tr>
<td>23</td>
<td>5</td>
<td>32-Bit Frozen Counter Event with Time</td>
</tr>
<tr>
<td>23</td>
<td>6</td>
<td>16-Bit Frozen Counter Event with Time</td>
</tr>
<tr>
<td>23</td>
<td>7</td>
<td>32-Bit Frozen Delta Counter Event with Time</td>
</tr>
<tr>
<td>23</td>
<td>8</td>
<td>16-Bit Frozen Delta Counter Event with Time</td>
</tr>
<tr>
<td>30</td>
<td>0</td>
<td>Analog Input, all variations</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>32-Bit Analog Input</td>
</tr>
<tr>
<td>30</td>
<td>2</td>
<td>16-Bit Analog Input</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>32-Bit Analog Input without Flag</td>
</tr>
</tbody>
</table>
## OBJECT REQUEST

<table>
<thead>
<tr>
<th>Object group</th>
<th>Variation</th>
<th>Description</th>
<th>Function codes (dec)</th>
<th>Qualifier codes (hex)</th>
<th>Function codes (dec)</th>
<th>Qualifier codes (hex)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>4</td>
<td>16-Bit Analog Input without Flag</td>
<td>1, 20, 21, 22</td>
<td>00, 01, 06, 07, 08, 17, 28</td>
<td>129</td>
<td>00, 01, 17, 28</td>
</tr>
<tr>
<td>31</td>
<td>0</td>
<td>Frozen Analog Input, all variations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>1</td>
<td>32-Bit Frozen Analog Input</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>2</td>
<td>16-Bit Frozen Analog Input</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>3</td>
<td>32-Bit Frozen Analog Input with Time of Freeze</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>4</td>
<td>16-Bit Frozen Analog Input with Time of Freeze</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>5</td>
<td>32-Bit Frozen Analog Input without Flag</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>6</td>
<td>16-Bit Frozen Analog Input without Flag</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>0</td>
<td>Analog Change Event, all variations</td>
<td>1</td>
<td>06, 07, 08</td>
<td>129, 130</td>
<td>17, 28</td>
</tr>
<tr>
<td>32</td>
<td>1</td>
<td>32-Bit Analog Change Event without Time</td>
<td>1</td>
<td>06, 07, 08</td>
<td>129, 130</td>
<td>17, 28</td>
</tr>
<tr>
<td>32</td>
<td>2</td>
<td>16-Bit Analog Change Event without Time</td>
<td>1</td>
<td>06, 07, 08</td>
<td>129, 130</td>
<td>17, 28</td>
</tr>
<tr>
<td>32</td>
<td>3</td>
<td>32-Bit Analog Change Event with Time</td>
<td>1</td>
<td>06, 07, 08</td>
<td>129, 130</td>
<td>17, 28</td>
</tr>
<tr>
<td>32</td>
<td>4</td>
<td>16-Bit Analog Change Event with Time</td>
<td>1</td>
<td>06, 07, 08</td>
<td>129, 130</td>
<td>17, 28</td>
</tr>
<tr>
<td>33</td>
<td>0</td>
<td>Frozen Analog Event, all variations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>1</td>
<td>32-Bit Frozen Analog Event without Time</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>2</td>
<td>16-Bit Frozen Analog Event without Time</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>3</td>
<td>32-Bit Frozen Analog Event with Time</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>4</td>
<td>16-Bit Frozen Analog Event with Time</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>0</td>
<td>Analog Output Status, all variations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>1</td>
<td>32-Bit Analog Output Status</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>2</td>
<td>16-Bit Analog Output Status</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>0</td>
<td>Analog Output Block, all variations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>1</td>
<td>32-Bit Analog Output Block</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>2</td>
<td>16-Bit Analog Output Block</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>0</td>
<td>Time and Date, all variations</td>
<td>1</td>
<td>06, 07, 08</td>
<td>129</td>
<td>17, 28</td>
</tr>
<tr>
<td>50</td>
<td>1</td>
<td>(def) Time and Date</td>
<td>1</td>
<td>06, 07, 08</td>
<td>129</td>
<td>17, 28</td>
</tr>
<tr>
<td>50</td>
<td>1</td>
<td>(def) Time and Date</td>
<td>2</td>
<td>06, 07, 08</td>
<td>129</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>2</td>
<td>Time and Date with Interval</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>0</td>
<td>Time and Date CTO, all variations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>1</td>
<td>Time and Date CTO</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.1.16.4. Specific DNP features

Time synchronization

If time synchronization (minute-pulse or second-pulse) of the relay’s real-time clock is realized via a digital input, the following applies to the DNP interface of the relay:

- Depending on the pulse type, either the date-to-minute or the date-to-second information of the DNP time synchronization message is used.
- The relay sends only one request for time synchronization to the DNP master, which is at power up.
Unsolicited reporting pick up

Due to implementation differences in DNP master devices, the following alternative unsolicited reporting (SPA parameter 503V24) pick ups are available in the relay:

- 1 = Unsolicited reporting starts immediately, without permission from the master.
- 2 = The relay sends an empty unsolicited response message when communication begins, which the master confirms. After this, the relay starts to send unsolicited responses.
- 3 = The relay sends an empty unsolicited response message when communication begins, which the master confirms. After this, the master enables unsolicited reporting for certain or all classes using function 20. Classes which are not enabled remain disabled.

Only the last alternative is compliant with the DNP 3.0 standard.

Event handling

The maximum capacity of the DNP event buffer is 100 events. When unsolicited reporting has been enabled (SPA parameter 503V24), the event reporting uses the following SPA parameters, called send throttle parameters:

<table>
<thead>
<tr>
<th>SPA Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>503V18</td>
<td>Class 1 Event delay</td>
</tr>
<tr>
<td>503V19</td>
<td>Class 1 Event count</td>
</tr>
<tr>
<td>503V20</td>
<td>Class 2 Event delay</td>
</tr>
<tr>
<td>503V21</td>
<td>Class 2 Event count</td>
</tr>
<tr>
<td>503V22</td>
<td>Class 3 Event delay</td>
</tr>
<tr>
<td>503V23</td>
<td>Class 3 Event count</td>
</tr>
</tbody>
</table>

Example:

(class 1)

The events are reported when the event delay (SPA parameter 503V18) has elapsed or the defined amount of events (SPA parameter 503V19) are generated for class 1.

If send throttles are not wanted, the event delay should be set to 0 and the event count to 1. In this case, the class events are sent to the host immediately as they occur.

Event buffer overflow

DNP 3.0 event buffer overflow is indicated with the internal target IIN2.3, as defined by the standard. IIN2.3 can also indicate event buffer overflow in the internal communication between the DNP3.0 module and the main CPU module of the relay. In this case, the relay automatically activates and resets the IIN2.3 bit.
As events have been lost in both cases, the DNP 3.0 master should perform an integrity scan after the IIN2.3 bit has been reset.

**DNP counters and frozen counters**

DNP counters in use have a corresponding frozen counter. The frozen counters in object group 21 have the same DNP point index as the ordinary DNP counters. Further, frozen counters can only be read as static objects, and frozen counter events (object group 23) are not supported.

**Collision avoidance and detection**

The relay supports both collision avoidance and detection. Collision detection can be enabled or disabled with SPA parameter 503V235. Collision avoidance occurs before message transmission. When preparing to transmit and the link is busy, the relay first waits until the link becomes idle. After this, a backoff time starts. When the backoff time elapses, the relay checks the link again. If the link is not busy, the relay starts the transmission. The backoff time is calculated as follows:

\[
\text{backoff time} = \text{silent interval} + \text{random delay}
\]

The silent interval is set with SPA parameter 503V232 and the maximum random delay with SPA parameters 503V233 (the width of a single time slot in milliseconds) and 503V234 (the maximum number of time slots). By setting the time-slot width to 10 milliseconds and the maximum number of time slots to 10, for instance, the maximum random delay is 100 milliseconds.

Collision detection is always active during transmission (provided that it has been enabled). While sending a message, the relay supervises collisions on the link. If a collision is detected, the transmission is immediately cancelled. After this, the relay tries to transmit the message again, using collision avoidance before sending the message.

**Scaling DNP analog values**

The DNP analog values can be scaled using either an internal (fixed) or a user-defined scaling factor. If the scaling factor index for a certain analog value is set to 0, the internal scaling factor is used. If set to 1...5, the user-defined scaling factor of the corresponding scaling factor parameter, SPA parameter 503V (100+index), is used.
Example:

Phase-to-phase voltage $U_{ab}$  
Internal scaling factor  
Default DNP range

To show the analog value in primary units, and if $U_n$ (VT) = 20000 V:
1. Take any unused scaling factor and set it to 20000.
2. Set the scaling index pointer of the analog value to point at the scaling factor.
3. The value range is now $0.00 \times 20000...2.00 \times 20000 = 0...20000$ V.

DNP analog values deadband

The deadband is always defined in units of the original value when scaled using the internal (fixed) scaling factor, irrespective of whether the internal scaling factor is used for value presentation or not.

Example:

For a deadband of 2% $U_n$ (VT) when the internal scaling factor is 100, the deadband value is set as follows: $0.02 \times 100 = 2$. If the scaling factor is set to 20 kV, the scaled deadband is $20 \text{ kV} \times 0.02 = 400$ V.

5.1.17. SPA bus communication protocol parameters

Altering parameter values via serial communication requires the use of the SPA password in some cases. The password is a user-defined number within the range 1...999, the default value being 001. SPA parameters are found on channels 0...5, 503...504, 507 and 601...603.

To enter the setting mode, enter the password into parameter $V160$. To exit the setting mode, enter the same password into parameter $V161$. The password protection is also reactivated in case of loss of auxiliary voltage.

The password can be changed with parameter $V162$, but it is not possible to read the password via this parameter. Abbreviations used in the following tables:

- $R$ = readable data
- $W$ = writeable data
- $P$ = password protected writeable data
### Table 5.1.17.-1 Settings

<table>
<thead>
<tr>
<th>Variable</th>
<th>Actual settings (R), channel 0</th>
<th>Group/Channel 1 (R, W, P)</th>
<th>Group/Channel 2 (R, W, P)</th>
<th>Setting range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pickup value of element 59P-1</td>
<td>S1</td>
<td>S1</td>
<td>2S1</td>
<td>0.60...1.40 × (VT)</td>
</tr>
<tr>
<td>Operate time of element 59P-1</td>
<td>S2</td>
<td>S2</td>
<td>2S2</td>
<td>0.06...600 s</td>
</tr>
<tr>
<td>IDMT operation mode setting for element 59P-1</td>
<td>S3</td>
<td>1S3</td>
<td>2S3</td>
<td>0...2</td>
</tr>
<tr>
<td>IDMT time dial 59P-1 TD</td>
<td>S4</td>
<td>1S4</td>
<td>2S4</td>
<td>0.05...2.00</td>
</tr>
<tr>
<td>Resetting time of element 59P-1</td>
<td>S5</td>
<td>1S5</td>
<td>2S5</td>
<td>0.07...60.0 s</td>
</tr>
<tr>
<td>Drop-off/pickup ratio 59P-1 D/P</td>
<td>S6</td>
<td>1S6</td>
<td>2S6</td>
<td>0.95...0.99</td>
</tr>
<tr>
<td>U₁/U₂ mode setting of elements 59P-2/27P-2</td>
<td>S7</td>
<td>1S7</td>
<td>2S7</td>
<td>0 = 59P-2 and 27P-2</td>
</tr>
<tr>
<td>Pickup value of element 59P-2</td>
<td>S8(3)</td>
<td>1S8</td>
<td>2S8</td>
<td>0.80...1.60 × Uₙ (VT)</td>
</tr>
<tr>
<td>Pickup value of element 47</td>
<td>S9(3)</td>
<td>1S9</td>
<td>2S9</td>
<td>0.05...1.00 × Uₙ (VT)</td>
</tr>
<tr>
<td>Operate time of element 59P-2</td>
<td>S10</td>
<td>1S10</td>
<td>2S10</td>
<td>0.05...600 s</td>
</tr>
<tr>
<td>IDMT operation mode setting for element 59P-2</td>
<td>S11</td>
<td>1S11</td>
<td>2S11</td>
<td>0...2</td>
</tr>
<tr>
<td>IDMT time dial 59P-2 TD</td>
<td>S12</td>
<td>1S12</td>
<td>2S12</td>
<td>0.05...2.00</td>
</tr>
<tr>
<td>Pickup value of element 27P-1</td>
<td>S13</td>
<td>1S13</td>
<td>2S13</td>
<td>0.20...1.20 × Uₙ (VT)</td>
</tr>
<tr>
<td>Operate time of element 27P-1</td>
<td>S14</td>
<td>1S14</td>
<td>2S14</td>
<td>0.10...600 s</td>
</tr>
<tr>
<td>IDMT operation mode setting for element 27P-1</td>
<td>S15</td>
<td>1S15</td>
<td>2S15</td>
<td>0...1</td>
</tr>
<tr>
<td>IDMT dial 27P-1 TD</td>
<td>S16</td>
<td>1S16</td>
<td>2S16</td>
<td>0.10...2.00</td>
</tr>
<tr>
<td>Resetting time of element 27P-1</td>
<td>S17</td>
<td>1S17</td>
<td>2S17</td>
<td>0.07...60.0 s</td>
</tr>
<tr>
<td>Drop-off/pickup ratio 27P-1 D/P</td>
<td>S18</td>
<td>1S18</td>
<td>2S18</td>
<td>1.01...1.05</td>
</tr>
<tr>
<td>Pickup value of element 27P-2</td>
<td>S19(3)</td>
<td>1S19</td>
<td>2S19</td>
<td>0.20...1.20 × Uₙ (VT)</td>
</tr>
<tr>
<td>Pickup value of element U₁</td>
<td>S20(3)</td>
<td>1S20</td>
<td>2S20</td>
<td>0.20...1.20 × Uₙ (VT)</td>
</tr>
<tr>
<td>Operate time of element 27P-2</td>
<td>S21</td>
<td>1S21</td>
<td>2S21</td>
<td>0.10...600 s</td>
</tr>
<tr>
<td>IDMT operation mode setting for element 27P-2</td>
<td>S22</td>
<td>1S22</td>
<td>2S22</td>
<td>0...1</td>
</tr>
<tr>
<td>IDMT time dial 27P-2 TD</td>
<td>S23</td>
<td>1S23</td>
<td>2S23</td>
<td>0.10...2.00</td>
</tr>
<tr>
<td>Pickup value of element 59N-1</td>
<td>S24</td>
<td>1S24</td>
<td>2S24</td>
<td>2.0...80.0% Uₙ (VT)</td>
</tr>
<tr>
<td>Operate time of element 59N-1</td>
<td>S25</td>
<td>1S25</td>
<td>2S25</td>
<td>0.10...600 s</td>
</tr>
<tr>
<td>Resetting time of element 59N-1</td>
<td>S26</td>
<td>1S26</td>
<td>2S26</td>
<td>0.07...60.0 s</td>
</tr>
<tr>
<td>Pickup value of element 59N-2</td>
<td>S27(3)</td>
<td>1S27</td>
<td>2S27</td>
<td>2.0...80.0% Uₙ (VT)</td>
</tr>
<tr>
<td>Operate time of element 59N-2</td>
<td>S28</td>
<td>1S28</td>
<td>2S28</td>
<td>0.10...600 s</td>
</tr>
<tr>
<td>Predefined time of CBFAIL</td>
<td>S29</td>
<td>1S29</td>
<td>2S29</td>
<td>0.10...60.0 s</td>
</tr>
<tr>
<td>Checksum, SGF 1</td>
<td>S61</td>
<td>1S61</td>
<td>2S61</td>
<td>0...255</td>
</tr>
<tr>
<td>Checksum, SGF 2</td>
<td>S62</td>
<td>1S62</td>
<td>2S62</td>
<td>0...4095</td>
</tr>
<tr>
<td>Checksum, SGF 3</td>
<td>S63</td>
<td>1S63</td>
<td>2S63</td>
<td>0...15</td>
</tr>
<tr>
<td>Checksum, SGF 4</td>
<td>S64</td>
<td>1S64</td>
<td>2S64</td>
<td>0...1023</td>
</tr>
<tr>
<td>Checksum, SGF 5</td>
<td>S65</td>
<td>1S65</td>
<td>2S65</td>
<td>0...255</td>
</tr>
<tr>
<td>Checksum, SGB 1</td>
<td>S71</td>
<td>1S71</td>
<td>2S71</td>
<td>0...32767</td>
</tr>
<tr>
<td>Variable</td>
<td>Actual settings (R), channel 0</td>
<td>Group/Channel 1 (R, W, P)</td>
<td>Group/Channel 2 (R, W, P)</td>
<td>Setting range</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------------------------------</td>
<td>---------------------------</td>
<td>---------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Checksum, SGB 2</td>
<td>S72</td>
<td>1S72</td>
<td>2S72</td>
<td>0...32767</td>
</tr>
<tr>
<td>Checksum, SGB 3</td>
<td>S73(^{b)})</td>
<td>1S73</td>
<td>2S73</td>
<td>0...32767</td>
</tr>
<tr>
<td>Checksum, SGB 4</td>
<td>S74(^{b)})</td>
<td>1S74</td>
<td>2S74</td>
<td>0...32767</td>
</tr>
<tr>
<td>Checksum, SGB 5</td>
<td>S75(^{b)})</td>
<td>1S75</td>
<td>2S75</td>
<td>0...32767</td>
</tr>
<tr>
<td>Checksum, SGR 1</td>
<td>S81</td>
<td>1S81</td>
<td>2S81</td>
<td>0...8191</td>
</tr>
<tr>
<td>Checksum, SGR 2</td>
<td>S82</td>
<td>1S82</td>
<td>2S82</td>
<td>0...8191</td>
</tr>
<tr>
<td>Checksum, SGR 3</td>
<td>S83</td>
<td>1S83</td>
<td>2S83</td>
<td>0...8191</td>
</tr>
<tr>
<td>Checksum, SGR 4</td>
<td>S84</td>
<td>1S84</td>
<td>2S84</td>
<td>0...8191</td>
</tr>
<tr>
<td>Checksum, SGR 5</td>
<td>S85</td>
<td>1S85</td>
<td>2S85</td>
<td>0...8191</td>
</tr>
<tr>
<td>Checksum, SGR 6</td>
<td>S86(^{c)})</td>
<td>1S86</td>
<td>2S86</td>
<td>0...8191</td>
</tr>
<tr>
<td>Checksum, SGR 7</td>
<td>S87(^{c)})</td>
<td>1S87</td>
<td>2S87</td>
<td>0...8191</td>
</tr>
<tr>
<td>Checksum, SGR 8</td>
<td>S88(^{c)})</td>
<td>1S88</td>
<td>2S88</td>
<td>0...8191</td>
</tr>
<tr>
<td>Checksum, SGL 1</td>
<td>S91</td>
<td>1S91</td>
<td>2S91</td>
<td>0...16383</td>
</tr>
<tr>
<td>Checksum, SGL 2</td>
<td>S92</td>
<td>1S92</td>
<td>2S92</td>
<td>0...16383</td>
</tr>
<tr>
<td>Checksum, SGL 3</td>
<td>S93</td>
<td>1S93</td>
<td>2S93</td>
<td>0...16383</td>
</tr>
<tr>
<td>Checksum, SGL 4</td>
<td>S94</td>
<td>1S94</td>
<td>2S94</td>
<td>0...16383</td>
</tr>
<tr>
<td>Checksum, SGL 5</td>
<td>S95</td>
<td>1S95</td>
<td>2S95</td>
<td>0...16383</td>
</tr>
<tr>
<td>Checksum, SGL 6</td>
<td>S96</td>
<td>1S96</td>
<td>2S96</td>
<td>0...16383</td>
</tr>
<tr>
<td>Checksum, SGL 7</td>
<td>S97</td>
<td>1S97</td>
<td>2S97</td>
<td>0...16383</td>
</tr>
<tr>
<td>Checksum, SGL 8</td>
<td>S98</td>
<td>1S98</td>
<td>2S98</td>
<td>0...16383</td>
</tr>
</tbody>
</table>

