Installation and commissioning manual
Line distance protection terminal for solidly earthed systems
REL 511-C1*2.5

About this manual
Document No: 1MRK 506 198-UEN
Issued: December 2006
Revision: B

© Copyright 2006 ABB. All rights reserved.
COPYRIGHT

WE RESERVE ALL RIGHTS TO THIS DOCUMENT, EVEN IN THE EVENT THAT A PATENT IS ISSUED AND A DIFFERENT COMMERCIAL PROPRIETARY RIGHT IS REGISTERED. IMPROPER USE, IN PARTICULAR REPRODUCTION AND DISSEMINATION TO THIRD PARTIES, IS NOT PERMITTED.

THIS DOCUMENT HAS BEEN CAREFULLY CHECKED. HOWEVER, IN CASE ANY ERRORS ARE DETECTED, THE READER IS KINDLY REQUESTED TO NOTIFY THE MANUFACTURER AT THE ADDRESS BELOW.

THE DATA CONTAINED IN THIS MANUAL IS INTENDED SOLELY FOR THE CONCEPT OR PRODUCT DESCRIPTION AND IS NOT TO BE DEEMED TO BE A STATEMENT OF GUARANTEED PROPERTIES. IN THE INTERESTS OF OUR CUSTOMERS, WE CONSTANTLY SEEK TO ENSURE THAT OUR PRODUCTS ARE DEVELOPED TO THE LATEST TECHNOLOGICAL STANDARDS. AS A RESULT, IT IS POSSIBLE THAT THERE MAY BE SOME DIFFERENCES BETWEEN THE HW/SW PRODUCT AND THIS INFORMATION PRODUCT.

Manufacturer:

ABB Power Technologies AB
Substation Automation Products
SE-721 59 Västerås
Sweden
Telephone: +46 (0) 21 34 20 00
Facsimile: +46 (0) 21 14 69 18
www.abb.com/substationautomation
## Contents

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chapter 1</strong> Introduction ........................................................... 1</td>
<td></td>
</tr>
<tr>
<td>Introduction to the installation and commissioning manual ........ 2</td>
<td></td>
</tr>
<tr>
<td>About the complete set of manuals for a terminal ..................... 2</td>
<td></td>
</tr>
<tr>
<td>About the installation and commissioning manual ..................... 2</td>
<td></td>
</tr>
<tr>
<td>Intended audience .......................................................................... 3</td>
<td></td>
</tr>
<tr>
<td>General ...................................................................................... 3</td>
<td></td>
</tr>
<tr>
<td>Requirements ............................................................................ 3</td>
<td></td>
</tr>
<tr>
<td>Related documents ......................................................................... 4</td>
<td></td>
</tr>
<tr>
<td>Revision notes ................................................................................ 4</td>
<td></td>
</tr>
<tr>
<td>Acronyms and abbreviations .......................................................... 4</td>
<td></td>
</tr>
<tr>
<td><strong>Chapter 2</strong> Safety information .............................................. 13</td>
<td></td>
</tr>
<tr>
<td>Warning signs .................................................................................... 14</td>
<td></td>
</tr>
<tr>
<td>Caution signs ..................................................................................... 16</td>
<td></td>
</tr>
<tr>
<td>Note signs.......................................................................................... 17</td>
<td></td>
</tr>
<tr>
<td><strong>Chapter 3</strong> Overview ............................................................. 19</td>
<td></td>
</tr>
<tr>
<td>Commissioning and installation overview .................................... 20</td>
<td></td>
</tr>
<tr>
<td><strong>Chapter 4</strong> Unpacking and checking the terminal .................. 21</td>
<td></td>
</tr>
<tr>
<td>Receiving, unpacking and checking .................................................. 22</td>
<td></td>
</tr>
<tr>
<td><strong>Chapter 5</strong> Installing the terminal ........................................... 23</td>
<td></td>
</tr>
<tr>
<td>Overview ................................................................................................ 24</td>
<td></td>
</tr>
<tr>
<td>Mounting the terminal .................................................................... 25</td>
<td></td>
</tr>
<tr>
<td>Mounting in a 19-inch rack ........................................................... 26</td>
<td></td>
</tr>
<tr>
<td>Mounting in a 19-inch rack with an additional box type RHGS ..... 27</td>
<td></td>
</tr>
<tr>
<td>Mounting in a flush or semi-flush installation ......................... 28</td>
<td></td>
</tr>
<tr>
<td>Mounting on a wall ....................................................................... 30</td>
<td></td>
</tr>
<tr>
<td>Mounting the terminal on a wall .................................................... 31</td>
<td></td>
</tr>
<tr>
<td>Preparing a wall mounted terminal for electrical installation ....... 32</td>
<td></td>
</tr>
<tr>
<td>Making the electrical connections .................................................. 33</td>
<td></td>
</tr>
<tr>
<td>Connecting the CT circuits ............................................................. 33</td>
<td></td>
</tr>
<tr>
<td>Connecting the auxiliary power, VT and signal connectors .......... 33</td>
<td></td>
</tr>
<tr>
<td>Connecting to protective earth ...................................................... 35</td>
<td></td>
</tr>
<tr>
<td>Making the screen connection ...................................................... 35</td>
<td></td>
</tr>
<tr>
<td>Installing the optical fibres ........................................................... 36</td>
<td></td>
</tr>
</tbody>
</table>
Contents

Installing the serial communication cable for RS485 SPA/IEC........... 37
RS485 serial communication module........................................... 37
Informative excerpt from EIA Standard RS-485 ......................... 39
Data on RS485 serial communication module cable .................... 41
Installing the 56/64 kbit data communication cables................. 42

Chapter 6 Checking the external circuitry .................................... 45
Overview .................................................................................... 46
Checking the CT and VT circuits ................................................. 47
Checking the power supply ......................................................... 48
Checking the binary I/O circuits ................................................. 49
Binary input circuits ................................................................ 49
Binary output circuits ............................................................... 49

Chapter 7 Energising the terminal .............................................. 51
Overview .................................................................................... 52
Energising the terminal .............................................................. 53
Checking the self supervision signals ....................................... 55
Reconfiguring the terminal ......................................................... 55
Setting the terminal time ........................................................... 55
Checking the self supervision function ................................... 55
Navigating the menus ............................................................... 55
Self supervision HMI data ......................................................... 56

Chapter 8 Configuring the 56/64 kbit data communication modules ........................................ 57
Calculation of optical power budget ......................................... 58
Fault tracing .............................................................................. 59
Comfail function ...................................................................... 59
Explanation of contents in column 2 of table 42 ...................... 60

Chapter 9 Setting and configuring the terminal ......................... 63
Overview .................................................................................... 64
Entering settings through the local HMI .................................... 65
Configuring the setting restriction of HMI function .................... 66
Activating the restriction of setting .......................................... 67
Local HMI ............................................................................... 67
Serial communication, change of active group ....................... 67
Serial communication, setting ................................................. 67
Downloading settings and configuration from a PC ................. 68
Establishing front port communication ................................. 68
Establishing rear port communication .................................... 68
Using the SPA/IEC rear port ............................................... 68
Using LON rear port ................................................................. 69
Downloading the configuration and setting files ...................... 69

Chapter 10 Requirement of trig condition for disturbance report
71

Requirement of trig condition for disturbance report.................. 72

Chapter 11 Establishing connection and verifying the
SPA/IEC-communication ....................................................... 73

Entering settings ......................................................................... 74
Entering SPA settings................................................................. 74
Entering IEC settings.................................................................. 74
Verifying the communication..................................................... 76
Verifying SPA communication.................................................. 76
Verifying IEC communication.................................................... 76
Optical budget calculation for serial communication with SPA/IEC . 77

Chapter 12 Establishing connection and verifying the LON com-
munication .............................................................................. 79

Reference ................................................................................... 80
Verification of the optical budget .............................................. 80
Optical budget calculation for serial communication with LON 80

Chapter 13 Verifying settings by secondary injection ............... 81

Overview.................................................................................... 82
Preparing for test ........................................................................ 84
Overview................................................................................... 84
Preparing the connection to the test equipment ...................... 84
Setting the terminal in test mode............................................... 85
Connecting test equipment to the terminal.............................. 85
Verifying the connection and the analog inputs....................... 86
Releasing the function(s) to be tested...................................... 87
Checking the disturbance report settings................................. 87
Identifying the function to test in the technical reference manual .............................................. 88
Automatic switch onto fault logic (SOTF).................................. 89
External activation of SOTF function........................................ 89
Automatic initiation of SOTF...................................................... 89
Completing the test....................................................................... 89
Autorecloser (AR)........................................................................ 90
Preparing.................................................................................. 91
Checking the AR functionality.................................................. 92
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measuring the operate limit of set values</td>
<td>125</td>
</tr>
<tr>
<td>Phase overcurrent protection</td>
<td>125</td>
</tr>
<tr>
<td>Residual overcurrent protection (non-dir.)</td>
<td>125</td>
</tr>
<tr>
<td>Completing the test</td>
<td>125</td>
</tr>
<tr>
<td>Local acceleration logic (ZCLC)</td>
<td>126</td>
</tr>
<tr>
<td>Supervision of AC input quantities (DA)</td>
<td>127</td>
</tr>
<tr>
<td>Verifying the settings</td>
<td>127</td>
</tr>
<tr>
<td>Completing the test</td>
<td>127</td>
</tr>
<tr>
<td>Power swing detection (PSD)</td>
<td>128</td>
</tr>
<tr>
<td>Testing overview</td>
<td>129</td>
</tr>
<tr>
<td>Testing the one-of-three-phase operation</td>
<td>129</td>
</tr>
<tr>
<td>Testing the two-of-three-phase operation</td>
<td>129</td>
</tr>
<tr>
<td>Testing the tEF timer and functionality</td>
<td>130</td>
</tr>
<tr>
<td>Testing the tR1 timer</td>
<td>131</td>
</tr>
<tr>
<td>Testing the tR2 timer</td>
<td>131</td>
</tr>
<tr>
<td>Testing the block input</td>
<td>132</td>
</tr>
<tr>
<td>Completing the test</td>
<td>132</td>
</tr>
<tr>
<td>Setting lockout (HMI)</td>
<td>133</td>
</tr>
<tr>
<td>Verifying the settings</td>
<td>133</td>
</tr>
<tr>
<td>Completing the test</td>
<td>133</td>
</tr>
<tr>
<td>Scheme communication logic (ZCOM)</td>
<td>134</td>
</tr>
<tr>
<td>Testing permissive underreach</td>
<td>134</td>
</tr>
<tr>
<td>Testing permissive overreach</td>
<td>134</td>
</tr>
<tr>
<td>Testing blocking scheme</td>
<td>135</td>
</tr>
<tr>
<td>Checking of unblocking logic</td>
<td>135</td>
</tr>
<tr>
<td>Command function with continuous unblocking (Unblock = 1)</td>
<td>135</td>
</tr>
<tr>
<td>Completing the test</td>
<td>136</td>
</tr>
<tr>
<td>Scheme communication logic for residual overcurrent protection (EFC)</td>
<td>137</td>
</tr>
<tr>
<td>Testing the directional comparison logic function</td>
<td>137</td>
</tr>
<tr>
<td>Blocking scheme</td>
<td>137</td>
</tr>
<tr>
<td>Permissive scheme</td>
<td>138</td>
</tr>
<tr>
<td>Completing the test</td>
<td>138</td>
</tr>
<tr>
<td>Four parameter setting groups (GRP)</td>
<td>139</td>
</tr>
<tr>
<td>Verifying the settings</td>
<td>139</td>
</tr>
<tr>
<td>Synchrocheck and energizing check (SYN)</td>
<td>140</td>
</tr>
<tr>
<td>Testing the phasing function</td>
<td>142</td>
</tr>
<tr>
<td>Testing the frequency difference</td>
<td>143</td>
</tr>
<tr>
<td>Testing the synchrocheck</td>
<td>143</td>
</tr>
<tr>
<td>Testing the voltage difference</td>
<td>143</td>
</tr>
<tr>
<td>Testing the voltage difference</td>
<td>144</td>
</tr>
<tr>
<td>Testing the phase difference</td>
<td>145</td>
</tr>
<tr>
<td>Testing the frequency difference</td>
<td>148</td>
</tr>
<tr>
<td>Testing the reference voltage</td>
<td>148</td>
</tr>
<tr>
<td>Testing the energizing check</td>
<td>149</td>
</tr>
<tr>
<td>Testing the energizing check</td>
<td>149</td>
</tr>
<tr>
<td>Testing the dead line live bus (DLLB)</td>
<td>149</td>
</tr>
<tr>
<td>Testing the dead bus live line (DBLL)</td>
<td>150</td>
</tr>
<tr>
<td>Testing both directions (DLLB or DBLL)</td>
<td>151</td>
</tr>
<tr>
<td>Testing the dead bus dead line (DBDL)</td>
<td>151</td>
</tr>
<tr>
<td>Testing the voltage selection</td>
<td>152</td>
</tr>
<tr>
<td>Testing the voltage selection for single CB arrangements</td>
<td>152</td>
</tr>
</tbody>
</table>
Contents

Testing the voltage selection for 1 1/2 circuit breaker diameter .......................................................... 153
Completing the test ......................................................... 154
Definite time non-directional overcurrent protection (TOC) .......................................................... 155
Measuring the operate limit of set values ......................................................................................... 155
Time delayed phase overcurrent .................................................................................................. 155
Time delayed residual overcurrent (non-dir.) .................................................................................. 155
Completing the test ................................................. 156
Time delayed overvoltage protection (TOV) .................................................................................. 157
Verifying the settings ..................................................... 157
Time delayed phase overvoltage protection .................................................................................. 157
Time delayed residual overvoltage protection (non-dir.) ......................................................... 157
Completing the test ..................................................... 157
Time delayed undervoltage protection (TUV) .................................................................................. 158
Verifying the settings ..................................................... 158
Completing the test ..................................................... 158
Tripping logic (TR) ................................................................. 159
3ph operating mode .................................................................................................................. 159
1ph/3ph operating mode ............................................................................................................. 159
1ph/2ph/3ph operating mode ....................................................................................................... 160
Completing the test ..................................................... 161
Two step time delayed directional phase overcurrent protection (TOC3) .......................................................... 162
Measuring the operate and time limit for set values ........................................................................ 162
  Measuring the operate limit of the low step overcurrent protection ............................................ 162
  Measuring the definite time delay of the low set stage ............................................................... 162
  Measuring the inverse time delay of the low set stage .............................................................. 162
  Measuring the operate limit of the high step overcurrent protection .......................................... 163
  Measuring the operate limit of the directional lines ............................................................... 163
Completing the test ..................................................... 164
Two step time delayed non-directional phase overcurrent protection (TOC2) .......................................................... 165
Measuring the operate and time limit for set values ........................................................................ 165
  Measuring the operate limit of the low step overcurrent protection ............................................ 165
  Measuring the definite time delay of the low set stage ............................................................... 165
  Measuring the inverse time delay of the low set stage .............................................................. 165
  Measuring the operate limit of the high step overcurrent protection .......................................... 166
Completing the test ..................................................... 166

Chapter 14 Verifying the internal configuration ................................................................. 167
Overview ................................................................................................................................. 168
Testing the interaction of the distance protection ................................................................. 169

Chapter 15 Testing the protection system .............................................................................. 171
Contents

Overview.......................................................................................... 172
Testing the interaction of the distance protection ............................ 173

Chapter 16 Checking the directionality ................................. 175
Overview.......................................................................................... 176
Testing the directionality of the distance protection......................... 177

Chapter 17 Fault tracing and repair .................................... 179
Fault tracing..................................................................................... 180
  Using information on the local HMI............................................. 180
  Using front-connected PC or SMS.............................................. 181
Repair instruction............................................................................. 183
Repair support................................................................................. 185
Chapter 1   Introduction

About this chapter
This chapter introduces the user to the manual.
1 Introduction to the installation and commissioning manual

1.1 About the complete set of manuals for a terminal

The users manual (UM) is a complete set of four different manuals:

- The Application Manual (AM) contains descriptions, such as application and functionality descriptions as well as setting calculation examples sorted per function. The application manual should be used when designing and engineering the protection terminal to find out when and for what a typical protection function could be used. The manual should also be used when calculating settings and creating configurations.

- The Technical Reference Manual (TRM) contains technical descriptions, such as function blocks, logic diagrams, input and output signals, setting parameter tables and technical data sorted per function. The technical reference manual should be used as a technical reference during the engineering phase, installation and commissioning phase, and during the normal service phase.

- The Operator’s Manual (OM) contains instructions on how to operate the protection terminal during normal service (after commissioning and before periodic maintenance tests). The operator’s manual can be used to find out how to handle disturbances or how to view calculated and measured network data in order to determine the cause of a fault.

- The Installation and Commissioning Manual (ICM) contains instructions on how to install and commission the protection terminal. The manual can also be used as a reference if a periodic test is performed. The manual covers procedures for mechanical and electrical installation, energizing and checking of external circuitry, setting and configuration as well as verifying settings and performing a directional test. The chapters and sections are organized in the chronological order (indicated by chapter/section numbers) in which the protection terminal should be installed and commissioned.

1.2 About the installation and commissioning manual

The installation and commissioning manual contains the following chapters:

- The chapter “Safety information” presents warning and note signs, which the user should pay attention to.
Introduction to the installation and commissioning manual

Chapter 1

Introduction

• The chapter “Overview” gives an overview over the major tasks when installing and commissioning the terminal.
• The chapter “Unpacking and checking the terminal” contains instructions on how to receive the terminal.
• The chapter “Installing the terminal” contains instructions on how to install the terminal.
• The chapter “Checking the external circuitry” contains instructions on how to check that the terminal is properly connected to the protection system.
• The chapter “Energising the terminal” contains instructions on how to start-up the terminal.
• The chapter “Setting and configuring the terminal” contains instructions on how to download settings and configuration to the terminal.
• The chapter “Establishing connection and verifying the SPA/IEC-communication” contains instructions on how to enter SPA/IEC settings and verifying the SPA/IEC communication.
• The chapter “Establishing connection and verifying the LON communication” contains a reference to another document.
• The chapter “Verifying settings by secondary injection” contains instructions on how to verify that each included function operates correctly according to the set values.
• The chapter “Primary injection testing” describes a test with primary current through the protected zone.
• The chapter “Testing the protection system” contains instructions on how to test that the terminal is in contact with the primary system.
• The chapter “Fault tracing and repair” contains instructions on how to fault trace.

1.3 Intended audience

1.3.1 General

The installation and commissioning manual is addressing the installation, commissioning and maintenance personnel responsible for taking the protection into normal service and out of service.

1.3.2 Requirements

The installation and commissioning personnel must have a basic knowledge in handling electronic equipment. The commissioning and maintenance personnel must be well experienced in using protection equipment, test equipment, protection functions and the configured functional logics in the protection.
# 1.4 Related documents

**Documents related to REL 511-C1**

- Operator's manual
- Installation and commissioning manual
- Technical reference manual
- Application manual
- Buyer's guide

**Identity number**

- 1MRK 506 196-UEN
- 1MRK 506 198-UEN
- 1MRK 506 197-UEN
- 1MRK 506 199-UEN
- 1MRK 506 195-BEN

# 1.5 Revision notes

<table>
<thead>
<tr>
<th>Revision</th>
<th>Description</th>
</tr>
</thead>
</table>
| B        | Minor updates in chapter:  
  • Configuring the 56/64 kbit data communication modules / Configuring the fibre optical modem  
  • Verifying settings by secondary injection / Line differential protection, phase segregated (DIFL) |

# 1.6 Acronyms and abbreviations

<table>
<thead>
<tr>
<th>AC</th>
<th>Alternating Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACrv2</td>
<td>Setting A for programmable overvoltage IDMT curve, step 2</td>
</tr>
<tr>
<td>A/D converter</td>
<td>Analog to Digital converter</td>
</tr>
<tr>
<td>ADBS</td>
<td>Amplitude dead-band supervision</td>
</tr>
<tr>
<td>AIM</td>
<td>Analog input module</td>
</tr>
<tr>
<td>ANSI</td>
<td>American National Standards Institute</td>
</tr>
<tr>
<td>ASCT</td>
<td>Auxiliary summation current transformer</td>
</tr>
<tr>
<td>ASD</td>
<td>Adaptive Signal Detection</td>
</tr>
<tr>
<td>AWG</td>
<td>American Wire Gauge standard</td>
</tr>
<tr>
<td>BIM</td>
<td>Binary input module</td>
</tr>
<tr>
<td>BLKDEL</td>
<td>Block of delayed fault clearing</td>
</tr>
<tr>
<td>BOM</td>
<td>Binary output module</td>
</tr>
<tr>
<td>BR</td>
<td>Binary transfer receive over LDCM</td>
</tr>
<tr>
<td>BS</td>
<td>British Standard</td>
</tr>
<tr>
<td>BSR</td>
<td>Binary Signal Receive (SMT) over LDCM</td>
</tr>
<tr>
<td>BST</td>
<td>Binary Signal Transmit (SMT) over LDCM</td>
</tr>
<tr>
<td>BT</td>
<td>Binary Transfer Transmit over LDCM</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>C34.97</td>
<td>Controller Area Network. ISO standard (ISO 11898) for serial communication</td>
</tr>
<tr>
<td>CAN</td>
<td>Configuration and programming tool</td>
</tr>
<tr>
<td>CB</td>
<td>Circuit breaker</td>
</tr>
<tr>
<td>CBM</td>
<td>Combined backplane module</td>
</tr>
<tr>
<td>CCS</td>
<td>Current circuit supervision</td>
</tr>
<tr>
<td>CEM</td>
<td>Controller area network emulation module</td>
</tr>
<tr>
<td>CIM</td>
<td>Communication interface module</td>
</tr>
<tr>
<td>CMPPPS</td>
<td>Combined Mega Pulses Per Second</td>
</tr>
<tr>
<td>CO cycle</td>
<td>Close-Open cycle</td>
</tr>
<tr>
<td>Co-directional</td>
<td>Way of transmitting G.703 over a balanced line. Involves two twisted pairs making it possible to transmit information in both directions</td>
</tr>
<tr>
<td>Contra-directional</td>
<td>Way of transmitting G.703 over a balanced line. Involves four twisted pairs of with two are used for transmitting data in both directions, and two pairs for transmitting clock signals</td>
</tr>
<tr>
<td>CPU</td>
<td>Central Processor Unit</td>
</tr>
<tr>
<td>CR</td>
<td>Carrier Receive</td>
</tr>
<tr>
<td>CRC</td>
<td>Cyclic Redundancy Check</td>
</tr>
<tr>
<td>CRL</td>
<td>POR carrier for WEI logic</td>
</tr>
<tr>
<td>CS</td>
<td>Carrier send</td>
</tr>
<tr>
<td>CT</td>
<td>Current transformer</td>
</tr>
<tr>
<td>CT1L1</td>
<td>Input to be used for transmit CT group 1 line L1 in signal matrix tool</td>
</tr>
<tr>
<td>CT1L1NAM</td>
<td>Signal name for CT-group 1 line L1 in signal matrix tool</td>
</tr>
<tr>
<td>CT2L3</td>
<td>Input to be used for transmission of CT-group 2 line L3 to remote end</td>
</tr>
<tr>
<td>CT2N</td>
<td>Input to be used for transmission of CT-group 2 neutral N to remote end.</td>
</tr>
<tr>
<td>CVT</td>
<td>Capacitive voltage transformer</td>
</tr>
<tr>
<td>DAR</td>
<td>Delayed auto-reclosing</td>
</tr>
<tr>
<td>db</td>
<td>dead band</td>
</tr>
<tr>
<td>DBDL</td>
<td>Dead bus dead line</td>
</tr>
<tr>
<td>DBLL</td>
<td>Dead bus live line</td>
</tr>
<tr>
<td>DC</td>
<td>Direct Current</td>
</tr>
<tr>
<td>DIN-rail</td>
<td>Rail conforming to DIN standard</td>
</tr>
<tr>
<td>DIP-switch</td>
<td>Small switch mounted on a printed circuit board</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td>DLLB</td>
<td>Dead line live bus</td>
</tr>
<tr>
<td>DSP</td>
<td>Digital signal processor</td>
</tr>
<tr>
<td>DTT</td>
<td>Direct transfer trip scheme</td>
</tr>
<tr>
<td>EHV</td>
<td>Extra high voltage network</td>
</tr>
<tr>
<td>EIA</td>
<td>Electronic Industries Association</td>
</tr>
<tr>
<td>EMC</td>
<td>Electro magnetic compatibility</td>
</tr>
<tr>
<td>ENGV1</td>
<td>Enable execution of step one</td>
</tr>
<tr>
<td>ENMULT</td>
<td>Current multiplier used when THOL is used for two or more lines</td>
</tr>
<tr>
<td>EMI</td>
<td>Electro magnetic interference</td>
</tr>
<tr>
<td>ESD</td>
<td>Electrostatic discharge</td>
</tr>
<tr>
<td>FOX 20</td>
<td>Modular 20 channel telecommunication system for speech, data and protection signals</td>
</tr>
<tr>
<td>FOX 512/515</td>
<td>Access multiplexer</td>
</tr>
<tr>
<td>FOX 6Plus</td>
<td>Compact, time-division multiplexer for the transmission of up to seven duplex channels of digital data over optical fibers</td>
</tr>
<tr>
<td>FPGA</td>
<td>Field Programmable Gate Array</td>
</tr>
<tr>
<td>FRRATED</td>
<td>Rated system frequency</td>
</tr>
<tr>
<td>FSMPL</td>
<td>Physical channel number for frequency calculation</td>
</tr>
<tr>
<td>G.703</td>
<td>Electrical and functional description for digital lines used by local telephone companies. Can be transported over balanced and unbalanced lines</td>
</tr>
<tr>
<td>G.711</td>
<td>Standard for pulse code modulation of analog signals on digital lines</td>
</tr>
<tr>
<td>GCM</td>
<td>Communication interface module with carrier of GPS receiver module</td>
</tr>
<tr>
<td>GI</td>
<td>General interrogation command</td>
</tr>
<tr>
<td>GIS</td>
<td>Gas insulated switchgear.</td>
</tr>
<tr>
<td>GOOSE</td>
<td>Generic Object Orientated Substation Event</td>
</tr>
<tr>
<td>GPS</td>
<td>Global positioning system</td>
</tr>
<tr>
<td>GR</td>
<td>GOOSE Receive (interlock)</td>
</tr>
<tr>
<td>HDLC protocol</td>
<td>High level data link control, protocol based on the HDLC standard</td>
</tr>
<tr>
<td>HFBR connector type</td>
<td>Fibre connector receiver</td>
</tr>
<tr>
<td>HMI</td>
<td>Human-Machine Interface</td>
</tr>
<tr>
<td>HSAR</td>
<td>High-Speed Auto-Reclosing</td>
</tr>
<tr>
<td>HV</td>
<td>High voltage</td>
</tr>
<tr>
<td>HVDC</td>
<td>High voltage direct current</td>
</tr>
<tr>
<td>HysAbsFreq</td>
<td>Absolute hysteresis for over and under frequency operation</td>
</tr>
<tr>
<td>HysAbsMagn</td>
<td>Absolute hysteresis for signal magnitude in percentage of Ubase</td>
</tr>
<tr>
<td>HysRelMagn</td>
<td>Relative hysteresis for signal magnitude</td>
</tr>
</tbody>
</table>
# Introduction to the installation and commissioning manual

