REF542plus

Manual Part 3:
Installation and Commissioning
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THE DATA CONTAINED IN THIS MANUAL IS INTENDED SOLELY FOR THE 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 HARDWARE/SOFTWARE PRODUCT AND THIS INFORMATION PRODUCT.
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1 Introduction

This part of the manual describes the installation and commissioning of the REF542plus switchbay protection and control unit. The following section and its sub-sections contain information on:

- Mounting and installation instructions
- Commissioning
- Decommissioning and storage
2 Abbreviations and Definitions

In the following abbreviations and definitions used in this manual are listed together.

2.1 Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIS</td>
<td>Air Isolated Switchgear</td>
</tr>
<tr>
<td>AR</td>
<td>Auto Reclosure</td>
</tr>
<tr>
<td>CT</td>
<td>Current Transformer</td>
</tr>
<tr>
<td>DFT</td>
<td>Discrete Fourier Transformation</td>
</tr>
<tr>
<td>EMC</td>
<td>Electro Magnetic Compatibility</td>
</tr>
<tr>
<td>FUPLA</td>
<td>FUntktionblock Programming LAnguage also used as abbreviation for function plan or chart</td>
</tr>
<tr>
<td>GIS</td>
<td>Gas Isolated Switchgear</td>
</tr>
<tr>
<td>HMI</td>
<td>Human Machine Interface as control unit</td>
</tr>
<tr>
<td>LCD</td>
<td>Liquid Crystal Display</td>
</tr>
<tr>
<td>LED</td>
<td>Light Emitting Diode</td>
</tr>
<tr>
<td>LAG</td>
<td>Lon Application Guide</td>
</tr>
<tr>
<td>LV</td>
<td>Low Voltage</td>
</tr>
<tr>
<td>MC</td>
<td>Micro Controller</td>
</tr>
<tr>
<td>PC</td>
<td>Personal Computer</td>
</tr>
<tr>
<td>RHMI</td>
<td>Remote Human Machine Interface, the same meaning as HMI</td>
</tr>
<tr>
<td>VDEW</td>
<td>Association of German Utilities</td>
</tr>
</tbody>
</table>

2.2 Definitions

Notes and warnings on hazards are at the beginning of every section and also in the text. They are in a different font to distinguish them from normal text.

The safety warnings must be observed in all circumstances. If they are not observed, no guarantee claims will be accepted.

Note

A note indicates items that are significant in the specific context. A note may contain information on the interplay of various software components and appears as shown below.

Example:

Note

Please read this section completely for information on the various formats for safety notes.
Hazard information level 1
Level 1 hazard information indicates hazards affecting substations and devices. It should always be observed, because otherwise function interruptions or malfunctions may occur. An example is shown below:

Caution  Do not make any changes to the FUPLA unless you are familiar with the REF542plus and the configuration software

Hazard information level 2
Level 2 hazard information indicates hazards affecting life and limb. It must be observed to avoid injury to the operator or other personnel.

Example:

Warning!  Never attempt to remove the protection covers on the busbars by force.
3 **Operation of the REF542plus**

In this chapter you will find the following information:

Operator’s responsibilities

Guarantee provisions

General safety notes

Special safety warnings that must always be observed when working with the REF542plus.

### 3.1 Operator’s responsibilities

Please observe the following information for the operator:

The operating personnel for the REF542plus must have the appropriate qualifications for work on the unit.

Your operating personnel must be authorized to work with or on REF542plus. (E.g. switching authorization in substations)

Changes to the application as delivered may be made only by ABB personnel

For guarantee reasons, changes to the application as delivered made by the customer must always be approved by the appropriate ABB sales department

We recommend that only ABB personnel make adjustments to the unit. Once the guarantee has expired, the unit is opened at your own risk and is permitted after consultation with the ABB office that sold the unit.

### 3.2 Guarantee Provisions

The data provided in this documentation is intended solely to describe the product and must not be considered as assured properties. In the interest of users, we are continually striving to bring our products up to the latest state of the art in technology. For this reason there may be differences between the product and the product description and the manual.