\(^{a)}\) If the protection element is out of operation, the number indicating the currently used value will be displaced by “999” when the parameter is read via the SPA bus and by dashes on the LCD.

\(^{b)}\) If the optional I/O module has not been installed, a dash will be shown on the LCD and “999999” when the parameter is read via the SPA bus.

\(^{c)}\) If the optional I/O module has not been installed, a dash will be shown on the LCD and “9999” when the parameter is read via the SPA bus.

**Recorded data**

Parameter V1 shows the element and phase which caused the trip or 27P-1 Alarm. Parameter V2 shows the trip target code.

Parameters V3...V8 show the number of pickups of the protection elements, parameters V9...V12 the number of trips of the protection elements.
<table>
<thead>
<tr>
<th>Recorded data</th>
<th>Parameter (R)</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Element/phase which caused the trip</td>
<td>V1</td>
<td>1 = 59P-1 ($U_{ca}$)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 = 59P-1 ($U_{bc}$)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 = 59P-1 ($U_{ab}$)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 = 59N-1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16 = 59P-2 ($U_{ca}$)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>32 = 59P-2 ($U_{bc}$)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>64 = 59P-2 ($U_{ab}$)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>128 = 59N-2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>256 = 27P-1 ($U_{ca}$)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>512 = 27P-1 ($U_{bc}$)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1024 = 27P-1 ($U_{ab}$)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2048 = 27P-2 ($U_{ca}$)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4096 = 27P-2 ($U_{bc}$)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8192 = 27P-2 ($U_{ab}$)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16384 = 47 ($U_J$)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>32768 = 27D ($U_1$)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>65536 = External trip</td>
</tr>
<tr>
<td>Trip target code</td>
<td>V2</td>
<td>0 = - - -</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 = 59P-1 Pickup</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 = 59P-1 Trip</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 = 59P-2/47 Pickup</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 = 59P-2/47 Trip</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 = 27P-1 Pickup</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 = 27P-1 Trip</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 = 27P-2/27D Pickup</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 = 27P-2/27D Trip</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9 = 59N-1 Pickup</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 = 59N-1 Trip</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11 = 59N-2 Pickup</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 = 59N-2 Trip</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13 = External Trip</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14 = CBFAIL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15 = 27P-1 Alarm</td>
</tr>
<tr>
<td>Number of pickups of element 59P-1</td>
<td>V3</td>
<td>0...999</td>
</tr>
<tr>
<td>Number of pickups of element 59P-2/47</td>
<td>V4</td>
<td>0...999</td>
</tr>
<tr>
<td>Number of pickups of element 27P-1</td>
<td>V5</td>
<td>0...999</td>
</tr>
<tr>
<td>Number of pickups of element 27P-2/27D</td>
<td>V6</td>
<td>0...999</td>
</tr>
<tr>
<td>Number of pickups of element 59N-1</td>
<td>V7</td>
<td>0...999</td>
</tr>
<tr>
<td>Number of pickups of element 59N-2</td>
<td>V8</td>
<td>0...999</td>
</tr>
<tr>
<td>Number of trips of elements 59P-1 and 59P-2/47</td>
<td>V9</td>
<td>0...65535</td>
</tr>
<tr>
<td>Number of trips of elements 27P-1 and 27P-2/27D</td>
<td>V10</td>
<td>0...65535</td>
</tr>
<tr>
<td>Number of trips of</td>
<td>V11</td>
<td>0...65535</td>
</tr>
<tr>
<td>Number of external trips</td>
<td>V12</td>
<td>0...65535</td>
</tr>
</tbody>
</table>

The last five recorded values can be read with parameters V1...V18 on channels 1...5. Event n denotes the last recorded value, n-1 the next one, and so forth.
### Table 5.1.17.-3 Recorded data: Channels 1...5

<table>
<thead>
<tr>
<th>Recorded data</th>
<th>Event (R)</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase-to-phase voltage $U_{ab}$</td>
<td>n Channel 1</td>
<td>1V1</td>
</tr>
<tr>
<td>Phase-to-phase voltage $U_{bc}$</td>
<td>n Channel 2</td>
<td>1V2</td>
</tr>
<tr>
<td>Phase-to-phase voltage $U_{ca}$</td>
<td>n Channel 3</td>
<td>1V3</td>
</tr>
<tr>
<td>Residual voltage $U_n$</td>
<td>n Channel 4</td>
<td>1V4</td>
</tr>
<tr>
<td>Maximum pickup phase-to-phase voltage</td>
<td>n Channel 5</td>
<td>1V5</td>
</tr>
<tr>
<td>Minimum pickup phase-to-phase voltage</td>
<td>n Channel 1</td>
<td>1V6</td>
</tr>
<tr>
<td>Maximum pickup negative phase-sequence voltage $U_2$</td>
<td>n Channel 2</td>
<td>1V7</td>
</tr>
<tr>
<td>Minimum pickup positive phase-sequence voltage $U_1$</td>
<td>n Channel 3</td>
<td>1V8</td>
</tr>
<tr>
<td>Maximum residual voltage $U_n$</td>
<td>n Channel 4</td>
<td>1V9</td>
</tr>
<tr>
<td>Pickup duration of element 59P-1</td>
<td>n Channel 5</td>
<td>1V10</td>
</tr>
<tr>
<td>Pickup duration of element 59P-2/47</td>
<td>n Channel 1</td>
<td>1V11</td>
</tr>
<tr>
<td>Pickup duration of element 27P-1</td>
<td>n Channel 2</td>
<td>1V12</td>
</tr>
<tr>
<td>Pickup duration of element 27P-2/27D</td>
<td>n Channel 3</td>
<td>1V13</td>
</tr>
<tr>
<td>Pickup duration of element 59N-1</td>
<td>n Channel 4</td>
<td>1V14</td>
</tr>
<tr>
<td>Pickup duration of element 59N-2</td>
<td>n Channel 5</td>
<td>1V15</td>
</tr>
<tr>
<td>Pickup duration of external trip</td>
<td>n Channel 1</td>
<td>1V16</td>
</tr>
<tr>
<td>Time stamp of the recorded data, date</td>
<td>n Channel 2</td>
<td>1V17</td>
</tr>
<tr>
<td>Time stamp of the recorded data, time</td>
<td>n Channel 3</td>
<td>1V18</td>
</tr>
</tbody>
</table>

^a If is not based on negative phase-sequence voltage $U_2$, dashes are shown on the LCD and "999" when read via serial communication.

^b If is not based on positive phase-sequence voltage $U_1$, dashes are shown on the LCD and "999" when read via serial communication.
## Disturbance recorder

### Table 5.1.17.-4  Parameters for the disturbance recorder

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter (channel 0)</th>
<th>R, W</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remote triggering</td>
<td>M1&lt;sup&gt;a)&lt;/sup&gt;</td>
<td>W</td>
<td>1</td>
</tr>
<tr>
<td>Clear recorder memory</td>
<td>M2</td>
<td>W</td>
<td>1</td>
</tr>
<tr>
<td>Sampling rate</td>
<td>M15&lt;sup&gt;b)&lt;/sup&gt;</td>
<td>R, W</td>
<td>800/960 Hz</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>400/480 Hz</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>50/60 Hz</td>
</tr>
<tr>
<td>Station identification/unit number</td>
<td>M18</td>
<td>R, W</td>
<td>0...9999</td>
</tr>
<tr>
<td>Rated frequency</td>
<td>M19</td>
<td>R</td>
<td>50 or 60 Hz</td>
</tr>
<tr>
<td>Name of the station</td>
<td>M20</td>
<td>R, W</td>
<td>Max 16 characters</td>
</tr>
<tr>
<td>Digital channel texts</td>
<td>M40...M47</td>
<td>R</td>
<td>-</td>
</tr>
<tr>
<td>Analog channel texts</td>
<td>M60...M63</td>
<td>R</td>
<td>-</td>
</tr>
<tr>
<td>Analog channel conversion factor and unit for primary voltage transformer(s)</td>
<td>M80&lt;sup&gt;c,d)&lt;/sup&gt;</td>
<td>R, W</td>
<td>Factor 0.00...600, unit (V, kV), e.g. 20.0,kV</td>
</tr>
<tr>
<td></td>
<td>M81 and M82</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Analog channel conversion factor and unit for residual voltage U_n</td>
<td>M83&lt;sup&gt;c)&lt;/sup&gt;</td>
<td>R, W</td>
<td>Factor 0.00...600, unit (V, kV), e.g. 20.0,kV</td>
</tr>
<tr>
<td>Internal trigger signals' checksum</td>
<td>V236</td>
<td>R, W</td>
<td>0...4095</td>
</tr>
<tr>
<td>Internal trigger signal's edge</td>
<td>V237</td>
<td>R, W</td>
<td>0...4095</td>
</tr>
<tr>
<td>Checksum of internal signal storing mask</td>
<td>V238&lt;sup&gt;d)&lt;/sup&gt;</td>
<td>R, W</td>
<td>0...4095</td>
</tr>
<tr>
<td>Post-triggering recording length</td>
<td>V240</td>
<td>R, W</td>
<td>0...100%</td>
</tr>
<tr>
<td>External trigger signal's checksum</td>
<td>V241</td>
<td>R, W</td>
<td>0...31</td>
</tr>
<tr>
<td>External trigger signal's edge</td>
<td>V242</td>
<td>R, W</td>
<td>0...31</td>
</tr>
<tr>
<td>Checksum of external signal storing mask</td>
<td>V243&lt;sup&gt;d)&lt;/sup&gt;</td>
<td>R, W</td>
<td>0...31</td>
</tr>
<tr>
<td>Triggering state, clearing and restart</td>
<td>V246</td>
<td>R, W</td>
<td>R: 0 = Recorder not triggered 1 = Recorder triggered and recording stored in the memory W: 0 = Clear recorder memory 2 = Download restart; sets the first information and the time stamp for triggering ready to be read 4 = Manual triggering</td>
</tr>
</tbody>
</table>

<sup>a)</sup> M1 can be used for broadcast triggering by using the unit address “900”.

<sup>b)</sup> Parameters can be written if the recorder has not been triggered.

<sup>c)</sup> The disturbance recorder requires this parameter to be set. The conversion factor is the transformation ratio multiplied by the rated of the relay. If this parameter is set to zero, the disturbance recorder data cannot be analyzed and dashes are shown on the LCD instead of the primary values.

<sup>d)</sup> This value is copied to parameters M81 and M82.
### Table 5.1.17.-5 Disturbance recorder internal triggering and storing

<table>
<thead>
<tr>
<th>Event</th>
<th>Weighting factor</th>
<th>Default value of triggering mask, V236</th>
<th>Default value of triggering edge, V237(^a)</th>
<th>Default value of storing mask, V238</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pickup of element 59P-1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Trip of element 59P-1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Pickup of element 59P-2 or 47</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Trip of element 59P-2 or 47</td>
<td>8</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Pickup of element 27P-1</td>
<td>16</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Trip of element 27P-1</td>
<td>32</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Pickup of element 27P-2 or 27D</td>
<td>64</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Trip of element 27P-2 or 27D</td>
<td>128</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Pickup of element 59N-1</td>
<td>256</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Trip of element 59N-1</td>
<td>512</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Pickup of element 59N-2</td>
<td>1024</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Trip of element 59N-2</td>
<td>2048</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Σ</strong></td>
<td><strong>682</strong></td>
<td><strong>0</strong></td>
<td><strong>751</strong></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) 0 = rising edge; 1 = falling edge.