## Chapter 1

### Introduction

<table>
<thead>
<tr>
<th><strong>Symbol</strong></th>
<th><strong>Description</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>HystAbs</td>
<td>Overexcitation level of absolute hysteresis as a percentage</td>
</tr>
<tr>
<td>HystRel</td>
<td>Overexcitation level of relative hysteresis as a percentage</td>
</tr>
<tr>
<td>IBIAS</td>
<td>Magnitude of the bias current common to L1, L2 and L3</td>
</tr>
<tr>
<td>IDBS</td>
<td>Integrating dead-band supervision</td>
</tr>
<tr>
<td>IDMT</td>
<td>Minimum inverse delay time</td>
</tr>
<tr>
<td>IDMTtmin</td>
<td>Inverse delay minimum time in seconds</td>
</tr>
<tr>
<td>IdMin</td>
<td>Operational restrictive characteristic, section 1 sensitivity, multiple Ibase</td>
</tr>
<tr>
<td>IDNSMAG</td>
<td>Magnitude of negative sequence differential current</td>
</tr>
<tr>
<td>Idunre</td>
<td>Unrestrained prot. limit multiple of winding1 rated current</td>
</tr>
<tr>
<td>ICHARGE</td>
<td>Amount of compensated charging current</td>
</tr>
<tr>
<td>IEC</td>
<td>International Electrical Committee</td>
</tr>
<tr>
<td>IEC 186A</td>
<td></td>
</tr>
<tr>
<td>IEC 60044-6</td>
<td>IEC Standard, Instrument transformers – Part 6: Requirements for protective current transformers for transient performance</td>
</tr>
<tr>
<td>IEC 60870-5-103</td>
<td>Communication standard for protective equipment. A serial master/slave protocol for point-to-point communication</td>
</tr>
<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers</td>
</tr>
<tr>
<td>IEEE 802.12</td>
<td>A network technology standard that provides 100 Mbits/s on twisted-pair or optical fiber cable</td>
</tr>
<tr>
<td>IEEE P1386.1</td>
<td>PCI Mezzanine Card (PMC) standard for local bus modules. References the CMC (IEEE P1386, also known as Common Mezzanine Card) standard for the mechanics and the PCI specifications from the PCI SIG (Special Interest Group) for the electrical</td>
</tr>
<tr>
<td>EMF</td>
<td>Electro magnetic force</td>
</tr>
<tr>
<td>IED</td>
<td>Intelligent electronic device</td>
</tr>
<tr>
<td>I-GIS</td>
<td>Intelligent gas insulated switchgear</td>
</tr>
<tr>
<td>IL1RE</td>
<td>Real current component, phase L1</td>
</tr>
<tr>
<td>IL1IM</td>
<td>Imaginary current component, phase L1</td>
</tr>
<tr>
<td>IminNegSeq</td>
<td>Negative sequence current must be higher than this to be used</td>
</tr>
<tr>
<td>INAMPL</td>
<td>Present magnitude of residual current</td>
</tr>
<tr>
<td>INSTMAGN</td>
<td>Magnitude of instantaneous value</td>
</tr>
<tr>
<td>INSTNAME</td>
<td>Instance name in signal matrix tool</td>
</tr>
<tr>
<td>IOM</td>
<td>Binary Input/Output module</td>
</tr>
<tr>
<td>IPOSIM</td>
<td>Imaginary part of positive sequence current</td>
</tr>
<tr>
<td>IPOSRE</td>
<td>Real component of positive sequence current</td>
</tr>
<tr>
<td>IP 20</td>
<td>Enclosure protects against solid foreign objects 12.5mm in diameter and larger but no protection against ingress of liquid according to IEC60529. Equivalent to NEMA type 1.</td>
</tr>
</tbody>
</table>
**Introduction to the installation and commissioning manual**

## Chapter 1

### Introduction

**IP 40**
Enclosure protects against solid foreign objects 1.0mm in diameter or larger but no protection against ingestion of liquid according to IEC60529.

**IP 54**
Degrees of protection provided by enclosures (IP code) according to IEC 60529. Dust protected. Protected against splashing water. Equivalent to NEMA type 12.

**Ip>block**
Block of the function at high phase current in percentage of base

**IRVBLK**
Block of current reversal function

**IRV**
Activation of current reversal logic

**ITU**
International Telecommunications Union

**k2**
Time multiplier in IDMT mode

**kForIEEE**
Time multiplier for IEEE inverse type curve

**LAN**
Local area network

**LIB 520**

**LCD**
Liquid chrystal display

**LDCM**
Line differential communication module

**LDD**
Local detection device

**LED**
Light emitting diode

**LNT**
LON network tool

**LON**
Local operating network

**MAGN**
Magnitude of deadband value

**MCB**
Miniature circuit breaker

**MCM**
Mezzanine carrier module

**MIM**
Milliampere Input Module

**MIP**

**MPPS**

**MPM**
Main processing module

**MV**
Medium voltage

**MVB**
Multifunction vehicle bus. Standardized serial bus originally developed for use in trains

**MVsubEna**
Enable substitution

**NegSeqROA**
Operate angle for internal/external negative sequence fault discriminator.

**NSANGLE**
Angle between local and remote negative sequence currents

**NUMSTEP**
Number of steps that shall be activated

**NX**

**OCO cycle**
Open-Close-Open cycle

**PCI**
Peripheral Component Interconnect
### Chapter 1
Introduction

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCM</td>
<td>Pulse code modulation</td>
</tr>
<tr>
<td>PISA</td>
<td>Process interface for sensors &amp; actuators</td>
</tr>
<tr>
<td>PLD</td>
<td>Programmable Logic Device</td>
</tr>
<tr>
<td>PMC</td>
<td></td>
</tr>
<tr>
<td>POTT</td>
<td>Permissive overreach transfer trip</td>
</tr>
<tr>
<td>PPS</td>
<td>Precise Positioning System</td>
</tr>
<tr>
<td>Process bus</td>
<td>Bus or LAN used at the process level, that is, in near proximity to the measured and/or controlled components</td>
</tr>
<tr>
<td>PSM</td>
<td>Power supply module</td>
</tr>
<tr>
<td>PST</td>
<td>Parameter setting tool</td>
</tr>
<tr>
<td>PT ratio</td>
<td>Potential transformer or voltage transformer ratio</td>
</tr>
<tr>
<td>PUTT</td>
<td>Permissive underreach transfer trip</td>
</tr>
<tr>
<td>R1A</td>
<td>Source resistance A (near end)</td>
</tr>
<tr>
<td>R1B</td>
<td>Source resistance B (far end)</td>
</tr>
<tr>
<td>RADSS</td>
<td>Resource Allocation Decision Support System</td>
</tr>
<tr>
<td>RASC</td>
<td>Synchrocheck relay, from COMBIFLEX range.</td>
</tr>
<tr>
<td>RCA</td>
<td>Functionality characteristic angle</td>
</tr>
<tr>
<td>REVAL</td>
<td>Evaluation software</td>
</tr>
<tr>
<td>RFPP</td>
<td>Resistance of phase-to-phase faults</td>
</tr>
<tr>
<td>RFPE</td>
<td>Resistance of phase-to-earth faults</td>
</tr>
<tr>
<td>RISC</td>
<td>Reduced instruction set computer</td>
</tr>
<tr>
<td>RMS value</td>
<td>Root mean square value</td>
</tr>
<tr>
<td>RS422</td>
<td>A balanced serial interface for the transmission of digital data in point-to-point connections</td>
</tr>
<tr>
<td>RS485</td>
<td>Serial link according to EIA standard RS485</td>
</tr>
<tr>
<td>RS530</td>
<td>A generic connector specification that can be used to support RS422, V.35 and X.21 and others</td>
</tr>
<tr>
<td>RTU</td>
<td>Remote Terminal Unit</td>
</tr>
<tr>
<td>RTC</td>
<td>Real Time Clock</td>
</tr>
<tr>
<td>SA</td>
<td>Substation Automation</td>
</tr>
<tr>
<td>SC</td>
<td>Switch or push-button to close</td>
</tr>
<tr>
<td>SCS</td>
<td>Station control system</td>
</tr>
<tr>
<td>SLM</td>
<td>Serial communication module. Used for SPA/LON/IEC communication</td>
</tr>
<tr>
<td>SMA connector</td>
<td>Sub Miniature version A connector</td>
</tr>
<tr>
<td>SMS</td>
<td>Station monitoring system</td>
</tr>
<tr>
<td>SPA</td>
<td>Strömberg Protection Acquisition, a serial master/slave protocol for point-to-point communication</td>
</tr>
<tr>
<td><strong>Abbreviation</strong></td>
<td><strong>Description</strong></td>
</tr>
<tr>
<td>------------------</td>
<td>----------------</td>
</tr>
<tr>
<td><strong>SPGGIO</strong></td>
<td>Single Point Gxxxxx Generic Input/Output</td>
</tr>
<tr>
<td><strong>SRY</strong></td>
<td>Switch for CB ready condition</td>
</tr>
<tr>
<td><strong>ST3UO</strong></td>
<td>RMS voltage at neutral point</td>
</tr>
<tr>
<td><strong>STL1</strong></td>
<td>Start signal from phase L1</td>
</tr>
<tr>
<td><strong>ST</strong></td>
<td>Switch or push-button to trip</td>
</tr>
<tr>
<td><strong>SVC</strong></td>
<td>Static VAR compensation</td>
</tr>
<tr>
<td><strong>t1 1Ph</strong></td>
<td>Open time for shot 1, single phase</td>
</tr>
<tr>
<td><strong>t1 3PhHS</strong></td>
<td>Open time for shot 1, high speed reclosing three phase</td>
</tr>
<tr>
<td><strong>tAutoContWait</strong></td>
<td>Wait period after close command before next shot</td>
</tr>
<tr>
<td><strong>tCBCClosedMin</strong></td>
<td>Minimum time that the circuit breaker must be closed before new sequence is permitted</td>
</tr>
<tr>
<td><strong>tExtended t1</strong></td>
<td>Open time extended by this value if Extended t1 is true</td>
</tr>
<tr>
<td><strong>THL</strong></td>
<td>Thermal Overload Line cable</td>
</tr>
<tr>
<td><strong>THOL</strong></td>
<td>Thermal overload</td>
</tr>
<tr>
<td><strong>tInhibit</strong></td>
<td>Reset reclosing time for inhibit</td>
</tr>
<tr>
<td><strong>tPulse</strong></td>
<td>Pulse length for single command outputs</td>
</tr>
<tr>
<td><strong>TP</strong></td>
<td>Logic Pulse Timer</td>
</tr>
<tr>
<td><strong>tReporting</strong></td>
<td>Cycle time for reporting of counter value</td>
</tr>
<tr>
<td><strong>tRestore</strong></td>
<td>Restore time delay</td>
</tr>
<tr>
<td><strong>TCS</strong></td>
<td>Trip circuit supervision</td>
</tr>
<tr>
<td><strong>TNC connector</strong></td>
<td>Type of bayonet connector, like BNC connector</td>
</tr>
<tr>
<td><strong>TPZ, TPY, TPX, TPS</strong></td>
<td>Current transformer class according to IEC</td>
</tr>
<tr>
<td><strong>tReclaim</strong></td>
<td>Duration of the reclaim time</td>
</tr>
<tr>
<td><strong>TRIPENHA</strong></td>
<td>Trip by enhanced restrained differential protection</td>
</tr>
<tr>
<td><strong>TRIPRES</strong></td>
<td>Trip by restrained differential protection</td>
</tr>
<tr>
<td><strong>TRL1</strong></td>
<td>Trip signal from phase 1</td>
</tr>
<tr>
<td><strong>truck</strong></td>
<td>Isolator with wheeled mechanism</td>
</tr>
<tr>
<td><strong>tSync</strong></td>
<td>Maximum wait time for synchrocheck OK</td>
</tr>
<tr>
<td><strong>TTRIP</strong></td>
<td>Estimated time to trip (in minutes)</td>
</tr>
<tr>
<td><strong>UBase</strong></td>
<td>Base setting for phase-phase voltage in kilovolts</td>
</tr>
<tr>
<td><strong>U/I-PISA</strong></td>
<td>Process interface components that delivers measured voltage and current values</td>
</tr>
<tr>
<td><strong>UNom</strong></td>
<td>Nominal voltage in % of UBase for voltage based timer</td>
</tr>
<tr>
<td><strong>UPS</strong></td>
<td>Measured signal magnitude (voltage protection)</td>
</tr>
<tr>
<td><strong>UTC</strong></td>
<td>Coordinated Universal Time. A coordinated time scale, maintained by the Bureau International des Poids et Mesures (BIPM), which forms the basis of a coordinated dissemination of standard frequencies and time signals</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>V.36</td>
<td>Same as RS449. A generic connector specification that can be used to support RS422 and others</td>
</tr>
<tr>
<td>VDC</td>
<td>Volts Direct Current</td>
</tr>
<tr>
<td>WEI</td>
<td>Week-end infeed logic</td>
</tr>
<tr>
<td>VT</td>
<td>Voltage transformer</td>
</tr>
<tr>
<td>VTSZ</td>
<td>Block of trip from weak-end infeed logic by an open breaker</td>
</tr>
<tr>
<td>X1A</td>
<td>Source reactance A (near end)</td>
</tr>
<tr>
<td>X1B</td>
<td>Source reactance B (far end)</td>
</tr>
<tr>
<td>X1L</td>
<td>Positive sequence line reactance</td>
</tr>
<tr>
<td>X.21</td>
<td>A digital signalling interface primarily used for telecom equipment</td>
</tr>
<tr>
<td>XLeak</td>
<td>Winding reactance in primary ohms</td>
</tr>
<tr>
<td>XOL</td>
<td>Zero sequence line reactance</td>
</tr>
<tr>
<td>ZCOM-CACC</td>
<td>Forward overreaching zone used in the communication scheme</td>
</tr>
<tr>
<td>ZCOM-CR</td>
<td>Carrier Receive Signal</td>
</tr>
<tr>
<td>ZCOM-TRIP</td>
<td>Trip from the communication scheme</td>
</tr>
<tr>
<td>ZCOM-LCG</td>
<td>Alarm Signal Line-check Guard</td>
</tr>
</tbody>
</table>
Chapter 2  Safety information

About this chapter
This chapter contains safety information. Warning signs are presented which attend the user to be careful during certain operations in order to avoid human injuries or damage to equipment.
Warning signs

**Warning!**

Strictly follow the company and country safety regulations. Working in a high voltage environment requires serious approach to avoid human injuries and damage to equipment.

**Warning!**

Do not touch circuitry during operation. Potentially lethal voltages and currents are present.

**Warning!**

Always avoid to touch the circuitry when the cover is removed. The product contains electronic circuitries which can be damaged if exposed to static electricity (ESD). The electronic circuitries also contain high voltage which is lethal to humans.

**Warning!**

Always use suitable isolated test pins when measuring signals in open circuitry. Potentially lethal voltages and currents are present.

**Prohibition!**

Never connect or disconnect a wire and/or a connector to or from a IED during normal operation. Hazardous voltages and currents are present that may be lethal. Operation may be disrupted and IED and measuring circuitry may be damaged.

**Warning!**

Always connect the IED to protective earth, regardless of the operating conditions. This also applies to special occasions such as bench testing, demonstrations and off-site configuration. Operating the IED without proper earthing may damage both IED and measuring circuitry and may cause injuries in case of an accident.

**Warning!**

Never disconnect a secondary connection of current transformer circuit without short-circuiting the transformer’s secondary winding. Operating a current transformer with the secondary winding open will cause a massive potential build-up that may damage the transformer and may cause injuries to humans.
Warning signs

Chapter 2
Safety information

**Warning!**

Never remove any screw from a powered IED or from a IED connected to powered circuitry. Potentially lethal voltages and currents are present.
## 2 Caution signs

**Caution!**
Always transport modules using certified conductive bags. Always handle modules using a conductive wrist strap connected to protective ground and on a suitable antistatic surface. Electrostatic discharge (ESD) may cause damage to the module.

**Caution!**
Do not connect live wires to the IED. Internal circuitry may be damaged.

**Caution!**
Always use a conductive wrist strap connected to protective ground when replacing modules. Electrostatic discharge (ESD) may damage the module and IED circuitry.

**Caution!**
Take care to avoid electrical shock if accessing wiring and connection IEDs when installing and commissioning.

**Caution!**
Changing the active setting group will inevitably change the IED’s operation. Be careful and check regulations before making the change.
3 Note signs

Note!
The protection assembly is designed for a maximum continuous current of four times rated value.

Note!
Activating the setting lockout function, which prevents unauthorised changes of the settings, without proper configuration may seriously affect the IED’s operation.
Chapter 3 Overview

About this chapter
This chapter introduces the user to the installation and commissioning tasks.
1 Commissioning and installation overview

The settings for each function must be calculated before the commissioning task can start. A configuration, made in the configuration and programming tool, must also be available if the terminal does not have a factory configuration downloaded.

The terminal is unpacked and visually checked. It is preferably mounted in a cubicle or on a wall. The connection to the protection system has to be checked in order to verify that the installation was successful.

The installation and commissioning task starts with configuring the digital communication modules, if included. The terminal can then be configured and set, which means that settings and a configuration has to be applied if the terminal does not have a factory configuration downloaded. Then the operation of each included function according to applied settings has to be verified by secondary injection. A complete check of the configuration can then be made. A conformity test of the secondary system has also to be done. When the primary system has been energised a directionality check should be made.
Chapter 4  Unpacking and checking the terminal

About this chapter
This chapter contains instructions on how to receive the terminal.
Receiving, unpacking and checking

1. Remove the transport casing.
2. Visually inspect the terminal.
3. Check that all items are included in accordance with the delivery documents.

The user is requested to check that all software functions are included according to the delivery documents after the terminal has been energised.

4. Check for transport damages.

In case of transport damage appropriate action must be taken against the latest carrier and the nearest ABB office or representative should be informed. ABB should be notified immediately if there are any discrepancies in relation to the delivery documents.

Store the terminal in the original transport casing in a dry and dust free place, if the terminal is not to be installed or commissioned immediately. Observe the environmental requirements stated in the technical data.
Chapter 5  Installing the terminal

About this chapter
This chapter describes how to install the terminal.
1 Overview

The mechanical and electrical environmental conditions at the installation site must be within permissible range according to the technical data of the terminal. Dusty, damp places, places liable to rapid temperature variations, powerful vibrations and shocks, surge voltages of high amplitude and fast rise time, strong induced magnetic fields or similar extreme conditions should be avoided.

Sufficient space must be available in front of and at rear of the terminal to allow access for maintenance and future modifications. Flush mounted terminals should be mounted so that terminal modules can be added and replaced without excessive demounting.
Mounting the terminal

Most of the REx 5xx terminals can be rack, flush, semi-flush or wall mounted with the use of different mounting kits. An additional box of type RHGS can be mounted to one side of a 1/2 or 3/4 terminal. The 19-inch 1/1 wide terminal cannot be semi-flush mounted because the mounting distance frame will cover the ventilation openings at the top and bottom.

A suitable mounting kit is available. Mounting kits include instruction sheets and all parts needed including screws. The following mounting kits are available:

- 19-inch rack mounting kits, 1/2, 3/4 and 1/1 terminal width variants. See section 2.1 "Mounting in a 19-inch rack".
- Side-by-side mounting kit. See section 2.2 "Mounting in a 19-inch rack with an additional box type RHGS".
- Flush mounting kit. See section 2.3 "Mounting in a flush or semi-flush installation".
- Semi-flush mounting kit. See section 2.3 "Mounting in a flush or semi-flush installation".
- Wall mounting kit. See section 2.4 "Mounting on a wall".
2.1 Mounting in a 19-inch rack

<table>
<thead>
<tr>
<th>PosNo</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 and 4</td>
<td>Mounting angle</td>
</tr>
<tr>
<td>2 and 3</td>
<td>TORX T20 screws</td>
</tr>
</tbody>
</table>

*Figure 1: 19-inch rack mounting*
Mounting the terminal

Chapter 5
Installing the terminal

Procedure
1. Carefully fasten the mounting angles to the sides of the terminal.
   Use the TORX T20 screws available in the mounting kit.
2. Place the terminal assembly in the rack.
3. Fasten the mounting angles with appropriate screws.

2.2 Mounting in a 19-inch rack with an additional box type RHGS

Make sure a side-by-side mounting kit and a suitable 19-inch rack mounting kit are available before proceeding.

Assemble the two terminals by using a side-by-side mounting kit. Then mount the brackets and install the assembled terminals in the rack as described in section 2.1 "Mounting in a 19-inch rack".

![Diagram of side-by-side assembly](xx03000028.vsd)

<table>
<thead>
<tr>
<th>PosNo</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Side-by-side mounting plate</td>
</tr>
<tr>
<td>2</td>
<td>Screws (TORX T20)</td>
</tr>
<tr>
<td>3</td>
<td>Mounting angle</td>
</tr>
</tbody>
</table>

Figure 2: Side-by-side assembly

Procedure
1. Place the two terminals next to each other on a flat surface.
2. **Fasten a side-by-side mounting plate (PosNo 1).**
   Use four of the delivered screws.

3. **Carefully turn the two terminals up-side down.**

4. **Fasten the second side-by-side mounting plate.**
   Use the remaining four screws.

5. **Follow the instructions in section 2.1 "Mounting in a 19-inch rack" to mount the mounting angles (PosNo 5) and install the side-by-side assembly in the rack.**

### 2.3 Mounting in a flush or semi-flush installation

Make sure a flush or semi-flush mounting kit is available before proceeding.

The procedure for flush and semi-flush mounting is mainly the same. In semi-flush mounts a distance frame is added. The delivered mounting seal is only necessary to fulfil IP 54.
Mounting the terminal

Chapter 5

Installing the terminal

Figure 3: Flush and semi-flash mounting

<table>
<thead>
<tr>
<th>PosNo</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sealing strip</td>
</tr>
<tr>
<td>2</td>
<td>Distance frame (only for semi-flush)</td>
</tr>
<tr>
<td>3</td>
<td>Sealing strip for distance frame (only for semi-flush)</td>
</tr>
<tr>
<td>4</td>
<td>Side holder</td>
</tr>
<tr>
<td>5</td>
<td>Groove</td>
</tr>
<tr>
<td>6</td>
<td>Locking screw (TORX T10)</td>
</tr>
</tbody>
</table>

Note!

Flush or semi-flash mount cannot be used for side-by-side mounted terminals when IP 54 must be fulfilled.
Mounting the terminal

Chapter 5
Installing the terminal

Procedure

1. **Cut the sealing strip in appropriate lengths.**

   The strip is delivered with the mounting kit. In the semi-flush mounting kit two strips are delivered, one for the terminal and one self-adhering for the distance frame. The length of the strip is enough for the largest available terminal.

   Cut the strip into four, one part for each side of the terminal. When cutting, make sure no gaps will be present between each part. Preferably, seal the joints at the corners (posNo 1).

   Repeat the procedure for the self-adhering strip which are to be adhered to the distance frame.

2. **Dispose the strip remains.**

   The remains should be source separated as soft plastic.

3. **Carefully press the cut strips into the front panel groove.**

4. **Adhere the cut strips (posNo 3) to the edge of the distance frame (posNo 2).**

   semi-flush mounting only.

5. **Make a panel cut-out.**

   See the Technical reference manual for cut-out dimensions.

6. **Insert the terminal into the cut-out.**

7. **Add and lock the side holders (PosNo 4) to the terminal.**

   Thread a side holder into the groove (posNo 5) at the back end of the terminal. Insert and lightly fasten the locking screw (posNo 6). Next, thread a side holder on the other side of the terminal, and lightly fasten its locking screw.

   Repeat this with the remaining two side holders.

8. **Lock the terminal to the cut-out.**

   Firmly tighten the locking screws. It is important that all four side holder locking screws are tightened the same in order to maintain a good and even seal in IP 54 environments.

2.4 Mounting on a wall

The mounting bars are prepared for adding DIN-rails or equivalent above and below the mounted terminal. If used, make sure all necessary parts such as rails and terminal blocks are available before starting. Make sure the wall mounting kit is available.
2.4.1 Mounting the terminal on a wall

Procedure

1. Mount the bars (posNo 1) onto the wall.
   
   See the Technical reference manual for measurements.
   
   Depending on the wall different preparations may be needed, like drilling and inserting plastic or expander plugs (concrete/plasterboard walls) or threading (metal sheet wall).

2. Mount the DIN-rail(s) on the mounting bars.

3. Mount the terminal blocks on the DIN-rail(s).

   It is much easier to do this without the unit in place.

---

**Figure 4:** Wall mounting

<table>
<thead>
<tr>
<th>PosNo</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mounting bar</td>
</tr>
<tr>
<td>2</td>
<td>Side plate</td>
</tr>
</tbody>
</table>
4. Make all external electrical connections to the terminal blocks. It is much easier to do this without the unit in place.

5. Mount the side plates (posNo 2) to the terminal.

6. Mount the terminal to the mounting bars.

2.4.2 Preparing a wall mounted terminal for electrical installation

Procedure
1. Remove all screws from one side plate.
2. Remove two screws from the other side plate.
3. Careful swing the terminal out from the wall.

See figure 5.

Figure 5: View from above over a wall mounted terminal that is prepared for electrical connection.
3 Making the electrical connections

Always make sure established guidelines for this type of terminal is followed during installation. When necessary use screened twisted-pair cables to minimize susceptibility. Otherwise use any kind of regular nonscreened tinned cable or equivalent.

When using screened cabling always use 360° full screen cable bushings to ensure screen coupling. Ensure that all signals of a single circuit are in the same single cable. Avoid mixing current and voltage measuring signals in the same cable. Also use separate cables for control and measuring circuits.