If the instructions and recommendations of our documentation are observed, then, according to our experience, the best possible operational reliability of our products is guaranteed.

It is virtually impossible for comprehensive documentation to cover every possible event that may possibly occur when using technical devices and apparatus. We therefore request that our representatives or we be consulted in the event of any unusual incidents and in cases for which this Manual do not provide comprehensive information.

We explicitly refuse to accept any responsibility for all direct damages that occur as a result of erroneous usage of our devices, even if no special instructions on this are included in the manual.

The documentation has been carefully checked. If the user should find any defects in spite of this, we request that you inform us as quickly as possible.

We provide a 1 year guarantee for the functioning of the REF542plus.

The guarantee provisions are a component of the related contract documents.
Special arrangements may be made in consultation with the operator and will be specified in the contract documentation.

In general, all agreements, assurances, legal relationships and all ABB obligations arise from the current valid contract documentation, including any reference to the warranty provisions, which are not influenced by the content of this documentation.

ABB assumes no responsibility for damages resulting from improper use of REF542plus.

In the event of a guarantee claim, please contact the ABB office that sold the unit.

### 3.3 Safety Regulations

The safety notes in the following chapters represent only a general selection of the points that must be observed. Additional safety notes applicable to the actual content of the chapter can be found in the other specific parts of the manual.

Safety notes are either at the beginning of the section or directly at the relevant position in the text.

#### 3.3.1 General safety notes

**Documentation**

**Note**

The content of the documentation supplied with the device must be followed in all circumstances when the device is in operation.

**Operating an electrical device**

**Warning!**

When any electrical device is being operated, specific parts of the device are subject to voltage. If safety warnings are not followed, hazards to personnel and property will result. Personal injury and damage to property may also occur.

**Safe Operation**

**Note**

The device must be properly transported and stored to ensure fault-free and safe operation. In addition, commissioning, control, service and maintenance must be properly and thoroughly conducted.
3.3.2 Specific safety information

Five safety rules

**Warning!** The five safety rules according the so called "VBG4 Electrical Substations and Equipment" must be observed in all circumstances for personal safety:
1. Isolate the system before beginning work.
2. Secure against reactivation.
3. Ensure that there is no voltage.
4. Ground and short circuit.
5. Cover or shut out neighboring parts under power.

Additional safety standards

**Warning!** The following safety standards must be observed in all circumstances:
1. IEC 60255 for protection relays in high-voltage substations
2. DIN 57627 plug connections

Working on and operating the device

**Note** Only qualified personnel may work on and operate the device.

Qualified personnel are:

- Entrusted with the setup, installation, commissioning and operation of the device and the system in which it is installed.
- Qualified and authorized to conduct switching operations in accordance with the standards of safety engineering. This specifically includes switching on and off, isolating, grounding and signage.
- Trained in safety engineering standards and are familiar with the maintenance and use of safety equipment.
- Trained in first aid.
4 Mounting and Installation

In this chapter you will find information:

on what to do first on delivery of the REF542plus

the requirements for the installation location and the environmental conditions,

how to set up the REF542plus and integrate it into the bay and

how to check the wiring to run the commissioning process.

4.1 Unpacking

The REF542 bay control and protection unit does not require special shipping protection. The packaging is adapted for the shipping type and destination. Please proceed as follows:

Visually inspect the unit and the packaging when unpacking it.
Any shipping damage found in the packaging or the unit should be reported immediately to the last shipper, who should be informed in writing of liability for the damage.

Check the delivery for completeness using the order documentation.
If there is anything missing or any discrepancies with the order documentation, contact the ABB sales office immediately.

Mount the unit as described in the following section. If the unit is not for immediate use, store it in a suitable place in its original packaging.

4.2 Mounting

The REF542 plus consists of two parts, a Central Unit and a separate Human Machine Interface (HMI) as the Control Unit. The Central Unit contains the power supply, processor and analog and binary Input and Output (I/O) modules, as well as optional modules for supplementary functions. The HMI Control Unit is a stand-alone unit with its own power supply. It can be installed on the Low Voltage (LV) compartment door or in a dedicated compartment close to the Central Unit. The HMI is normally used to set the protection parameters and to locally operate the switching devices in the switchbay. An isolated and shielded twisted pair according to the RS485 standard interface shall be used for the connection of the HMI as the Control unit to the Central Unit.
The figures below show the dimensions of the HMI Control Unit and Central Unit.