### Table 5.1.17.-6 Disturbance recorder external triggering and storing

<table>
<thead>
<tr>
<th>Event</th>
<th>Weighting factor</th>
<th>Default value of triggering mask, V241</th>
<th>Default value of triggering edge, V242(^a)</th>
<th>Default value of storing mask, V243</th>
</tr>
</thead>
<tbody>
<tr>
<td>DI1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>DI2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>DI3</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>DI4</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>DI5</td>
<td>16</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Σ</strong></td>
<td><strong>0</strong></td>
<td><strong>0</strong></td>
<td><strong>0</strong></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) 0 = rising edge; 1 = falling edge.

### Table 5.1.17.-7 Control parameters

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter</th>
<th>R, W, P</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading of the event buffer</td>
<td>L</td>
<td>R</td>
<td>Time, channel number and event code</td>
</tr>
<tr>
<td>Re-reading of the event buffer</td>
<td>B</td>
<td>R</td>
<td>Time, channel number and event code</td>
</tr>
</tbody>
</table>
| Reading of relay state data        | C         | R       | 0 = Normal state  
1 = The relay has been subject to an automatic reset  
2 = Overflow of the event buffer  
3 = Both 1 and 2                      |
<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter</th>
<th>R, W, P</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resetting of relay state data</td>
<td>C</td>
<td>W</td>
<td>0 = Reset E50 and E51&lt;br&gt;1 = Reset only E50&lt;br&gt;2 = Reset only E51&lt;br&gt;4 = Reset all events including E51 except for E50</td>
</tr>
<tr>
<td>Time reading and setting</td>
<td>T</td>
<td>R, W</td>
<td>SS.sss</td>
</tr>
<tr>
<td>Date and time reading and setting</td>
<td>D</td>
<td>R, W</td>
<td>YY-MM-DD HH.MM;SS.sss</td>
</tr>
<tr>
<td>Type designation of the relay</td>
<td>F</td>
<td>R</td>
<td>REU610</td>
</tr>
<tr>
<td>Unlatching output contacts</td>
<td>V101</td>
<td>W</td>
<td>1 = Unlatch</td>
</tr>
<tr>
<td>Clearing targets and memorized values and unlatching contacts (master reset)</td>
<td>V102</td>
<td>W</td>
<td>1 = Clear and un latch</td>
</tr>
<tr>
<td>Resetting of trip lockout</td>
<td>V103</td>
<td>W</td>
<td>1 = Reset</td>
</tr>
<tr>
<td>Rated frequency</td>
<td>V104</td>
<td>R, W (P)</td>
<td>50 or 60 Hz</td>
</tr>
<tr>
<td>Time setting range for demand values in minutes</td>
<td>V105</td>
<td>R, W</td>
<td>0...999 min</td>
</tr>
<tr>
<td>Non-volatile memory settings</td>
<td>V106</td>
<td>R, W</td>
<td>0...31</td>
</tr>
<tr>
<td>Time setting for disabling new trip targets on the LCD</td>
<td>V108</td>
<td>R, W (P)</td>
<td>0...999 min</td>
</tr>
<tr>
<td>Testing the self-supervision</td>
<td>V109</td>
<td>W (P)</td>
<td>1 = Self-supervision output contact is activated and the READY target LED starts to flash&lt;br&gt;0 = Normal operation</td>
</tr>
<tr>
<td>LED test for pickup and trip targets</td>
<td>V110</td>
<td>W (P)</td>
<td>0 = Pickup and trip LEDs off&lt;br&gt;1 = Trip LED on, pickup LED off&lt;br&gt;2 = Pickup LED on, trip LED off&lt;br&gt;3 = and trip LEDs on</td>
</tr>
<tr>
<td>LED test for programmable LEDs</td>
<td>V111</td>
<td>W (P)</td>
<td>0...255</td>
</tr>
<tr>
<td>Trip-circuit supervision</td>
<td>V113</td>
<td>R, W</td>
<td>0 = Not in use&lt;br&gt;1 = In use</td>
</tr>
<tr>
<td>Store counter&lt;sup&gt;)&lt;/sup&gt;</td>
<td>V114</td>
<td>R</td>
<td>0...65535</td>
</tr>
<tr>
<td>Nominal voltage</td>
<td>V134</td>
<td>R, W (P)</td>
<td>0 = 100 V&lt;br&gt;1 = 110 V&lt;br&gt;2 = 115 V&lt;br&gt;3 = 120 V</td>
</tr>
<tr>
<td>Remote control of setting group</td>
<td>V150</td>
<td>R, W</td>
<td>0 = Setting group 1&lt;br&gt;1 = Setting group 2</td>
</tr>
<tr>
<td>Event mask for E31...E34</td>
<td>V155</td>
<td>R, W</td>
<td>0...63</td>
</tr>
<tr>
<td>Event mask for 1E1...1E16</td>
<td>V155</td>
<td>R, W</td>
<td>0...65535</td>
</tr>
<tr>
<td>Event mask for 1E17...1E24</td>
<td>V156</td>
<td>R, W</td>
<td>0...255</td>
</tr>
<tr>
<td>Event mask for 1E25...1E30</td>
<td>V157</td>
<td>R, W</td>
<td>0...63</td>
</tr>
<tr>
<td>Event mask for 2E1...2E16</td>
<td>V155</td>
<td>R, W</td>
<td>0...65535</td>
</tr>
<tr>
<td>Event mask for 2E17...2E26</td>
<td>V156</td>
<td>R, W</td>
<td>0...1023</td>
</tr>
<tr>
<td>Entering the SPA password for settings</td>
<td>V160</td>
<td>W</td>
<td>1...999</td>
</tr>
<tr>
<td>Changing the SPA password or taking the password protection into use</td>
<td>V161</td>
<td>W (P)</td>
<td>1...999</td>
</tr>
<tr>
<td>Changing the HMI Setting password</td>
<td>V162</td>
<td>W</td>
<td>1...999</td>
</tr>
<tr>
<td>Changing the HMI Communication password</td>
<td>V163</td>
<td>W</td>
<td>1...999</td>
</tr>
<tr>
<td>Description</td>
<td>Parameter</td>
<td>R, W, P</td>
<td>Value</td>
</tr>
<tr>
<td>-----------------------------------------------------------------</td>
<td>-----------</td>
<td>---------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Clearing trip counters 59P-1 and 59P-2; 27P-1 and 27P-2; 59N-1 and 59N-2; External trips</td>
<td>V166</td>
<td>W (P)</td>
<td>1 = Clear trip counters</td>
</tr>
<tr>
<td>Restoring factory settings</td>
<td>V167</td>
<td>W (P)</td>
<td>2 = Restore factory settings for CPU</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3 = Restore factory settings for DNP</td>
</tr>
<tr>
<td>Warning code</td>
<td>V168</td>
<td>R</td>
<td>0...63</td>
</tr>
<tr>
<td>IRF code</td>
<td>V169</td>
<td>R</td>
<td>0...255</td>
</tr>
<tr>
<td>Unit address of the relay</td>
<td>V200</td>
<td>R, W</td>
<td>1...254</td>
</tr>
<tr>
<td>Data transfer rate (SPA), kbps</td>
<td>V201</td>
<td>R, W</td>
<td>9.6/4.8</td>
</tr>
<tr>
<td>Rear communication</td>
<td>V202</td>
<td>W</td>
<td>1 = Rear connector activated</td>
</tr>
<tr>
<td>Rear communication protocol</td>
<td>V203(3)</td>
<td>R, W</td>
<td>0 = SPA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 = IEC_103</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 = Modbus RTU</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3 = Modbus ASCII</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4 = DNP 3.0 (read-only)</td>
</tr>
<tr>
<td>Connection type</td>
<td>V204</td>
<td>R, W</td>
<td>0 = Loop</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 = Star</td>
</tr>
<tr>
<td>Line-idle state</td>
<td>V205</td>
<td>R, W</td>
<td>0 = Light off</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 = Light on</td>
</tr>
<tr>
<td>Optional communication module</td>
<td>V206</td>
<td>R, W (P)</td>
<td>0 = Not in use</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 = In use</td>
</tr>
<tr>
<td>HMI language set information</td>
<td>V226</td>
<td>R</td>
<td>00...99</td>
</tr>
<tr>
<td>CPU software number</td>
<td>V227</td>
<td>R</td>
<td>1MRS118513</td>
</tr>
<tr>
<td>CPU software revision</td>
<td>V228</td>
<td>R</td>
<td>A...Z</td>
</tr>
<tr>
<td>CPU build number</td>
<td>V229</td>
<td>R</td>
<td>XXX</td>
</tr>
<tr>
<td>DNP protocol name</td>
<td>2V226</td>
<td>R</td>
<td>DNP 3.0</td>
</tr>
<tr>
<td>DNP software number</td>
<td>2V227</td>
<td>R</td>
<td>1MRS118531</td>
</tr>
<tr>
<td>DNP software revision</td>
<td>2V228</td>
<td>R</td>
<td>A...Z</td>
</tr>
<tr>
<td>DNP build number</td>
<td>2V229</td>
<td>R</td>
<td>XXX</td>
</tr>
<tr>
<td>Relay serial number</td>
<td>V230</td>
<td>R</td>
<td>BAxxxxxx</td>
</tr>
<tr>
<td>CPU serial number</td>
<td>V231</td>
<td>R</td>
<td>ACxxxxxx</td>
</tr>
<tr>
<td>DNP serial number</td>
<td>V232</td>
<td>R</td>
<td>AKxxxxxx</td>
</tr>
<tr>
<td>Test date</td>
<td>V235</td>
<td>R</td>
<td>YYMMDD</td>
</tr>
<tr>
<td>Date reading and setting</td>
<td>V250</td>
<td>R, W</td>
<td>YY-MM-DD</td>
</tr>
<tr>
<td>Time reading and setting</td>
<td>V251</td>
<td>R, W</td>
<td>HH.MM;SS.sss</td>
</tr>
</tbody>
</table>

**Notes:**

- **a)** The store counter can be used for monitoring parameter changes, for instance. The store counter is incremented by one on each parameter change via the HMI or serial communication. When the counter reaches its maximum value, it will roll over. If the factory settings are restored, the counter is cleared.
- **b)** In case of a warning, the value 255 is stored in V169. This enables the master to continuously read only V169.
- **c)** If the optional DNP 3.0 module has been installed, the DNP 3.0 communication protocol is automatically selected.
- **d)** If the optional communication module is not installed, a warning of a faulty communication module appears on the LCD together with the fault code.

The measured voltages can be read with parameters **I1...I4**, the positive phase-sequence voltage with parameter **I5**, the negative phase-sequence voltage with parameter **I6** and the status of the digital inputs with parameters **I7...I11**.
Table 5.1.17.-8  Input signals

<table>
<thead>
<tr>
<th>Description</th>
<th>Channel</th>
<th>Parameter (R)</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured phase-to-phase voltage $U_{ab}$</td>
<td>0</td>
<td>I1</td>
<td>$0...2 \times U_n$ (VT)</td>
</tr>
<tr>
<td>Measured phase-to-phase voltage $U_{bc}$</td>
<td>0</td>
<td>I2</td>
<td>$0...2 \times U_n$ (VT)</td>
</tr>
<tr>
<td>Measured phase-to-phase voltage $U_{ca}$</td>
<td>0</td>
<td>I3</td>
<td>$0...2 \times U_n$ (VT)</td>
</tr>
<tr>
<td>Measured phase-to-phase voltage $U_n$</td>
<td>0</td>
<td>I4</td>
<td>$0...200% U_n$ (VT)</td>
</tr>
<tr>
<td>Calculated positive phase-sequence voltage</td>
<td>0</td>
<td>I5</td>
<td>$0...2 \times U_n$ (VT)</td>
</tr>
<tr>
<td>Calculated negative phase-sequence voltage</td>
<td>0</td>
<td>I6</td>
<td>$0...2 \times U_n$ (VT)</td>
</tr>
<tr>
<td>DI1 status</td>
<td>0,2</td>
<td>I7</td>
<td>$0/2^{a)}$</td>
</tr>
<tr>
<td>DI2 status</td>
<td>0,2</td>
<td>I8</td>
<td>$0/2^{a)}$</td>
</tr>
<tr>
<td>DI3 status</td>
<td>0,2</td>
<td>I9</td>
<td>$0/2^{b)(a)}$</td>
</tr>
<tr>
<td>DI4 status</td>
<td>0,2</td>
<td>I10</td>
<td>$0/2^{b)(a)}$</td>
</tr>
<tr>
<td>DI5 status</td>
<td>0,2</td>
<td>I11</td>
<td>$0/2^{b)(a)}$</td>
</tr>
</tbody>
</table>

a) When the value is 1, the digital input is energized.

b) If the optional I/O module has not been installed, a dash is shown on the LCD and "9" when the parameter is read via the SPA bus.

Each protection element has its internal output signal. These signals can be read with parameters $O1...O15$ and the recorded functions with parameters $O61...O75$.

The state of the output contacts can be read or changed with parameters $O41...O49$ and the recorded functions read with parameters $O101...O109$.

Table 5.1.17.-9  Output signals

<table>
<thead>
<tr>
<th>Status of the protection elements</th>
<th>Channel</th>
<th>State of element (R)</th>
<th>Recorded functions (R)</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pickup of element 59P-1</td>
<td>0,1</td>
<td>O1</td>
<td>O61</td>
<td>0/1</td>
</tr>
<tr>
<td>Trip of element 59P-1</td>
<td>0,1</td>
<td>O2</td>
<td>O62</td>
<td>0/1</td>
</tr>
<tr>
<td>Pickup of element 59P-2 or 47</td>
<td>0,1</td>
<td>O3</td>
<td>O63</td>
<td>0/1</td>
</tr>
<tr>
<td>Trip of element 59P-2 or 47</td>
<td>0,1</td>
<td>O4</td>
<td>O64</td>
<td>0/1</td>
</tr>
<tr>
<td>Pickup of element 27P-1</td>
<td>0,1</td>
<td>O5</td>
<td>O65</td>
<td>0/1</td>
</tr>
<tr>
<td>Trip of element 27P-1</td>
<td>0,1</td>
<td>O6</td>
<td>O66</td>
<td>0/1</td>
</tr>
<tr>
<td>Pickup of element 27P-2 or 27D</td>
<td>0,1</td>
<td>O7</td>
<td>O67</td>
<td>0/1</td>
</tr>
<tr>
<td>Trip of element 27P-2 or 27D</td>
<td>0,1</td>
<td>O8</td>
<td>O68</td>
<td>0/1</td>
</tr>
<tr>
<td>Pickup of element 59N-1</td>
<td>0,1</td>
<td>O9</td>
<td>O69</td>
<td>0/1</td>
</tr>
<tr>
<td>Trip of element 59N-1</td>
<td>0,1</td>
<td>O10</td>
<td>O70</td>
<td>0/1</td>
</tr>
</tbody>
</table>
### Status of the protection elements

<table>
<thead>
<tr>
<th>Operation</th>
<th>Channel</th>
<th>State of element (R)</th>
<th>Recorded functions (R)</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pickup of element 59N-2</td>
<td>0,1</td>
<td>O11</td>
<td>O71</td>
<td>0/1</td>
</tr>
<tr>
<td>Trip of element 59N-2</td>
<td>0,1</td>
<td>O12</td>
<td>O72</td>
<td>0/1</td>
</tr>
<tr>
<td>External trip</td>
<td>0,1</td>
<td>O13</td>
<td>O73</td>
<td>0/1</td>
</tr>
<tr>
<td>Trip lockout</td>
<td>0,1</td>
<td>O14</td>
<td>O74</td>
<td>0/1</td>
</tr>
<tr>
<td>CBFAIL trip</td>
<td>0,1</td>
<td>O15</td>
<td>O75</td>
<td>0/1</td>
</tr>
</tbody>
</table>

### Table 5.1.17.-10 Outputs

<table>
<thead>
<tr>
<th>Operation of output contact</th>
<th>Channel</th>
<th>State of output (R, W, P)</th>
<th>Recorded functions (R)</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output PO1</td>
<td>0,2</td>
<td>O41</td>
<td>O101</td>
<td>0/1</td>
</tr>
<tr>
<td>Output PO2</td>
<td>0,2</td>
<td>O42</td>
<td>O102</td>
<td>0/1</td>
</tr>
<tr>
<td>Output PO3(\text{a)})</td>
<td>0,2</td>
<td>O43</td>
<td>O103</td>
<td>0/1(\text{b)})</td>
</tr>
<tr>
<td>Output SO1</td>
<td>0,2</td>
<td>O44</td>
<td>O104</td>
<td>0/1</td>
</tr>
<tr>
<td>Output SO2</td>
<td>0,2</td>
<td>O45</td>
<td>O105</td>
<td>0/1</td>
</tr>
<tr>
<td>Output PO3 (trip lockout)(\text{c)})</td>
<td>0,2</td>
<td>O46</td>
<td>-</td>
<td>0/1(\text{b)})</td>
</tr>
<tr>
<td>Output SO3</td>
<td>0,2</td>
<td>O47</td>
<td>O107</td>
<td>0/1(\text{d)})</td>
</tr>
<tr>
<td>Output SO4</td>
<td>0,2</td>
<td>O48</td>
<td>O108</td>
<td>0/1(\text{d)})</td>
</tr>
<tr>
<td>Output SO5</td>
<td>0,2</td>
<td>O49</td>
<td>O109</td>
<td>0/1(\text{d)})</td>
</tr>
<tr>
<td>Enabling activation of output contacts PO1, PO2, PO3, SO1, SO2, SO3, SO4 and SO5 via the SPA bus</td>
<td>0,2</td>
<td>O51</td>
<td>-</td>
<td>0/1</td>
</tr>
</tbody>
</table>

\(\text{a)}\) State of output when the trip lockout function is not in use.