Note!
Screened and twisted pair cables are a requirement for galvanic communications in application with 56/64 kbit/s. The screen must be earthed according to figures in the sections “Making the screen connection” and “Installing the communication cables”.

3.1 Connecting the CT circuits

CTs are connected using back-side mounted screw connectors.

Use a solid conductor with a cross section area between 2.5-6 mm² (AWG14-10) or a stranded conductor with a cross section area between 2.5-4 mm².

If the terminal is equipped with a test-switch of type RTXP 24 COMBIFLEX wires with 20 A sockets must be used to connect the CT circuits.

3.2 Connecting the auxiliary power, VT and signal connectors

Auxiliary power, VTs and signals are connected using COMBICON (Phoenix technology) plug-in screw connectors.

Procedure
1. Connect signals to the COMBICON plug.
2. Plug the connector to the corresponding back-side mounted receptable.
3. Lock the plug to the receptable by fastening the lock screws.

Use a solid or stranded conductor with a cross section area between 0.5-2.5 mm² (AWG20-14). Use a ferrule with plastic collar to connect two conductors, cross section area between 0.5-1.5 mm² (AWG20-16).
Figure 6: Voltage connector, showing connection point X20:5

Figure 7: Connected cables with ferrules

Where: 1 is ferrule
If the terminal is equipped with a test-switch of type RTXP 24 COMBIFLEX wires with 20 A sockets must be used to connect the VT circuits and the auxiliary power.

### 3.3 Connecting to protective earth

Connect the unit to the earthing bar of the cubicle with a green/yellow conductor, cross section at least 1.5 mm² (AWG16), connected to the protective earth connector at the back of the terminal.

### 3.4 Making the screen connection

When using screened cables always make sure screens are earthed and connected in accordance to applicable engineering methods. This may include checking for appropriate earthing points near the terminal, for instance, in the cubicle and/or near the source of measuring. Ensure that earth connections are made with short (max. 10 cm) conductors of an adequate cross section, at least 6 mm² (AWG10) for single screen connections.
Installing the optical fibres

Connectors are generally color coded; connect blue or dark grey cable connectors to blue or dark grey (receive) back-side connectors. Connect black or grey cable connectors to black or grey (transmit) back-side connectors.

**Caution!**

*The fibre optical cables are very sensitive to handling. Do not bend too sharply. The minimum curvature radius is 15 cm for the plastic fibre cables and 25 cm for the glass fibre cables. If cable straps are used to fix the cables, apply with loose fit.*

*Always hold the connector, never the cable, when connecting or disconnecting optical fibres. Do not twist, pull or bend the fibre. Invisible damage may increase fibre attenuation thus making communication impossible.*

**Note!**

*Please, strictly follow the instructions from the manufacturer for each type of optical cables/connectors.*
5 Installing the serial communication cable for RS485 SPA/IEC

5.1 RS485 serial communication module

![Diagram of pin arrangement on modem terminal](en03000109.vsd)

Where:
A Signal A
B Signal B
1) Do not use
GND Ground

Figure 8: Pin arrangement on modem terminal. Baud rate: 9600

The distance between earth points should be < 100 m, see figure 9. Only the outer shielding is connected to the protective earth at the terminal. The inner and outer shieldings are connected to the protective earth at the external equipment. Use insulating tape for the inner shield to prevent contact with the protective earth. Make sure that the terminals are properly earthed with as short connections as possible from the earth screw, for example to an earthed frame.

The terminal and the external equipment should preferably be connected to the same battery.
Where:

1. The inner shields shall be connected together (with an isolated terminal block) and only have one earthing point in the whole system, preferably at the external equipment (PC).

   The outer shield shall be connected to Protective Earth (PE) in every cable end i.e. to PE at all relay terminals and to PE at External equipment (PC). The first terminal will have only one cable end but all others of course two.

   | Cc | Communication cable |
   | PE | Protective earth screw |

Figure 9: Communication cable installation
5.2 Informative excerpt from EIA Standard RS-485

Informative excerpt from EIA Standard RS-485 - Electrical Characteristics of Generators and Receivers for Balanced Digital Multipoint Systems

RS-485 Wire - Media dependent Physical layer

1 Normative references
EIA Standard RS-485 - Electrical Characteristics of Generators and Receivers for Balanced Digital Multipoint Systems

2 Transmission method
RS-485 differential bipolar signaling

2.1 Differential signal levels
Two differential signal levels are defined:
- \( A^+ \) = line A positive with respect to line B
- \( A^- \) = line A negative with respect to line B

2.2 Galvanic isolation
The RS485 circuit shall be isolated from earth by:
- \( R_{iso} \geq 10 \, \text{M}\Omega \)
- \( C_{iso} \leq 10 \, \text{pF} \)
Three isolation options exist:

a) The entire node electronics can be galvanically isolated
b) The bus interface circuit can be isolated from the rest of node electronics by optoisolators, transformer coupling or otherwise.
c) The RS485 chip can include built-in isolation

2.3 Bus excitation and signal conveyance

2.3.1 Requirements

a) The RS485 specification requires the Signal A and Signal B wires.
b) Each node also requires (5 V) Excitation of the RS485 termination network.
c) V_{im} - the common mode voltage between any pair of RS485 chips may not exceed 10 V.
d) A physical ground connection between all RS485 circuits will reduce noise.

2.3.2 Bus segment termination network

The termination network below required at each end of each Bus Ph-segment.

![Figure 11: RS-485 bus segment termination](en03000112.vsd)

ExV is supplied by the Node at end of the Bus Segment

The specifications of the components are:

a) Ru + 5 V to Signal B = 390 Ω, 0.25 W ±2.5%
b) Rt Signal B to Signal A = 220 Ω, 0.25 W ±2.5%
c) Rd Signal A to GND = 390 Ω, 0.25 W ±2.5%

2.3.3 Bus power distribution

The end node in each Ph-segment applies 5 V bus excitation power to the Termination network via the Excitation pair (ExV+ and GND) used in the Type 3 Physical layer specification.
## 5.3 Data on RS485 serial communication module cable

<table>
<thead>
<tr>
<th>Type</th>
<th>Twisted-pair S-STP (Screened – Screened Twisted Pair)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shield</td>
<td>Individual foil for each pair with overall copper braid</td>
</tr>
<tr>
<td>Length</td>
<td>Maximum 100 m from one system earth to the next system earth (includes length from platform point to system earth on both sides)</td>
</tr>
<tr>
<td>Temp</td>
<td>According to application</td>
</tr>
<tr>
<td>Impedance</td>
<td>120 Ω</td>
</tr>
<tr>
<td>Capacitance</td>
<td>Less than or equal to 42 pF/m</td>
</tr>
<tr>
<td>Example</td>
<td>Belden 9841</td>
</tr>
</tbody>
</table>
6 Installing the 56/64 kbit data communication cables

When using galvanic connection between protection terminal and communication equipment or point to point galvanic connection between two protection terminals it is essential that the cable installation is carefully done. This is true regardless of type of module used, G.703, V.36, short range galvanic etc., only the possible length of the cable differs. The factors that must be taken into account are the susceptibility for noise disturbance, due to that the levels of the communication signal are very low.

For best result a cable with twisted pairs and double screens should be used, one screen for each twisted pair and one surrounding all pairs. Each signal shall utilize its own twisted pair as in figure 12. The screen for each separate pair shall be connected to internal screen or ground connection of equipment in one and the same end only, if available, or in other case connected to earth close to the equipment.

The outer screen surrounding all pairs shall be connected to a solid earth at each end close to the equipment.

Note also that recommendation about cable lengths given for modules according ITU/EIA interface, excluding the short range galvanic module, are under the assumption that the two devices, the protection terminal and the communication terminal, are within the same building and that the earthing system of the building is of good quality. It also presumes that the environment is relatively free from electromagnetic interference.
Installing the 56/64 kbit data communication cables

Chapter 5
Installing the terminal

Figure 12: Communication cable installation

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cc</td>
<td>Communication cable</td>
</tr>
<tr>
<td>Lc</td>
<td>Line connector</td>
</tr>
<tr>
<td>Rx</td>
<td>Receive input</td>
</tr>
<tr>
<td>Sc</td>
<td>Screen (or earth/ground) connection</td>
</tr>
<tr>
<td>Tx</td>
<td>Transmit output</td>
</tr>
</tbody>
</table>

en03000087.vsd
Chapter 6  Checking the external circuitry

About this chapter
This chapter describes what to check and which checks that should be made to ensure a correct connection to the external circuitry, such as auxiliary power supply, CT’s and VT’s. These checks must be made with the protection terminal de-energised.
1 Overview

The user must check the installation which includes verifying that the terminal is connected to the other parts of the protection system. This is done with the terminal and all connected circuits de-energised.
2 Checking the CT and VT circuits

Check that the wiring is in strict accordance with the supplied wiring diagram.

Note!

Do not continue further until any errors are corrected.

Test the circuitry. The following tests are recommended:

• Polarity check.
• CT circuit current measurement (primary injection test).
• Earthing check.

The polarity check verifies the integrity of the circuits and the phase relationship. The check should be performed as close as possible to the terminal.

The primary injection test verifies the CT ratio and the wiring all the way through from the primary system to the terminal. Injection must be performed for each phase-to-neutral circuit and each phase-to-phase pair. In each case currents in all phases and the neutral line are measured.
3 Checking the power supply

Check that the value of the auxiliary supply voltage remains within the permissible range under all operating conditions. Check that the polarity is correct.
4 Checking the binary I/O circuits

4.1 Binary input circuits
Preferably, disconnect the binary input connector from the binary input cards. Check all connected signals so that both input level and polarity are in accordance with the terminal’s specifications.

4.2 Binary output circuits
Preferably, disconnect the binary output connector from the binary output cards. Check all connected signals so that both load and polarity are in accordance with the terminal’s specifications.
Chapter 7  Energising the terminal

About this chapter
This chapter describes the start up sequence and what to check after the terminal has been energised.
Overview

Before the procedures in this chapter can be carried out the connection to external circuitry must have been checked which ensures that the installation was made correctly.

The user must energise the power supply to the terminal to start it up. This could be done in number of ways, from energising a whole cubicle to energising a single terminal. The user should reconfigure the terminal to activate the hardware modules in order to enable the self supervision function detect eventual hardware errors. Then the terminal time must be set. The self supervision function should also be checked to verify that the terminal unit operates properly. The user could also check the software version, the terminals serial number and the installed modules and their ordering number to ensure that the terminal is according to delivery and ordering specifications.
2 Energising the terminal

When the terminal is energised the window on the local HMI remains dark. After 10 seconds the green LED starts flashing and after approximately 30 seconds the window lights up. After another 10 seconds the window displays ‘Terminal Startup’ and after about 30 seconds the main menu is displayed. The upper row should indicate ‘Ready’. A steady green light indicates a successful startup.

![Typical terminal startup sequence](xx02000679.vsd)

1. Terminal energised. Liquid Crystal Display (LCD) is dark.
2. Green Light Emitting Diod (LED) starts flashing
3. LCD lights up
4. “Terminal startup” is displayed
5. The main menu is displayed. A steady green light indicates a successful startup.

*Figure 13: Typical terminal startup sequence*

If the upper row in the window indicates ‘Fail’ instead of ‘Ready’ and the green LED is flashing an internal failure in the terminal has been detected. See the self supervision function in this chapter to investigate the fault.

After startup the appearance of the local HMI should be as shown in figure 14.
Figure 14: Example of the local HMI531.
3 Checking the self supervision signals

3.1 Reconfiguring the terminal

I/O modules configured as logical I/O modules (BIM, BOM, IOM, DCM, IOPSM or MIM) are supervised. Not configured I/O modules are not supervised.

Each logical I/O module has an error flag that is set if anything is wrong with any signal or the whole module. The error flag is also set when there is no physical I/O module of the correct type present in the connected slot.

Procedure
1. **Browse to the ‘Reconfigure’ menu.**
   The Reconfigure menu is located in the local HMI under:
   
   ```
   Configuration/I/O-modules/Reconfigure
   ```

2. **Select ‘Yes’ and press ‘E’**.

3.2 Setting the terminal time

This procedure describes how to set the terminal time.

1. **Display the set time dialog.**
   Navigate the menus to:
   
   ```
   Settings/Time
   ```
   Press the E button to enter the dialog.

2. **Set the date and time.**
   Use the **Left** and **Right** arrow buttons to move between the time and date values (year, month, day, hours, minutes and seconds). Use the **Up** and **Down** arrow buttons to change the value.

3. **Confirm the setting.**
   Press the E button to set the calendar and clock to the new values.

3.3 Checking the self supervision function

3.3.1 Navigating the menus

This procedure describes how to navigate the menus in order to find the reason of an internal failure when indicated by the flashing green LED of the HMI module.
Checking the self supervision signals

Chapter 7

Energising the terminal

Procedure

1. Display the self supervision menu.

   Navigate the menus to:

   **TerminalReport**
   **SelfSuperv**

2. Scroll the supervision values to identify the reason of the failure.

   Use the *Left* and/or *Right* arrow buttons to scroll between values.

### 3.4 Self supervision HMI data

Table 1: Output signals for the self supervision function

<table>
<thead>
<tr>
<th>Indicated result</th>
<th>Possible reason</th>
<th>Proposed action</th>
</tr>
</thead>
<tbody>
<tr>
<td>InternFail = OK</td>
<td>No problem detected.</td>
<td>None.</td>
</tr>
<tr>
<td>InternFail = Fail</td>
<td>A failure has occurred.</td>
<td>Check the rest of the indicated results to find the fault.</td>
</tr>
<tr>
<td>InternWarning = OK</td>
<td>No problem detected.</td>
<td>None.</td>
</tr>
<tr>
<td>InternWarning = Warning</td>
<td>A warning has been issued.</td>
<td>Check the rest of the indicated results to find the fault.</td>
</tr>
<tr>
<td>MPM-modFail = OK</td>
<td>No problem detected.</td>
<td>None.</td>
</tr>
<tr>
<td>MPM-modFail = Fail</td>
<td>The main processing module has failed.</td>
<td>Contact your ABB representative for service.</td>
</tr>
<tr>
<td>MPM-modWarning = OK</td>
<td>No problem detected.</td>
<td>None.</td>
</tr>
<tr>
<td>MPM-modWarning = Warning</td>
<td>There is a problem with:</td>
<td>Set the clock. If the problem persists, contact your ABB representative for service.</td>
</tr>
<tr>
<td></td>
<td>• the real time clock.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• the time synchronization.</td>
<td></td>
</tr>
<tr>
<td>ADC-module = OK</td>
<td>No problem detected.</td>
<td>None.</td>
</tr>
<tr>
<td>ADC-module = Fail</td>
<td>The A/D conversion module has failed.</td>
<td>Contact your ABB representative for service.</td>
</tr>
<tr>
<td>Slot04BIM1 = Fail</td>
<td>I/O module has failed.</td>
<td>Check that the I/O module has been configured and connected to the IOP1- block. If the problem persists, contact your ABB representative for service.</td>
</tr>
<tr>
<td>Slot04BIM1 = Fail</td>
<td>(Example data, see following section for details)</td>
<td></td>
</tr>
<tr>
<td>RealTimeClock = OK</td>
<td>No problem detected.</td>
<td>None.</td>
</tr>
<tr>
<td>RealTimeClock = Warning</td>
<td>The real time clock has been reset.</td>
<td>Set the clock.</td>
</tr>
<tr>
<td>TimeSync = OK</td>
<td>No problem detected.</td>
<td>None.</td>
</tr>
<tr>
<td>TimeSync = Warning</td>
<td>No time synchronization.</td>
<td>Check the synchronization source for problems. If the problem persists, contact your ABB representative for service.</td>
</tr>
</tbody>
</table>
Chapter 8 Configuring the 56/64 kbit data communication modules

About this chapter
This chapter contains instructions on how to configure the 56/64 kbit data communication modules, such as galvanic and optical modems.
1 Calculation of optical power budget

Refer to table 2 and table 3 for maximum distance in a back-to-back application

Table 2: Input data for calculation of optical power budget

<table>
<thead>
<tr>
<th>General data</th>
<th>Attenuation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of optical Tx/Rx-module</td>
<td>0</td>
</tr>
<tr>
<td>Bit rate</td>
<td>64 kbit/s</td>
</tr>
<tr>
<td>Transmission code</td>
<td>MCMI</td>
</tr>
<tr>
<td>Optical fibre</td>
<td>Single mode</td>
</tr>
<tr>
<td>Optical connector</td>
<td>FC-PC</td>
</tr>
<tr>
<td>Optical wavelength</td>
<td>1300 nm</td>
</tr>
<tr>
<td>Spectral bandwidth</td>
<td>30.0 nm</td>
</tr>
<tr>
<td>Transmitter Tx</td>
<td>LED</td>
</tr>
<tr>
<td>Optical min output power (S)</td>
<td>-22 dBm</td>
</tr>
<tr>
<td>Receiver Rx</td>
<td>Pin Diode</td>
</tr>
<tr>
<td>Sensitivity for BER 0 10^-10 (R)</td>
<td>-38 dBm</td>
</tr>
<tr>
<td>Available power budget</td>
<td>-16 dB</td>
</tr>
</tbody>
</table>

Table 3: Examples of optical power budget calculation

<table>
<thead>
<tr>
<th>Terminal equipment</th>
<th>Example 1</th>
<th>Example 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available power budget (S_R)</td>
<td>16 dB</td>
<td>16 dB</td>
</tr>
<tr>
<td>Equipment margin</td>
<td>Included</td>
<td>Included</td>
</tr>
<tr>
<td>Type of optical connectors</td>
<td>FC-PC for single mode</td>
<td></td>
</tr>
<tr>
<td>Terminal box</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patch panel connectors</td>
<td>FC-PC for single mode</td>
<td>0</td>
</tr>
<tr>
<td>Connectors for S-R</td>
<td>0.5 dB each</td>
<td>Included</td>
</tr>
<tr>
<td>Total available optical power</td>
<td>16 dB</td>
<td>16 dB</td>
</tr>
<tr>
<td>Optical cable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of optical fibre</td>
<td>Single mode 1300 nm</td>
<td></td>
</tr>
<tr>
<td>Fibre attenuation (installed)</td>
<td>0.22 dB/km</td>
<td>0.34 dB/km</td>
</tr>
<tr>
<td>Splice attenuation</td>
<td>0.08 dB per splice</td>
<td></td>
</tr>
<tr>
<td>Av. cable length between splices</td>
<td>3.0 km</td>
<td></td>
</tr>
<tr>
<td>Average number of splices</td>
<td>0.33 splice/km</td>
<td>0.027 dB/km</td>
</tr>
<tr>
<td>Number of repair splices</td>
<td>0.10 splice/km</td>
<td>0.008 dB/km</td>
</tr>
<tr>
<td>Fibre margin</td>
<td>0.010 dB/km</td>
<td>0.010 dB/km</td>
</tr>
<tr>
<td>Total fibre attenuation per km</td>
<td>0.265 dB/km</td>
<td>0.385 dB/km</td>
</tr>
<tr>
<td>Maximum optical transmission distance</td>
<td>60 km</td>
<td>41 km</td>
</tr>
</tbody>
</table>
2 Fault tracing

Procedure
1. Check that the settings are correct.
2. Check that the optical budget is correct.
3. COMFAIL occurs for the following reasons:

The COMFAIL signal will be triggered when there is a problem in the communication link between the two terminals, depending on type of 56/64 modem. Also, normal actions such as a change of setting, switch off of remote terminal during maintenance etc., can cause COMFAIL.

2.0.1 Comfail function

Drop-out delay; $t = 200\text{ms}$

Figure 15: Comfail triggering.

The 200 ms alarm dropout delay is, for example, required as hysteresis for terminals with reserve overcurrent, REL 551 or distance reserve function REL 561, if the differential function is blocked by communication delays and interruptions etc.

The communication failure signal, COMFAIL, depends on the following internal signals (variables) in each terminal for REx 5xx. Table 4 shows a summary with additional explanations below.
Table 4: Summary

<table>
<thead>
<tr>
<th>No.</th>
<th>COMFAIL triggering</th>
<th>COMFAIL triggering time (Drop-out delay 200 ms)</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Transmit error</td>
<td>≥ 50 ms</td>
<td>Messages can not be sent</td>
</tr>
<tr>
<td>2</td>
<td>Receive error</td>
<td>≥ 100 ms</td>
<td>No valid messages received</td>
</tr>
<tr>
<td>3</td>
<td>Block differential protection</td>
<td>0 ms</td>
<td>Block of the differential protection due to setting changes etc.</td>
</tr>
<tr>
<td>4</td>
<td>Remote terminal COMFAIL</td>
<td>0 ms</td>
<td>COMFAIL from the remote terminal. For error no 1, 2, 3, and no 5, 6, 7, 8, 9, 10 the COMFAIL is sent in the second consecutive message (within 10 ms)</td>
</tr>
<tr>
<td>5</td>
<td>Time synchronization error</td>
<td>≥ 2 s</td>
<td>Problems in the synchronization of internal differential clock in the differential protection. The clock refers to the synchronized counters 0-39999 μs in each terminal. The clock is independent of the real time clock in the terminal.</td>
</tr>
<tr>
<td>6</td>
<td>Differential clock drift</td>
<td>&gt; 0 ms</td>
<td>Unacceptable drift of the internal differential clock in the slave terminal compared to the internal differential clock in the master terminal (slave- master -slave)</td>
</tr>
<tr>
<td>7</td>
<td>Communication channel loop delay - instantaneous</td>
<td>0 ms</td>
<td>Checks if the loop time (slave - master-slave) in the differential communication channel 31 ms</td>
</tr>
<tr>
<td>8</td>
<td>Communication channel loop delay - time delayed</td>
<td>≥ 2 s</td>
<td>Checks if the loop time (local - remote- local) in the differential communication channel 24 ms</td>
</tr>
<tr>
<td>9</td>
<td>Abnormal clock deviation</td>
<td>0 ms</td>
<td>Internal differential clock deviation (slave-mast er -slave)</td>
</tr>
<tr>
<td>10</td>
<td>Data flow Only in version *2.3</td>
<td>0 ms</td>
<td>Long time between attempts to send messages and adjustment of the real time terminal clock. The terminal clock is the real time clock in the terminal for time tagging of events etc.</td>
</tr>
</tbody>
</table>

2.0.2

Explanation of contents in column 2 of table 42

1. Transmit errors are due to that the terminal cannot send messages via the telecommunication channel (PCM). The line differential function initiates the sending of one message every 5 ms. If this command can not be executed for 10 consecutive times (= 10 x 5 ms) due to blocked, missing or unsynchronized communication channel, COMFAIL is triggered. For non-consecutive interruptions, an integration algorithm is used that prolongs the COMFAIL triggering time.

2. Receive errors occur when no expected messages are received. The line differential function expects to receive one message every 5 ms. If this does not occur 10 consecutive times (= 10x5 ms), COMFAIL is triggered. For non-consecutive interruptions, an integration algorithm is used that prolongs the COMFAIL triggering time.
3. Block differential protection. Block of differential protection occurs during change of settings or setting group.

4. Remote terminal COMFAIL. For error No 1, 2, 3 and No 5, 6, 7, 8, 9, 10 the COMFAIL is sent in the second consecutive message (within 10 ms). Thus, some short interruptions can be recorded only in one terminal. The communication channel must be in operation to be able to receive this signal.

5. Time synchronization error refers to synchronization check and is only performed by the terminal set as Slave for the internal differential clocks synchronization. If 50 time synchronization messages (included with every 8 line differential function message) are not correctly received (= 8 x 5 ms x 50 = 2000 ms), COMFAIL will be triggered. If more than 750 synchronization messages are not correctly received, a re-synchronization of the internal differential clock will be made. For non-consecutive interruptions, an integration algorithm prolongs the COMFAIL triggering time.

6. Differential Clock drift refers to a difference > 50 ms between the internal differential clocks in the differential protection in the terminal set as Slave and the one set as Master for synchronization of the internal differential clock. The COMFAIL triggering time depends on a number of factors from a drift compensation algorithm. This check is normally not activated unless the communication channel has been lost for a long time.

7. Communication channel loop delay-instantaneous is checked every 40 ms (at each synchronization message). If the communication channel loop (Slave-Master-Slave) delay is more than 31 ms for one message, COMFAIL is triggered instantaneously. This check is done in the terminal set as Slave for the internal differential clock by a comparison with the real time clock in the terminal at sending and receiving of a looped message.

8. Communication channel loop delay-time delayed checks if the communication channel delay for transmitted and received signal is > 24 ms (Local-Remote-Local). The check is performed every 40 ms (at each synchronization message) by comparing the real time clock time at sending and receiving of a looped message. COMFAIL is triggered after 50 consecutive messages with excessive loop time. COMFAIL triggering time = 2000 ms (≈ 50x40 ms). For non-consecutive messages with excessive loop time, an integration algorithm is used that prolongs the COMFAIL triggering.

9. Abnormal clock deviation checks if the synchronization in the Slave of the internal differential clocks in the differential protection have an abnormal deviation, (Slave-Master-Slave). COMFAIL is triggered instantaneously, but will probably only occur after long interruptions in the communication channel. However, the start or re synchronization procedure can also activate COMFAIL due to this function.

10. Data flow checks if the time between initiations of the sending messages from the line differential function is longer than 20 ms, using the real time clock for the check. This check will also trigger the COMFAIL if the external time synchronization of the real time clock by minute pulse or SPA/LON from Station Clock or GPS, adjusts the terminal clock forward > 15 ms. The COMFAIL triggering is instantaneous. The channel interruption measurements for short, medium and long interruptions, presented on the HMI are based on measurements of timing from the real time clock which are made independently in each terminal. These measurements are also independent from the internal differential clock. The mea-
surements presented on the front HMI are not connected to COMFAIL or by in-
dications of channel delay exceeding 12 ms, since the delay is not a channel
interrupt, the channel is still working.
Chapter 9  Setting and configuring the terminal

About this chapter
This chapter describes how to set the terminal, either through a PC or the local HMI, and download a configuration to the terminal in order to make commissioning possible.

The chapter does not contain instructions on how to create a configuration or calculate settings. Please consult the application manual for further information about how to calculate settings.
1 Overview

The customer specific values for each setting parameter and a configuration file has to be available before the terminal can be set and configured, if the terminal is not delivered with a configuration.

Use the CAP 531 configuration tool to verify if the terminal has the expected configuration. A new configuration is performed with the CAP tool. The binary outputs can be selected from a signal list where the signals are grouped under their function names. It is also possible to specify a user-defined name for each input and output signal.

The configuration can be downloaded through the front connector on the local HMI or via the rear SPA port.