**Figure 1:** Dimension of the HMI Control Unit

**Figure 2:** Dimension of the Central Unit case, standard version

**Figure 3:** Dimension of the Central Unit case, wide version
The following table shows the data relevant for mounting.

**Table 1: Relevant data for mounting**

<table>
<thead>
<tr>
<th>Design</th>
<th>Standard version: … kg</th>
<th>depending on equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>Wide version: … kg</td>
<td>depending on equipment</td>
</tr>
<tr>
<td>Installation type</td>
<td>HMI: semiflush on the LV door</td>
<td>Central unit: in the LV compartment</td>
</tr>
<tr>
<td>Dimensions</td>
<td>185 x 244.8 x 261.5 mm (W x H x D)</td>
<td>Standard version</td>
</tr>
<tr>
<td></td>
<td>229 x 244.8 x 261.5 mm (W x H x D)</td>
<td>Wide version</td>
</tr>
<tr>
<td>Panel cutout</td>
<td>206 x 121 mm (W x H)</td>
<td></td>
</tr>
</tbody>
</table>

### 4.2.1 Set-up Area and Required Environmental Conditions

Please note the following information regarding the set-up area:

- Allow sufficient space for access to the. The connections must be easily accessible.
- Access to the Central Unit in the LV compartment must be easy for the following reasons:
  - to replace the unit,
  - to expand the unit,
  - to replace specific electronic equipment boards and
  - to replace specific modules if necessary.
- Because the unit is sensitive to non-permitted severe environmental conditions, please observe the following:
  - The set-up area must be free of excessive air contamination (dust, aggressive substances...).
  - The natural air circulation around the unit must be free.
  - The set-up area must maintain the specified environmental conditions
4.2.2 Installation in LV panels

Figure 4: REF542plus installed in gas-insulated switchgears (GIS)

Figure 5: REF542plus installed in air-insulated switchgears (AIS)
4.2.3 Connection diagrams

Connector Plate

![Connector Plate Diagram]

Figure 1: REF542plus connector plate for the wide case mixed analog input version

Figure 6: Example of mounting of the Central Unit in the LV compartment and the HMI on the door
Figure 2: REF542plus connector plate for the short case mixed analog input version

Figure 3: REF542plus connector plate for analog input with transformers or with sensors
### Table 2: Connectors on Central Unit