\(\text{b)}\) Either O43/O103 or O46 is to be used at a time.

\(\text{c)}\) State of output when the trip lockout function is in use.

\(\text{d)}\) If the optional I/O module has not been installed, a dash is shown on the LCD and "9" when the parameter is read via the SPA bus.

Parameters O41...O49 and O51 control the physical output contacts which can be connected to circuit breakers, for instance.
### Parameters for IEC 60870-5-103 remote communication protocol

**Table 5.1.17.-11 Settings**

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter (channel 507)</th>
<th>R, W, P</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit address of the relay</td>
<td>507V200</td>
<td>R, W</td>
<td>1...254</td>
</tr>
<tr>
<td>Data transfer rate (IEC 60870-5-103), kbps</td>
<td>507V201</td>
<td>R, W (P)</td>
<td>9.6/4.8</td>
</tr>
</tbody>
</table>

### Parameters for Modbus remote communication protocol

**Table 5.1.17.-12 Settings**

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter (channel 504)</th>
<th>R, W, P</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>User-defined register 1</td>
<td>504V1</td>
<td>R, W</td>
<td>0...65535&lt;sup&gt;a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>User-defined register 2</td>
<td>504V2</td>
<td>R, W</td>
<td>0...65535&lt;sup&gt;a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>User-defined register 3</td>
<td>504V3</td>
<td>R, W</td>
<td>0...65535&lt;sup&gt;a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>User-defined register 4</td>
<td>504V4</td>
<td>R, W</td>
<td>0...65535&lt;sup&gt;a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>User-defined register 5</td>
<td>504V5</td>
<td>R, W</td>
<td>0...65535&lt;sup&gt;a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>User-defined register 6</td>
<td>504V6</td>
<td>R, W</td>
<td>0...65535&lt;sup&gt;a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>User-defined register 7</td>
<td>504V7</td>
<td>R, W</td>
<td>0...65535&lt;sup&gt;a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>User-defined register 8</td>
<td>504V8</td>
<td>R, W</td>
<td>0...65535&lt;sup&gt;a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>User-defined register 9</td>
<td>504V9</td>
<td>R, W</td>
<td>0...65535&lt;sup&gt;a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>User-defined register 10</td>
<td>504V10</td>
<td>R, W</td>
<td>0...65535&lt;sup&gt;a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>User-defined register 11</td>
<td>504V11</td>
<td>R, W</td>
<td>0...65535&lt;sup&gt;a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>User-defined register 12</td>
<td>504V12</td>
<td>R, W</td>
<td>0...65535&lt;sup&gt;a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>User-defined register 13</td>
<td>504V13</td>
<td>R, W</td>
<td>0...65535&lt;sup&gt;a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>User-defined register 14</td>
<td>504V14</td>
<td>R, W</td>
<td>0...65535&lt;sup&gt;a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>User-defined register 15</td>
<td>504V15</td>
<td>R, W</td>
<td>0...65535&lt;sup&gt;a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>User-defined register 16</td>
<td>504V16</td>
<td>R, W</td>
<td>0...65535&lt;sup&gt;a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Unit address of the relay</td>
<td>504V200</td>
<td>R, W</td>
<td>1...254</td>
</tr>
<tr>
<td>Data transfer rate (Modbus), kbps</td>
<td>504V201</td>
<td>R, W</td>
<td>9.6/4.8/2.4/1.2/0.3</td>
</tr>
<tr>
<td>Modbus link parity</td>
<td>504V220</td>
<td>R, W</td>
<td>0 = even 1 = odd 2 = no parity</td>
</tr>
<tr>
<td>CRC order of Modbus RTU link</td>
<td>504V221</td>
<td>R, W</td>
<td>0 = low/high 1 = high/low</td>
</tr>
</tbody>
</table>

<sup>a)</sup> The default value is 0.
### Parameters for DNP 3.0 remote communication protocol

**Table 5.1.17.-13 Settings**

<table>
<thead>
<tr>
<th>Description</th>
<th>SPA parameter (channel 503)</th>
<th>R, W</th>
<th>Value range</th>
<th>Default</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit address</td>
<td>503V1</td>
<td>R, W</td>
<td>0...65532</td>
<td>1</td>
<td>Address of the relay in the DNP 3.0 network</td>
</tr>
<tr>
<td>Master address</td>
<td>503V2</td>
<td>R, W</td>
<td>0...65532</td>
<td>2</td>
<td>Address of the master station (destination address for unsolicited responses)</td>
</tr>
<tr>
<td>Primary data link timeout</td>
<td>503V3</td>
<td>R, W</td>
<td>0 = no data link timeout used 1...65535 ms</td>
<td>0</td>
<td>Used when the relay sends data using service 3</td>
</tr>
<tr>
<td>Primary data link layer retransmission count</td>
<td>503V4</td>
<td>R, W</td>
<td>0...255</td>
<td>0</td>
<td>Number of retransmissions on data link layer</td>
</tr>
<tr>
<td>Application layer confirmation timeout</td>
<td>503V6</td>
<td>R, W</td>
<td>0...65535 ms</td>
<td>5000</td>
<td>Used when the relay sends messages with confirmation request</td>
</tr>
<tr>
<td>Application layer retransmission count</td>
<td>503V7</td>
<td>R, W</td>
<td>0...255</td>
<td>0</td>
<td>Number of retransmissions on the application layer when the relay sends messages with confirmation request</td>
</tr>
<tr>
<td>Confirmation on application layer</td>
<td>503V9</td>
<td>R, W</td>
<td>0 = enabled only for event messages 1 = enabled for all messages</td>
<td>0</td>
<td>Used to enforce inclusion of confirmation request in all application messages (DNP 3.0 standard requires inclusion of confirmation request in event messages only)</td>
</tr>
<tr>
<td>Default variation of binary input objects</td>
<td>503V10</td>
<td>R, W</td>
<td>1...2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Default variation of binary input change event objects</td>
<td>503V11</td>
<td>R, W</td>
<td>1...2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Default variation of analog input objects</td>
<td>503V15</td>
<td>R, W</td>
<td>1...4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Default variation of analog input change event objects</td>
<td>503V16</td>
<td>R, W</td>
<td>1...4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Default variation of counter objects</td>
<td>503V13</td>
<td>R, W</td>
<td>1...2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Default variation of counter change event objects</td>
<td>503V14</td>
<td>R, W</td>
<td>1, 2, 5, 6</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Default variation of frozen counter objects</td>
<td>503V30</td>
<td>R, W</td>
<td>1, 2, 5, 6</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Class 1 event delay</td>
<td>503V18</td>
<td>R, W</td>
<td>0...255 s</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Class 1 event count</td>
<td>503V19</td>
<td>R, W</td>
<td>0...255 s</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Class 2 event delay</td>
<td>503V20</td>
<td>R, W</td>
<td>0...255 s</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Class 2 event count</td>
<td>503V21</td>
<td>R, W</td>
<td>0...255 s</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Class 3 event delay</td>
<td>503V22</td>
<td>R, W</td>
<td>0...255 s</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Class 3 event count</td>
<td>503V23</td>
<td>R, W</td>
<td>0...255 s</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Unsolicited reporting mode</td>
<td>503V24</td>
<td>R, W</td>
<td>0 = UR disabled 1 = immediate 2 = empty UR 3 = empty UR and enable UR</td>
<td>0</td>
<td>Refer to Unsolicited reporting pick up in Section 5.1.16.4. Specific DNP features.</td>
</tr>
</tbody>
</table>
### Measurements

**Table 5.1.17.-14 Measured values**

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter (channel 0)</th>
<th>R, W, P</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>One-minute average voltage value</td>
<td>V61</td>
<td>R</td>
<td>0...2 × Un (VT)³⁰</td>
</tr>
<tr>
<td>Average voltage value during the specified time range</td>
<td>V62</td>
<td>R</td>
<td>0...2 × Un (VT)³⁰</td>
</tr>
<tr>
<td>Maximum one-minute average voltage value during the specified time range</td>
<td>V63</td>
<td>R</td>
<td>0...2 × Un (VT)³⁰</td>
</tr>
<tr>
<td>Maximum voltage of the three phase-to-phase voltages since last reset</td>
<td>V64</td>
<td>R</td>
<td>0...2 × Un (VT)</td>
</tr>
<tr>
<td>Date of maximum voltage</td>
<td>V65</td>
<td>R</td>
<td>YY-MM-DD</td>
</tr>
<tr>
<td>Time of maximum voltage</td>
<td>V66</td>
<td>R</td>
<td>hh.mm;ss.sss</td>
</tr>
<tr>
<td>Minimum voltage of three phase-to-phase voltages since last reset</td>
<td>V67</td>
<td>R</td>
<td>0...2 × Un (VT)</td>
</tr>
<tr>
<td>Date of minimum voltage</td>
<td>V68</td>
<td>R</td>
<td>YY-MM-DD</td>
</tr>
<tr>
<td>Time of minimum voltage</td>
<td>V69</td>
<td>R</td>
<td>hh.mm;ss.sss</td>
</tr>
</tbody>
</table>

³⁰ If the demand value is reset and the specified time has not elapsed, dashes are shown on the LCD and “999” when the parameter is read via the SPA bus.

---

### Event codes

Special codes are determined to represent certain events, such as pickup and tripping of protection elements and different states of output signals.
The events are stored in the event buffer of the relay. The maximum capacity of the buffer is 100 events. Under normal conditions the buffer is empty.

The contents of the buffer can be read using the \texttt{L} command, 5 events at a time. Using the \texttt{L} command erases the previously read events from the buffer, with the exception of events E50 and E51 which have to be reset by using the \texttt{C} command. If a fault occurs and reading fails for example in data communication, the events can be re-read by using the \texttt{B} command. If needed, the \texttt{B} command can also be repeated.

The \texttt{L} and \texttt{B} commands are only available on channel 0.

Events to be included in the event reporting are marked with the multiplier 1. The event mask is formed by the sum of the weighting factors of all those events which are to be included in event reporting.

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|}
\hline
Event mask & Code & Setting range & Default setting \\
\hline
V155 & E31...E36 & 0...63 & 1 \\
1V155 & 1E1...1E16 & 0...65535 & 21845 \\
1V156 & 1E17...1E24 & 0...255 & 85 \\
1V157 & 1E25...1E30 & 0...63 & 1 \\
2V155 & 2E1...2E16 & 0...65535 & 3 \\
2V156 & 2E17...2E26 & 0...1023 & 0 \\
\hline
\end{tabular}
\caption{Event masks}
\end{table}

\section*{Channel 0}

Events always included in the event reporting:

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|}
\hline
Channel & Event & Description \\
\hline
0 & E1 & IRF \\
0 & E2 & IRF disappeared \\
0 & E3 & Warning \\
0 & E4 & Warning disappeared \\
\hline
\end{tabular}
\caption{Event codes E1...E4}
\end{table}

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|}
\hline
Channel & Event & Description \\
\hline
0 & E50 & Relay restart \\
0 & E51 & Event buffer overflow \\
\hline
\end{tabular}
\caption{Event codes E50...E51}
\end{table}

Events possible to mask out:
### Table 5.1.17.1.-4 Event codes E31...E36

<table>
<thead>
<tr>
<th>Channel</th>
<th>Event</th>
<th>Description</th>
<th>Weighting factor</th>
<th>Default value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>E31</td>
<td>Disturbance recorder triggered</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>E32</td>
<td>Disturbance recorder memory cleared</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>E33</td>
<td>HMI Setting password opened</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>E34</td>
<td>HMI Setting password closed</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>E35</td>
<td>HMI Communication password opened</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>E36</td>
<td>HMI Communication password closed</td>
<td>32</td>
<td>0</td>
</tr>
</tbody>
</table>

Default value of event mask V155 1

### Channel 1

### Table 5.1.17.1.-5 Event codes E1...E16

<table>
<thead>
<tr>
<th>Channel</th>
<th>Event</th>
<th>Description</th>
<th>Weighting factor</th>
<th>Default value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>E1</td>
<td>Pickup signal from element 59P-1 activated</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>E2</td>
<td>Pickup signal from element 59P-1 reset</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>E3</td>
<td>Trip signal from element 59P-1 activated</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>E4</td>
<td>Trip signal from element 59P-1 reset</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>E5</td>
<td>Pickup signal from element 59P-2 or 47 activated</td>
<td>16</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>E6</td>
<td>Pickup signal from element 59P-2 or 47 reset</td>
<td>32</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>E7</td>
<td>Trip signal from element 59P-2 or 47 activated</td>
<td>64</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>E8</td>
<td>Trip signal from element 59P-2 or 47 reset</td>
<td>128</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>E9</td>
<td>Pickup signal from element 27P-1 activated</td>
<td>256</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>E10</td>
<td>Pickup signal from element 27P-1 reset</td>
<td>512</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>E11</td>
<td>Trip signal from element 27P-1 activated</td>
<td>1024</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>E12</td>
<td>Trip signal from element 27P-1 reset</td>
<td>2048</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>E13</td>
<td>Pickup signal from element 27P-2 or 27D activated</td>
<td>4096</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>E14</td>
<td>Pickup signal from element 27P-2 or 27D reset</td>
<td>8192</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>E15</td>
<td>Trip signal from element 27P-2 or 27D activated</td>
<td>16384</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>E16</td>
<td>Trip signal from element 27P-2 or 27D reset</td>
<td>32768</td>
<td>0</td>
</tr>
</tbody>
</table>