Each function included in the terminal has several setting parameters which have to be set in order to make the terminal behave as intended. A default value is provided for each parameter from factory. A setting file can be prepared using the parameter setting tool (PST), which is available in the CAP 540 package.

All settings can be:

• Entered manually through the local HMI.
• Downloaded from a PC, either locally or remotely using SMS/SCS. Front or rear port communication has to be established before the settings can be downloaded.

Note!

Be sure to configure the functional input HMI–BLOCKSET to only one of the available binary inputs before setting the parameter SettingRestrict to Block in the local HMI.
2 Entering settings through the local HMI

Each of the included functions in the terminal has to be set and this can be performed through the local HMI. The user must browse to the desired function and enter the appropriate value. The parameters for each function can be found in the local HMI. See the technical reference manual for a complete list of setting parameters for each function. Some of the included functions may not be used. In this case the user can set the parameter “Operation” to “Off” to disable the function.

Some settings can only be set through the local HMI, such as the setting access, the slave number and baud rate when communicating with a PC software. The setting access can be blocked by the binary input signal HMI--BLOCKSET. When this signal is active the user can still read all information, including the setting values.
Configuring the setting restriction of HMI function

Configuring the HMI--BLOCKSET functional signal can only be done from the local HMI.

**Procedure**

1. **Navigate the menus to:**
   
   Configuration/BuiltInHMI/HMI--BLOCKSET

2. **Select a binary input**

   Select a binary input not used or reserved for any other purpose.

Connect the selected binary input to the DC control voltage via a normally closed contact of a control switch, which can be locked by a key. Only when the normally closed contact is open, the change of settings and configuration of the REx 5xx terminal is possible. See figure 16.
4 Activating the restriction of setting

4.1 Local HMI

Activating the restriction of setting via local HMI can only be done from the local HMI.

Procedure
1. Navigate the menus to:
   Configuration/BuiltInHMI/SettingRestrict
2. Set SettingRestrict = Block.

Note!
The HMI--BLOCKSET functional input must be configured to the selected binary input before setting the setting restriction function in operation. Carefully read the instructions.

4.2 Serial communication, change of active group

Activating the restriction of setting, or change of active group via the rear communication port, can only be done from the local HMI.

Procedure
1. Navigate the menus to:
   Configuration/TerminalCom/SPACom/Rear/ActGrpRestrict
2. Set ActGrpRestrict = Block

4.3 Serial communication, setting

Activating the restriction of setting or change of active group, can only be done from the local HMI.

Procedure
1. Navigate the menus to:
   Configuration/TerminalCom/SPACom/Rear/SettingRestrict
2. Set SettingRestrict = Block
5 

5.1 Establishing front port communication

When a PC is used to download settings and configuration, you need the terminal toolbox CAP 540 (including CAP 531 and PST).

A special cable is needed when connecting a PC to the front of the REx 5xx terminal. This cable can be ordered from ABB. It must be plugged into the optical contact on the left side of the local HMI. The other end of the cable shall be plugged directly into the COM-port on the PC. The cable includes an optical contact, an opto/electrical converter and an electrical cable with a standard 9-pole D-sub contact. This ensures a disturbance-free and safe communication with the terminal.

When communicating from a PC, the slave number and baud rate (communication speed) settings must be equal in the PC-program and in the REx 5xx terminal.

Procedure

1. Plug the cable to the optical contact on the local HMI.
2. Plug the other end of the cable to the COM port of the PC.
3. Set the slave number and baud rate in the terminal.

   The slave number and baud rate settings in the REx 5xx terminal is done on the local HMI at:

   Configuration/TerminalCom/SPACom/Front

4. Set the slave number and baud rate in the PC-program.

   The slave number and baud rate must be the same as in the terminal. See the CAP 540 manual.

5.2 Establishing rear port communication

Settings can be performed via any of the optical ports at the rear of the REx 5xx terminal. When a PC is connected to the SMS system, the CAP 540 and the PST softwares are used. Settings can also be done via the SCS system, based on MicroLIBRARY.

5.2.1 Using the SPA/IEC rear port

For all settings and configuration via the SPA communication bus, the SPA/IEC 60870-5-103 port on the rear, it is necessary to first deactivate the restriction for settings. Otherwise, no setting is allowed. This setting only applies for the SPA/IEC 60870-5-103 port during SPA bus communication. The parameter can only be set on the local HMI, and is located at:

Configuration/TerminalCom/SPACom/Rear/SettingRestrict

It is also possible to permit changes between active setting groups with ActGrpRestrict in the same menu section.
Selecting the protocols for the rear ports
To define the protocols to be used, a setting is done on the local HMI under the menu:

Configuration/TerminalCom/SPA-IEC-LON

When the protocols have been selected the terminal will automatically restart.

When communicating with SMS or SCS with the SPA or IEC 60870-5-103 protocol the slave number and baud rate (communication speed) settings must be equal in the PC-program and in the REx 5xx terminal.

Using the SPA rear port
The slave number and baud rate settings of the rear SPA port on the REx 5xx terminal, for SPA bus communication, is done on the local HMI at:

Configuration/TerminalCom/SPACom/Rear

Using IEC 870-5-103 rear port
The slave number and baud rate settings of the rear IEC 60870-5-103 port on the REx 5xx terminal, for IEC 870-5-103 bus communication, is done on the local HMI at:

Configuration/TerminalCom/IECCom/Communication

5.2.2 Using LON rear port
The LON port is not affected by eventual restricted settings valid for the SPA/IEC port. When communicating via the LON port, the settings are done with the LNT, LON Network Tool. The settings are shown on the local HMI at:

Configuration/TerminalCom/LON Com

From this menu, it is also possible to send the “ServicePinMsg” to the LNT.

5.3 Downloading the configuration and setting files
When downloading a configuration to the REx 5xx terminal with the CAP 531 configuration tool, the terminal is automatically set in configuration mode. When the terminal is set in configuration mode, all functions are blocked. The red LED on the terminal flashes, and the green LED is lit while the terminal is in the configuration mode.

When the configuration is downloaded and completed, the terminal is automatically set into normal mode. For further instructions please refer to the users manuals for CAP 540 and PST.
Chapter 10 Requirement of trig condition for disturbance report

About this chapter
This chapter describes how to override the limitation on the storage capacity of the flash memory.
1 Requirement of trig condition for disturbance report

Disturbance reports, setting and internal events in REx 5xx are stored in a non volatile flash memory. Flash memories are used in many embedded solutions for storing information due to high reliability, high storage capacity, short storage time and small size.

In REx 5xx there is a potential failure problem, caused by too many write operations to the flash memory.

Our experience shows that after storing more than fifty thousand disturbances, settings or internal events the flash memory exceeds its storing capacity and the component is finally defected.

When the failure occurs there is no risk of unwanted operation of the protection terminal due to the self-supervision function that detects the failure. The terminal will give a signal for internal fail and go into blocking mode.

The above limitation on the storage capacity of the flash memory gives the following recommendation for the disturbance report trig condition:

- Cyclic trig condition more often than once/day not recommended.
- Minute pulse input is not used as a trig condition.
- Total number of stored disturbance reports shall not exceed fifty thousand.
Chapter 11 Establishing connection and verifying the SPA/IEC-communication

About this chapter
This chapter contains instructions on how to establish connection and verify that the SPA/IEC-communication operates as intended, when the terminal is connected to a monitoring or control system via the rear SPA/IEC port.
1

Entering settings

If the terminal is connected to a monitoring or control system via any of the rear SPA and/or IEC ports, the applicable selection of protocols for the rear ports must be made.

1.1 Entering SPA settings

When using the SPA protocol, the rear SPA/IEC port must be set for SPA use.

The SPA/IEC port is located at terminal X13 on the rear side of the terminal. Three types of interfaces can be used:

- for plastic fibres with connector type HFBR
- for glass fibres with connectors type ST
- for galvanic RS485

Procedure

1. **Set the operation of the rear SPA/IEC port to “SPA”.**
   
   The operation of the rear SPA/IEC port can be found on the local HMI at:
   
   Configuration/TerminalCom/SPA-IEC-LON

   When the setting is entered the terminal will automatically restart. After the restart the SPA/IEC port operates as a SPA port.

2. **Set the slave number and baud rate for the rear SPA port**
   
   The slave number and baud rate can be found on the local HMI at:
   
   Configuration/TerminalCom/SPACom/Rear

   Set the same slave number and baud rate as set in the SMS system for the terminal.

1.2 Entering IEC settings

When using the IEC protocol, one of the rear ports must be set for IEC use. The selected port can be located at terminal X13 or terminal X15 on the rear side of the terminal. Valid interface depends on selected port. Three types of interfaces can be used:

- for plastic fibres with connector type HFBR
- for glass fibres with connectors type ST
- for galvanic RS485

Procedure

1. **Set the operation of one of the rear ports to “IEC”.**
   
   The operation of the rear ports can be found on the local HMI at:
Configuration/TerminalCom/SPA-IEC-LON

When the setting is entered the terminal will automatically restart. After the restart the selected IEC port operates as a IEC port.

2. **Set the slave number and baud rate for the rear IEC port**

   The slave number and baud rate can be found on the local HMI at:

   Configuration/TerminalCom/IECCom/Communication

   Set the same slave number and baud rate as set in the IEC master system for the terminal.

3. **Set the main function type of the terminal.**

   The main function type can be found on the local HMI at:

   Configuration/TerminalCom/IECCom/FunctionType

   The main function type can be set to values from 1 to 255 according to the standard. The value zero is default and corresponds to not used. Examples of values that can be used are:

   **Table 5: Main function type examples**

<table>
<thead>
<tr>
<th>Value</th>
<th>Function type according to IEC 60870-5-103</th>
</tr>
</thead>
<tbody>
<tr>
<td>128</td>
<td>Distance protection</td>
</tr>
<tr>
<td>160</td>
<td>Overcurrent protection</td>
</tr>
<tr>
<td>192</td>
<td>Line differential protection</td>
</tr>
</tbody>
</table>

   If the setting “OpFnType” is set to “ON” then the set value for function type will be used for all event blocks and the disturbance recorder, otherwise the setting on each event block and the disturbance recorder will decide the function type of that function block.
2 Verifying the communication

To verify that the rear communication with the SMS/SCS system is working, there are some different methods. Choose one of the following.

2.1 Verifying SPA communication

Procedure
1. Use a SPA-emulator and send “RF” to the terminal. The answer from the terminal should be “REx500 25”.
2. Generate one binary event by activating a function which is configured to an event block where the used input is set to generate events on SPA. The configuration must be made with the CAP5xx software. Verify that the event is presented in the SMS/SCS system.

During the following tests of the different functions in the terminal, verify that the events and indications in the SMS/SCS system are as expected.

2.2 Verifying IEC communication

To verify that the IEC communication with the IEC master system is working, there are some different methods. Choose one of the following.

Procedure
1. Check that the master system time-out for response from the terminal, for example after a setting change, is > 40 seconds.
2. Use a protocol analyzer and record the communication between the terminal and the IEC master. Check in the protocol analyzer’s log that the terminal answers the master messages.
3. Generate one binary event by activating a function which is configured to an event block where the used input is set to generate events on IEC. The configuration must be made with the CAP5xx software. Verify that the event is presented in the IEC master system.

During the following tests of the different functions in the terminal, verify that the events and indications in the IEC master system are as expected.
### 3 Optical budget calculation for serial communication with SPA/IEC

<table>
<thead>
<tr>
<th>Table 6: Example</th>
<th>Distance 1 km Glass</th>
<th>Distance 25 m Plastic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum attenuation for REx 5xx</td>
<td>-11 dB</td>
<td>-7 dB</td>
</tr>
<tr>
<td>4 dB/km multi mode: 820 nm - 62.5/125 um</td>
<td>4 dB</td>
<td>-</td>
</tr>
<tr>
<td>0.16 dB/m plastic: 620 nm - 1mm</td>
<td>-</td>
<td>4 dB</td>
</tr>
<tr>
<td>Margins for installation, aging etc.</td>
<td>5 dB</td>
<td>1 dB</td>
</tr>
<tr>
<td>Losses in connection box, two contacts (0.7 dB/contact)</td>
<td>1.4 dB</td>
<td>-</td>
</tr>
<tr>
<td>Losses in connection box, two contacts (1 dB/contact)</td>
<td>-</td>
<td>2 dB</td>
</tr>
<tr>
<td>Margin for repair splices (0.5 dB/splice)</td>
<td>0.5 dB</td>
<td>-</td>
</tr>
<tr>
<td>Maximum total attenuation</td>
<td>11 dB</td>
<td>7 dB</td>
</tr>
</tbody>
</table>
Chapter 11
Establishing connection and verifying the

Optical budget calculation for serial communication with SPA/IEC
Chapter 12 Establishing connection and verifying the LON communication

About this chapter
This chapter refers to another document.
1 Reference


1.1 Verification of the optical budget

1.1.1 Optical budget calculation for serial communication with LON

<table>
<thead>
<tr>
<th>Table 7: Example</th>
<th>Distance 1 km Glass</th>
<th>Distance 20 m Plastic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum attenuation for REx 5xx</td>
<td>-11 dB</td>
<td>-7 dB</td>
</tr>
<tr>
<td>4 dB/km multi mode: 820 nm - 62.5/125 um</td>
<td>4 dB</td>
<td>-</td>
</tr>
<tr>
<td>0.2 dB/m plastic: 620 nm - 1mm</td>
<td>-</td>
<td>4 dB</td>
</tr>
<tr>
<td>Margins for installation, aging etc.</td>
<td>5 dB</td>
<td>1 dB</td>
</tr>
<tr>
<td>Losses in connection box, two contacts (0.7 dB/contact)</td>
<td>1.4 dB</td>
<td>-</td>
</tr>
<tr>
<td>Losses in connection box, two contacts (1dB/contact)</td>
<td>-</td>
<td>2 dB</td>
</tr>
<tr>
<td>Margin for repair splices (0.5 dB/splice)</td>
<td>0.5 dB</td>
<td>-</td>
</tr>
<tr>
<td>Maximum total attenuation</td>
<td>11 dB</td>
<td>7 dB</td>
</tr>
</tbody>
</table>
Chapter 13 Verifying settings by secondary injection

About this chapter
This chapter describes how to verify that the protection functions operate correctly according to the settings. Only the tested function should be in operation.
Overview

Required tools for testing of a terminal:

- Calculated settings
- Configuration diagram
- Terminal diagram
- Technical reference manual
- Three-phase test equipment

The terminal has to be set and configured before the testing can start.

The terminal diagram, available in the Technical reference manual, is a general diagram for the terminal. But note that the same diagram is not always applicable for each specific delivery (especially for the configuration of all the binary inputs and outputs). It is for this reason necessary to check before testing that the available terminal diagram corresponds to the terminal.

The Technical reference manual contains application and functionality summaries, function blocks, logic diagrams, input and output signals, setting parameters and technical data sorted per function.

The test equipment should be able to provide a three-phase supply of voltages and currents. The magnitude of voltage and current as well as the phase angle between voltage and current must be variable. The voltages and currents from the test equipment must be obtained from the same source and they must have a very small harmonic contents. If the test equipment cannot indicate the phase angle, a separate phase-angle meter is necessary.

Prepare the terminal for test before testing a particular function. Consider the logic diagram of the tested protection function when performing the test. All included functions in the terminal are tested according to the corresponding test instructions in this chapter. The functions can be tested in any order according to user preferences and the test instructions are therefore presented in alphabetical order. Only the functions that are used (Operation is set to On) should be tested.

The response from a test can be viewed in different ways:

- Binary outputs signals
- Service values in the local HMI (logical signal or phasors)
- A PC with CAP (configuration software) in debug mode

All used setting groups should be tested.

Note!

This terminal is designed for a maximum continuous current of four times the rated current.
Note!

Please observe the measuring accuracy of the terminal, the test equipment and the angular accuracy for both of them.

Note!

Please consider the configured logic from the function block to the output contacts when measuring the operate time.
2 Preparing for test

2.1 Overview

This section describes how to prepare the terminal in order to verify settings.

The preparation starts with making the connections to the test switch if included. This means connecting the test equipment according to a valid terminal diagram for the specific REx 5xx terminal. The terminal can then be set in test mode in order to facilitate the test of individual functions and prevent unwanted operation from functions other than the tested. The test switch should then be connected to the terminal. The user could also verify the connection and that the analog inputs signals are measured correctly by injecting currents and voltages as required by the specific REx 5xx terminal. The tested function should then be released. The disturbance report settings could be checked to ensure that correct indications are given. The user could also identify the function to test in the technical reference manual to retrieve signals and parameters names etc.

2.2 Preparing the connection to the test equipment

The REx 5xx terminal can be equipped with a test switch of type RTXP 24. The test switch and its associated test plug handle (RTXH 24) are a part of the COMBITEST system which gives a secure and convenient testing of the terminal.

When the test-plug handle is inserted into the test switch, preparations for testing are automatically carried out in the proper sequence (i.e. blocking of tripping circuits, short circuiting of CT’s, opening of voltage circuits, making relay terminals available for secondary injection). Terminals 1 and 12 of the test switch are not disconnected as they are used for dc supply of the protection terminal.

The test-plug handle leads may be connected to any type of test equipment or instrument. When a number of protection terminals of the same type are tested, the test-plug handle need be moved only from the test switch of one protection terminal to the test switch of the other, without altering previously made connections.

To prevent unwanted tripping when the handle is withdrawn, latches on the handle secure it in the half withdrawn position. In this position, all voltages and currents are restored to the protection terminal and any reenergizing transients are given a chance to decay before the trip circuits are restored. When the latches are released, the handle can be completely withdrawn form the test switch, restoring the trip circuits to the protection terminal.

If a test switch is not used necessary actions need to be taken according to circuit diagram.
Warning!

Never disconnect a secondary connection of current transformer circuit without short-circuiting the transformer’s secondary winding. Operating a current transformer with the secondary winding open will cause a massive potential build-up that may damage the transformer and may cause injuries to humans.

2.3 Setting the terminal in test mode

The terminal can be set in test mode before test. This means that all included functions can be blocked or released as decided during the test. In this way, it is possible to test slower back-up measuring functions without the interference of faster measuring functions. Test mode is indicated when the yellow LED is flashing.

Procedure

1. **Browse to the ‘Operation’ menu and press ‘E’**.

   The Operation menu is located in the local HMI under:
   
   Test/TestMode/Operation

2. **Choose ‘On’ and press ‘E’**.

3. **Press ‘C’ twice to exit the menu**.

   The dialog ‘Save testGroup?’ appears.

4. **Choose ‘Yes’ and leave the menu**.

   The window repeatedly displays ‘Busy’ and after that the yellow LED starts flashing which indicates that the terminal is in test mode.

2.4 Connecting test equipment to the terminal

Before testing, connect the testing equipment according to the valid terminal diagram for each specific REx 5xx terminal. Pay special attention to the correct connection of the input and output current terminals, and to the connection of the residual current. Check that the input and output logical signals in the logic diagram for the tested function are configured to the corresponding binary inputs and outputs of the tested terminal.
2.5 Verifying the connection and the analog inputs

The user must verify that the connection and that the analog signals are measured correctly.

Procedure
1. Compare the injected value with the measured value.
   The phasor menu is located in the local-HMI under:
   
   ServiceReport/Phasors/Primary and Secondary

   Consider set ratio factors for CT’s and VT’s.

2. Compare the frequency reading with the set frequency and the direction of the power with the injected power.
   The frequency and active power are located in the local-HMI under:
   
   ServiceReport/ServiceValues

3. Inject a unsymmetrical three-phase current and voltage at rated value in two phases.

4. Compare the injected value with the measured value.
   The phasor menu is located in the local-HMI under:
2.6 Releasing the function(s) to be tested

The user can release the function(s) to be tested. This is done in order to set only the tested function(s) in operation and prevent other functions from operating. The user can release the tested function(s) by setting the corresponding parameter under BlockFunctions to NO in the local HMI. When testing a function in this blocking feature, remember that not only the actual function must be activated, but the whole sequence of interconnected functions (from measuring inputs to binary output contacts), including logic and so on. Before starting a new test mode session the user should scroll through every function to ensure that only the function to be tested (and the interconnected ones) are set to NO. A function is also blocked if the BLOCK input signal on the corresponding function block is active, which depends on the configuration. The user should therefore ensure that the logical status of the BLOCK input signal is equal to 0 for the tested function. The user could also individually block event blocks to ensure that no events are reported to remote station during the test.

Note!

The function is blocked if the corresponding setting under the BlockFunctions menu remains on and the TEST-INPUT signal remains active. All functions that where blocked or released from previous test mode session are still valid when a new test mode session is entered.

Procedure

1. **Browse to the 'BlockFunctions' menu.**
   
   The BlockFunctions menu is located in the local HMI under:

   Test/TestMode/BlockFunctions

2. **Browse to the function that should be released.**
   
   Use the left and right arrow buttons. Press ‘E’ when the desired function has been found.

3. **Select ‘No’.**

4. **Press ‘C’ twice to leave the menu.**

   The ‘Save TestGroup?’ dialog appears.

5. **Choose ‘Yes’ leave the menu.**

2.7 Checking the disturbance report settings

The terminal must be set in testmode (Operation=ON) to activate the disturbance report settings.

The user can select how the disturbances are indicated on the local HMI during the test. The user can for example select if the disturbance summary should be stored, scrolled on the local HMI or if LED information should be stored. Scroll to the disturbance report settings which are located in the local HMI under:
Test/TestMode/DisturbReport

Table 8: Disturbance report settings

<table>
<thead>
<tr>
<th>Operation</th>
<th>DisturbSummary</th>
<th>Then the results are...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off</td>
<td>Off</td>
<td>• Disturbances are not stored.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• LED information is not displayed on the HMI and not stored.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• No disturbance summary is scrolled on the HMI.</td>
</tr>
<tr>
<td>Off</td>
<td>On</td>
<td>• Disturbances are not stored.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• LED information (yellow - start, red - trip) are displayed on the local HMI but not stored in the terminal.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Disturbance summary is scrolled automatically on the local HMI for the two latest recorded disturbances, until cleared.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The information is not stored in the terminal.</td>
</tr>
<tr>
<td>On</td>
<td>On or Off</td>
<td>• The disturbance report works as in normal mode.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Disturbances are stored. Data can be read from the local HMI, a front-connected PC, or SMS.- LED information (yellow - start, red - trip) is stored.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The disturbance summary is scrolled automatically on the local HMI for the two latest recorded disturbances, until cleared.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• All disturbance data that is stored during test mode remains in the terminal when changing back to normal mode.</td>
</tr>
</tbody>
</table>

2.8 Identifying the function to test in the technical reference manual

The user can use the technical reference manual (TRM) to identify function blocks, logic diagrams, input and output signals, setting parameters and technical data.
3 Automatic switch onto fault logic (SOTF)

Prepare the terminal for verification of settings as outlined in section “Preparing for test” in this chapter.

The SOTF is checked by secondary injection tests together with the distance or overcurrent protection function and with the DLD function. The switch-onto-fault function is activated either by the external input SOTF-BC, or by the internal DLD function. The latter is done by a prefault condition with the phase voltages and currents at zero. A reverse three-phase fault with zero impedance and a three-phase fault with an impedance corresponding to the whole line is applied. For this fault an instantaneous trip shall be achieved together with the indication SOTF-TRIP.

3.1 External activation of SOTF function

Procedure
1. **Activate the switch-onto-fault (SOTF-BC) input.**
   During normal operating conditions, the SOTF-BC input is de-energised.
2. **Apply a three phase fault condition corresponding to a fault at approximately 45% of the line or with an impedance at 50% of used zone setting and current greater than 30% of \( I_r \).**
3. **Check that the correct trip outputs, external signals and indication are obtained.**

3.2 Automatic initiation of SOTF

Procedure
1. **Deactivate the switch-onto-fault (SOTF-BC) input.**
2. **Set current and voltage inputs to 0 for at least 1 second.**
3. **Apply a three phase fault condition corresponding to a fault at approximately 45% of the line or with an impedance at 50% of used zone setting and current greater than 30% of \( I_r \).**
4. **Check that the correct trip outputs, external signals and indication are obtained.**

3.3 Completing the test

Continue to test another function or complete the test by setting the test mode to off. Restore connections and settings to the original values, if they were changed for testing purpose.
4 Autorecloser (AR)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

The test is performed together with protection and trip functions. Figure 18 illustrates a recommended testing scenario, where the circuit breaker is simulated by an external bistable relay (BR), for example an RXMVB2 or an RXMVD. The following switches are needed:

- Switch close (SC)
- Switch trip (ST)
- Switch ready (SRY).

SC and ST can be push-buttons with spring return. If no bistable relay is available, replace it with two self-reset auxiliary relays and use self-holding connection.

Use a secondary injection relay test set to operate the protection function. It is possible to use the BR to control the injected analogue quantities so that the fault only appears when the BR is picked up—simulating a closed breaker position.

To make the arrangement more elaborate, include the simulation of the operation gear condition, AR01-CBREADY, for the sequences Close-Open (CO) and Open-Close-Open (OCO).

The AR01-CBREADY condition at the CO sequence type is usually low for a recharging time of 5-10 s after a closing operation. Then it is high. The example in figure 18 shows that it is simulated with SRY, a manual switch.
4.1 Preparing

1. Check the settings of the autorecloser (AR) function.

   The operation can be set at Stand-by (Off) in HMI tree:

   Settings/Functions/Group n/AutoRecloser/AutoRecloser n

   If any timer setting is changed so as to speed-up or facilitate the testing, they must be set to normal after the testing. A verification test has to be done afterwards.

2. Check that the functional input signal SYNC is set to TRUE if the internal or external synchrocheck is not used.

3. Read and note the reclosing operate counters from the HMI tree:
ServiceReport/Functions/AutoRecloser/AutoRecloser n/Counters

4. The AR01-CBCLOSED breaker position, the commands Trip and Closing, AR01-CLOSECB, and other signals should preferably be arranged for event recording provided with time measurements. Otherwise, a separate timer or recorder can be used to check the AR open time and other timers.

4.2 Checking the AR functionality

1. Ensure that the voltage inputs to Synchro-check, when applied, give accepted conditions at open breaker (BR).
   They can, for example, be Live busbar and Dead line.
2. Set the operation at On.
3. Make a BR pickup by a closing pulse, the SC-pulse.
4. Close SRY, Breaker ready and leave it closed.
5. Inject AC quantities to give a trip and start AR in phase L1.
   Observe or record the BR operation. The BR relay should trip and re-close. After the closing operation, the SRY switch could be opened for about 5 s and then closed.
   The AR open time and the operating sequence should be checked, for example, in the event recording.
   Check the operate indications and the operate counters.
   Should the operation not be as expected, the reason must be investigated. It could be due to an AR Off state or wrong program selection, or not accepted synchro-check conditions.