<table>
<thead>
<tr>
<th>Connector</th>
<th>Descriptions</th>
<th>Type of connector plug</th>
</tr>
</thead>
<tbody>
<tr>
<td>X10</td>
<td>Auxiliary voltage for power supply</td>
<td>3 pin Weidmuller female BLAT3BSNOR + fixing set SLABB2RORSET</td>
</tr>
<tr>
<td>X20</td>
<td>Binary Inputs of the 1st BIO</td>
<td>Harting 09 06 000 9474, DIN 41612</td>
</tr>
<tr>
<td>X21</td>
<td>Binary outputs of the 1st BIO</td>
<td>Harting 09 06 000 9474, DIN 41612</td>
</tr>
<tr>
<td>X30</td>
<td>Binary Inputs of the 2nd BIO</td>
<td>Harting 09 06 000 9474, DIN 41612</td>
</tr>
<tr>
<td>X31</td>
<td>Binary outputs of the 2nd BIO</td>
<td>Harting 09 06 000 9474, DIN 41612</td>
</tr>
<tr>
<td>X40</td>
<td>Binary Inputs of the 3rd BIO</td>
<td>Harting 09 06 000 9474, DIN 41612</td>
</tr>
<tr>
<td>X41</td>
<td>Binary outputs of the 3rd BIO</td>
<td>Harting 09 06 000 9474, DIN 41612</td>
</tr>
<tr>
<td>X50</td>
<td>Analog output</td>
<td>Harting 09 06 000 9474, DIN 41612</td>
</tr>
<tr>
<td>X70</td>
<td>Ethernet interface (full version)</td>
<td>Not available yet</td>
</tr>
<tr>
<td>X71</td>
<td>CAN interface (full version)</td>
<td>Not available yet</td>
</tr>
<tr>
<td>X72</td>
<td>RS232 interface</td>
<td>9 pin D-sub connector male</td>
</tr>
<tr>
<td>X73</td>
<td>RS485 interface</td>
<td>9 pin D-sub connector male</td>
</tr>
<tr>
<td>X74</td>
<td>IRIG-B interface (full version)</td>
<td>Not available yet</td>
</tr>
<tr>
<td>X75</td>
<td>Fast I/O inputs (full version)</td>
<td>Not available yet</td>
</tr>
<tr>
<td>X76</td>
<td>Fast I/O outputs (full version)</td>
<td>Not available yet</td>
</tr>
<tr>
<td>X77</td>
<td>Fast I/O inputs (full version)</td>
<td>Not available yet</td>
</tr>
<tr>
<td>X80</td>
<td>Analog inputs (from CT and/or VT)</td>
<td>Connector kit Compel c/w 24 contacts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Short version code 350.040.902</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Long version code 350.040.903</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crimp any single contact with hand tool</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No 350.048.011</td>
</tr>
<tr>
<td>X81..88</td>
<td>Analog input (sensor channel 1..8)</td>
<td>BNC Twin Cam CPE 23.717.140-0333</td>
</tr>
</tbody>
</table>

### Table 3: Connectors on Central Unit for SPABUS connection, electrical RS232 (modified)

<table>
<thead>
<tr>
<th>Connector</th>
<th>Descriptions</th>
<th>Type of connector plug</th>
</tr>
</thead>
<tbody>
<tr>
<td>X60</td>
<td>RS232 (modified)</td>
<td>9 pin D-sub connector male (z-modem)</td>
</tr>
</tbody>
</table>

**Note**

The RS232 connector, modified and galvanic isolated, can be applied to connect to a LON/SPA gateway.

### Table 4: Connectors on Central Unit for SPABUS connection, plastic fiber optical cable

<table>
<thead>
<tr>
<th>Connector</th>
<th>Descriptions</th>
<th>Type of connector plug</th>
</tr>
</thead>
<tbody>
<tr>
<td>X60</td>
<td>TX (optical interface)</td>
<td>Snap in HP HFBR 4501 (gray)</td>
</tr>
<tr>
<td>X61</td>
<td>RX (optical interface)</td>
<td>Snap in HP HFBR 4511 (blue)</td>
</tr>
</tbody>
</table>

**Caution**

The cable length for SPABUS connection with plastic fiber optical cable should not exceed 30 m
### Table 5: Connectors on Central Unit for SPABUS connection, glass fiber optical cable

<table>
<thead>
<tr>
<th>Connector</th>
<th>Descriptions</th>
<th>Type of connector plug</th>
</tr>
</thead>
<tbody>
<tr>
<td>X60</td>
<td>TX (optical interface)</td>
<td>ST plug HITRONIC ST-125</td>
</tr>
<tr>
<td>X61</td>
<td>RX (optical interface)</td>
<td>ST plug HITRONIC ST-125</td>
</tr>
</tbody>
</table>

**Caution**

The cable length for SPABUS connection with glass fiber optical cable should not exceed 1000 m.

### Table 6: Connectors on Central Unit for LON (per LAG 1.4) respectively IEC 60870-5-103

<table>
<thead>
<tr>
<th>Connector</th>
<th>Descriptions</th>
<th>Type of connector plug</th>
</tr>
</thead>
<tbody>
<tr>
<td>X60</td>
<td>TX (optical interface)</td>
<td>ST plug HITRONIC ST-125</td>
</tr>
<tr>
<td>X61</td>
<td>RX (optical interface)</td>
<td>ST plug HITRONIC ST-125</td>
</tr>
</tbody>
</table>

**Caution**

The cable length for LON (per LAG 1.4) connection with glass fiber optical cable should not exceed 2000 m.