Default value of event mask 1V155 21845

### Table 5.1.17.1.-6 Event codes E17...E24

<table>
<thead>
<tr>
<th>Channel</th>
<th>Event</th>
<th>Description</th>
<th>Weighting factor</th>
<th>Default value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>E17</td>
<td>Pickup signal from element 59N-1 activated</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>E18</td>
<td>Pickup signal from element 59N-1 reset</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>E19</td>
<td>Trip signal from element 59N-1 activated</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>E20</td>
<td>Trip signal from element 59N-2 reset</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>E21</td>
<td>Pickup signal from element 59N-2 activated</td>
<td>16</td>
<td>1</td>
</tr>
</tbody>
</table>
### Channel 1

<table>
<thead>
<tr>
<th>Event</th>
<th>Description</th>
<th>Weighting factor</th>
<th>Default value</th>
</tr>
</thead>
<tbody>
<tr>
<td>E22</td>
<td>Pickup signal from element 59N-2 reset</td>
<td>32</td>
<td>0</td>
</tr>
<tr>
<td>E23</td>
<td>Trip signal from element 59N-2 activated</td>
<td>64</td>
<td>1</td>
</tr>
<tr>
<td>E24</td>
<td>Trip signal from element 59N-2 reset</td>
<td>128</td>
<td>0</td>
</tr>
</tbody>
</table>

Default value of event mask 1V156 85

#### Table 5.1.17.1.-7 Event codes E25...E30

<table>
<thead>
<tr>
<th>Event</th>
<th>Description</th>
<th>Weighting factor</th>
<th>Default value</th>
</tr>
</thead>
<tbody>
<tr>
<td>E25</td>
<td>Trip lockout activated</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>E26</td>
<td>Trip lockout reset</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>E27</td>
<td>External trip activated</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>E28</td>
<td>External trip reset</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>E29</td>
<td>CBFAIL activated</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>E30</td>
<td>CBFAIL reset</td>
<td>32</td>
<td>0</td>
</tr>
</tbody>
</table>

Default value of event mask 1V157 1

### Channel 2

#### Table 5.1.17.1.-8 Event codes E1...E16

<table>
<thead>
<tr>
<th>Event</th>
<th>Description</th>
<th>Weighting factor</th>
<th>Default value</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>PO1 activated</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>E2</td>
<td>PO1 reset</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>E3</td>
<td>PO2 activated</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>E4</td>
<td>PO2 reset</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>E5</td>
<td>PO3 activated</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>E6</td>
<td>PO3 reset</td>
<td>32</td>
<td>0</td>
</tr>
<tr>
<td>E7</td>
<td>SO1 activated</td>
<td>64</td>
<td>0</td>
</tr>
<tr>
<td>E8</td>
<td>SO1 reset</td>
<td>128</td>
<td>0</td>
</tr>
<tr>
<td>E9</td>
<td>SO2 activated</td>
<td>256</td>
<td>0</td>
</tr>
<tr>
<td>E10</td>
<td>SO2 reset</td>
<td>512</td>
<td>0</td>
</tr>
<tr>
<td>E11</td>
<td>SO3 activated</td>
<td>1024</td>
<td>0</td>
</tr>
<tr>
<td>E12</td>
<td>SO3 reset</td>
<td>2048</td>
<td>0</td>
</tr>
<tr>
<td>E13</td>
<td>SO4 activated</td>
<td>4096</td>
<td>0</td>
</tr>
<tr>
<td>E14</td>
<td>SO4 reset</td>
<td>8192</td>
<td>0</td>
</tr>
<tr>
<td>E15</td>
<td>SO5 activated</td>
<td>16384</td>
<td>0</td>
</tr>
<tr>
<td>E16</td>
<td>SO5 reset</td>
<td>32768</td>
<td>0</td>
</tr>
</tbody>
</table>

Default value of event mask 2V155 3
### Table 5.1.17.1.-9 Event codes E17...E26

<table>
<thead>
<tr>
<th>Channel</th>
<th>Event</th>
<th>Description</th>
<th>Weighting factor</th>
<th>Default value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>E17</td>
<td>DI1 activated</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>E18</td>
<td>DI1 deactivated</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>E19</td>
<td>DI2 activated</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>E20</td>
<td>DI2 deactivated</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>E21</td>
<td>DI3 activated</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>E22</td>
<td>DI3 deactivated</td>
<td>32</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>E23</td>
<td>DI4 activated</td>
<td>64</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>E24</td>
<td>DI4 deactivated</td>
<td>128</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>E25</td>
<td>DI5 activated</td>
<td>256</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>E26</td>
<td>DI5 deactivated</td>
<td>512</td>
<td>0</td>
</tr>
</tbody>
</table>

Default value of event mask 2V156 0

### 5.1.18. Self-supervision (IRF) system

The relay is provided with an extensive self-supervision system which continuously supervises the software and the electronics of the relay. It handles run-time fault situations and informs the user about an existing fault via a LED on the HMI and a text message on the LCD. The fault codes can also be read via serial communication. There are two types of fault targets: IRF targets and warnings.

#### Internal relay fault

When an internal relay fault preventing relay operation is detected, the relay first tries to eliminate the fault by restarting. Only after the fault is found to be permanent, the green target LED (ready) begins to flash and the self-supervision output contact is activated. All other output contacts are returned to the initial state and locked for the internal relay fault. Further, a fault target message appears on the LCD, including a fault code.

IRF targets have the highest priority on the HMI. None of the other HMI targets can override the IRF target. As long as the green target LED (ready) is flashing, the fault target cannot be cleared. In case an internal fault disappears, the green target LED (ready) stops flashing and the relay is returned to the normal service state, but the fault target message remains on the LCD until manually cleared.

The IRF code indicates the type of internal relay fault. When a fault appears, the code is to be recorded and stated when ordering service. The fault codes are listed in the following table:
### Table 5.1.18-1 IRF codes

<table>
<thead>
<tr>
<th>Fault code</th>
<th>Type of fault</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Error in output relay PO1</td>
</tr>
<tr>
<td>5</td>
<td>Error in output relay PO2</td>
</tr>
<tr>
<td>6</td>
<td>Error in output relay PO3</td>
</tr>
<tr>
<td>7</td>
<td>Error in output relay SO1</td>
</tr>
<tr>
<td>8</td>
<td>Error in output relay SO2</td>
</tr>
<tr>
<td>9</td>
<td>Error in the enable signal for output relay PO1, PO2, SO1 or SO2</td>
</tr>
<tr>
<td>10, 11, 12</td>
<td>Error in the feedback, enable signal or output relay PO1, PO2, SO1 or SO2</td>
</tr>
<tr>
<td>13</td>
<td>Error in optional output relay SO3</td>
</tr>
<tr>
<td>14</td>
<td>Error in optional output relay SO4</td>
</tr>
<tr>
<td>15</td>
<td>Error in optional output relay SO5</td>
</tr>
<tr>
<td>16</td>
<td>Error in the enable signal for optional output relay SO3, SO4 or SO5</td>
</tr>
<tr>
<td>17, 18, 19</td>
<td>Error in the feedback, enable signal or optional output relay SO3, SO4 or SO5</td>
</tr>
<tr>
<td>20, 21</td>
<td>Auxiliary voltage dip</td>
</tr>
<tr>
<td>30</td>
<td>Faulty program memory</td>
</tr>
<tr>
<td>50, 59</td>
<td>Faulty work memory</td>
</tr>
<tr>
<td>51, 52, 53&lt;sup&gt;a)&lt;/sup&gt;, 54, 56</td>
<td>Faulty parameter memory&lt;sup&gt;b)&lt;/sup&gt;</td>
</tr>
<tr>
<td>55</td>
<td>Faulty parameter memory, calibration parameters</td>
</tr>
<tr>
<td>80</td>
<td>Optional I/O module missing</td>
</tr>
<tr>
<td>81</td>
<td>Optional I/O module unknown</td>
</tr>
<tr>
<td>82</td>
<td>Optional I/O module configuration error</td>
</tr>
<tr>
<td>85</td>
<td>Power supply module faulty</td>
</tr>
<tr>
<td>86</td>
<td>Power supply module unknown</td>
</tr>
<tr>
<td>90</td>
<td>Hardware configuration error</td>
</tr>
<tr>
<td>95</td>
<td>Communication module unknown</td>
</tr>
<tr>
<td>104</td>
<td>Faulty configuration set (for IEC 60870-5-103)</td>
</tr>
<tr>
<td>131, 139, 195, 203, 222, 223</td>
<td>Internal reference voltage error</td>
</tr>
<tr>
<td>253</td>
<td>Error in the measuring unit</td>
</tr>
</tbody>
</table>

<sup>a</sup>) Can be corrected by restoring factory settings for CPU.<br>
<sup>b</sup>) All settings will be zero during the fault.

For further information on internal relay faults, refer to the Operator’s Manual.

## Warnings

In case of a warning, the relay continues to operate except for those protection functions possibly affected by the fault, and the green target LED (ready) remains lit as during normal operation. Further, a fault target message, which depending on the type of fault includes a fault code, appears on the LCD. If more than one type of fault occur at the same time, one single numeric code which indicates all the faults is displayed. The fault target message cannot be manually cleared but it disappears with the fault.
When a fault appears, the fault target message is to be recorded and stated when ordering service. The fault codes are listed in the following table:

**Table 5.1.18.-2 Warning codes**

<table>
<thead>
<tr>
<th>Fault</th>
<th>Weight value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery low</td>
<td>1</td>
</tr>
<tr>
<td>Trip-circuit supervision(^a)</td>
<td>2</td>
</tr>
<tr>
<td>Power supply module temperature high</td>
<td>4</td>
</tr>
<tr>
<td>Communication module faulty or missing</td>
<td>8</td>
</tr>
<tr>
<td>DNP 3.0 configuration error(^b)</td>
<td>16</td>
</tr>
<tr>
<td>DNP 3.0 module faulty</td>
<td>32</td>
</tr>
<tr>
<td>(\sum)</td>
<td>63</td>
</tr>
</tbody>
</table>

\(^a\) The external fault warning can be routed to SO2 with SGF1/8.

\(^b\) Can be corrected by restoring factory settings for DNP

For further information on warnings, refer to the Operator’s Manual.

### 5.1.19. Relay parameterization

The parameters of the relay can be set either locally via the HMI or externally via serial communication with Relay Setting Tool.

#### Local parameterization

When the parameters are set locally, the setting parameters can be chosen via the hierarchical menu structure. The wanted language can be selected for parameter descriptions. Refer to the Operator’s Manual for further information.

#### External parameterization

Relay Setting Tool is used for parameterizing the relay units. Adjusting the parameter values using Relay Setting Tool is done off-line, after which the parameters can be downloaded to the relay via a communication port.

### 5.2. Design description

#### 5.2.1. Input/output connections

All external circuits are connected to the terminals on the rear panel of the relay.

- Terminals X2.1-_ are dimensioned for one 0.5...6.0 mm\(^2\) (AWG 20-8) wire or two max 2.5 mm\(^2\) (AWG 24-12) wires
- Terminals X3.1-_ and X4.1-_ are dimensioned for one 0.2...2.5 mm\(^2\) wire or two 0.2...1.0 mm\(^2\) (AWG 24-16) wires.
The energizing phase-to-phase voltages of the relay are connected to terminals:

- X2.1/1-2
- X2.1/3-4
- X2.1/5-6

For inputs for phase-to-phase voltages and residual voltage, refer to Table 5.2.1.-1.

The relay can also be used in single or two-phase applications by leaving one or two energizing inputs unoccupied. However, at least terminals X2.1/1-2 must be connected.

The energizing residual voltage of the relay is connected to terminals X2.1/7-8, see Table 5.2.1.-1.

The input terminals of the optional I/O module are located on connection socket X3.1, see Table 5.2.1.-4 and Table 5.2.1.-5.

When connection socket X3.1 is used, the optional I/O module must be installed.

The nominal voltage (100/110/115/120 V) of the matching transformers has to be selected with SPA parameter V134.

Terminals X4.1/21-24 and X3.1/1-6 (optional) are digital input terminals, see Table 5.2.1.-5. The digital inputs can be used to generate a blocking signal, to unlatch output contacts or for remote control of relay settings, for instance. The requested functions are selected separately for each input in switchgroups SGB1...5. The digital inputs can also be used to trigger the disturbance recorder; this function is selected with SPA parameter V243.

The auxiliary voltage of the relay is connected to terminals X4.1/1-2, see Table 5.2.1.-2. At DC supply, the positive lead is connected to terminal X4.1/1. The permitted auxiliary voltage range of the relay is marked on the front panel of the relay under the handle of the plug-in unit.

Output contacts PO1, PO2 and PO3 are heavy-duty trip contacts capable of controlling most circuit breakers, see Table 5.2.1.-4. The signals to be routed to PO1...PO3 are selected with the switches of switchgroups SGR1...SGR3. On delivery from the factory, the trip signals from all the protection elements are routed to PO1, PO2 and PO3.

Output contacts SO1...SO5 can be used for signalling on pickup and tripping of the relay, see Table 5.2.1.-4. Output contacts SO3...SO5 are optional and available only if the optional I/O module has been installed. The signals to be routed to SO1...SO5...
are selected with the switches of switchgroups SGR4...SGR8. On delivery from the factory, the pickup and alarm signals from all the protection elements are routed to SO1 and SO2.

The IRF contact functions as an output contact for the self-supervision system of the voltage relay, see Table 5.2.1.-3. Under normal operating conditions, the relay is energized and the contact is closed (X4.1/3-5). When a fault is detected by the self-supervision system or the auxiliary voltage is disconnected, the output contact drops off and the contact closes (X4.1/3-4).

Fig. 5.2.1.-1...Fig. 5.2.1.-3 present a rear view of the relay, showing four connecting sockets: one for measuring transformers, one for the optional I/O module, one for power supply and one for optional serial communication.

Fig. 5.2.1.-1 Rear view of the relay with the fibre-optic communication module for plastic and glass fibre
Fig. 5.2.1.-2  Rear view of the relay with the RS-485 communication module
Fig. 5.2.1.-3 Rear view of the relay with the DNP 3.0 communication module for RS-485

The wiring of $U_{ab}$, $U_{bc}$, and $U_{ca}$ has to be done identically for each of the matching transformer used.

<table>
<thead>
<tr>
<th>Table 5.2.1.-1</th>
<th>Inputs for phase-to-phase voltages and residual voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal</td>
<td>Function</td>
</tr>
<tr>
<td>X2.1-1</td>
<td>REU610AVVxxxxx</td>
</tr>
<tr>
<td>X2.1-2</td>
<td>$U_{ab}$</td>
</tr>
</tbody>
</table>
The wiring of $U_{ab}$, $U_{bc}$ and $U_{ca}$ has to be done identically for each of the matching transformer used.