4.3 Checking the reclosing condition

The number of cases can be varied according to the application. Examples of selection cases are:

4.3.1 Checking the Inhibit signal

1. Check that the function is operative and that the breaker conditions are okay.
2. Apply an AR01-INHIBIT input signal and start the reclosing function.
3. Check that there is no reclosing.
4.3.2 Checking the closing onto a fault

1. Set the breaker simulating relay, BR, in position open.
2. Then close it with the SC switch and start the AR within one second.
3. Check that there is no reclosing.

4.3.3 Checking the breaker not ready

1. Close the BR breaker relay and see that everything except for AR01-CBREADY is in normal condition (SRY is open).
2. Start the AR function.
3. Check that there is no reclosing.

4.4 Testing the multi-breaker arrangement

If a multi-breaker arrangement is used for the application and priorities are given for the master (high) and slave (low) terminals, test that correct operation takes place and that correct signals are issued. The signals WFMASTER, UNSUC, WAIT and INHIBIT should be involved.

4.5 Completing the test

After the test, restore the equipment to normal or desired state. Especially check these items:

1. Check and record the counter contents (Reset if it is the user’s preference).
   The counters menu is located in the local HMI under:
   ServiceReport/Functions/AutoRecloser/AutoRecloser n/Counters/Clear Counters
2. Reset the setting parameters as required.
3. Disconnect the test switch or disconnected links of connection terminals.
4. Reset indications and events.
   The ClearDistRep menu is located in the local HMI under:
   DisturbReport/ClearDistRep

Continue to test another function or complete the test by setting the test mode to off. Restore connections and settings to the original values, if they were changed for testing purpose.
Current reversal and weak end infeed logic (ZCAL)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

The testing instructions are related to each separate phase, when phase segregated scheme communication logic ZC1P is used. Only one type of fault is necessary, when three-phase scheme communication logic ZCOM is used.

The current reversal logic and the week end infeed functions are tested during the secondary injection test of the impedance or overcurrent protection zones together with the scheme communication logic for the distance protection function (ZCOM or ZC1P).

5.1 Current reversal logic

It is possible to check the delay of the ZCOM-CS (ZC1P-CSLn) carrier send signal with tDelay by changing from a reverse to a forward fault.

By continuously activating the ZCOM-CR (ZC1P-CRLn) input and changing from a reverse to a forward fault, the delay tDelay can be checked.

5.1.1 Checking of current reversal

Procedure

1. **Activate the carrier receive (ZCOM-CRLn) signal.**

2. **Set the healthy condition to an impedance at 50% of the reach of the reverse zone connected to ZCAL-IRVLn.**

3. **After the start condition is obtained for reverse zone, apply a fault at 50% of the reach of the forward zone connected to ZCAL-WEIBLKLn.**

4. **Check that correct trip outputs and external signals are obtained for the type of fault generated.**

The operation time should be about the tDelay setting longer than the carrier accelerated trip (ZCOM-TRIP or ZC1P-TRLn) previously recorded for permissive scheme communication.

**Note!**

The reverse zone timer must not operate before the forward zone fault is applied. The user might need to block the reverse zone timer during testing of current reversal.

**Note!**

The forward zone timer must be set longer than 90 ms.
5. Repeat the procedure for other phases.
   Only when ZC1P is used.

6. Restore the forward and reverse zone timer to its original setting.

5.2 Weak end infeed logic

5.2.1 WEI logic at permissive schemes

Procedure
1. Check the blocking of the echo with the injection of a ZCOM-CR or ZC1P-CRLn signal >40 ms after a reverse fault is applied.
2. Measure the duration of the echoed signal by applying a ZCOM-CR or ZC1P-CRLn carrier receive signal.
3. Check the trip functions and the voltage level for trip by reducing a phase voltage and applying a ZCOM-CR or ZC1P-CRLn carrier receive signal.
4. Repeat the procedure for other phases.
   Only when ZC1P is used.

5.2.2 Testing conditions

Only one type of fault is sufficient, with ZCOM function. Apply three faults (one in each phase), when ZC1P function is used. For phase L1-N fault, set these parameters:

Table 9:

<table>
<thead>
<tr>
<th>Phase</th>
<th>I (Amps)</th>
<th>Phase-angle (Deg)</th>
<th>V (Volts)</th>
<th>Phase-angle (Deg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>0</td>
<td>0</td>
<td>Set less than UPN&lt;</td>
<td>0</td>
</tr>
<tr>
<td>L2</td>
<td>0</td>
<td>240</td>
<td>63</td>
<td>240</td>
</tr>
<tr>
<td>L3</td>
<td>0</td>
<td>120</td>
<td>63</td>
<td>120</td>
</tr>
</tbody>
</table>

Change all settings cyclically for other faults (L2-N and L3-N).

Weak end infeed set for trip
1. Apply input signals according table 9.
2. Activate the carrier receive (ZCOM-CR or ZC1P-CRLn) signal of the terminal.
3. After the relay has operated, turn off the input signals.
4. Check that trip, carrier-send signal, and indication are obtained.
5. Repeat the procedure for other phases.
   Only when ZC1P is used.
Weak end infeed set for echo
1. Apply input signals according table 9.
2. Activate the carrier receive (ZCOM-CR or ZC1P-CRLn) signal of the terminal.
3. After the relay has operated turn off the input signals.
4. Check that the carrier send signal is obtained.
5. Repeat the procedure for other phases.
   Only when ZC1P is used.

5.3 Completing the test
Continue to test another function or complete the test by setting the test mode to off.
Current reversal and weak end infeed logic for residual overcurrent protection (EFCA)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

First, test the time delayed residual overcurrent protection according to the corresponding instruction. Then continue with the instructions below.

Logical signals for current reversal and WEI logic for residual overcurrent protection are available under menu tree:

Service Report/Functions/EarthFault/ComIRevWeiEF/FuncOutputs

6.1 Testing the current reversal logic

Procedure
1. Inject the polarising voltage $3U_0$ to 5% of $U_b$ and the phase angle between voltage and current to $155^\circ$, the current leading the voltage.
2. Inject current ($155^\circ$ leading the voltage) in one phase to about 110% of the setting operating current ($I_{O>Dir}$).
3. Check that the EFCA-IRVL output is activated after the set time ($t_{PickUp}$).
4. Abruptly reverse the current to $65^\circ$ lagging the voltage, to operate the forward directional element.
5. Check that the EFCA-IRVL output still is activated after the reversal with a time delay that complies with the setting ($t_{Delay}$).
6. Switch off the polarising voltage and the current.

6.2 Testing the weak-end-infeed logic

6.2.1 If setting parameter WEI=Echo

Procedure
1. Inject the polarising voltage $3U_0$ to 5% of $U_b$ and the phase angle between voltage and current to $155^\circ$, the current leading the voltage.
2. Inject current ($155^\circ$ leading the voltage) in one phase to about 110% of the setting operating current ($I_{O>Dir}$).
3. Activate the EFCA-CRL binary input.

No EFCA-ECHO and EFC--CS should appear.
4. Abruptly reverse the current to 65° lagging the voltage, to operate the forward directional element.

   No EFCA-ECHO and EFC-CS should appear.

5. Switch off the current and check that the EFCA-ECHO and EFC-CS appears on the corresponding binary output or on the local HMI unit, about 200 ms after resetting the directional element.

6. Switch off the EFCA-CRL binary input.

7. Activate the EFCA-BLOCK binary input.

8. Activate the EFCA-CRL binary input.

   No EFCA-ECHO and EFC-CS should appear.

9. Switch off the polarising voltage and reset the EFCA-BLOCK and EFCA-CRL binary input.

6.2.2 If setting WEI=Trip

Procedure

1. Inject the polarising voltage 3U0 to about 90% of the setting (Ugr) operating voltage.

2. Activate the EFCA-CRL binary input.

   No EFCA-ECHO, EFC-CS and EFCA-TRWEI outputs should appear.

3. Increase the injected voltage to about 110% of the setting (Ugr) operating voltage.

4. Activate the EFCA-CRL binary input.

5. Check that the EFCA-ECHO, EFC-CS and EFCA-TRWEI appears on the corresponding binary output or on the local HMI unit.

6. Reset the EFCA-CRL binary input.

7. Activate the EFCA-BLOCK binary input.

8. Activate the EFCA-CRL binary input.

   No EFCA-ECHO, EFC-CS and EFCA-TRWEI outputs should appear.

9. Reset the EFCA-CRL and EFCA-BLOCK binary input.

10. Inject the polarising voltage 3U0 to about 110% of the setting (Ugr) and the phase angle between voltage and current to 155°, the current leading the voltage.

11. Inject current (155° leading the voltage) in one phase to about 110% of the setting operating current (IN>Dir).

12. Activate the EFCA-CRL binary input.

   No EFCA-ECHO, EFC-CS and EFCA-TRWEI should appear.
13. Abruptly reverse the current to 65° lagging the voltage, to operate the forward directional element. No EFCA-ECHO, EFC-CS and EFCA-TRWEI should appear.

14. Switch off the current and check that the EFCA-ECHO, EFC-CS and EFCA-TRWEI appears on the corresponding binary output or on the local HMI unit, about 200 ms after resetting the directional element.

15. Switch off the polarising voltage and reset the EFCA-CRL binary input.

6.3 Completing the test

Continue to test another function or complete the test by setting the test mode to off.
Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

Measure the set operate values for currents and voltages. Observe the functional output signals on the local HMI under the menu:

```
ServiceReport/Functions/DeadLineDet/FuncOutputs
```

It is also possible to configure the output signals to the binary outputs for testing purposes.

**Procedure**

1. Set the currents and voltages in phases L1, L2, and L3 to their rated values.
2. Decrease the current in phase L1 slowly, until the DLD--STIL1 signal changes to a logical 1.
   - Observe the functional output signal DLD--STIL1 on the HMI.
3. Record the value and compare it with the set value IP<.
4. Increase the current to its original value.
5. Repeat steps 2 to 4 for phases L2 (signal DLD--STIL2) and L3 (signal DLD--STIL3).
6. Decrease the voltage in phase L1 slowly, until the DLD--STUL1 signal changes to a logical 1.
   - Observe the functional output signal DLD--STUL1 on the HMI.
7. Record the value and compare it with the set value UP<.
8. Increase the voltage to its original value.
9. Repeat steps 6 to 8 for phases L2 (signal DLD--STUL2) and L3 (signal DLD--STUL3).
10. Make sure that all signals are reconfigured to their initial state.
11. Continue to test another function or complete the test by setting the test mode to off.
8 Time delayed residual overcurrent protection (TEF)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

Normally, the test of the earth-fault overcurrent protection is made in conjunction with the testing of the distance protection functions, using the same multiphase test-set. Observe that the polarising voltage is equal to -3Uo.

8.1 Checking the operate values of the current measuring elements

Procedure
1. Set the logical input signals to logical 0 and note on the local HMI that the TEF--TRIP and the TEF--TRSOTF signal is not activated (= logical 0).
   
   Values of the logical signals belonging to the time delayed residual overcurrent protection are available under menu tree:

   ServiceReport/Functions/EarthFault/TimeDelayEF

2. Set the polarising voltage to 2% of U₀ and the phase angle between voltage and current to 65°, the current lagging the voltage.

3. Check that the operate current of the forward directional element is equal to the IN> Dir setting.

   The IN> Dir function activates the TEF--STFW output.

4. Check with angles $\varphi = 20^\circ$ and $110^\circ$ that the measuring element operates when $3I_0 \cos (65^\circ - \varphi) \geq IN> Dir$.

5. Reverse the polarising voltage ($\varphi = 180^\circ + 65^\circ = 245^\circ$) and check that the operate current of the reverse directional element is $0.6 \cdot IN> Dir$.

   The function activates the TEF--STRV output.
6. To activate the directional function, set Direction = Directional.

7. Set the polarising voltage to 2% of $U_b$ and the phase angle between voltage and current to $65^\circ$.

8. Check the operate current of the IMin function.

   The function activates the TEF--START output.

9. When independent time delay (definite) is selected, check the operate time of the t1 timer by injecting a current two times the set IMin operate value.

   When inverse time delay is selected, check the operate time at three points of the inverse characteristic. The formulas for operate time for different types of inverse time delay curves are shown in table 10. 

*Figure 19: Measuring characteristic of the directional element.*
Time delayed residual overcurrent protection
(TEF)

Chapter 13
Verifying settings by secondary injection

Table 10: Operate time formulas

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Operate time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal inverse</td>
<td>$t = \frac{0.14}{I_{0.02} - 1} \cdot k$ (Equation 1)</td>
</tr>
<tr>
<td>Very inverse</td>
<td>$t = \frac{13.5}{I - 1} \cdot k$ (Equation 2)</td>
</tr>
<tr>
<td>Extremely inverse</td>
<td>$t = \frac{80}{I^2 - 1} \cdot k$ (Equation 3)</td>
</tr>
<tr>
<td>Logarithmic inverse</td>
<td>$t = 5.8 - (1.35 \cdot \ln I)$ (Equation 4)</td>
</tr>
</tbody>
</table>

Where:

- $I$ is a multiple of set current $3I_0$
- $k$ is a time multiplying factor, settable in the range of 0.05 to 1.10

Also check the $t_{\text{Min}}$ (minimum operate time) and $I_{\text{Min}}$ (minimum operate current) functions.

10. Activate the TEF--BC input to check the function of the switch-on-to-fault logic.

11. Check that the TEF--TRSOTF output is activated with a 300 ms time delay when injecting a current two times the set $I_{\text{Min}}$ operate value in forward direction.

12. Set the phase angle of the polarising voltage to $\phi = 245^\circ$ and check that the directional current function and the switch-onto-fault logic gives no operation when the current is in the reverse direction.

13. Connect the rated DC voltage to the TEF--BLOCK configured binary input and switch on the fault current.

No TEF--TRIP nor TEF--START signal should appear.

14. Switch off the fault current.

15. Connect the rated DC voltage to the TEF--BLKTR configured binary input and switch on the fault current.

No TEF--TRIP nor TEF--TRSOTF should appear. But the output TEF--START shall be activated.

16. Continue to test another function or complete the test by setting the test mode to off.
9 Distance protection (ZMn)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter. Consider to release Zone 1, the PHS and the TR0n. If the autorecloser is not released and in service, trip will always be three phase.

Measure operating characteristics during constant current conditions. Keep the measured current as close as possible to its rated value or lower. But ensure that it is higher than 30% of the rated current.

Ensure that the maximum continuous current of a terminal does not exceed four times its rated value, if the measurement of the operating characteristics runs under constant voltage conditions.

To verify the settings for the operating points according to figure 20, 21 or 22 and (table 11 and 12) the following fault types should be tested:

- One phase-to-phase fault (when the Ph-Ph measurement included in terminal)
- One phase-to-earth fault (when the Ph-E measurement included in terminal)

The shape of the operating characteristic depends on the values of the setting parameters.

Figure 20: Test points for the distance protection (ZMn), operating characteristic case 1
Distance protection (ZMn)

Chapter 13
Verifying settings by secondary injection

Figure 21: Test points for the distance protection (ZMn), operating characteristic case 2

Figure 22: Test points for the distance protection (ZMn), operating characteristic case 3
Table 11: Test points for phase-to-phase loops L1-L2 (Ohm/Loop)

<table>
<thead>
<tr>
<th>Test point</th>
<th>Reach</th>
<th>Set value</th>
<th>According to figure</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>X</td>
<td>2 \cdot X1PP_{set}</td>
<td>20, 21 and 22</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>2 \cdot R1PP_{set}</td>
<td></td>
</tr>
<tr>
<td>P2</td>
<td>X</td>
<td>0.8 \cdot X1PP_{set} : 2</td>
<td>20, 21 and 22</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>0.8 \cdot R1PP_{set} : 2 + RFPP_{set}</td>
<td></td>
</tr>
<tr>
<td>P3</td>
<td>X</td>
<td>0</td>
<td>20, 21 and 22</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>RFPP_{set}</td>
<td></td>
</tr>
<tr>
<td>P4</td>
<td>X</td>
<td>0.5 \cdot 2 \cdot X1PP_{set}</td>
<td>20, 21 and 22</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>0.5 \cdot 2 \cdot R1PP_{set}</td>
<td></td>
</tr>
<tr>
<td>P5</td>
<td>X</td>
<td>P2X</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>arg</td>
<td>ArgNegRes_{set} (for directional zone)</td>
<td></td>
</tr>
<tr>
<td>P5</td>
<td>X</td>
<td>P2X</td>
<td>21 and 22</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>P2_{set} - 2 \cdot RFPP_{set}</td>
<td></td>
</tr>
<tr>
<td>P6</td>
<td>arg</td>
<td>ArgDir_{set} (for directional zone)</td>
<td>20, 21 and 22</td>
</tr>
<tr>
<td>P7</td>
<td>X</td>
<td>0.1 \cdot P1X</td>
<td>20, 21 and 22</td>
</tr>
<tr>
<td></td>
<td>arg</td>
<td>ArgNegRes_{set} (for directional zone)</td>
<td></td>
</tr>
</tbody>
</table>

Table 12: Test points for phase-to-earth L3-E (Ohm/Loop)

<table>
<thead>
<tr>
<th>Test point</th>
<th>Reach</th>
<th>Set value</th>
<th>According to figure</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>X</td>
<td>2 \cdot X1PE_{set} + X0PE_{set}</td>
<td>20, 21 and 22</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>2 \cdot R1PE_{set} + R0PE_{set}</td>
<td></td>
</tr>
<tr>
<td>P2</td>
<td>X</td>
<td>0.8 \cdot 2 \cdot X1PE_{set} + X0PE_{set}</td>
<td>20, 21 and 22</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>0.8 \cdot 2 \cdot R1PE_{set} + R0PE_{set} + RFPE_{set}</td>
<td></td>
</tr>
<tr>
<td>P3</td>
<td>X</td>
<td>0</td>
<td>20, 21 and 22</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>RFPE_{set}</td>
<td></td>
</tr>
<tr>
<td>P4</td>
<td>X</td>
<td>0.5 \cdot 2 \cdot X1PE_{set} + X0PE_{set}</td>
<td>20, 21 and 22</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>0.5 \cdot 2 \cdot R1PE_{set} + R0PE_{set}</td>
<td></td>
</tr>
<tr>
<td>P5</td>
<td>X</td>
<td>P2X</td>
<td>20</td>
</tr>
<tr>
<td>arg</td>
<td></td>
<td>ArgNegRes_{set} (for directional zone)</td>
<td></td>
</tr>
</tbody>
</table>
9.1 Measuring the operate limit of set values

Procedure
1. Supply the terminal with healthy conditions for at least two seconds.
2. Apply the fault condition and slowly decrease the measured impedance to find the operating value for the phase-to-phase loop for zone 1 according to test point P1 in table 11. Compare the result of the measurement with the set value.
3. Repeat steps 1 to 2 to find the operating value for test point P2, P3 in table 11 and the operating value for the phase-to-earth loop according to test point P1, P2, P3 in table 12.
4. Supply the terminal with healthy conditions for at least two seconds.
5. Apply the fault condition and slowly increase the measured resistance to find the operating value for test point P5 in table 11. Compare the result of the measurement with the set value.
6. Repeat steps 4 to 5 to find the operating value for test point P7 in table 11 and P5 and P7 in table 12.
7. Supply the terminal with healthy conditions for at least two seconds.
8. Apply the fault condition and slowly increase the measured reactance to find the operating value for test point P6 in table 11. Compare the result of the measurement with the set value.
9. Repeat steps 7 to 8 to find the operating value for test point P6 in table 12.
10. Repeat steps 1 to 3 for all other used measuring zones.

Observe that the zone that are not tested has to be blocked and the zone that is tested has to be released.
9.2 Measuring the operate time of distance protection zones

Procedure
1. Supply the terminal with healthy conditions for at least two seconds.
2. Apply the fault condition to find the operating time for the phase-to-phase loop according to test point P4 in table 11 for zone 1. Compare the result of the measurement with the setting t1PP.
3. Repeat steps 1 to 2 to find the operating time for the phase-to-earth loop according to test point P4 in table 12. Compare the result of the measurement with the setting t1PE.
4. Repeat steps 1 to 3 to find the operating time for all other used measuring zones.

Observe that the zone that are not tested has to be blocked and the zone that is tested has to be released.

9.3 Completing the test

Continue to test another function or complete the test by setting the test mode to off.
Evaluation of the results from the disturbance recording function requires access to a workstation either permanently connected to the terminal or temporarily connected to the serial port on the front. The CAP tool software package must be installed in the workstation.

Disturbance upload can be performed by the use of SMS 510, CAP 540 or by any third party tool with IEC 60870-5-103 protocol. Disturbance files can be analyzed by any tool reading Comtrade formatted disturbance files including REVAL and WinEve.

It could be useful to have a printer for hard copies. The behavior of the disturbance recording function can be checked when protective functions of the terminal are tested. When the terminal is set to operate in test mode, there is a separate setting for operation of the disturbance report, which also affects the disturbance recorder.

A manual trig can be started any time. This results in a snapshot of the actual values of all recorded channels.
11 Event function (EV)

During testing, the terminal can be set in test mode from the PST. The functionality of the event reporting during test mode is set from the PST as follows:

• Use event masks
• Report no events
• Report all events

In Test Mode, individual event blocks can be blocked from the PST.

Individually event blocks can also be blocked from the local HMI under the menu:

Test/TestMode/BlockEventFunc
12 Event recorder (ER)

During testing, the event recorder can be switched off if desired. This is found in the SMS or Substation Control System (SCS).
13 Fault locator (FLOC)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

The distance to fault, as calculated for each fault separately, will automatically be displayed on the local HMI for each fault that also causes the non-delayed tripping operation and has been detected by the built-in, phase-selection function. The FLOC- function will not calculate the distance to the fault if faults are repeated in periods shorter than 10 seconds. The values of the currents and voltages are stored in the terminal memory as new disturbances. Start of the calculation of a distance to fault can always be manually initiated.

Distances to faults for the last 10 recorded disturbances can be found on the local HMI under the menu:

DisturbReport/Disturbances/Disturbance n (n=1-10)/FaultLocator

Table 13: Test settings

<table>
<thead>
<tr>
<th>Parameter:</th>
<th>Condition:</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Higher than 30% I₀</td>
</tr>
<tr>
<td>Healthy conditions</td>
<td>U = 63.5 V, I = 0 A &amp; ZF = 0°</td>
</tr>
<tr>
<td>Impedance [Z]</td>
<td>Test point</td>
</tr>
<tr>
<td>Note:</td>
<td></td>
</tr>
<tr>
<td>• Z ≤ (X₀ + 2 · X₁)/3</td>
<td>For single-phase faults</td>
</tr>
<tr>
<td>• Z ≤ X₁</td>
<td>For three and two phase faults</td>
</tr>
<tr>
<td>• Z ≤ (X₀ + 2 · X₁ XM)/3</td>
<td>For single-phase fault with mutual zero-sequence current</td>
</tr>
<tr>
<td>Impedance angle ZΦ</td>
<td>Test angle</td>
</tr>
<tr>
<td>Note:</td>
<td></td>
</tr>
<tr>
<td>• ZΦ = arctan[(X₀ + 2 · X₁) / (R₀ + 2R₁)]</td>
<td>For single-phase faults</td>
</tr>
<tr>
<td>• ZΦ = arctan(X₁/R₁)</td>
<td>For two-phase faults</td>
</tr>
</tbody>
</table>

13.1 Measuring the operate limit

Procedure
1. Set the test point ([Z] fault impedance and ZΦ impedance phase angle ) for a condition that meets the requirements in table 13.
2. Supply the relay with healthy conditions for at least two seconds.
3. Apply a fault condition.

Check that the distance-to-fault value displayed on the HMI complies with the following equations (the error should be less than five percent):
Verifying settings by secondary injection

13.2 Completing the test

Continue to test another function or complete the test by setting the test mode to off. Restore connections and settings to the original values, if they were changed for testing purpose.
14 Fuse failure supervision (FUSE)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

The verification is divided in two main parts. The first part is common to all fuse failure supervision options, and checks that binary inputs and outputs operate as expected according to actual configuration. In the second part the relevant set operate values are measured.

The corresponding binary signals that inform the operator about the operation of the FUSE function are available on the local human-machine interface (HMI) unit under the menu:

Service Report/Functions/FuseFailure/FuncOutputs

14.1 Checking that the binary inputs and outputs operate as expected

Procedure
1. Simulate normal operating conditions with the three-phase currents in phase with their corresponding phase voltages and with all of them equal to their rated values.
2. Connect the nominal dc voltage to the FUSE-DISC binary input.
   • The signal FUSE-VTSU should appear with almost no time delay.
   • No signals FUSE-VTSZ and FUSE-VTF3PH should appear on the terminal.
   • Only the distance protection function operates.
   • No other undervoltage-dependent functions must operate.
3. Disconnect the dc voltage from the FUSE-DISC binary input terminal.
4. Connect the nominal dc voltage to the FUSE-MCB binary input.
   • The FUSE-VTSU and FUSE-VTSZ signals should appear without any time delay.
   • No undervoltage-dependent functions must operate.
5. Disconnect the dc voltage from the FUSE-MCB binary input terminal.
6. Disconnect one of the phase voltages and observe the logical output signals on the terminal binary outputs.
   FUSE-VTSU and FUSE-VTSZ signals should simultaneously appear.
7. After more than 5 seconds disconnect the remaining two phase voltages and all three currents.
   • There should be no change in the high status of the output signals FUSE-VTSU and FUSE-VTSZ.
   • The signal FUSE-VTF3PH will appear.
8. Simultaneously establish normal voltage and current operating conditions and observe the corresponding output signals.

They should change to the logical 0 as follows:

- Signal FUSE-VTF3PH after about 25 ms
- Signal FUSE-VTSU after about 50 ms
- Signal FUSE-VTSZ after about 200 ms

14.2 Measuring the operate value for the negative sequence function

Measure the operate value for the negative sequence function, if included in the terminal.

Procedure

1. Simulate normal operating conditions with the three-phase currents in phase with their corresponding phase voltages and with all of them equal to their rated values.

2. Slowly decrease the measured voltage in one phase until the FUSE-VTSU signal appears.

3. Record the measured voltage and calculate the corresponding negative-sequence voltage according to the equation.

Observe that the voltages in the equation are phasors:

\[ 3 \cdot U_L^2 = U_L^1 + a^2 \cdot U_L^2 + a \cdot U_L^3 \]  
(Equation 8)

Where:

\[ U_L^1, U_L^2, \text{ and } U_L^3 = \text{the measured phase voltages} \]

\[ a = 1 \cdot e^{-j \frac{2\pi}{3}} = -0.5 + j \frac{\sqrt{3}}{2} \]

4. Compare the result with the set value (consider that the set value 3U2> is in percentage of the base voltage U1b) of the negative-sequence operating voltage.