### Table 7: Connectors on Central Unit for MODBUS RTU, electrical RS485

<table>
<thead>
<tr>
<th>Connector</th>
<th>Descriptions</th>
<th>Type of connector plug</th>
</tr>
</thead>
<tbody>
<tr>
<td>X60</td>
<td>RS485 channel 1</td>
<td>2pin Weidmueller BLAT2BSNOR</td>
</tr>
<tr>
<td>X61</td>
<td>RS485 channel 2</td>
<td>2pin Weidmueller BLAT2BSNOR</td>
</tr>
</tbody>
</table>

**Caution**

To connect to the upper level automation system with MODBUS RTU a twisted pair cable shall be used. If the cable is shielded, connect only one side of the shield to the earth screw of the housing. The maximum baud rate is 115000 bit/s. The cable length should not exceed 130 m.

### Table 8: Connectors on Central Unit for MODBUS, glass fiber optical cable

<table>
<thead>
<tr>
<th>Connector</th>
<th>Descriptions</th>
<th>Type of connector plug</th>
</tr>
</thead>
<tbody>
<tr>
<td>X62</td>
<td>RX channel 1 (optical interface)</td>
<td>ST plug HP type HFBR <em>XS</em></td>
</tr>
<tr>
<td>X63</td>
<td>TX channel 1 (optical interface)</td>
<td>ST plug HP type HFBR <em>XS</em></td>
</tr>
<tr>
<td>X64</td>
<td>RX channel 2 (optical interface)</td>
<td>ST plug HP type HFBR <em>XS</em></td>
</tr>
<tr>
<td>X65</td>
<td>TX channel 2 (optical interface)</td>
<td>ST plug HP type HFBR <em>XS</em></td>
</tr>
</tbody>
</table>

**Caution**

The maximum baud rate is 115000 bit/s with glass fiber optical cable. Its length should not exceed 2000 m.
4.2.4 Wiring the REF542plus

Follow the bay documentation supplied for the wiring.

In conclusion, the checks described in the following paragraphs can be done to ensure that the wiring is correctly installed.

4.2.4.1 Checking the current transformer circuits

To check that the current transformer and the current transformer circuits are wired correctly, run the following checks:

Polarity check
The polarity check (as close as possible to the REF542plus) is used to check the current circuit and also the installation position and the polarity of the transducer. The polarity of the transducers to one another can also be checked with load current.

Current feed with heavy current source (primary test instrument).
The current feed provides information on the transducer transformation and the correct wiring to the REF542plus. The power supply should be per conductor and run from conductor to conductor in each case. All line currents and the residual current should be checked here.
The transducer transformation can also be checked with load current.

Recording the magnetizing characteristic
Recording the magnetizing characteristic ensures that the REF542plus is connected to a protective core and not to a measuring core.

Checking the transducer circuit ground
Every independent current circuit may be grounded at only one point to prevent balancing currents resulting from potential differences.

Check the grounding of the cable current transformer (when used)
If the neutral current is measured by a cable current transformer, the cable shielding should first be returned through the cable current transformer before connecting it to the ground.

This enables weak ground faults currents that flow along the cable sheath to dissipate. In this way, they will not be incorrectly measured at their own relay feeder. The following shows another view of the cable current transformer grounding.
4.2.4.2 Check the voltage transformer circuits

To check that the voltage transformer and the voltage transformer circuits are wired correctly, run the following checks:

- Polarity check
- Wiring check
- Check the transformer circuit grounding

Check the voltage transformer for neutral point-ground voltage (when used). To measure ground faults please proceed as follows: The voltage is referred to as neutral point-ground voltage of a ground fault measurement when it occurs with a metallic ground fault in the network between terminals "e" and "n" of the open delta winding.

In the event of a metallic ground fault in phase L1, the external phase-to-neutral voltages occur in phases L2 and L3 instead of the conductor-ground voltages. They are added geometrically and yield three times the amplitude between terminals "e" and "n".

4.2.4.3 Checking the auxiliary voltage

The auxiliary voltage must be in the tolerance range of the power supply module and have the proper polarity under all operating conditions.