### Table 5.2.1.-2 Auxiliary supply voltage

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>X4.1-1</td>
<td>Input, +</td>
<td>Input, +</td>
</tr>
<tr>
<td>X4.1-2</td>
<td>Input, -</td>
<td>Input, -</td>
</tr>
</tbody>
</table>

### Table 5.2.1.-3 IRF contact

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>X4.1-3</td>
<td>IRF, common</td>
<td>IRF, common</td>
</tr>
<tr>
<td>X4.1-4</td>
<td>Closed; IRF, or $U_{aux}$ disconnected</td>
<td>Closed; IRF, or $U_{aux}$ disconnected</td>
</tr>
<tr>
<td>X4.1-5</td>
<td>Closed; no IRF, and $U_{aux}$ connected</td>
<td>Closed; no IRF, and $U_{aux}$ connected</td>
</tr>
</tbody>
</table>

### Table 5.2.1.-4 Output contacts

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>X3.1-16</td>
<td>SO5, common&lt;sup&gt;a)&lt;/sup&gt;</td>
<td>SO5, common&lt;sup&gt;a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>X3.1-17</td>
<td>SO5, NC&lt;sup&gt;a)&lt;/sup&gt;</td>
<td>SO5, NC&lt;sup&gt;a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>X3.1-18</td>
<td>SO5, NO&lt;sup&gt;a)&lt;/sup&gt;</td>
<td>SO5, NO&lt;sup&gt;a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>X3.1-19</td>
<td>SO4, common&lt;sup&gt;a)&lt;/sup&gt;</td>
<td>SO4, common&lt;sup&gt;a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>X3.1-20</td>
<td>SO4, NC&lt;sup&gt;a)&lt;/sup&gt;</td>
<td>SO4, NC&lt;sup&gt;a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>X3.1-21</td>
<td>SO4, NO&lt;sup&gt;a)&lt;/sup&gt;</td>
<td>SO4, NO&lt;sup&gt;a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>X3.1-22</td>
<td>SO3, common&lt;sup&gt;a)&lt;/sup&gt;</td>
<td>SO3, common&lt;sup&gt;a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>X3.1-23</td>
<td>SO3, NC&lt;sup&gt;a)&lt;/sup&gt;</td>
<td>SO3, NC&lt;sup&gt;a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>X3.1-24</td>
<td>SO3, NO&lt;sup&gt;a)&lt;/sup&gt;</td>
<td>SO3, NO&lt;sup&gt;a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>X4.1-6</td>
<td>SO2, common</td>
<td>SO2, common</td>
</tr>
<tr>
<td>X4.1-7</td>
<td>SO2, NC</td>
<td>SO2, NC</td>
</tr>
<tr>
<td>X4.1-8</td>
<td>SO2, NO</td>
<td>SO2, NO</td>
</tr>
<tr>
<td>X4.1-9</td>
<td>SO1, common</td>
<td>SO1, common</td>
</tr>
<tr>
<td>X4.1-10</td>
<td>SO1, NC</td>
<td>SO1, NC</td>
</tr>
<tr>
<td>X4.1-11</td>
<td>SO1, NO</td>
<td>SO1, NO</td>
</tr>
<tr>
<td>X4.1-12</td>
<td>PO3 (trip lockout relay), NO</td>
<td>PO3 (trip lockout relay), NO</td>
</tr>
<tr>
<td>X4.1-13</td>
<td>PO2, NO</td>
<td>PO2, NO</td>
</tr>
<tr>
<td>X4.1-14</td>
<td>PO2, NO</td>
<td>PO2, NO</td>
</tr>
</tbody>
</table>
### Serial communication connections

The optical front connection of the relay is used to connect the relay to the SPA bus via the front communication cable, refer to Section 6. Ordering information. If a PC compatible to the IrDA® Standard specifications is used, wireless communication is possible as well. The maximum wireless operating distance depends on the transceiver of the PC.

Rear communication of the relay is optional and the physical connection varies with the communication option.

### Plastic fibre-optic connection

If the relay is provided with the optional fibre-optic communication module for plastic fibre, the fibre-optic cables are connected to terminals as follows:

#### Table 5.2.2–1  Plastic fibre-optic rear connection

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>X5.3-TX</td>
<td>Transmitter</td>
</tr>
<tr>
<td>X5.3-RX</td>
<td>Receiver</td>
</tr>
</tbody>
</table>
RS-485 connection

If the relay is provided with the optional RS-485 communication module, the cable is connected to terminals X5.5/1-2 and X5.5/4-6. The connection socket is a 6-pin header-type socket and the terminals are of screw compression type.

The RS-485 communication module follows the TIA/EIA-485 standard and is intended to be used in a daisy-chain bus wiring scheme with 2-wire, half-duplex, multi-point communication.

The maximum number of devices (nodes) connected to the bus where the relay is being used is 32, and the maximum length of the bus is 1200 meters.

When connecting the relay to the bus, a quality twisted pair shielded cable is to be used. The conductors of the pair are connected to A and B. If signal ground is being used for balancing potential differences between devices/nodes, a quality dual twisted pair shielded cable is to be used. In this case, one pair is connected to A and B, and one of the conductors of the other pair to signal ground. When connecting one device to another, A is connected to A and B to B.

The cable shield is to be connected directly to ground (shield GND) in one point/device of the bus. Other devices connected to the bus should have the cable shield connected to ground via a capacitor (shield GND via capacitor).

Signal ground can only be used for balancing potential differences between devices/nodes if all devices connected to the bus have isolated RS-485 interfaces.

The RS-485 communication module is provided with jumpers for setting bus termination and fail-safe biasing. The bus is to be terminated at both ends, which can be done by using the internal termination resistor on the communication module. The termination resistor is selected by setting jumper X5 to the ON position. If the internal termination resistor of 120 Ω is used, the impedance of the cable should be the same.

The bus is to be biased at one end to ensure fail-safe operation, which can be done using the pull-up and pull-down resistors on the communication module. The pull-up and pull-down resistors are selected by setting jumpers X3 and X4 to the ON position.

The jumpers have been set to no termination (X5 in the OFF position) and no biasing (X3 and X4 in the OFF position) as default.
Fig. 5.2.2.-1 Jumper location on the RS-485 communication module

### Table 5.2.2.-2 RS-485 rear connector

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>X5.5-6</td>
<td>Data A (+)</td>
</tr>
<tr>
<td>X5.5-5</td>
<td>Data B (-)</td>
</tr>
<tr>
<td>X5.5-4</td>
<td>Signal GND (for potential balancing)</td>
</tr>
<tr>
<td>X5.5-3</td>
<td>-</td>
</tr>
<tr>
<td>X5.5-2</td>
<td>Shield GND (via capacitor)</td>
</tr>
<tr>
<td>X5.5-1</td>
<td>Shield GND</td>
</tr>
</tbody>
</table>

**Combined fibre-optic connection (plastic and glass)**

If the relay is provided with the optional fibre-optic communication module for plastic and glass fibre, the plastic fibre-optic cables are connected to terminals X5.3-RX (Receiver) and X5.3-TX (Transmitter) and the glass fibre-optic cables to terminals X5.4-RX (Receiver) and X5.4-TX (Transmitter).

The fibre-optic interface is selected with jumpers X6 and X2 located on the PCB of the communication module (see Fig. 5.2.2.-2).
### Table 5.2.2.-3 Transmitter selection

<table>
<thead>
<tr>
<th>Transmitter</th>
<th>Position of jumper X6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic</td>
<td>X5.3-TX</td>
</tr>
<tr>
<td>Glass</td>
<td>X5.4-TX</td>
</tr>
</tbody>
</table>

### Table 5.2.2.-4 Receiver selection

<table>
<thead>
<tr>
<th>Transmitter</th>
<th>Position of jumper X2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic</td>
<td>X5.3-RX</td>
</tr>
<tr>
<td>Glass</td>
<td>X5.4-RX</td>
</tr>
</tbody>
</table>

### Table 5.2.2.-5 Fibre-optic rear connectors (plastic and glass)

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>X5.3-TX</td>
<td>Transmitter for plastic fibre</td>
</tr>
<tr>
<td>X5.3-RX</td>
<td>Receiver for plastic fibre</td>
</tr>
<tr>
<td>X5.4-TX</td>
<td>Transmitter for glass fibre</td>
</tr>
<tr>
<td>X5.4-RX</td>
<td>Receiver for glass fibre</td>
</tr>
</tbody>
</table>

**RS-485 connection for the DNP 3.0 communication module**

If the relay is provided with the optional DNP 3.0 communication module, the cable is connected to terminals X5.8/1-2 and X5.8/4-8. The connection socket is a 8-pin header-type socket and the terminals are of screw compression type.
The DNP communication module follows the DNP standard and is intended to be used in a daisy-chain bus wiring scheme with 2- or 4-wire, half-duplex, multi-point communication.

The maximum number of devices (nodes) connected to the bus where the relay is being used is 32, and the maximum length of the bus is 1200 meters in optimum conditions and with slow communication speed.

When connecting the relay to the bus, a quality twisted pair shielded cable is to be used. The conductors of the pair are connected to A and B. If signal ground is being used for balancing potential differences between devices/nodes, a quality dual twisted pair shielded cable is to be used. In this case, one pair is connected to A and B, and one of the conductors of the other pair to signal ground. When connecting one device to another, A is connected to A and B to B.

When using a 4-wire bus, one pair is connected to +RX and -RX and the other to +TX and -TX. If signal ground is being used, a quality cable with three or several pairs is to be used and one of the conductors of a pair connected to signal ground.

The cable shield is to be connected directly to ground (shield GND) in one point/device of the bus. Other devices connected to the bus should have the cable shield connected to ground via a capacitor (shield GND via capacitor).

Signal ground can only be used for balancing potential differences between devices/nodes if all devices connected to the bus have isolated DNP interfaces.

The DNP communication module is provided with jumpers for setting bus termination and fail-safe biasing. The bus is to be terminated at both ends, which can be done by using the internal termination resistor on the DNP communication module. The termination resistor is selected by setting jumper X6 or/and X12 to the ON position. If the internal termination resistor of 120Ω is used, the impedance of the cable should be the same.

The bus is to be biased at one end to ensure fail-safe operation, which can be done using the pull-up and pull-down resistors on the communication module. The pull-up and pull-down resistors are selected by setting jumpers X8, X7, X13 and X11 to the ON position.

The 2-wire bus is selected by default (jumper X14) without termination or biasing. The jumpers X6, X7, X8 and X12 are in OFF position. The jumpers X11 and X13 are in ON position.
### Table 5.2.2.-6  RS-485 rear connector (DNP 3.0)

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>X5.8-8</td>
<td>Data A (+ RX)</td>
</tr>
<tr>
<td>X5.8-7</td>
<td>Data B (- RX)</td>
</tr>
<tr>
<td>X5.8-6</td>
<td>Data A (+ TX)</td>
</tr>
<tr>
<td>X5.8-5</td>
<td>Data B (- TX)</td>
</tr>
<tr>
<td>X5.8-4</td>
<td>Signal GND (for potential balancing)</td>
</tr>
<tr>
<td>X5.8-3</td>
<td>-</td>
</tr>
<tr>
<td>X5.8-2</td>
<td>Shield GND (via capacitor)</td>
</tr>
<tr>
<td>X5.8-1</td>
<td>Shield GND</td>
</tr>
</tbody>
</table>

### Table 5.2.2.-7  Jumper numbering

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Function</th>
<th>Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>X8</td>
<td>Pull-up</td>
<td>Data A (+ TX)</td>
</tr>
<tr>
<td>X6</td>
<td>Termination</td>
<td>TX</td>
</tr>
<tr>
<td>X7</td>
<td>Pull-down</td>
<td>Data B (- TX)</td>
</tr>
<tr>
<td>X13</td>
<td>Pull-up</td>
<td>Data A (+ RX)</td>
</tr>
<tr>
<td>X12</td>
<td>Termination</td>
<td>RX</td>
</tr>
<tr>
<td>X11</td>
<td>Pull-down</td>
<td>Data B (- RX)</td>
</tr>
<tr>
<td>X14</td>
<td>4-wire/2-wire</td>
<td>-</td>
</tr>
</tbody>
</table>

**Fig. 5.2.2.-3**  Jumper location on the DNP 3.0 communication module
5.2.3. Technical data

Table 5.2.3.-1 Dimensions (for dimension drawings, refer to the Installation Manual)

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width, frame</td>
<td>177 mm, case 164 mm</td>
</tr>
<tr>
<td>Height, frame</td>
<td>177 mm (4U), case 160 mm</td>
</tr>
<tr>
<td>Depth, case</td>
<td>149.3 mm</td>
</tr>
<tr>
<td>Weight of relay</td>
<td>~3.5 kg</td>
</tr>
<tr>
<td>Weight of spare</td>
<td>~1.8 kg</td>
</tr>
</tbody>
</table>

Table 5.2.3.-2 Power supply

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$U_{aux}$ rated</td>
<td>$U_r = 100/110/120/220/240$ V AC</td>
</tr>
<tr>
<td></td>
<td>$U_r = 110/125/220/250$ V DC</td>
</tr>
<tr>
<td>$U_{aux}$ variation (temporary)</td>
<td>85...110% of $U_r$ (AC)</td>
</tr>
<tr>
<td></td>
<td>80...120% of $U_r$ (DC)</td>
</tr>
<tr>
<td>Burden of auxiliary voltage</td>
<td>&lt;9 W/13 W</td>
</tr>
<tr>
<td>Ripple in the DC auxiliary</td>
<td>Max 12% of the DC value (at frequency of 100 Hz)</td>
</tr>
<tr>
<td>Interruption time in the auxiliary DC voltage without resetting the relay</td>
<td>&lt;50 ms at $U_{aux}$ rated</td>
</tr>
<tr>
<td>Time to trip from switching on the auxiliary voltage</td>
<td>&lt;350 ms</td>
</tr>
<tr>
<td>Internal over temperature limit</td>
<td>+100°C</td>
</tr>
<tr>
<td>Fuse type</td>
<td>T2A/250 V</td>
</tr>
</tbody>
</table>

Table 5.2.3.-3 Energizing inputs

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated frequency</td>
<td>50/60 Hz ±5 Hz</td>
</tr>
<tr>
<td>Rated voltage, $U_n$ (VT)</td>
<td>100/110/115/120 V</td>
</tr>
<tr>
<td>Thermal withstand capability:</td>
<td>2 × $U_n$ (VT) (240 V)</td>
</tr>
<tr>
<td></td>
<td>3 × $U_n$ (VT) (360 V)</td>
</tr>
<tr>
<td>Burden at rated voltage</td>
<td>&lt;0.5 VA</td>
</tr>
</tbody>
</table>

Table 5.2.3.-4 Measuring range

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured phase-to-phase voltages $U_{ab}$, $U_{bc}$, and $U_{ca}$ as multiples of the rated voltages of the energizing inputs</td>
<td>0...2 × $U_n$ (VT)</td>
</tr>
<tr>
<td>Measured residual voltage ($U_n$) as a multiple of the rated voltage of the energizing input</td>
<td>0...2 × $U_n$ (VT)</td>
</tr>
</tbody>
</table>
### Table 5.2.3.-5  Digital inputs

<table>
<thead>
<tr>
<th>Rated voltage:</th>
<th>DI1...DI2</th>
<th>DI3...DI5 (optional)</th>
</tr>
</thead>
<tbody>
<tr>
<td>REU610CVVHxxx</td>
<td>110/125/220/250 V DC</td>
<td></td>
</tr>
<tr>
<td>Activating threshold</td>
<td>Max. 88 V DC (110 V DC - 20%)</td>
<td></td>
</tr>
<tr>
<td>REU610CVVLxxx</td>
<td>24/48/60/110/125/220/250 V DC</td>
<td></td>
</tr>
<tr>
<td>Activating threshold</td>
<td>Max. 19.2 V DC (24 V DC - 20%)</td>
<td></td>
</tr>
<tr>
<td>REU610CVVxxLx</td>
<td>24/48/60/110/125/220/250 V DC</td>
<td></td>
</tr>
<tr>
<td>Activating threshold</td>
<td>Max. 19.2 V DC (24 V DC - 20%)</td>
<td></td>
</tr>
<tr>
<td>REU610CVVxxHx</td>
<td>110/125/220/250 V DC</td>
<td></td>
</tr>
<tr>
<td>Activating threshold</td>
<td>Max. 88 V DC (110 V DC - 20%)</td>
<td></td>
</tr>
</tbody>
</table>