14.3 Measuring the operate value for the zero sequence function

Measure the operate value for the zero sequence function, if included in the terminal.
Procedure
1. Simulate normal operating conditions with the three-phase currents in phase with their corresponding phase voltages and with all of them equal to their rated values.
2. Slowly decrease the measured voltage in one phase until the FUSE-VTSU signal appears.
3. Record the measured voltage and calculate the corresponding zero-sequence voltage according to the equation.
   Observe that the voltages in the equation are phasors.

\[
3 \cdot U_0 = U_{L1} + U_{L2} + U_{L3}
\]

(Equation 9)

Where:
\(U_{L1}, U_{L2}\) and \(U_{L3}\) = the measured phase voltages.

4. Compare the result with the set value (consider that the set value \(3U0>\) is in percentage of the base voltage \(U1b\) of the zero-sequence operating voltage.

14.4 Checking the operation of the \(du/dt, di/dt\) based function
Check the operation of the \(du/dt, di/dt\) based function, if included in the terminal.

Procedure
1. Simulate normal operating conditions with the three-phase currents in phase with their corresponding phase voltages and with all of them equal to their rated values.
2. Connect the nominal dc voltage to the FUSE-CBCLOSED binary input.
3. Change the voltages and currents in all three phases simultaneously.

The voltage change should be greater than set \(DU>\) and the current change should be less than the set \(DI<\).

- The FUSE-VTSU and FUSE-VTSZ signals appear without any time delay. If the remaining voltage levels are higher than the set \(U<\) of the DLD function, only a pulse is achieved.
- FUSE-VTF3PH should appear after 5 seconds, if the remaining voltage levels are lower than the set \(U<\) of the DLD function.
4. **Apply normal conditions as in step 1.**

   The FUSE-VTSU, FUSE-VTSZ and FUSE-VTF3PH signals should re-set, if activated. See step 3.

5. **Change the voltages and currents in all three phases simultaneously.**

   The voltage change should be greater then set $DU>$ and the current change should be greater then the set $DI<$.

   The FUSE-VTSU, FUSE-VTSZ and FUSE-VTF3PH signals should not appear.

6. **Disconnect the dc voltage to the FUSE-CBCLOSED binary input.**

7. **Apply normal conditions as in step 1.**

8. **Repeat step 3.**

9. **Connect the nominal voltages in all three phases and feed a current below the operate level in all three phases.**

10. **Keep the current constant. Disconnect the voltage in all three phases simultaneously.**

    The FUSE-VTSU, FUSE-VTSZ and FUSE-VTF3PH signals should not appear.

### 14.5 Completing the test

Continue to test another function or complete the test by setting the test mode to off.
15 General fault criteria (GFC)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

The GFC measuring elements operate in underimpedance mode according to the same measuring principles as the impedance measuring zones. It is therefore necessary to follow the same principles when performing the secondary injection tests.

15.1 Testing the underimpedance mode

The measured loop reactance in forward direction should correspond to the following expression:

$$X_m = \frac{1}{3} \cdot (2 \cdot X_{1FwPE} + X_{0FwPE})$$  \hspace{1cm} \text{(Equation 10)}

A similar expression also applies to the measured loop impedance in reverse direction:

$$X_m = \frac{1}{3} \cdot (2 \cdot X_{1RvPE} + X_{0RvPE})$$  \hspace{1cm} \text{(Equation 11)}

The measured loop resistances in forward and reverse direction should correspond directly to the set values for the single-phase-to-earth-faults: RFPE and RLd.
Figure 23: Operating characteristics of the GFC and zone measuring elements

The measured phase reactance in forward direction should correspond directly to the set value X1FwPP. Similar applies also to the measured phase reactance in reverse direction, which must correspond directly to the set value X1RvPP.

The measured phase resistances in forward and reverse direction should correspond to the following expressions:

\[ R_m = \frac{1}{2} RFPP \]  
(Equation 12)

and

\[ R_m = \frac{1}{2} RLd \]  
(Equation 13)
The test is proposed to be carried out with constant current equal to rated current and lower the voltage until operation of the GFC.

The testing procedure for the manual testing of the operating characteristics of different impedance measuring zones and different faults is:

**Procedure**

1. Configure all the GFC start signals (GFC--STFWL1, GFC--STFWL2, GFC--STFWL3, GFC--STFWPE and so on to the selected binary outputs.
2. Set up the test equipment for three-phase impedance configuration and choose impedance plain when applicable.
3. Connect the corresponding GFC--STFn signal to the test equipment binary input No.1.
4. Set the test equipment to these parameters in the 3PZ display:
5. Set Z fault impedance and Z impedance angle for the GFC under test at +10% of the zone setting for one of the suggested testing points.
6. Supply the terminal with healthy conditions for at least two seconds.
7. Apply fault conditions.
8. Slowly decrease the measured Z impedance until the tested zone operates.
9. Check that the correct signal (GFC--STFWLn) appears on the HMI.
10. Compare the result of the measurement with the setting values.
11. Repeat steps 5 to 8 for other measuring points of the same GFC measuring zone in both forward and reverse direction.
12. Repeat steps 1 to 11 for all combinations of phase to ground fault.
13. Repeat 1 to 11 for phase to phase faults for all combinations when applicable.

15.2 Testing the overcurrent operating mode

The basic configuration of the measuring equipment and the tested terminal should be the same as that for the measurement of operating characteristics under the impedance measuring mode. The initial conditions for the measurement should also be the same.

When testing the GFC measuring elements in the corresponding phases it is necessary to slowly increase the current in the measured phase until the corresponding phase's selection signal (for the non-directional operation of the GFC) appears on the local HMI unit. If the two-phase or three-phase operation is of interest, the corresponding currents should be increased simultaneously. Compare the operating value with the set value for IP>.

When testing the residual current measuring element, it is necessary to slowly increase the measured current in one phase-to-earth-fault loop until the signal GFC--STPE appears on the local HMI unit. Compare the operating value with the set value for IN>.
Procedure
1. The test equipment must be set up for the “General” three-phase voltage and current source.
2. Configure the GFC--STLn signals to the corresponding binary outputs of the terminal, and connect them one after another to the corresponding binary inputs on the test equipment (when applicable).
3. Configure the binary input of the test equipment, corresponding to the signal condition from GFC--STLn.
4. On the six generators, set nominal current and voltage conditions in all three phases with 120 degrees phase shift between the phases (L1 reference).
5. Lower the voltage manually in phase L1 until the appropriate signal appears on the binary input on the test equipment.
6. Compare the measured results with the corresponding setting values IP> and IN>.
7. Repeat the measurement in the other two phases and compare the results with the setting values IP> and IN>.
8. Repeat the measurement in one phase and observe the GFC--STPE signal that indicates the operation of the measuring element for the residual current.
9. Compare the measured results with the corresponding setting values.

15.3 Testing the phase preference logic
The phase preference logic is tested with a three-phase testing equipment for distance protections. Initiating a two-phase-to-earth fault with the current disconnected in one of the faulty phases performs the test. Tripping is allowed only in a phase with preference to the disconnected, in accordance with the preference scheme. The test is repeated with all three types of two-phase-to-earth faults, and one of the faulty phases disconnected from the current, one by one (totally 6 shots).

15.4 Completing the test
Continue to test another function or complete the test by setting the test mode to off.
16 High speed binary output logic (HSBO)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

Since the high-speed binary output logic is dependent upon other function blocks (HS---, ZM1-, ZC1P-, ZCOM- and TRIP-) in order to operate, those functions have to be set into operating mode (On).

16.1 HSBO- trip from communication logic

Whenever a trip appears during these tests, it should be possible to block it through the function input HSBO-BLKZCTR. Activation of either HSBO-BLKHSTR or HSBO-BLKHSCS should not block the trip outputs in this case. It should also be possible to block the trip signals at the backing function from which the internal signals are derived (ZC1P, ZCOM or TRIP).

Note!

No carrier send should appear during the tests in this section.

Test for three of the trip schemes in ZC1P (Blocking Scheme not included).

Procedure

1. Apply inputs in different combinations to ZC1P-CACCLn, ZC1P-CRLn / ZC1P-CRMPH and check the outputs of HSBO-TRLx. For each trip, test the blocking action for all three HSBO blocking inputs and ZC1P-BLOCK. Check results according to the used scheme.

   - ZC1P/SchemeType = Intertrip

   No local trip condition is required (-CACCLn). Trip output HSBO-TRLx will be activated directly according to corresponding -CRLx. Activation of -CRMPH should result in a three-phase trip.

   - ZC1P/SchemeType = PermissiveUR

   When -CACCLn is applied in the same time as -CRLn (same phases), a trip output should appear in the n-phase(s), HSBO-TRLn. If -CRMPH is applied instead of -CRLn, a trip should appear in the same phase as -CACCLn.

   - ZC1P/SchemeType = PermissiveOR

   Same result as for the permissive underreach test should be obtained.

2. Remove applied signals.
16.2 ZCOM trip schemes

Test for three of the trip schemes in ZCOM (Blocking Scheme not included) together with TRIP.

Procedure

1. Apply inputs in different combinations to TRIP-PSLn, ZCOM-CACC and ZCOM-CR and check the outputs of HSBO-TRLx. For each trip test the blocking action for all three HSBO blocking inputs, ZCOM-BLOCK and TRIP-BLOCK. Check results according to the used scheme and trip program.
   - ZCOM/SchemeType = Intertrip
   - TRIP/Program = 1/2/3ph

   When -PSLn is applied in the same time as -CR, a trip output should appear in the n-phase(s), HSBO-TRLn.
   - ZCOM/SchemeType = PermissiveUR
   - TRIP/Program = 1/3ph

   When -PSLn is applied in the same time as -CACC and -CR, a trip output should appear in the n-phase(s), HSBO-TRLn.
   - ZCOM/SchemeType = PermissiveOR
   - TRIP/Program = 3ph

   Each time -CACC and -CR are activated at the same time, a three-phase trip should be obtained, independent of any phase selection (-PSLn).

2. Remove applied signals.

16.3 HSBO- trip from the distance protection zone 1 function (ZM1)

In order to test the performance of the high-speed binary output function alone without any interference from other functions the binary outputs configured for the HSBO function must not carry any other signals. For example, if the outputs are shared with the TRIP function the TRIP function should be switched off.

Switch the HS function off as well.

Whenever a trip appears during these tests, it should be possible to block it through the function input HSBO-BLKHSTR.

Note that no carrier send will be issued from the distance protection function zone 1. Activation of HSBO-BLKZCTR or HSBO-BLKHSCS should not block any outputs in this test.

Use the 3-phase test set to achieve the specified conditions.

Suggested fault characteristics, for all types of faults:
High speed binary output logic (HSBO)

Chapter 13
Verifying settings by secondary injection

- Prefault conditions: \( U_{\text{phase}} = U_b \), \( 0^\circ \), \( I = 0.0 \) A, \( 0^\circ \)
- Fault conditions: Within set operating characteristic of ZM1 function.

**Procedure**

1. Apply faults according to table 14. Trip and carrier send outputs should appear as indicated (with YES).
2. Remove applied signals.
3. Set the terminal in normal service.

| Table 14: Output signals for different fault types |
|-----------------|---|---|---|---|---|---|
| Fault type      | Signal | L1 | L2 | L3 | L1,L2 | L2,L3 | L3,L1 | L1,L2,L3 |
| HSBO-TRL1       | YES | YES | YES | YES | YES | YES | YES | YES |
| HSBO-TRL2       | YES | YES | YES | YES | YES | YES | YES | YES |
| HSBO-TRL3       | YES | YES | YES | YES | YES | YES | YES | YES |
| HSBO-CSL1       | YES | YES | YES | YES | YES | YES | YES | YES |
| HSBO-CSL2       | YES | YES | YES | YES | YES | YES | YES | YES |
| HSBO-CSL3       | YES | YES | YES | YES | YES | YES | YES | YES |
| HSBO-CSMPH      | YES | YES | YES | YES | YES | YES | YES | YES |

**16.4 Completing the test**

Continue to test another function or complete the test by setting the test mode to off.
17 Instantaneous non-directional overcurrent protection (IOC)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

To verify the settings the following fault type should be tested:

• One for a phase-to-earth fault

Ensure that the maximum continuous current of the terminal does not exceed four times its rated value.

17.1 Measuring the operate limit of set values

17.1.1 Phase overcurrent protection

Procedure
1. Inject a phase current in the terminal with start below the setting value.
2. Increase the injected current in the Ln phase until the IOC--TRLn (n=1-3) signal appears.
3. Switch off the fault current.
   Observe the maximum permitted overloading of the current circuits in the terminal.
4. Compare the measured operating current with the set value.

17.1.2 Residual overcurrent protection (non-dir.)

Procedure
1. Inject a phase current in the terminal with start below the setting value.
2. Increase the injected current in the Ln phase until the IOC--TRN signal appears.
3. Switch off the fault current.
   Observe the maximum permitted overloading of the current circuits in the terminal.
4. Compare the measured operating current with the set value.

17.2 Completing the test

Continue to test another function or complete the test by setting the test mode to off.
Local acceleration logic (ZCLC)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

The logic is checked during the secondary injection test of the impedance measuring zones.

Procedure
1. Supply the terminal with healthy conditions for at least two seconds.
2. Deactivate the conditions for accelerated function.
3. Apply a phase to earth fault at 100% of line impedance.
4. Check that the fault is tripped with the second zone time delay.
5. Supply the terminal with healthy conditions for at least two seconds.
6. Activate the condition for accelerated function either by the auto-recloser or by the loss of load.
7. Apply a phase to earth fault at 100% of line impedance.
8. Check that the fault is tripped “instantaneously”.
9. Continue to test another function or complete the test by setting the test mode to off.
19 Supervision of AC input quantities (DA)

Stabilized ac current and voltage generators and corresponding current, voltage, power and frequency meters with very high accuracy are necessary for testing the alternating quantity measuring function. The operating ranges of the generators must correspond to the rated alternate current and voltage of each terminal.

Prepare the terminal for verification of settings as outlined in section “Preparing for test” in this chapter. Connect the generators and instruments to the corresponding input terminals of a unit under test.

19.1 Verifying the settings

Procedure
1. Supply the terminal with voltages and currents.
   Check that the values presented on the HMI unit correspond to the magnitude of input measured quantities within the limits of declared accuracy. The mean service values are available under the submenu:
   Service Report/ServiceValues

   The phasors of up to five input currents and voltages are available under the submenu:
   Service Report/Phasors/Primary

2. Check the operation of ADBS or IDBS when applicable. Compare with the expected values.
   The operation of ADBS or IDBS function can be checked separately with the RepInt = 0 setting. The value on the HMI follows the changes in the input measuring quantity continuously.

3. Check the set operate levels of the monitoring function by changing the magnitude of input quantities and observing the operation of the corresponding output relays.
   The output contact changes its state when the changes in the input measuring quantity are higher than the set values HIWARN, HIALARM, or lower than the set values LOWWARN, LOWALARM.

19.2 Completing the test

Continue to test another function or complete the test by setting the test mode to off. Restore connections and settings to the original values, if they were changed for testing purpose.
Power swing detection (PSD)

The aim of this instruction is to verify the setting of PSD and to verify that the PSD covers all impedance zones that shall be blocked by the PSD.

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

Before start of this process, all impedance measuring zones shall be set and in operation. The inner zone of the PSD must cover all zones to be blocked by the PSD with at least 10% margin. See figure 24 below.

Figure 24: Operating principle and characteristic of the PSD function

The PSD can operate in two modes by the configuration; “one of three phase operation” and “two out of three phase operation”. Look into the configuration to see which one is valid the terminal.
20.1 Testing overview

Procedure
1. Re-configure the binary output from the PSD--ZOUT signal to the PSD--START signal of the PSD function.
   It is also possible to observe the PSD--START signal on the regular output terminals, if provided during the engineering stage. Check the corresponding terminal documentation.

2. Decrease slowly the measured voltages in all three phases until the W-meter detects the appearance of the PSD--START signal.

3. Increase the measured voltages to their rated values.

4. Decrease instantaneously voltages in all three phases to the values, which are for approximately 20% lower than the set value R1IN.
   The START signal must not appear.

5. Increase the measured voltages to their rated values.

20.2 Testing the one-of-three-phase operation

Procedure
1. Check the existing (default) configuration of the following function input signals:
   PSD--REL1PH, PSD--BLK1PH, PSD--REL2PH, PSD--BLK2PH and record the connections.

2. Reconfigure the terminal according to the following list:
   • PSD--REL1PH to FIXD-ON
   • PSD--BLK1PH to FIXD-OFF
   • PSD--REL2PH to FIXD-OFF
   • PSD--BLK2PH to FIXD-ON

3. Disconnect the L2 and L3 currents from the terminal and check that they are short-circuited on the output terminal of the testing equipment.

4. Decrease slowly the measured voltages until the PSD--START signal appears.

5. Increase the measured voltages to their rated values.

20.3 Testing the two-of-three-phase operation

Procedure
1. Reconfigure the terminal according to the following list:
• PSD--REL1PH to FIXD-OFF
• PSD--BLK1PH to FIXD-ON
• PSD--REL2PH to FIXD-ON
• PSD--BLK2PH to FIXD-OFF

2. Decrease slowly the measured voltages to the value, which is for approximately 20% lower than the operation value for the R1IN measuring point.

   No PSD--START signal must appear.

3. Increase the measured voltages to their rated values.

4. Connect the phase L2 current to the terminal again.

5. Decrease the measured voltages until the PSD--START signal appears.

6. Increase the measured voltages to their rated values.

7. Connect the phase L3 current to the terminal.

8. Return the original configuration for the functional inputs PSD--REL1PH, PSD--BLK1PH, PSD--REL2PH, and PSD--BLK2PH.

20.4 Testing the tEF timer and functionality

Procedure
1. Check and record the default configuration for the PSD--TRSP, PSD--I0CHECK, PSD--BLK101, PSD--BLK102, and PSD--BLOCK functional inputs.

2. Re-configure the functional inputs PSD--TRSP and PSD--I0CHECK to two empty binary inputs of a terminal.

3. Configure functional inputs PSD--BLK101, and PSD--BLK102 to the FIXD-ON functional output and the PSD--BLOCK functional input to the FIXD-OFF functional input.

4. Connect the binary input towards the PSD--I0CHECK functional input via an open switch to the constant positive dc voltage.

5. Connect the binary input towards the PSD--TRSP functional input via a closed switch to the constant positive dc voltage.

6. Decrease the measured voltages slowly until the START signal appears.

7. Close the switch towards the binary input with PSD--I0CHECK connection and observe the PSD--START signal.

   It must reset instantaneously.

8. Open the switch towards the PSD--I0CHECK functional input.
9. Open the switch towards the PSD--TRSP functional input and close with some time delay the switch towards the PSD--I0CHECK functional input.

The PSD--START signal resets, if the time difference between opening the first and closing the second switch is shorter than the time delay set on the tEF timer. The PSD--START signal does not reset in the opposite case.

10. Increase the measured voltages to their rated values.

### 20.5 Testing the tR1 timer

**Procedure**

1. Disconnect the dc voltage from the binary inputs connected to the PSD--TRSP and PSD--I0CHECK functional inputs.
2. Connect the binary input towards the PSD--I0CHECK functional input via an open switch to the constant positive dc voltage.
3. Re-configure the PSD--BLKI02 functional input to the FIXD-OFF functional output.
4. Decrease the measured voltages slowly until the PSD--START signal appears.
5. Close the switch towards the PSD--I0CHECK binary input and observe the PSD--START signal.

   It must reset with the time delay set on the tR1 timer. It is also possible to measure this time delay with timer, which starts with closing of a switch and stops with the reset of a PSD--START signal on the corresponding binary output.

6. Increase the measured voltages to their rated values.

### 20.6 Testing the tR2 timer

**Procedure**

1. Disconnect the dc voltage from the binary input connected to the PSD--I0CHECK functional input.
2. Re-configure the functional input PSD--BLKI02 to the FIXD-ON functional input and PSD--BLKI01 to the FIXD-OFF functional output.
3. Decrease slowly the measured voltages until the PSD--START signal appears.

   It should reset after the time delay, set on tR2 timer. It is also possible to measure the time delay tR2.

4. Connect for this purpose the timer to the binary output with the PSD--START signal.
5. Start the timer with change of the signal from 0 to 1 and stop it with the change from 1 to 0.
6. Increase the measured voltages to their rated values

20.7 Testing the block input

Procedure
1. Re-configure the functional input PSD--BLOCK to the binary input, to which the PSD--I0CHECK has been configured so far.
2. Re-configure the functional input PSD--BLKI01 to the FIXD-ON functional input.
3. Decrease slowly the measured voltages in all three phases until the PSD--START signal appears.
4. Close the switch towards the PSD--BLOCK binary input and observe the PSD--START signal.
   It must reset instantaneously.
5. Increase the measured voltages to their rated values.
6. Re-configure the functional inputs PSD--TRSP, PSD--I0CHECK, PSD--BLKI01, PSD--BLKI02, and PSD--BLOCK to their original configuration.

20.8 Completing the test

Continue to test another function or complete the test by setting the test mode to off.
21 Setting lockout (HMI)

21.1 Verifying the settings

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

Procedure

1. Configure the HMI--BLOCKSET functional input to the binary input, which is determined by the engineering or the input that is not used by any other function.

2. Set the setting restriction to SettingRestrict = Block.

3. Connect rated DC voltage to the selected binary input.

4. Try to change the setting of any parameter for one of the functions. Reading of the values must be possible.

   The terminal must not respond to any attempt to change the setting value or configuration.

5. Disconnect the control DC voltage from the selected binary input.

6. Repeat the attempt under step 4.

   The terminal must accept the changed setting value or configuration.

7. Depending on the requested design for a complete REx 5xx terminal, leave the function active or reconfigure the function into the default configuration and set the setting restriction function out of operation to SettingRestrict = Open.

21.2 Completing the test

Continue to test another function or complete the test by setting the test mode to off. Restore connections and settings to the original values, if they were changed for testing purpose.
22 Scheme communication logic (ZCOM)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

Check the scheme logic during the secondary injection test of the impedance or overcurrent protection functions. For details see the ordering sheets for each particular REx 5xx terminal.

Activating the different zones verifies that the ZCOM-CS signal is issued from the intended zones. The ZCOM-CS signal from the independent tripping zone must have a tSendMin minimum time.

Check the tripping function by activating the ZCOM-CR and ZCOM-CRG inputs with the over-reaching zone used to achieve the ZCOM-CACC signal.

It is sufficient to activate the zones with only one type of fault with the secondary injection.

22.1 Testing permissive underreach

Procedure
1. Activate carrier receive (ZCOM-CR) signal of the terminal.
2. Supply the relay with healthy conditions for at least two seconds.
3. Apply a fault condition within the permissive zone.
4. Check that correct trip outputs, external signals, and indication are obtained for the actual type of fault generated.
5. Check that other zones operate according to their zone timer and that the carrier send (ZCOM-CS) signal is obtained only for the zone configured to give the actual signal.
6. Deactivate the carrier receive (ZCOM-CR) signal of the terminal.
7. Check that the trip time complies with the zone timers and that correct trip outputs, external signals, and indication are obtained for the actual type of fault generated.

22.2 Testing permissive overreach

Procedure
1. Activate the carrier receive (ZCOM-CR) signal of the terminal.
2. Supply the relay with healthy conditions for at least two seconds.
3. Apply a fault condition within the permissive zone.
4. Check that correct trip outputs, external signals, and indication are obtained for the actual type of fault generated.
5. Check that the other zones operate according to their zone timer and that the carrier send (ZCOM-CS) signal is obtained only for the zones that are configured to give the actual signal.

6. Deactivate the carrier receive (ZCOM-CR) signal of the terminal.

7. Supply the relay with healthy conditions for at least two seconds.

8. Apply a fault condition within the permissive zone.

9. Check that trip time complies with the zone timers and that correct trip outputs, external signals, and indication are obtained for the actual type of fault generated.

22.3 Testing blocking scheme

Procedure
1. Deactivate the carrier receive (ZCOM-CR) signal of the terminal.
2. Supply the relay with healthy conditions for at least two seconds.
3. Apply a fault condition within the forward directed zone used for scheme communication tripping.
4. Check that correct trip outputs and external signals are obtained for the type of fault generated and that the operate time complies with the tCoord timer (plus relay-measuring time).
5. Check that the other zones operate according to their zone times and that a carrier send (ZCOM-CS) signal is only obtained for the reverse zone.
6. Activate the carrier receive (ZCOM-CR) signal of the terminal.
7. Apply a fault condition in the forward directed zone used for scheme communication tripping.
8. Check that the no trip from scheme communication occurs.
9. Check that trip time from the forward directed zone used for scheme communication tripping complies with the zone timer and that correct trip outputs, external signals, and indication are obtained for the actual type of fault generated.

22.4 Checking of unblocking logic

Check the unblocking function (if the function is required) when you check the communication scheme.

22.4.1 Command function with continuous unblocking (Unblock = 1)

Procedure
1. Activate the carrier guard input signal (ZCOM-CRG) of the terminal.
2. Using the scheme selected, check that a carrier accelerated trip (ZCOM-TRIP) is obtained when the carrier guard signal is deactivated.

22.5 Completing the test

Continue to test another function or complete the test by setting the test mode to off.
Scheme communication logic for residual overcurrent protection (EFC)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter. Before testing the communication logic for residual overcurrent protection, the residual overcurrent protection has to be tested according to the corresponding instruction. Then continue with the instructions below.

If the current reversal and weak-end-infeed logic for earth-fault protection is included, proceed with the testing according to the corresponding instruction after the test of the communication logic for residual overcurrent protection. The current reversal and weak-end-infeed functions shall be tested together with the permissive scheme.

Testing the directional comparison logic function

23.1.1 Blocking scheme

Procedure

1. Inject the polarising voltage $3U_0$ to 5\% of $U_b$ and the phase angle between voltage and current to $65^\circ$, the current lagging the voltage.

2. Inject current ($65^\circ$ lagging the voltage) in one phase to about 110\% of the setting operating current, and switch off the current with the switch.

3. Switch on the fault current and measure the operating time of the EFC logic.

   Use the EFC--TRIP signal from the configured binary output to stop the timer.