4.2.4.4 Check the tripping and signaling contacts

Conduct this check as shown in the bay documentation.

4.2.4.5 Check the binary inputs

Check the polarity and the voltage value of the binary inputs on the REF542 in accordance with the technical data of the binary inputs.

4.2.5 Grounding of the REF542plus

As can be seen in the following figure, the power supply board at connector X10 must be grounded to the housing. Therefore the middle pin must be connected to the grounding point in the LV compartment. Beside that, the shielding of the cable connection to the HMI control unit must also be connected to ground respectively to the housing.
To ensure the EMC (Electro Magnetic Compatibility) the housing must be grounded by a low impedance galvanic connection to the grounding system. As it is shown in the figure, an appropriate cable connection, which is fixed from a specific screw on the housing to the grounding system in the LV compartment, must be foreseen. That is why an interweaving cable is used for the grounding connection. If, due to the installation construction, the low impedance connection from the housing to the grounding system is already given, the additional grounding connection by the interweaving cable can be abstain from.

The housing of the HMI Local Control Unit must also be grounded too. As can be seen in the next figure, a specific grounding cable is to be connected from the housing of the HMI Local Control Unit to the grounding system in the LV compartment.
Typical examples of analog and binary connections

The following pages show examples for wiring analog inputs (measuring inputs) on the REF542 plus with sensors or transducers, binary I/Os and analog output boards. Typical examples of usage in practice will be shown here. The following symbols are used in the circuit diagrams:

Table 10: Graphical symbols for electric diagram (IEC 60617)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Legend</th>
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<tbody>
<tr>
<td><img src="image1" alt="Symbol" /></td>
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</tr>
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<td><img src="image4" alt="Symbol" /></td>
<td>Make contact</td>
</tr>
<tr>
<td><img src="image5" alt="Symbol" /></td>
<td>Mechanical, pneumatic or hydraulic connection (link)</td>
<td><img src="image6" alt="Symbol" /></td>
<td>Break contact</td>
</tr>
<tr>
<td><img src="image7" alt="Symbol" /></td>
<td>Earth, ground</td>
<td><img src="image8" alt="Symbol" /></td>
<td>Change-over break before make contact</td>
</tr>
<tr>
<td><img src="image9" alt="Symbol" /></td>
<td>Conductors in a screened cable</td>
<td><img src="image10" alt="Symbol" /></td>
<td>Position switch, break contact</td>
</tr>
<tr>
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<td><img src="image12" alt="Symbol" /></td>
<td>Circuit breaker</td>
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<td>Disconnector</td>
</tr>
<tr>
<td><img src="image15" alt="Symbol" /></td>
<td>Plug and socket male and female</td>
<td><img src="image16" alt="Symbol" /></td>
<td>Operating device</td>
</tr>
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Figure 5: Grounding of the REF542 plus HMI Local Control Unit

---

**4.2.6 Typical examples of analog and binary connections**

The following pages show examples for wiring analog inputs (measuring inputs) on the REF542 plus with sensors or transducers, binary I/Os and analog output boards. Typical examples of usage in practice will be shown here. The following symbols are used in the circuit diagrams:

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4.2.7 Connection Example of the REF542plus Analog Inputs

Figure 6: Example of connection diagram for incoming or outgoing bays with transformers
Figure 7: Example of connection diagram for incoming or outgoing bays with sensors
Figure 8: Example of connection diagram for bus-tie and measuring bays with transformers
Figure 9: Example of connection diagram for bus-tie and measuring bays with sensors

Caution  Due to accuracy requirements the length of the cable connection to the sensors in other bay respectively panels should be less than 7 m
Figure 10: Example of connection diagram for the transformer differential protection with transformers

Caution  Due to accuracy requirements the length of the cable connection to the sensors in other bay respectively panels should be less than 7 m
Figure 11: Example of connection diagram for the transformer differential protection with sensors
Figure 12: Example of connection diagram for the synchronism check with transformers
Figure 13: Example of connection diagram for the synchronism check with sensors

**Caution** Due to accuracy requirements the length of the cable connection to the sensors in other bay respectively panels should be less than 7 m
**Figure 14:** Example of connection diagram for the synchronism check with transformers
Figure 15: Example of connection diagram for the synchronism check with sensors

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5 Commissioning

The following sections with their subsections contain information on:

- The devices and facilities required for the commissioning inspection.
- The required procedure for the commissioning inspection; For example, depending on the components to be tested: Protection, interlock conditions, communications, measured value recording and determining the direction.