#### Operating range
- ±20% of the rated voltage

#### Current drain
- 2...18 mA

#### Power consumption/input
- ≤0.9 W

### Table 5.2.3.-6  Non-trip output SO1 and optional SO4 and SO5

<table>
<thead>
<tr>
<th>Rated voltage</th>
<th>250 V AC/DC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous carry</td>
<td>5 A</td>
</tr>
<tr>
<td>Make and carry for 3.0 s</td>
<td>15 A</td>
</tr>
<tr>
<td>Make and carry for 0.5 s</td>
<td>30 A</td>
</tr>
<tr>
<td>Breaking capacity when the control-circuit time constant L/R &lt;40 ms, at 48/110/220 V DC</td>
<td>1 A/0.25 A/0.15 A</td>
</tr>
<tr>
<td>Minimum contact load</td>
<td>100 mA at 24 V AC/DC</td>
</tr>
</tbody>
</table>

### Table 5.2.3.-7  Non-trip output SO2, optional SO3, and IRF output

<table>
<thead>
<tr>
<th>Rated voltage</th>
<th>250 V AC/DC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous carry</td>
<td>5 A</td>
</tr>
<tr>
<td>Make and carry for 3.0 s</td>
<td>10 A</td>
</tr>
<tr>
<td>Make and carry for 0.5 s</td>
<td>15 A</td>
</tr>
<tr>
<td>Breaking capacity when the control-circuit time constant L/R &lt;40 ms, at 48/110/220 V DC</td>
<td>1 A/0.25 A/0.15 A</td>
</tr>
<tr>
<td>Minimum contact load</td>
<td>100 mA at 24 V AC/DC</td>
</tr>
</tbody>
</table>

### Table 5.2.3.-8  Trip outputs (PO1, PO2, PO3)

<table>
<thead>
<tr>
<th>Rated voltage</th>
<th>250 V AC/DC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous carry</td>
<td>5 A</td>
</tr>
<tr>
<td>Make and carry for 3.0 s</td>
<td>15 A</td>
</tr>
<tr>
<td>Make and carry for 0.5 s</td>
<td>30 A</td>
</tr>
<tr>
<td>Breaking capacity when the control-circuit time constant L/R &lt;40 ms, at 48/110/220 V DC (PO1 with both contacts connected in series)</td>
<td>5 A/3 A/1 A</td>
</tr>
<tr>
<td>Minimum contact load</td>
<td>100 mA at 24 V AC/DC</td>
</tr>
</tbody>
</table>

**Trip-circuit supervision (TCS):**
- Control voltage range: 20...265 V AC/DC
Current drain through the supervision circuit: ~1.5 mA
Minimum voltage over a contact: 20 V AC/DC (15...20 V)

**Table 5.2.3.-9 Enclosure class of the flush-mounted relay**

<table>
<thead>
<tr>
<th>Location</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front side</td>
<td>IP 54 Category 2</td>
</tr>
<tr>
<td>Rear side, top of the relay</td>
<td>IP 40</td>
</tr>
<tr>
<td>Rear side, connection terminals</td>
<td>IP 20</td>
</tr>
</tbody>
</table>

**Table 5.2.3.-10 Environmental tests and conditions**

Recommended service temperature range (continuous): -10...+55°C
Humidity: < 95% RH
Limit temperature range (short-term): -40...+70°C
Transport and storage temperature range: -40...+85°C according to IEC 60068-2-48
Dry heat test (humidity <50%): According to IEC 60068-2-2
Dry cold test: According to IEC 60068-2-1
Damp heat test, cyclic (humidity >93%): According to IEC 60068-2-30
Atmospheric pressure: 86...106 kPa

**Table 5.2.3.-11 Electromagnetic compatibility tests**

EMC immunity test level meets the requirements listed below:

**1 MHz burst disturbance test, class III**
- Common mode: 2.5 kV
- Differential mode: 1.0 kV

**Electrostatic discharge test, class IV**
- For contact discharge: 8 kV
- For air discharge: 15 kV

**Radio frequency interference tests:**
- Conducted, common mode: According to IEC 61000-4-6 and IEC 60255-22-6 (2000)
  - 10 V (rms), f = 150 kHz...80 MHz
- Radiated, amplitude-modulated:
  - According to IEC 61000-4-3 and IEC 60255-22-3 (2000)
  - 10 V/m (rms), f = 80...1000 MHz
  - 10 V/m, f = 900 MHz

**Fast transient disturbance tests**
- Trip outputs, energizing inputs, power supply: 4 kV
- I/O ports: 2 kV

**Surge immunity test**
- Trip outputs, energizing inputs, power supply: According to IEC 61000-4-5 and IEC 60255-22-5
  - 4 kV, line-to-ground
  - 2 kV, line-to-line
- I/O ports: 2 kV, line-to-ground
  - 1 kV, line-to-line
Power frequency (50 Hz) magnetic field
IEC 61000-4-8
300 A/m continuous

Power frequency immunity test:
According to IEC 60255-22-7 and IEC 61000-4-16
REU610CVVHxxx and REU610CVVxxHx
- Common mode
  300 V rms
- Differential mode
  150 V rms
REU610CVVLxxx and REU610CVVxxLx
- Common mode
  300 V rms
- Differential mode
  100 V rms

Voltage dips and short interruptions
According to IEC 61000-4-11
- 30%/10 ms
- 60%/100 ms
- 60%/1000 ms
- >95%/5000 ms

Electromagnetic emission tests
According to the EN 55011
- Conducted, RF-emission (Mains terminal) EN 55011, class A, IEC 60255-25
- Radiated RF-emission EN 55011, class A, IEC 60255-25

CE approval
Complies with the EMC directive EMC 2004/108/EC and the LV directive LV 2006/95/EC

Table 5.2.3.-12 Standard tests

<table>
<thead>
<tr>
<th>Insulation tests:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dielectric tests</td>
</tr>
<tr>
<td>Test voltage</td>
</tr>
<tr>
<td>2 kV, 50 Hz, 1 min</td>
</tr>
<tr>
<td>Impulse voltage test</td>
</tr>
<tr>
<td>Test voltage</td>
</tr>
<tr>
<td>5 kV, unipolar impulses, waveform 1.2/50 μs, source energy 0.5 J</td>
</tr>
<tr>
<td>Insulation resistance measurements</td>
</tr>
<tr>
<td>Isolation resistance</td>
</tr>
<tr>
<td>&gt;100 MΩ, 500 V DC</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mechanical tests:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vibration tests (sinusoidal)</td>
</tr>
<tr>
<td>According to IEC 60255-21-1, class I</td>
</tr>
<tr>
<td>Shock and bump test</td>
</tr>
<tr>
<td>According to IEC 60255-21-2, class I</td>
</tr>
</tbody>
</table>

Table 5.2.3.-13 Data communication

<table>
<thead>
<tr>
<th>Rear interface:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fibre-optic or RS-485 connection</td>
</tr>
<tr>
<td>SPA bus, IEC 60870-5-103, DNP 3.0 or Modbus protocol</td>
</tr>
<tr>
<td>9.6 or 4.8 kbps (additionally 2.4, 1.2 or 0.3 kbps for Modbus)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Front interface:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optical connection (infrared): wirelessly or via the front communication cable (1MRS050698)</td>
</tr>
<tr>
<td>SPA bus protocol</td>
</tr>
<tr>
<td>9.6 or 4.8 kbps (9.6 kbps with front communication cable)</td>
</tr>
</tbody>
</table>
Optional communication modules and protocols

- SPA-bus, IEC 60870-5-103, Modbus® (RTU and ASCII):
  - Plastic fibre
  - Plastic and glass fibre
  - RS485
- DNP 3.0:
  - RS485 including DNP 3.0 protocol

Auxiliary voltage

The relay requires a secured auxiliary voltage supply to operate. The internal power supply of the relay forms the voltages required by the relay electronics. The power supply is a galvanically isolated (flyback-type) DC/DC converter. When the auxiliary voltage is connected, the green target LED (ready) on the front panel is lit. For detailed information on power supply, refer to Table 5.2.3.-2.

The primary side of the power supply is protected with a fuse located on the printed circuit board of the relay.
Ordering information

When ordering voltage relays and/or accessories, specify the following:

- Order number
- HMI language set number
- Quantity

The order number identifies the voltage relay type and hardware as described in the figures below and is labelled on the marking strip under the lower handle of the relay.

Use the ordering key information in Fig. 6.-1 to generate the order number when ordering complete voltage relays.

REU610CVVHCNP 01

- **Language set:**
  - 01 = (IEC) English, Svenska, Suomi
  - 02 = (IEC) English, Deutsch, Français, Italiano, Español, Polski
  - 03 = (IEC) English, Español, Português, Français
  - 11 = (ANSI) English, Español, Português

- **Communication module:**
  - P = plastic fiber
  - G = plastic and glass fiber
  - R = RS-485
  - D = RS-485 including DNP 3.0 protocol
  - N = none

- **I/O extension module:**
  - H = 3xSO and 3xDI (110/125/220/250 V DC)
  - L = 3xSO and 3xDI (24/48/60/110/125/220/250 V DC)
  - N = none

- **Power supply:**
  - H = 100-240 V AC/110-250 V DC,
    2xDI (110/125/220/250 V DC),
    3xPO
    2xSO
  - L = 24-60 V DC,
    2xDI (24/48/60/110/125/220/250 V DC),
    3xPO
    2xSO

- **Residual voltage input:**
  - V = rated voltages (100/110/115/120 V)

- **Phase-to-phase voltage inputs:**
  - V = rated voltages (100/110/115/120 V)

Fig. 6.-1 Ordering key for complete relays

Use the ordering key information in Fig. 6.-2 to generate the order number when ordering spare units.
The following accessories are available:

<table>
<thead>
<tr>
<th>Item</th>
<th>Order number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi-flush mounting kit</td>
<td>1MRS050696</td>
</tr>
<tr>
<td>Inclined (/ 25°) semi-flush mounting kit</td>
<td>1MRS050831</td>
</tr>
<tr>
<td>Wall mounting kit</td>
<td>1MRS050697</td>
</tr>
<tr>
<td>19” Rack mounting kit, two relays side-by-side</td>
<td>1MRS050695</td>
</tr>
<tr>
<td>19” Rack mounting kit, single relay</td>
<td>1MRS050694</td>
</tr>
<tr>
<td>19” Rack mounting kit, single relay and RTXP18(REU610)</td>
<td>1MRS090937</td>
</tr>
<tr>
<td>19” equipment frame mounting kit (Combiflex), single relay and RTXP18(REU610)</td>
<td>1MRS090936</td>
</tr>
<tr>
<td>19” equipment frame mounting kit (Combiflex), single relay</td>
<td>1MRS050779</td>
</tr>
<tr>
<td>Front communication cable</td>
<td>1MRS050698</td>
</tr>
<tr>
<td>Communication modules:</td>
<td></td>
</tr>
<tr>
<td>• Plastic fibre</td>
<td>1MRS050889</td>
</tr>
<tr>
<td>• RS-485</td>
<td>1MRS050892</td>
</tr>
<tr>
<td>• Plastic and glass fibre</td>
<td>1MRS050891</td>
</tr>
<tr>
<td>• RS-485 including DNP 3.0 protocol</td>
<td>1MRS050887</td>
</tr>
</tbody>
</table>
## 7. Check lists

**Table 7.1 Setting group 1**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group/Channel 1 (R, P)</th>
<th>Setting range</th>
<th>Default setting</th>
<th>Customer's setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pickup value of element 59P-1</td>
<td>1S1</td>
<td>0.60…1.40 × Uₙ (VT)</td>
<td>1.2 × Uₙ (VT)</td>
<td></td>
</tr>
<tr>
<td>Operate time of element 59P-1</td>
<td>1S2</td>
<td>0.06…600 s</td>
<td>0.06 s</td>
<td></td>
</tr>
<tr>
<td>IDMT operation mode setting for element 59P-1</td>
<td>1S3</td>
<td>0…2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>IDMT time dial 59P-1 TD</td>
<td>1S4</td>
<td>0.05…2.00</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Resetting time of element 59P-1</td>
<td>1S5</td>
<td>0.07…60.0 s</td>
<td>0.07 s</td>
<td></td>
</tr>
<tr>
<td>Drop-off/pick-up ratio 59P-1 D/P</td>
<td>1S6</td>
<td>0.95…0.99</td>
<td>0.97</td>
<td></td>
</tr>
<tr>
<td>Uᵣ/U₂ mode setting of elements 59P-2 and 27P-2</td>
<td>1S7</td>
<td>0…2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Pickup value of element 59P-2</td>
<td>1S8</td>
<td>0.80…1.60 × Uₙ (VT)</td>
<td>1.20 × Uₙ (VT)</td>
<td></td>
</tr>
<tr>
<td>Pickup value of element 47</td>
<td>1S9</td>
<td>0.05…1.00 × Uₙ (VT)</td>
<td>0.05 × Uₙ (VT)</td>
<td></td>
</tr>
<tr>
<td>Operate time of element 59P-2</td>
<td>1S10</td>
<td>0.05…600 s</td>
<td>0.05 s</td>
<td></td>
</tr>
<tr>
<td>IDMT operation mode setting for element 59P-2</td>
<td>1S11</td>
<td>0…2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>IDMT time dial 59P-2 TD</td>
<td>1S12</td>
<td>0.05…2.00</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Pickup value of element 27P-1</td>
<td>1S13</td>
<td>0.20…1.20 × Uₙ (VT)</td>
<td>0.20 × Uₙ (VT)</td>
<td></td>
</tr>
<tr>
<td>Operate time of element 27P-1</td>
<td>1S14</td>
<td>0.10…600 s</td>
<td>0.10 s</td>
<td></td>
</tr>
<tr>
<td>IDMT operation mode setting for element 27P-1</td>
<td>1S15</td>
<td>0…1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>IDMT time dial 27P-1 TD</td>
<td>1S16</td>
<td>0.10…2.00</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>Resetting time of element 27P-1</td>
<td>1S17</td>
<td>0.07…60.0 s</td>
<td>0.07 s</td>
<td></td>
</tr>
<tr>
<td>Drop-off/pick-up ratio 27P-1 D/P</td>
<td>1S18</td>
<td>1.01…1.05</td>
<td>1.03</td>
<td></td>
</tr>
<tr>
<td>Pickup value of element 27P-2</td>
<td>1S19</td>
<td>0.20…1.20 × Uₙ (VT)</td>
<td>0.20 × Uₙ (VT)</td>
<td></td>
</tr>
<tr>
<td>Pickup value of element 27D</td>
<td>1S20</td>
<td>0.20…1.20 × Uₙ (VT)</td>
<td>0.20 × Uₙ (VT)</td>
<td></td>
</tr>
<tr>
<td>Operate time of element 27P-2</td>
<td>1S21</td>
<td>0.10…600 s</td>
<td>0.10 s</td>
<td></td>
</tr>
<tr>
<td>IDMT operation mode setting for element 27P-2</td>
<td>1S22</td>
<td>0…1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>IDMT time dial 27P-2 TD</td>
<td>1S23</td>
<td>0.10…2.00</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>Pickup value of element 59N-1</td>
<td>1S24</td>
<td>2.0…80.0% Uₙ (VT)</td>
<td>2.0% Uₙ (VT)</td>
<td></td>
</tr>
<tr>
<td>Operate time of element 59N-1</td>
<td>1S25</td>
<td>0.10…600 s</td>
<td>0.10 s</td>
<td></td>
</tr>
<tr>
<td>Resetting time of element 59N-1</td>
<td>1S26</td>
<td>0.07…60.0 s</td>
<td>0.07 s</td>
<td></td>
</tr>
<tr>
<td>Pickup value of element 59N-2</td>
<td>1S27</td>
<td>2.0…80.0% Uₙ (VT)</td>
<td>2.0% Uₙ (VT)</td>
<td></td>
</tr>
<tr>
<td>Operate time of element 59N-2</td>
<td>1S28</td>
<td>0.10…600 s</td>
<td>0.10 s</td>
<td></td>
</tr>
<tr>
<td>Predefined time of CBFAIL</td>
<td>1S29</td>
<td>0.10…60.0 s</td>
<td>0.10 s</td>
<td></td>
</tr>
<tr>
<td>Checksum, SGF1</td>
<td>1S61</td>
<td>0…255</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
Table 7.-2 Setting group 2