4. Compare the measured time with the set value $t_{Coord}$.

5. Activate the EFC--CR binary input.

6. Check that the EFC--CRL output is activated when EFC--CR input is activated.

7. Switch on the fault current (110\% of the setting) and wait longer than the set value $t_{Coord}$.

   No EFC--TRIP signal should appear.

8. Switch off the fault current.

9. Reset the EFC--CR binary input.

10. Activate the EFC--BLOCK digital input.

11. Switch on the fault current (110\% of the setting) and wait longer than the set value $t_{Coord}$.

   No EFC--TRIP signal should appear.

12. Switch off the fault current and the polarising voltage.
13. Reset the EFC--BLOCK digital input.

23.1.2 Permissive scheme

Procedure
1. Inject the polarising voltage 3U0 to 5% of Ub and the phase angle between voltage and current to 65°, the current lagging the voltage.
2. Inject current (65° lagging the voltage) in one phase to about 110% of the setting operating current, and switch off the current with the switch.
3. Switch on the fault current (110% of the setting) and wait longer than the set value tCoord.
   No EFC--TRIP signal should appear, and the EFC--CS binary output should be activated.
4. Switch off the fault current.
5. Activate the EFC--CR binary input.
6. Switch on the fault current (110% of the setting) and measure the operating time of the EFC logic.
   Use the EFC--TRIP signal from the configured binary output to stop the timer.
7. Compare the measured time with the set value tCoord.
8. Activate the EFC--BLOCK digital input.
9. Switch on the fault current (110% of the setting) and wait longer than the set value tCoord.
   No EFC--TRIP signal should appear.
10. Switch off the fault current and the polarising voltage.
11. Reset the EFC--CR binary input and the EFC--BLOCK digital input.

23.2 Completing the test

Continue to test another function or complete the test by setting the test mode to off.
24 Four parameter setting groups (GRP)

24.1 Verifying the settings

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

Procedure

1. Check the configuration of binary inputs that control the selection of active setting group.

2. Browse the ‘ActiveGroup’ menu to achieve information about the active setting group.

   The ActiveGroup menu is located in the local HMI under:

   ServiceReport/ActiveGroup

3. Connect the appropriate dc voltage to the corresponding binary input of the terminal and observe the information presented on the HMI display.

   The displayed information must always correspond to the activated input.

4. Check that corresponding output indicates the active group.

5. Continue to test another function or complete the test by setting the test mode to off.
25 Synchrocheck and energizing check (SYN)

This section contains instructions on how to test the synchro-check and energizing check for single and double CB with/without phasing function and for 1 1/2 breaker arrangements.

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

At periodical checks, the functions should preferably be tested with the used settings. To test a specific function, it might be necessary to change some setting parameters, for example:

- AutoEnerg = On/Off/DLLB/DBLL/Both
- ManEnerg = Off
- Operation = Off, On
- Activation of the voltage selection function if applicable

The tests explained in the test procedures below describe the settings, which can be used as references during testing before the final settings are specified. After testing, restore the equipment to the normal or desired settings.

A secondary injection test set with the possibility to alter the phase angle by regulation of the resistive and reactive components is needed. Here, the phase angle meter is also needed. To perform an accurate test of the frequency difference, a frequency generator at one of the input voltages is needed.

Figure 25 shows the general test connection principle, which can be used during testing. This description describes the test of the version intended for one bay.

Figure 26 shows the general test connection for a 1 1/2 CB diameter with one-phase voltage connected to the line side.
Chapter 13
Verifying settings by secondary injection

Figure 25: General test connection with three-phase voltage connected to the line side.

Figure 26: General test connection for a 1 1/2 CB diameter with one-phase voltage connected to the line side.
25.1 **Testing the phasing function**
(Applicable only if the phasing function is included in the terminal.)

These voltage inputs are used:

- **U-line**: UL1, UL2 or UL3 voltage input on the terminal.
- **U-bus**: U5 voltage input on the terminal

The settings in **Table 15** can be used during the test if the final setting is not determined.

**Table 15: Test settings for phasing**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation</td>
<td>Off</td>
</tr>
<tr>
<td>InputPhase</td>
<td>UL1</td>
</tr>
<tr>
<td>PhaseShift</td>
<td>0 deg</td>
</tr>
<tr>
<td>URatio</td>
<td>1.00</td>
</tr>
<tr>
<td>USelection</td>
<td>SingleBus</td>
</tr>
<tr>
<td>AutoEnerg</td>
<td>Off</td>
</tr>
<tr>
<td>ManEnerg</td>
<td>Off</td>
</tr>
<tr>
<td>ManDBDL</td>
<td>Off</td>
</tr>
<tr>
<td>UHigh</td>
<td>70% U1b</td>
</tr>
<tr>
<td>ULow</td>
<td>40% U1b</td>
</tr>
<tr>
<td>FreqDiff</td>
<td>0.05 Hz</td>
</tr>
<tr>
<td>PhaseDiff</td>
<td>45°</td>
</tr>
<tr>
<td>UDiff</td>
<td>30% U1b</td>
</tr>
<tr>
<td>tAutoEnerg</td>
<td>0.5 s</td>
</tr>
<tr>
<td>tManEnerg</td>
<td>0.5 s</td>
</tr>
<tr>
<td>OperationSynch</td>
<td>On</td>
</tr>
<tr>
<td>ShortPulse</td>
<td>Off</td>
</tr>
<tr>
<td>FreqDiffSynch</td>
<td>0.40 Hz</td>
</tr>
<tr>
<td>tPulse</td>
<td>0.20 s</td>
</tr>
<tr>
<td>tBreaker</td>
<td>0.20 s</td>
</tr>
<tr>
<td>VTConnection</td>
<td>Line</td>
</tr>
<tr>
<td>tSync</td>
<td>Os</td>
</tr>
<tr>
<td>FreqDiffBlock</td>
<td>Off</td>
</tr>
</tbody>
</table>
25.1.1 Testing the frequency difference
The frequency difference is set at 0.40 Hz on the HMI, and the test should verify that operation is achieved when the FreqDiffSynch frequency difference is lower than 0.40 Hz.

Procedure
1. Apply voltages U-line (UL1) = 80% U1b, f-line=50.0 Hz and U-Bus (U5) = 80% U1b, f-bus=50.3 Hz.
2. Check that a closing pulse is submitted with length=0.20 seconds and at closing angle=360 * 0.20 * 0.40=29 deg.
3. Repeat with U-Bus (U5) = 80% U1b, f-bus=50.5 Hz to verify that the function does not operate when freq.diff is above limit.
4. Repeat with different settings on tBreaker and FreqDiffSynch.
5. Make sure that the calculated closing angle is less than 60 deg.
6. Verify that closing command is issued at the correct phase angle when the frequency difference is less than the set value.

25.2 Testing the synchrocheck
During test of the synchrocheck function for a single bay arrangement, these voltage inputs are used:

<table>
<thead>
<tr>
<th>U-line</th>
<th>U1, U2 or U3 voltage input on the terminal</th>
</tr>
</thead>
<tbody>
<tr>
<td>U-bus</td>
<td>U5 voltage input on the terminal</td>
</tr>
</tbody>
</table>

25.2.1 At test of the synchrocheck function for a 1 1/2 CB diameter the following alternative voltage inputs can be used for the three synchrocheck functions. The voltage is selected by activation of different inputs in the voltage selection logic:

<table>
<thead>
<tr>
<th>SYN1</th>
<th>U-line</th>
<th>UL1</th>
<th>Activate SYN1_FD1CLD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>UL2</td>
<td>Activate SYN1_CB2CLD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>U4</td>
<td>Activate SYN1_CB2CLD and CB3CLD</td>
</tr>
<tr>
<td>U-bus</td>
<td>U5</td>
<td>No activation of inputs necessary</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SYN2</th>
<th>U-line</th>
<th>UL2</th>
<th>Activate SYN2_FD2CLD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>U4</td>
<td>Activate SYN2_CB3CLD</td>
</tr>
<tr>
<td>U-bus</td>
<td>UL1</td>
<td>Activate SYN2_FD1CLD</td>
<td></td>
</tr>
</tbody>
</table>
Set the voltage difference at 30% U1b on the HMI, and the test should check that operation is achieved when the voltage difference UDiff is lower than 30% U1b.

The settings in Table 16 can be used during the test if the final setting is not determined.

**Table 16: Test settings for voltage difference (NA=Not applicable)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Setting</th>
<th>Single bay</th>
<th>Single bay with phasing</th>
<th>Multiple bays</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation</td>
<td>On</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>InputPhase</td>
<td>UL1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UMeasure</td>
<td>Ph/N</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>PhaseShift</td>
<td>0 deg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>URatio</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USelection</td>
<td>SingleBus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AutoEnerg</td>
<td>Off</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ManEnerg</td>
<td>Off</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ManDBDL</td>
<td>Off</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UHigh</td>
<td>70% U1b</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ULow</td>
<td>40% U1b</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FreqDiff</td>
<td>0.05 Hz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PhaseDiff</td>
<td>45°</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UDiff</td>
<td>30% U1b</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tAutoEnerg</td>
<td>0.5 s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tManEnerg</td>
<td>0.5 s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OperationSynch</td>
<td>Off</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>ShortPulse</td>
<td>Off</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FreqDiffSynch</td>
<td>0.4 Hz</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>tPulse</td>
<td>0.2 s</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>tBreaker</td>
<td>0.2 s</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>VTConnection</td>
<td>Line</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tSync</td>
<td>Os</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FreqDiffBlock</td>
<td>Off</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
</tbody>
</table>
The settings are located in the local HMI under:

```
Settings/Functions/Group n (n=1-4)/SynchroCheck/SynchroCheck1
```

**Test with UDiff = 0%**
1. Apply voltages U-line (UL1) = 80% U1b and U-Bus (U5) = 80% U1b.
2. Check that the SYN1-AUTOOK and SYN1-MANOK outputs are activated.
3. The test can be repeated with different voltage values to verify that the function operates within UDiff <30%.

**Test with UDiff = 40%**
1. Increase the U-bus (U5) to 120% U1b, and the U-line (UL1) = 80% U1b.
2. Check that the two outputs are **NOT** activated.

**Test with UDiff = 20%, Uline < UHigh**
1. Decrease the U-line (UL1) to 60% U1b and the U-bus (U5) to be equal to 80% U1b.
2. Check that the two outputs are **NOT** activated.

**Test with URatio=0.20**
1. Run the tests under procedures “Test with UDiff = 0%”, “Test with UDiff = 40%” and “Test with UDiff = 20%, Uline < UHigh” but with U-bus voltages 5 times lower.

**Test with URatio=5.00**
1. Run the tests under procedures “Test with UDiff = 0%”, “Test with UDiff = 40%” and “Test with UDiff = 20%, Uline < UHigh” but with U-line voltages 5 times lower.

**25.2.3 Testing the phase difference**

The phase difference is set at 45° on the HMI, and the test should verify that operation is achieved when the PhaseDiff (phase difference) is lower than 45°.

Set these HMI settings:
Table 17: Test settings for phase difference (NA=Not applicable)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Setting</th>
<th>Single bay</th>
<th>Single bay with phas-ing</th>
<th>Multiple bays</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation</td>
<td>On</td>
<td>Single bay with phasing</td>
<td>Multiple bays</td>
<td></td>
</tr>
<tr>
<td>InputPhase</td>
<td>UL1</td>
<td>Single bay with phasing</td>
<td>Multiple bays</td>
<td></td>
</tr>
<tr>
<td>UMeasure</td>
<td>Ph/N</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>PhaseShift</td>
<td>0 deg</td>
<td>Single bay with phasing</td>
<td>Multiple bays</td>
<td></td>
</tr>
<tr>
<td>URatio</td>
<td>1.00</td>
<td>Single bay with phasing</td>
<td>Multiple bays</td>
<td></td>
</tr>
<tr>
<td>USelection</td>
<td>SingleBus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AutoEnerg</td>
<td>Off</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ManEnerg</td>
<td>Off</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ManDBDL</td>
<td>Off</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UHigh</td>
<td>70% U1b</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ULow</td>
<td>40% U1b</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FreqDiff</td>
<td>0.05 Hz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PhaseDiff</td>
<td>45°</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UDiff</td>
<td>15% U1b</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tAutoEnerg</td>
<td>0.5 s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tManEnerg</td>
<td>0.5 s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OperationSynch</td>
<td>Off</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>ShortPulse</td>
<td>Off</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>FreqDiffSynch</td>
<td>0.4 Hz</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>tPulse</td>
<td>0.2 s</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>tBreaker</td>
<td>0.2 s</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>VTConnection</td>
<td>Line</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>tSync</td>
<td>Os</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>FreqDiffBlock</td>
<td>Off</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
</tbody>
</table>

Test with UDiff = 0%

1. Apply voltages U-line (UL1) = 100% U1b and U-bus (U5) = 100% U1b, with a phase difference equal to 0° and a frequency difference that is lower than 50 mHz.

2. Check that the SYN1-AUTOOK and SYN1-MANOK outputs are activated.

The test can be repeated with other PhaseDiff values to verify that the function operates for values lower than the set ones. By changing the phase angle on U1 connected to U-bus, between ± 45°. The user can check that the two outputs are activated for a PhaseDiff lower than 45°. It should not operate for other values. See Figure 27.
3. Apply a PhaseShift setting of 10 deg.
4. Change the phase angle between +55 and -35 and verify that the two outputs are activated for phase differences between these values but not for phase differences outside. See Figure 28.
5. Change the PhaseShift setting to 350 deg. Change the phase angle between +35 and -55 and verify as above.

Figure 27: Test of phase difference.

Figure 28: Test of phase difference.
25.2.4 Testing the frequency difference

The frequency difference is set at 50 mHz on the HMI, and the test should verify that operation is achieved when the FreqDiff frequency difference is lower than 50 mHz.

Use the same HMI setting as in section 25.2.3 "Testing the phase difference".

Test with FreqDiff = 0 mHz
1. Apply voltages U-Line (UL1) equal to 100% U1b and U-Bus (U5) equal to 100% U1b, with a frequency difference equal to 0 mHz and a phase difference lower than 45°.
2. Check that the SYN1-AUTOOK and SYN1-MANOK outputs are activated.

Test with FreqDiff = 1 Hz
1. Apply voltage to the U-line (UL1) equal to 100% U1b with a frequency equal to 50 Hz and voltage U-bus (U5) equal to 100% U1b, with a frequency equal to 49 Hz.
2. Check that the two outputs are NOT activated.

The test can be repeated with different frequency values to verify that the function operates for values lower than the set ones. If the FREJA program, Test of synchronizing relay, is used the frequency can be changed continuously.

Note!

A frequency difference also implies a floating mutual-phase difference. So the SYN1-AUTOOK and SYN1-MANOK outputs might NOT be stable, even though the frequency difference is within set limits, because the phase difference is not stable!

25.2.5 Testing the reference voltage

1. Use the same basic test connection as in Figure 25.

   The UDiff between the voltage connected to U-bus and U-line should be 0%, so that the SYN1-AUTOOK and SYN1-MANOK outputs are activated first.

2. Change the U-Line voltage connection to UL2 without changing the setting on the HMI.
3. Check that the two outputs are NOT activated.
4. The test can also be repeated by moving the U-line voltage to the UL3 input.
25.3 Testing the energizing check

During test of the energizing check function for a single bay arrangement, these voltage inputs are used:

- **U-line**: UL1, UL2 or UL3 voltage input on the terminal.
- **U-bus**: U5 voltage input on the terminal

25.3.1

At test of the energizing check function for a 1 1/2 CB diameter the following alternative voltage inputs can be used for the three energizing check functions. The voltage is selected by activation of different inputs in the voltage selection logic:

<table>
<thead>
<tr>
<th>SYN1</th>
<th>U-line</th>
<th>UL1</th>
<th>Activate SYN1_FD1CLD and UF1OK</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>UL2</td>
<td>Activate SYN1_CB2CLD and UF2OK</td>
</tr>
<tr>
<td></td>
<td></td>
<td>UL3</td>
<td>Activate SYN1_CB2CLD and UB2OK</td>
</tr>
<tr>
<td>U-bus</td>
<td>U5</td>
<td>Activate SYN1_CB3CLD and UB2OK</td>
<td></td>
</tr>
<tr>
<td></td>
<td>U4</td>
<td>Activate SYN1_FB2CLD and UF2OK</td>
<td></td>
</tr>
<tr>
<td>SYN2</td>
<td>U-line</td>
<td>UL2</td>
<td>Activate SYN2_FB2CLD and UF2OK</td>
</tr>
<tr>
<td></td>
<td></td>
<td>U4</td>
<td>Activate SYN2_CB3CLD and UB2OK</td>
</tr>
<tr>
<td>U-bus</td>
<td>UL1</td>
<td>Activate SYN2_FB2CLD and UF2OK</td>
<td></td>
</tr>
<tr>
<td></td>
<td>U5</td>
<td>Activate SYN2_CB1CLD and UB1OK</td>
<td></td>
</tr>
<tr>
<td>SYN3</td>
<td>U-line</td>
<td>UL1</td>
<td>Activate SYN3_CB2CLD and UF1OK</td>
</tr>
<tr>
<td></td>
<td></td>
<td>UL2</td>
<td>Activate SYN3_CB2CLD and UF2OK</td>
</tr>
<tr>
<td></td>
<td></td>
<td>UL3</td>
<td>Activate SYN3_CB2CLD and UB1OK</td>
</tr>
<tr>
<td>U-bus</td>
<td>U4</td>
<td>Activate SYN3_FB2CLD and UF2OK</td>
<td></td>
</tr>
</tbody>
</table>

25.3.2 Testing the dead line live bus (DLLB)

The test should verify that the energizing function operates for a low voltage on the U-Line and for a high voltage on the U-bus. This corresponds to an energizing of a dead line to a live bus.

The settings in table 18 can be used during the test if the final setting is not determined.

Table 18: Test settings for DLLB (NA=Not applicable)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Setting</th>
<th>Single bay</th>
<th>Single bay with phasing</th>
<th>Multiple bays</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation</td>
<td>On</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>InputPhase</td>
<td>UL1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UMeasure</td>
<td>Ph/N</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>PhaseShift</td>
<td>0 deg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>URatio</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. Apply a single-phase voltage 100% U1b to the U-bus (U5), and a single-phase voltage 30% U1b to the U-line (UL1).

2. Check that the SYN1-AUTOOK and SYN1-MANOK outputs are activated.

3. Increase the U-Line (UL1) to 60% U1b and U-Bus(U5) to be equal to 100% U1b. The outputs should **NOT** be activated.

The test can be repeated with different values on the U-Bus and the U-Line.

### 25.3.3 Testing the dead bus live line (DBLL)

The test should verify that the energizing function operates for a low voltage on the U-bus and for a high one on the U-line. This corresponds to an energizing of a dead bus from a live line.

1. Change the HMI settings AutoEnerg and ManEnerg to DBLL.

2. Apply a single-phase voltage of 30% U1b to the U-bus (U5) and a single-phase voltage of 100% U1b to the U-line (UL1).
3. Check that the SYN1-AUTOOK and SYN1-MANOK outputs are activated.

4. Decrease the U-line to 60% U1b and keep the U-bus equal to 30% U1b.
   The outputs should NOT be activated.

5. The test can be repeated with different values on the U-bus and the U-line.

25.3.4 Testing both directions (DLLB or DBLL)

1. Change the HMI settings AutoEnerg and ManEnerg to Both.

2. Apply a single-phase voltage of 30% U1b to the U-line (UL1) and a single-phase voltage of 100% U1b to the U-bus (U5).

3. Check that the “SYN1-AUTOOK” and “SYN1-MANOK” outputs are activated.

4. Change the connection so that the U-line (UL1) is equal to 100% U1b and the U-bus (U5) is equal to 30% U1b.
   The outputs should still be activated.

5. The test can be repeated with different values on the U-bus and the U-line.

6. Restore the equipment to normal or desired settings.

25.3.5 Testing the dead bus dead line (DBDL)

The test should verify that the energizing function operates for a low voltage on both the U-bus and the U-line, i.e. closing of the breaker in a non energised system.

1. Set AutoEnerg to Off and ManEnerg to DBLL.

2. Set ManDBDL to On.

3. Apply a single-phase voltage of 30% U1b to the U-bus (U5) and a single-phase voltage of 30% U1b to the U-line (UL1).

4. Check that the SYN1-MANOK output is activated.

5. Increase the U-bus to 80% U1b and keep the U-line equal to 30% U1b.
   The outputs should NOT be activated.

6. Repeat the test with ManEnerg set to DLLB and Both, and different values on the U-bus and the U-line.
25.4 Testing the voltage selection

The settings in table 19 can be used during the test if the final setting is not determined.

Table 19: Test settings for voltage selection (NA=Not applicable)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Setting</th>
<th>Single bay</th>
<th>Single bay with phasing</th>
<th>Multiple bays</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation</td>
<td>On</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>InputPhase</td>
<td>UL1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UMeasure</td>
<td>Ph/N</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>PhaseShift</td>
<td>0 deg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>URatio</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USelection</td>
<td>DbleB</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AutoEnerg</td>
<td>Both</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ManEnerg</td>
<td>Both</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ManDBDL</td>
<td>Off</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UHigh</td>
<td>80% U1b</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ULow</td>
<td>40% U1b</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FreqDiff</td>
<td>0.05 Hz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PhaseDiff</td>
<td>45°</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UDiff</td>
<td>15% U1b</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tAutoEnerg</td>
<td>0.5 s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tManEnerg</td>
<td>0.5 s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OperationSynch</td>
<td>Off</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>ShortPulse</td>
<td>Off</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FreqDiffSynch</td>
<td>0.4 Hz</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>tPulse</td>
<td>0.2 s</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>tBreaker</td>
<td>0.2 s</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>VTConnection</td>
<td>Line</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tSync</td>
<td>Os</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FreqDiffBlock</td>
<td>Off</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

25.4.1 Testing the voltage selection for single CB arrangements

This test should verify that the correct voltage is selected for the measurement in the energizing function used in a double-bus arrangement. Apply a single-phase voltage of 30% U1b to the U-line (UL1) and a single-phase voltage of 100% U1b to the U-bus (U5).

If the SYN1-UB1/2OK inputs for the fuse failure are used, normally they must be activated, thus activated and deactivated must be inverted in the description of tests below.

1. Connect the signals below to binary inputs and binary outputs.
2. Apply signals according to the tables and verify that correct output signals are generated.

Table 20: Voltages

<table>
<thead>
<tr>
<th>Signal</th>
<th>Voltage from bus1 U5</th>
<th>Voltage from bus2 U4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage from bus1 U5</td>
<td>1 1 1 1 1 1 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Voltage from bus2 U4</td>
<td>0 0 0 0 0 0 1 1 1 1 1 1</td>
<td></td>
</tr>
</tbody>
</table>

Table 21: Binary inputs

<table>
<thead>
<tr>
<th>Signal</th>
<th>CB1OPEN</th>
<th>CB1CLD</th>
<th>CB2OPEN</th>
<th>CB2CLD</th>
<th>UB1FF</th>
<th>UB2FF</th>
<th>VTSU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal</td>
<td>1 0 0 0 0 0 1 1 1 1 1 0</td>
<td>0 1 1 1 1 1 0 1 1 0 0 0 1</td>
<td>1 1 1 1 1 0 0 1 0 0 0 0 0</td>
<td>0 0 0 0 0 1 1 1 1 1 1 1</td>
<td>0 0 1 0 0 0 0 0 0 0 1 0 0</td>
<td>0 0 0 1 0 0 0 0 0 0 0 1 0 0</td>
<td>0 0 0 0 1 0 0 0 0 0 0 0 1 0</td>
</tr>
</tbody>
</table>

Table 22: Binary outputs

<table>
<thead>
<tr>
<th>Signal</th>
<th>AUTOOK</th>
<th>MANOK</th>
<th>VSUB1</th>
<th>VSUB2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal</td>
<td>1 1 1 0 1 0 1 0 1 0 0 0 1 1 1 0 0 0</td>
<td>1 1 0 1 0 1 0 0 0 1 1 0 0 0 1 0 0 0</td>
<td>1 1 1 1 1 1 0 1 0 0 0 0 0 0 1 0 0 1</td>
<td>0 0 0 0 0 1 0 0 0 1 1 1 1 1 0</td>
</tr>
</tbody>
</table>

25.4.2 Testing the voltage selection for 1 1/2 circuit breaker diameter

This test should verify that correct voltage is selected for the measurement in the energizing function used for a diameter in a one and a half breaker arrangement. Apply single-phase voltages to the inputs according to the tables below. “H” means a voltage of 100% U1b and “L” means a voltage of 30% U1b. Verify that correct output signals are generated.

1. Connect the signals below to binary inputs and binary outputs.
2. Apply signals according to the tables and verify that correct output signals are generated.
Table 23: Voltage to input

<table>
<thead>
<tr>
<th>Signal</th>
<th>SYN1</th>
<th>SYN2</th>
<th>SYN3</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUS1 U5</td>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>BUS2 U4</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>LINE1 UL1</td>
<td>H</td>
<td>L</td>
<td>-</td>
</tr>
<tr>
<td>LINE2 UL2</td>
<td>-</td>
<td>H</td>
<td>L</td>
</tr>
</tbody>
</table>

Table 24: Binary inputs SYN1, SYN2 and SYN3

<table>
<thead>
<tr>
<th>Signal</th>
<th>SYN1</th>
<th>SYN2</th>
<th>SYN3</th>
</tr>
</thead>
<tbody>
<tr>
<td>FD1CLD</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>FD1OPEN</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>FD2CLD</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>FD2OPEN</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>CB1CLD</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CB1OPEN</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CB2CLD</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>CB2OPEN</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>CB3CLD</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>CB3OPEN</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 25: Binary outputs SYN1, SYN2, SYN3

<table>
<thead>
<tr>
<th>Signal</th>
<th>SYN1</th>
<th>SYN2</th>
<th>SYN3</th>
</tr>
</thead>
<tbody>
<tr>
<td>VSUF1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>VSUF2</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>VSUB1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>VSUB2</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>AUTOOK</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

25.5 Completing the test

Continue to test another function or complete the test by setting the test mode to off.
26 Definite time non-directional overcurrent protection (TOC)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

To verify the settings the following fault type should be tested:

- One for a phase-to-earth fault

Ensure that the maximum continuous current of the terminal does not exceed four times its rated value.

26.1 Measuring the operate limit of set values

26.1.1 Time delayed phase overcurrent

Procedure

1. Inject a phase current in the terminal with start below the setting value.

2. Increase the injected current (measured current) in the Ln phase until the starting signal TOC--STLn \((n=1-3)\) appears.

3. Switch off the fault current.

   Observe the maximum permitted overloading of the current circuits in the terminal.

4. Compare the measured operating current with the set value IP>.

5. Set the fault current to about 1.5 times the measured operating current.

6. Switch on the fault current and measure the operating time of the TOC protection. Use the TOC--TRP signal.

7. Compare the measured time with the set value tP.

26.1.2 Time delayed residual overcurrent (non-dir.)

Procedure

1. Inject a phase current in the terminal with start below the setting value.

2. Increase the injected residual current (measured current) in the Ln phase until the starting signal TOC--STN appears.

3. Switch off the fault current.

   Observe the maximum permitted overloading of the current circuits in the terminal.
4. Compare the measured operating current with the set value $\text{IN}$.  
5. Set the fault current to about 1.5 times the measured operating current.  
6. Switch on the fault current and measure the operating time of the TOC protection. Use the TOC–TRN signal.  
7. Compare the measured time with the set value $\text{tN}$.  

### 26.2 Completing the test

Continue to test another function or complete the test by setting the test mode to off.
Time delayed overvoltage protection (TOV)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

To verify the settings the following fault types should be tested:

- One for a single-phase voltage feeding.

27.1 Verifying the settings

27.1.1 Time delayed phase overvoltage protection

Procedure
1. Apply the single phase voltage with start below the setting value.
2. Slowly increase the voltage until the TOV--STPE signal appears.
3. Note the operate value and compare it with the set value.
4. Switch off the applied voltage.
5. Set and apply about 20% higher voltage than the measured operate value for one-phase.
6. Measure the time delay for the TOV--TRPE signal and compare it with the set value.

27.1.2 Time delayed residual overvoltage protection (non-dir.)

Procedure
1. Apply the single phase voltage with start below the setting value.
2. Slowly increase the voltage until the STN appears.
3. Note the operate value and compare it with the set value.
4. Switch off the applied voltage.
5. Set and apply about 20% higher voltage than the measured operate value for one-phase.
6. Measure the time delay for the TOV--TRN signal and compare it with the set value.

27.2 Completing the test

Continue to test another function or complete the test by setting the test mode to off. Restore connections and settings to the original values, if they were changed for testing purpose.
28 Time delayed undervoltage protection (TUV)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

To verify the settings the following fault type should be tested:

- Decrease of voltage in one phase

28.1 Verifying the settings

Procedure

1. Supply the terminal with three-phase voltages to their rated values.
2. Slowly decrease the voltage in one of the phases, until the TUV-START signal appears.
3. Note the operate value and compare it with the set value.
4. Increase the measured voltage to rated operate conditions.
5. Instantaneously decrease the voltage in one-phase to a value about 20% lower than the measured operate value.
6. Measure the time delay for the TUV-TRIP signal, and compare it with the set value.

28.2 Completing the test

Continue to test another function or complete the test by setting the test mode to off. Restore connections and settings to the original values, if they were changed for testing purpose.
29 Tripping logic (TR)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

The function is tested functionally together with other protection functions (distance protection ZMn--, line differential protection DIFL-, earth-fault overcurrent protection IOC-- or TOC--, etc.) within the REx 5xx terminals. It is recommended to test the function together with the autoreclosing function, when built into the terminal or when a separate external unit is used for the reclosing purposes.

29.1 3ph operating mode

The function must issue a three-phase trip in all cases, when trip is initiated by any protection or some other built-in or external function. The following functional output signals must always appear simultaneously: TRIP-TRIP, TRIP-TRL1, TRIP-TRL2, TRIP-TRL3 and TRIP-TR3P.

29.2 1ph/3ph operating mode

The following tests should be carried out in addition to some other tests, which depends on the complete configuration of a terminal:

Procedure

1. **Initiate one-by one different single-phase-to-earth faults.**

   Consider sufficient time interval between the faults, to overcome a reclaim time of eventually activated autoreclosing function. Only a single-phase trip should occur for each separate fault and only one of the trip outputs (TRIP-TRLn) should be activated at a time. Functional outputs TRIP-TRIP and TRIP-TR1P should be active at each fault. No other outputs should be active.

2. **Initiate different phase-to-phase and three-phase faults.**

   Consider sufficient time interval between the faults, to overcome a reclaim time of eventually activated autoreclosing function. Only a three-phase trip should occur for each separate fault and all of the trip outputs (TRIP-TRLn) should be activated at a time. Functional outputs TRIP-TRIP and TRIP-TR3P should be active at each fault. No other outputs should be active.

3. **Initiate a single-phase-to-earth fault and switch it off immediately when the trip signal is issued for the corresponding phase. Initiate the same fault once again within the reclaim time of the used autoreclosing function.**

   A three-phase trip must be initiated for the second fault.

   Check that the corresponding trip signals appear after both faults.
If not the autoreclosing function is used the functional outputs TRIP-TRIP, TRIP-TR1P and the corresponding phase signal (TRIP-TRLn) should be active at each fault.

4. **Initiate a single-phase-to-earth fault and switch it off immediately when the trip signal is issued for the corresponding phase. Initiate the second single-phase-to-earth fault in one of the remaining phases within the time interval, shorter than two seconds and shorter than the dead-time of the autoreclosing function, when included in protection scheme.**

Check that the second trip is a three-phase trip.

### 29.3 1ph/2ph/3ph operating mode

The following tests should be carried out in addition to some other tests, which depends on the complete configuration of a terminal:

**Procedure**

1. **Initiate one-by one different single-phase-to-earth faults.**

   Consider sufficient time interval between the faults, to overcome a reclaim time of eventually activated autoreclosing function. Only a single-phase trip should occur for each separate fault and only one of the trip outputs (TRIP-TRLn) should be activated at a time. Functional outputs TRIP-TRIP and TRIP-TR1P should be active at each fault. No other outputs should be active.

2. **Initiate one-by one different phase-to-phase faults.**

   Consider sufficient time interval between the faults, to overcome a reclaim time of eventually activated autoreclosing function. Only a two-phase trip should occur for each separate fault and only corresponding two trip outputs (TRIP-TRLn) should be activated at a time. Functional outputs TRIP-TRIP and TRIP-TR2P should be active at each fault. No other outputs should be active.

3. **Initiate a three-phase fault.**

   Consider sufficient time interval between the faults, to overcome a reclaim time of eventually activated autoreclosing function. Only a three-phase trip should occur for the fault and all trip outputs (TRIP-TRLn) should be activated at the same time. Functional outputs TRIP-TRIP and TRIP-TR3P should be active at each fault. No other outputs should be active.

4. **Initiate a single-phase-to-earth fault and switch it off immediately when the trip signal is issued for the corresponding phase. Initiate the same fault once again within the reclaim time of the used autoreclosing function.**

   A three-phase trip must be initiated for the second fault.

   Check that the corresponding trip signals appear after both faults.
If not the autoreclosing function is used the functional outputs TRIP-TRIP, TRIP-TR1P and the corresponding phase signal (TRIP-TRLn) should be active at each fault.

5. Initiate a single-phase-to-earth fault and switch it off immediately when the trip signal is issued for the corresponding phase. Initiate the second single-phase-to-earth fault in one of the remaining phases within the time interval, shorter than two seconds and shorter than the dead-time of the autoreclosing function, when included in protection scheme.

Check that the second trip is a single-phase trip in a second initiated phase.

6. Initiate a phase-to-phase fault and switch it off immediately when the trip signal is issued for the corresponding two phases. Initiate another phase-to-phase fault (not between the same phases) within the time, shorter than 2 seconds.

Check, that the output signals, issued for the first fault, correspond to two-phase trip for included phases.

The output signals for the second fault must correspond to the three-phase tripping action.

29.4 Completing the test

Continue to test another function or complete the test by setting the test mode to off.
30 Two step time delayed directional phase overcurrent protection (TOC3)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

Consider to apply an three-phase symmetrical voltage at rated value and $Z\Phi=0^\circ$ if the settings are directional. If distance protection (ZMn) not are included in the terminal test of directional lines has to be carried out.

Ensure that the maximum continuous current of a terminal does not exceed four times its rated value, if the measurement of the operating characteristics runs under constant voltage conditions.

To verify the settings the following fault type should be tested:

- One for a phase-to-earth fault

30.1 Measuring the operate and time limit for set values

30.1.1 Measuring the operate limit of the low step overcurrent protection

Procedure
1. Inject a phase current slightly smaller than the functional value $I_{>\text{Low}}$.
2. Increase the current slowly and check the function value by observing when the signal TOC3-STNDLS appears.
3. Compare the result of the measurement with the set value.

30.1.2 Measuring the definite time delay of the low set stage

1. Set a current 1.5 times $I_{>\text{Low}}$ on the injection test equipment and three-phase symmetrical voltage if directional.
2. Switch the current on and compare the operation time on TOC3-TRLS with the set value $t_{\text{Low}}$.
   - The operate time shall be $t_{\text{Relay}}+t_{\text{Low}}$.

30.1.3 Measuring the inverse time delay of the low set stage

1. Set temporarily $t_{\text{Low}} = 0.000 \text{ s}$.
   - If $I_{>\text{Low}}$ is set higher than $I_{>\text{Inv}}$, check that there is no trip signal TOC3-TRLS when the current is less than $I_{>\text{Low}}$. 
Two step time delayed directional phase overcurrent protection (TOC3)

Chapter 13
Verifying settings by secondary injection

2. Check the time delay at two points of the inverse time curve.
   Check with the current I>Low or 2·I>Inv (the highest value of these two) and the current that according to the inverse time curve corresponds to tMin.

3. Increase the current 10% and check that the operation time is equal to tMin.
4. Set tLow to the correct value and check with a high current that the operation time is equal to tMin+tLow.

30.1.4 Measuring the operate limit of the high step overcurrent protection

1. Set temporarily tHigh=0.000 s.
2. Inject a phase current slightly smaller than the operation value I>High and three-phase symmetrical voltage if directional.
3. Increase the current slowly and check the operation value by observing when the signal TOC3-TRHS appears.
4. Compare the result of the measurement with the set value.
5. Set tHigh to the correct value.
6. Set a current 1.5 times I>High on the injection test equipment
7. Switch the current on and compare the operation time with the set value tHigh.

30.1.5 Measuring the operate limit of the directional lines.

Figure 29: Definitions for forward and reverse directions

Procedure
1. Inject a current 1.2 times I>Low and a three-phase symmetrical voltage.
2. Slowly decrease the impedance angle to find the operating value according to figure 29.
3. Compare the result of the measurement with the set value.

30.2 Completing the test

Continue to test another function or complete the test by setting the test mode to off.
31 Two step time delayed non-directional phase overcurrent protection (TOC2)

Prepare the terminal for test as outlined in section 2 "Preparing for test" in this chapter.

Ensure that the maximum continuous current of a terminal does not exceed four times its rated value, if the measurement of the operating characteristics runs under constant voltage conditions.

To verify the settings the following fault type should be tested:

- One for a phase-to-earth fault

31.1 Measuring the operate and time limit for set values

31.1.1 Measuring the operate limit of the low step overcurrent protection

Procedure
1. Inject a phase current slightly smaller than the functional value \( I_{\text{Low}} \).
2. Increase the current slowly and check the function value by observing when the signal TOC2-STLS appears.
3. Compare the result of the measurement with the set value.

31.1.2 Measuring the definite time delay of the low set stage

Procedure
1. Set a current 1.5 times \( I_{\text{Low}} \) on the injection test equipment.
2. Switch the current on and compare the operation time on TOC2-TRLS with the set value \( t_{\text{Low}} \).
   The operate time shall be \( t_{\text{Low}} + \) operate time of the low set stage.

31.1.3 Measuring the inverse time delay of the low set stage

Procedure
1. Set temporarily \( t_{\text{Low}} = 0.000 \) s.
   If \( I_{\text{Low}} \) is set higher than \( I_{\text{Inv}} \), check that there is no trip signal TOC2-TRLS when the current is less than \( I_{\text{Low}} \).
2. Check the time delay at two points of the inverse time curve.
   Check with the current \( I_{\text{Low}} \) or \( 2 \cdot I_{\text{Inv}} \) (the highest value of these two) and the current that according to the inverse time curve corresponds to \( t_{\text{Min}} \).
3. Increase the current 10% and check that the operation time is equal to \( t_{\text{Min}} \).
4. Set tLow to the correct value and check with a high current that the operation time is equal to tMin+tLow.

31.1.4 Measuring the operate limit of the high step overcurrent protection

1. Set temporarily tHigh=0.000 s.
2. Inject a phase current slightly smaller than the operation value I>High.
3. Increase the current slowly and check the operation value by observing when the signal TOC2-TRHS appears.
4. Compare the result of the measurement with the set value.
5. Set tHigh to the correct value.
6. Set a current 1.5 times I>High on the injection test equipment
7. Switch the current on and compare the operation time with the set value tHigh.

31.2 Completing the test

Continue to test another function or complete the test by setting the test mode to off. Restore connections and settings to the original values, if they were changed for testing purpose.
Chapter 14 Verifying the internal configuration

About this chapter
The aim of this chapter is to verify that the internal communications and output signals are according to the specification and normal protection praxis. This means that all included protection functions must be in operation.
1 Overview

Before start of this process, all individual devices that are involved in the fault clearance process must have been tested as individuals and set in operation. The breaker must be ready for an open-close-open cycle.

The shaping of the test process is dependent on the complexity of the design of the switchyard. Hereby follows some items which could be used as guidelines.
Testing the interaction of the distance protection

This procedure describes how to test the interaction of the distance protection zone 1 at phase L1-earth fault in forward direction. It is recommended that all other distance protection zones and other protection functions are tested in a similar way. The test must be done without the test switch in order to verify the interaction between the terminal and surrounding equipment. Make sure that all personnel is informed, also in remote station.

Procedure
1. Make sure that the protection terminal and fitting breaker(s) to be tested are in service.
2. Connect the test equipment to the terminal.
3. Set the test equipment so that the impedance present to the relay is half the set value.
4. Energise the protection terminal and evaluate the result i.e.
   - Check that correct trip has been accomplished according to configuration and philosophy.
   - Check that all binary output signals that should be activated have been activated.
   - Check that all other protection functions that should be activated by this type of fault have been activated.
   - Check that no other protection functions that should not be activated have not been activated.
   - Check whenever applicable that the disturbance report, event list and disturbance recorder have been activated and performed correct information.
Chapter 15 Testing the protection system

About this chapter
This chapter describes how to verify the conformity of the protection system without the protected object energised.
Overview

Before start of this process, all individual devices that are involved in the fault clearance process of the protected object must have been tested as individuals and set in operation. The breaker must be ready for an open-close-open cycle.

Scheme performance test is the final test that should be carried out before the protected object is taken into service.

Due to the complexity in combination with already performed tests, it is not necessary to test all protection functions and all fault types in this process. The most important protection functions in the terminal for single line to earth fault and phase-phase fault could be used for the test.

The shaping of the test process is dependent on the complexity of the design of the switchyard. Hereby follows some items which could be used as guidelines.
Testing the interaction of the distance protection

Chapter 15
Testing the protection system

2 Testing the interaction of the distance protection

This procedure describes how to test the interaction of distance protection zone 1 at a transient phase L1-L2 fault in forward direction. The test must be done without the test switch in order to verify the interaction between the terminal and surrounding equipment. Make sure that involved personnel is informed also in remote station.

This procedure describes how to test the interaction of an overcurrent protection stage at a transient phase L1-L2 fault in forward direction. The test must be done without the test switch in order to verify the interaction between the terminal and surrounding equipment. Make sure that involved personnel is informed also in remote station.

Procedure

1. Make sure that the protection terminal and related breaker(s) to be tested are in service.
2. Connect the test equipment to the terminal.
3. Set the test equipment so that the impedance present to the relay is half the set value of zone 1.
4. Prepare a transient fault sequence.
5. Simulate the condition for the synchro-check as for live bus and dead line.
6. Energise the protection terminal and evaluate the result i.e.
   • Check that correct trip has been accomplished according to configuration and philosophy.
   • Check that the autoreclosure have made an reclosing of the protected object.
   • Check that activation of all other external devices have been accomplished according to configuration and protection philosophy.
   - Check, whenever applicable, that carrier receive signal has arrived at remote end.
   - Check, whenever applicable, that start of external disturbance recorder has been accomplished.
   - Check that event and alarm signals has been given etc.
   • Check that no abnormal events have occurred.
   • Notice the AR dead time and do corrections if needed.
7. Make a new fault case for permanent fault and repeat the steps 1 - 6 above.

Specially note that a permanent trip should occur after the last attempt according to the programming of the AR.

It is recommended to repeat the procedure 1 - 6 for a protection function which detects earth-faults i.e. residual overcurrent protection.
Chapter 16 Checking the directionality

About this chapter
This chapter describes how to check that the directionality is correct for each directional dependent functions. The scope is also to verify that all analog values are correct. This must be done with the protection system in operation, the protected object energized and the load current above the min operation current of the terminal.
1 Overview

Before start of this process, all individual devices that are involved in the fault clearance process of the protected object must have been tested as individuals and set in operation. The breaker must be ready for an open-close-open cycle.

As a condition for the test, the following must be fulfilled:

- The magnitude of the load current must be more than 5% of the terminal nominal rate current.
- The load impedance must have an angle $-15^\circ < \varphi < 115^\circ$ or $165^\circ < \varphi < 295^\circ$.

The directionality test is performed when the protected object is energized and certain minimum load current with known direction is floating through the protected object.

The design of the test procedure depends on type of protection function to be tested. Here follows some items which could be used as guidelines.
2 Testing the directionality of the distance protection

The test, which also is valid as test of the directional phase overcurrent protection, is performed under the menus:

Service Report/Functions/Impedance/General/ImpDirection and .../ImpValues.

Procedure

1. Make sure that all control and protection functions that are belonging to the object that are going to be energised are tested and set in operation.

2. Check that the load current will be more than 5% of the terminal nominal rate current.

After energizing the line, the local HMI displays if the current direction in each phase is in forward or reverse direction. The measurement is based on ULx/ILx.

Menu for display is located in the menu

ServiceReport/Functions/Impedance/General/ImpDirection

For forward direction the display indicates: angle $-15^\circ<\phi<115^\circ$

- L1 = Forward
- L2 = Forward
- L3 = Forward

For reverse direction of the three measuring loops, the display shows: angle $165^\circ<\phi<295^\circ$

- L1 = Reverse
- L2 = Reverse
- L3 = Reverse

If one of the loops is in the opposite direction than the other two, this indicates that the phase sequence of the incoming voltage or current is incorrect.

The actual impedance measured is shown in the menu

ServiceReport/Functions/Impedance/General/ImpValues

XL1 = 0,00 Ohm
RL1 = 63,5 Ohm
Testing the directionality of the distance protection

Chapter 16
Checking the directionality

XL2 = 0,00 Ohm
RL2 = 63,5 Ohm
XL3 = 0,00 Ohm
RL3 = 63,5 Ohm

The actual values of the current and voltage phasors can also be used to check the directionality of the distance protection on the HMI under the menu:

Service Report/Phasors/Primary (Secondary)
Chapter 17 Fault tracing and repair

About this chapter
This chapter describes how to carry out fault tracing and eventually, a change of circuit board.
1 Fault tracing

1.1 Using information on the local HMI

If an internal fault has occurred, the local HMI displays information under:

- TerminalReport
- SelfSuperv

Under these menus the indications of eventual internal failure (serious fault) or internal warning (minor problem) are listed.

Shown as well, are the indications regarding the faulty unit according to table 26.

**Table 26: HMI information**

<table>
<thead>
<tr>
<th>HMI information</th>
<th>Signal name</th>
<th>Activates summary signal</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>InternFail</td>
<td>INT--FAIL</td>
<td></td>
<td>Internal fail summary</td>
</tr>
<tr>
<td>Intern Warning</td>
<td>INT--WARNING</td>
<td></td>
<td>Internal warning summary</td>
</tr>
<tr>
<td>CPU-modFail</td>
<td>INT--CPUFAIL</td>
<td>INT--FAIL</td>
<td>Main processing module failed</td>
</tr>
<tr>
<td>CPU-modWarning</td>
<td>INT--CPUWARN</td>
<td>INT--WARNING</td>
<td>Main processing module warning (failure of clock, time synch., fault locator or disturbance recorder)</td>
</tr>
<tr>
<td>ADC-module</td>
<td>INT--ADC</td>
<td>INT--FAIL</td>
<td>A/D conversion module failed</td>
</tr>
<tr>
<td>Slotnn-XXXyy</td>
<td>INT--IOyy</td>
<td>INT--FAIL</td>
<td>I/O module yy failed</td>
</tr>
<tr>
<td>Real Time Clock</td>
<td>INT--RTC</td>
<td>INT--WARNING</td>
<td>Internal clock is reset - Set the clock</td>
</tr>
<tr>
<td>Time Sync</td>
<td>INT--TSYNC</td>
<td>INT--WARNING</td>
<td>No time synchronisation</td>
</tr>
</tbody>
</table>

Also the internal signals, such as INT--FAIL and INT--WARNING can be connected to binary output contacts for signalling to a control room.

In the Terminal Status - Information, the present information from the self-supervision function can be viewed. Indications of failure or warnings for each hardware module are provided, as well as information about the external time synchronisation and the internal clock. All according to table 27. Loss of time synchronisation can be considered as a warning only. The REx 5xx terminal has full functionality without time synchronisation.
1.2 Using front-connected PC or SMS

- Self-supervision summary = INT--FAIL and INT--WARNING
- CPU-module status summary = INT--CPUFAIL and INT--CPUWARN

When an internal fault has occurred, extensive information can be retrieved about the fault from the list of internal events. The list is available in the TERM-STS Terminal Status part of the CAP tool. This time-tagged list has information with the date and time of the last 40 internal events.

The internal events in the list do not only refer to faults in the terminal, but also to other activities, such as change of settings, clearing of disturbance reports and loss of external time synchronisation.

The following events are logged as Internal events:

<table>
<thead>
<tr>
<th>Event message</th>
<th>Description</th>
<th>Set/reset event</th>
</tr>
</thead>
<tbody>
<tr>
<td>INT--FAILOff</td>
<td>Internal fail status</td>
<td>Reset event</td>
</tr>
<tr>
<td>INT--FAILOn</td>
<td></td>
<td>Set event</td>
</tr>
<tr>
<td>INT--WARNINGOff</td>
<td>Internal warning status</td>
<td>Reset event</td>
</tr>
<tr>
<td>INT--WARNINGOn</td>
<td></td>
<td>Set event</td>
</tr>
<tr>
<td>INT--CPUFAILOff</td>
<td>Main processing module fatal error status</td>
<td>Reset event</td>
</tr>
<tr>
<td>INT--CPUFAILOn</td>
<td></td>
<td>Set event</td>
</tr>
<tr>
<td>INT--CPUWARNOff</td>
<td>Main processing module non-fatal error status</td>
<td>Reset event</td>
</tr>
<tr>
<td>INT--CPUWARNOn</td>
<td></td>
<td>Set event</td>
</tr>
<tr>
<td>INT--ADCOff</td>
<td>A/D conversion module status</td>
<td>Reset event</td>
</tr>
<tr>
<td>INT--ADCO</td>
<td></td>
<td>Set event</td>
</tr>
<tr>
<td>INT--IONOff</td>
<td>In/Out module No. n status</td>
<td>Reset event</td>
</tr>
<tr>
<td>INT--IONOn</td>
<td></td>
<td>Set event</td>
</tr>
<tr>
<td>INT--RTC Off</td>
<td>Real Time Clock (RTC) status</td>
<td>Reset event</td>
</tr>
<tr>
<td>INT--RTC On</td>
<td></td>
<td>Set event</td>
</tr>
<tr>
<td>INT--TSYNC Off</td>
<td>External time synchronisation status</td>
<td>Reset event</td>
</tr>
<tr>
<td>INT--TSYNC On</td>
<td></td>
<td>Set event</td>
</tr>
<tr>
<td>DREP-MEMUSED On</td>
<td>&gt;80% of the disturbance recording memory used</td>
<td>Set event</td>
</tr>
<tr>
<td>SETTING CHANGED</td>
<td>Any settings in terminal changed</td>
<td></td>
</tr>
<tr>
<td>DISTREP CLEARED</td>
<td>All disturbances in Disturbance report cleared</td>
<td></td>
</tr>
</tbody>
</table>

The events in the internal event list are time tagged with a resolution of 1 ms.

This means that when using the PC for fault tracing, it provides information on the:
• Module that should be changed.
• Sequence of faults, if more than one unit is faulty.
• Exact time when the fault occurred.
2 Repair instruction

Warning!
Never disconnect a secondary connection of current transformer circuit without short-circuiting the transformer’s secondary winding. Operating a current transformer with the secondary winding open will cause a massive potential build-up that may damage the transformer and may cause injuries to humans.

Warning!
Never connect or disconnect a wire and/or a connector to or from a terminal during normal service. Hazardous voltages and currents are present that may be lethal. Operation may be disrupted and terminal and measuring circuitry may be damaged.

An alternative is to open the terminal and send only the faulty circuit board to ABB for repair. When a printed circuit board is sent to ABB, it must always be placed in a metallic, ESD-proof, protection bag. The user can also purchase separate modules for replacement.

Note!
Strictly follow the company and country safety regulations.

Caution!
Always use a conductive wrist strap connected to protective earth when replacing modules. Electrostatic discharge (ESD) may damage the module and terminal circuitry.

Most electronic components are sensitive to electrostatic discharge and latent damage may occur. Please observe usual procedures for handling electronics and also use an ESD wrist strap. A semi-conducting layer must be placed on the workbench and connected to earth.

Disassemble and reassemble the REx 5xx terminal accordingly:

1. Switch off the dc supply.
2. Short-circuit the current transformers and disconnect all current and voltage connections from the terminal.
3. Disconnect all signal wires by removing the female connectors.
4. Disconnect the optical fibres.
5. Unscrew the main back plate of the terminal.
6. If the transformer module is to be changed — unscrew the small back plate of the terminal.
7. Pull out the faulty module.
8. Check that the new module has correct identity number.
9. Check that the springs on the card rail have connection to the corresponding metallic area on the circuit board when the new module is inserted.
10. Reassemble the terminal.

If the REx 5xx terminal has the optional increased measuring accuracy, a file with unique calibration data for the transformer module is stored in the Main processing module. Therefore it is not possible to change only one of these modules with maintained accuracy.
If a REx 5xx terminal needs to be repaired, the whole terminal must be removed and sent to ABB Logistic Center. Before returning the material, an inquiry must be sent to ABB Logistic Center.

e-mail: offer.selog@se.abb.com