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group/Channel 2 (R, P)</th>
<th>Setting range</th>
<th>Default setting</th>
<th>Customer's setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pickup value of element 59P-1</td>
<td>2S1</td>
<td>0.60...1.40 \times U_n (VT)</td>
<td>1.2 \times U_n (VT)</td>
<td></td>
</tr>
<tr>
<td>Operate time of element 59P-1</td>
<td>2S2</td>
<td>0.06...600 s</td>
<td>0.06 s</td>
<td></td>
</tr>
<tr>
<td>IDMT operation mode setting for element 59P-1</td>
<td>2S3</td>
<td>0...2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>IDMT time dial 59P-1 TD</td>
<td>2S4</td>
<td>0.05...2.00</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Resetting time of element 59P-1</td>
<td>2S5</td>
<td>0.07...60.0 s</td>
<td>0.07 s</td>
<td></td>
</tr>
<tr>
<td>Drop-off/pick-up ratio 59P-1 D/P</td>
<td>2S6</td>
<td>0.95...0.99</td>
<td>0.97</td>
<td></td>
</tr>
<tr>
<td>U_1/U_2 mode setting of elements 59P-2 and 27P-2</td>
<td>2S7</td>
<td>0...2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Pickup value of element 59P-2</td>
<td>2S8</td>
<td>0.80...1.60 \times U_n (VT)</td>
<td>1.20 \times U_n (VT)</td>
<td></td>
</tr>
<tr>
<td>Pickup value of element 47</td>
<td>2S9</td>
<td>0.05...1.00 \times U_n (VT)</td>
<td>0.05 \times U_n (VT)</td>
<td></td>
</tr>
<tr>
<td>Variable</td>
<td>Group/ Channel 2</td>
<td>Setting range</td>
<td>Default setting</td>
<td>Customer’s setting</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>------------------</td>
<td>--------------------------------------</td>
<td>-----------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>Operate time of element 59P-2</td>
<td>2S10</td>
<td>0.05...600 s</td>
<td>0.05 s</td>
<td></td>
</tr>
<tr>
<td>IDMT operation mode setting for element 59P-2</td>
<td>2S11</td>
<td>0...2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>IDMT time dial 59P-2 TD</td>
<td>2S12</td>
<td>0.05...2.00</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Pickup value of element 27P-1</td>
<td>2S13</td>
<td>0.20...1.20 × Uₙ (VT)</td>
<td>0.20 × Uₙ (VT)</td>
<td></td>
</tr>
<tr>
<td>Operate time of element 27P-1</td>
<td>2S14</td>
<td>0.10...600 s</td>
<td>0.10 s</td>
<td></td>
</tr>
<tr>
<td>IDMT operation mode setting for element 27P-1</td>
<td>2S15</td>
<td>0...1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>IDMT time dial 27P-1</td>
<td>2S16</td>
<td>0.10...2.00</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>Resetting time of element 27P-1</td>
<td>2S17</td>
<td>0.07...60.0 s</td>
<td>0.07 s</td>
<td></td>
</tr>
<tr>
<td>Drop-off/pick-up ratio D/P&lt;</td>
<td>2S18</td>
<td>1.01...1.05</td>
<td>1.03</td>
<td></td>
</tr>
<tr>
<td>Pickup value of element 27P-2</td>
<td>2S19</td>
<td>0.20...1.20 × Uₙ (VT)</td>
<td>0.20 × Uₙ (VT)</td>
<td></td>
</tr>
<tr>
<td>Pickup value of element 27D</td>
<td>2S20</td>
<td>0.20...1.20 × Uₙ (VT)</td>
<td>0.20 × Uₙ (VT)</td>
<td></td>
</tr>
<tr>
<td>Operate time of element 27P-2</td>
<td>2S21</td>
<td>0.10...600 s</td>
<td>0.10 s</td>
<td></td>
</tr>
<tr>
<td>IDMT operation mode setting for element 27P-2</td>
<td>2S22</td>
<td>0...1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>IDMT time dial 27P-2 TD</td>
<td>2S23</td>
<td>0.10...2.00</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>Pickup value of element 59N-1</td>
<td>2S24</td>
<td>2.0...80.0% Uₙ (VT)</td>
<td>2.0% Uₙ (VT)</td>
<td></td>
</tr>
<tr>
<td>Operate time of element 59N-1</td>
<td>2S25</td>
<td>0.10...600 s</td>
<td>0.10 s</td>
<td></td>
</tr>
<tr>
<td>Resetting time of element 59N-1</td>
<td>2S26</td>
<td>0.07...60.0 s</td>
<td>0.07 s</td>
<td></td>
</tr>
<tr>
<td>Pickup value of element 59N-2</td>
<td>2S27</td>
<td>2.0...80.0% Uₙ (VT)</td>
<td>2.0% Uₙ (VT)</td>
<td></td>
</tr>
<tr>
<td>Operate time of element 59N-2</td>
<td>2S28</td>
<td>0.10...600 s</td>
<td>0.10 s</td>
<td></td>
</tr>
<tr>
<td>Predefined time of CBFAIL</td>
<td>2S29</td>
<td>0.10...60.0 s</td>
<td>0.10 s</td>
<td></td>
</tr>
<tr>
<td>Checksum, SGF1</td>
<td>2S61</td>
<td>0...255</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Checksum, SGF2</td>
<td>2S62</td>
<td>0...4095</td>
<td>2730</td>
<td></td>
</tr>
<tr>
<td>Checksum, SGF3</td>
<td>2S63</td>
<td>0...15</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Checksum, SGF4</td>
<td>2S64</td>
<td>0...1023</td>
<td>128</td>
<td></td>
</tr>
<tr>
<td>Checksum, SGF5</td>
<td>2S65</td>
<td>0...255</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Checksum, SGB1</td>
<td>2S71</td>
<td>0...32767</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Checksum, SGB2</td>
<td>2S72</td>
<td>0...32767</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Checksum, SGB3</td>
<td>2S73</td>
<td>0...32767</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Checksum, SGB4</td>
<td>2S74</td>
<td>0...32767</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Checksum, SGB5</td>
<td>2S75</td>
<td>0...32767</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Checksum, SGR1</td>
<td>2S81</td>
<td>0...8191</td>
<td>2730</td>
<td></td>
</tr>
<tr>
<td>Checksum, SGR2</td>
<td>2S82</td>
<td>0...8191</td>
<td>2730</td>
<td></td>
</tr>
<tr>
<td>Checksum, SGR3</td>
<td>2S83</td>
<td>0...8191</td>
<td>2730</td>
<td></td>
</tr>
<tr>
<td>Checksum, SGR4</td>
<td>2S84</td>
<td>0...8191</td>
<td>1365</td>
<td></td>
</tr>
<tr>
<td>Checksum, SGR5</td>
<td>2S85</td>
<td>0...8191</td>
<td>1365</td>
<td></td>
</tr>
</tbody>
</table>
### Variable Group/Channel 2 (R, P)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Setting range</th>
<th>Default setting</th>
<th>Customer's setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Checksum, SGR6</td>
<td>0...8191</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Checksum, SGR7</td>
<td>0...8191</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Checksum, SGR8</td>
<td>0...8191</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Checksum, SGL1</td>
<td>0...16383</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Checksum, SGL2</td>
<td>0...16383</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Checksum, SGL3</td>
<td>0...16383</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Checksum, SGL4</td>
<td>0...16383</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Checksum, SGL5</td>
<td>0...16383</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Checksum, SGL6</td>
<td>0...16383</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Checksum, SGL7</td>
<td>0...16383</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Checksum, SGL8</td>
<td>0...16383</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

### Table 7.-3 Control parameters

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter (channel 0)</th>
<th>Setting range</th>
<th>Default setting</th>
<th>Customer's setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network frequency</td>
<td>V104</td>
<td>50 or 60 Hz</td>
<td>60 Hz</td>
<td></td>
</tr>
<tr>
<td>Trip-circuit supervision</td>
<td>V113</td>
<td>0/1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Nominal voltage</td>
<td>V134</td>
<td>0 = 100 V</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 = 110 V</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 = 115 V</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 = 120 V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data communication address of the relay</td>
<td>V200</td>
<td>1...254&lt;sup&gt;a)&lt;/sup&gt;</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Data transfer rate for SPA</td>
<td>V201</td>
<td>4.8/9.6</td>
<td>9.6</td>
<td></td>
</tr>
<tr>
<td>Rear communication protocol</td>
<td>V203</td>
<td>0 = SPA</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 = IEC 103</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 = Modbus RTU</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 = Modbus ASCII</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connection type selection (loop/star)</td>
<td>V204</td>
<td>0/1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Line-idle state selection (light-off/light-on)</td>
<td>V205</td>
<td>0/1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Rear communication module enabled/disabled</td>
<td>V206</td>
<td>1/0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a)</sup> For all the protocols except for DNP 3.0.

### Table 7.-4 Disturbance recorder parameters

<table>
<thead>
<tr>
<th>Variable</th>
<th>Setting range</th>
<th>Default setting</th>
<th>Customer's setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling rate</td>
<td>M15</td>
<td>800/960 Hz/400/480 Hz/50/60 Hz</td>
<td>800/960 Hz</td>
</tr>
<tr>
<td>Station identification/unit number</td>
<td>M18</td>
<td>0...9999</td>
<td>0</td>
</tr>
<tr>
<td>Variable</td>
<td>Parameter (channel 0)</td>
<td>Setting range</td>
<td>Default setting</td>
</tr>
<tr>
<td>----------</td>
<td>-----------------------</td>
<td>---------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Station name</td>
<td>M20</td>
<td>Max 16 characters</td>
<td>-ABB-</td>
</tr>
<tr>
<td>Analog channel conversion factor and units</td>
<td>M80, M81, M82</td>
<td>Factor 0.00…600, unit (V, kV), e.g. 20.0 kV</td>
<td>0.01, VT</td>
</tr>
<tr>
<td>Analog channel conversion factor and units</td>
<td>M83</td>
<td>Factor 0.00…600, unit (V, kV), e.g. 20.0 kV</td>
<td>0.01, VT</td>
</tr>
<tr>
<td>Internal trigger signals’ checksum</td>
<td>V236</td>
<td>0…4095</td>
<td>2730</td>
</tr>
<tr>
<td>Internal trigger signal’s edge</td>
<td>V237</td>
<td>0…4095</td>
<td>0</td>
</tr>
<tr>
<td>Checksum of internal signal storing mask</td>
<td>V238</td>
<td>0…4095</td>
<td>2798</td>
</tr>
<tr>
<td>Post-trigger time in percent</td>
<td>V240</td>
<td>0…100%</td>
<td>50</td>
</tr>
<tr>
<td>External trigger signal's checksum</td>
<td>V241</td>
<td>0…31</td>
<td>0</td>
</tr>
<tr>
<td>External trigger signal’s edge</td>
<td>V242</td>
<td>0…31</td>
<td>0</td>
</tr>
<tr>
<td>Checksum of external signal storing mask</td>
<td>V243</td>
<td>0…31</td>
<td>0</td>
</tr>
</tbody>
</table>
### Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASCII</td>
<td>American Standard Code for Information Interchange</td>
</tr>
<tr>
<td>AWG</td>
<td>American wire gauge</td>
</tr>
<tr>
<td>CBFAIL</td>
<td>Circuit-breaker failure protection</td>
</tr>
<tr>
<td>CBFP</td>
<td>Circuit-breaker failure protection</td>
</tr>
<tr>
<td>CD</td>
<td>Change detect; compact disk</td>
</tr>
<tr>
<td>CPU</td>
<td>Central processing unit</td>
</tr>
<tr>
<td>CRC</td>
<td>Cyclical redundancy check</td>
</tr>
<tr>
<td>DI</td>
<td>Digital input</td>
</tr>
<tr>
<td>EEPROM</td>
<td>Electrically Erasable Programmable Read-Only Memory</td>
</tr>
<tr>
<td>EMC</td>
<td>Electromagnetic compatibility</td>
</tr>
<tr>
<td>EPA</td>
<td>Enhanced Performance Architecture</td>
</tr>
<tr>
<td>ER</td>
<td>Event records</td>
</tr>
<tr>
<td>FR</td>
<td>Fault record</td>
</tr>
<tr>
<td>GI</td>
<td>General interrogation</td>
</tr>
<tr>
<td>HMI</td>
<td>Human-machine interface</td>
</tr>
<tr>
<td>HR</td>
<td>Holding register</td>
</tr>
<tr>
<td>IDMT</td>
<td>Inverse definite minimum time characteristic</td>
</tr>
<tr>
<td>IEC</td>
<td>International Electrotechnical Commission</td>
</tr>
<tr>
<td>IEC_103</td>
<td>Standard IEC 60870-5-103</td>
</tr>
<tr>
<td>IED</td>
<td>Intelligent electronic device</td>
</tr>
<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers, Inc.</td>
</tr>
<tr>
<td>IR</td>
<td>Input register</td>
</tr>
<tr>
<td>IRF</td>
<td>Internal relay fault</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>LCD</td>
<td>Liquid crystal display</td>
</tr>
<tr>
<td>LED</td>
<td>Light-emitting diode</td>
</tr>
<tr>
<td>LRC</td>
<td>Longitudinal redundancy check</td>
</tr>
<tr>
<td>MP</td>
<td>Minute-pulse</td>
</tr>
<tr>
<td>MSB</td>
<td>Most significant bit</td>
</tr>
<tr>
<td>NACK</td>
<td>Negative acknowledgments</td>
</tr>
<tr>
<td>NC</td>
<td>Normally closed</td>
</tr>
<tr>
<td>NO</td>
<td>Normally open</td>
</tr>
<tr>
<td>NPS</td>
<td>Negative-phase-sequence</td>
</tr>
<tr>
<td>OSI</td>
<td>Open System Interconnection</td>
</tr>
<tr>
<td>PC</td>
<td>Personal computer</td>
</tr>
<tr>
<td>PCB</td>
<td>Printed circuit board</td>
</tr>
<tr>
<td>PLC</td>
<td>Programmable logical controller</td>
</tr>
<tr>
<td>PO</td>
<td>Power output, process object</td>
</tr>
<tr>
<td>RMS</td>
<td>Root mean square</td>
</tr>
<tr>
<td>RTU</td>
<td>Remote terminal unit</td>
</tr>
<tr>
<td>Key Code</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>-------------------------------------------</td>
</tr>
<tr>
<td>SGB</td>
<td>Switchgroup for digital inputs</td>
</tr>
<tr>
<td>SGL</td>
<td>Switchgroup for LEDs</td>
</tr>
<tr>
<td>SGR</td>
<td>Switchgroup for output contacts</td>
</tr>
<tr>
<td>SO</td>
<td>Signal output</td>
</tr>
<tr>
<td>SP</td>
<td>Second-pulse</td>
</tr>
<tr>
<td>SPA</td>
<td>Data communication protocol developed by ABB</td>
</tr>
<tr>
<td>TCS</td>
<td>Trip-circuit supervision</td>
</tr>
<tr>
<td>UDR</td>
<td>User-defined register</td>
</tr>
<tr>
<td>UR</td>
<td>Unsolicited reporting</td>
</tr>
<tr>
<td>VT</td>
<td>Voltage transformer</td>
</tr>
</tbody>
</table>