5.1 Safety Information

The devices, adapters and procedures described are only examples. Experience and safety in handling the various devices is a requirement.

5.2 Switching on the feeder

Caution

Before switching on the feeder check that the REF542plus is fully functional in the corresponding bay. Pay particular attention to the protective functions and the interlocking!

5.3 Test Equipment

The most important device for the commissioning of the REF542plus is an appropriate relay test equipment. The test equipment should have a three phase current and voltage system. Also the simulation of current and voltage sensors by the test equipment shall also be possible. For example a test equipment manufactured by KOCOS in Korbach/Germany can be used.

5.4 Testing the interlock conditions,

This test is intended to check the interlocking of the switchgear that the user wants and is required. The two types of interlocking must be taken into account here:

- Bay-level interlocking of specific switchgear and
- Station-level interlocking of the bay versus other bays.

The interlock conditions for the bay under test can be found in the order documentation. The interlock conditions specified by the user can be found there.

All possible circumstances must be checked.
5.5 Determining the transformer direction

The connection of the measuring inputs and the correct polarity of the current and voltage transformers or sensors is very important for distance, comparison and directional functions.

In addition to testing the polarity, the transformation ratio and the magnetizing characteristic, the wiring of the transformers/sensors must also be checked during these test.

5.5.1 Current transformer

The transformers must have a positive winding.

This can be easily checked with a 9 V battery and an analog DC voltmeter. If the primary coil of the current transformer is connected to the battery, the analog voltmeter connected on the secondary side must show positive. When the battery is disconnected, the voltmeter must measure a negative impulse.

The positive terminal of the battery must be connected to P1 of the primary coil and the positive input of the voltmeter to s1 for this test. The same applies for the negative terminal at P2 of the primary coil and the voltmeter negative input at s2 of the secondary coil.

The test setup for checking the direction of a core is shown in the following figure.

![Figure 16: Setup for the polarity test of current transformers](image)

This polarity check, also referred to as patch test, must be run for every core. To guarantee correct operation even with a multi core current transformer with different cores such as protection and measuring cores, it is recommended that the magnetizing characteristic (hysteresis) be recorded. A Variac with appropriately high voltage is connected to the secondary terminals. The flowing current is measured while the output voltage is rising. The characteristic of the measured values, voltage over current, yields the magnetizing characteristic of the core, which can then be compared with the manufacturer's data.

The transformation ratio of the current transformer cores is checked with a special primary current feed device. The feed device is primarily connected to the current transformer and the secondary value is measured at the secondary terminals of the transformer or at the protective cabinet with an ampere meter.
5.5.2 Voltage transformer

The same polarity test or patch test is run with voltage transformers. The difference is that the battery is connected to the secondary side and the analog DC test instrument to the primary coil of the voltage transformer.

The test setup for checking a core is shown in the following figure.

![Figure 17: Polarity test of voltage transformers](image)

Every core must be tested here.

If the Variac described in the current transformer section for recording the magnetizing characteristic has a sufficiently high output voltage (e.g. 500 V), it can also be used to run a qualitative test of the voltage transformer transformation ratio. The Variac voltage is applied to the primary side of the voltage transformer and a voltmeter is used to measure the secondary voltage at the corresponding transformer or protective cabinet terminals.

5.5.3 Current sensor

Because the current sensor, the Rogowski coil, is an air-core coil, it must be subjected to the same polarity test as the current transformers.

The test design is shown in the following diagram. A higher voltage value may be required for the battery.

![Figure 18: Polarity test of current sensors (Rogowski coil)](image)

The transformation ratio is tested exactly as with a current transformer. The display in the REF542 protection and control unit can also be checked at the same time. It is not necessary to record a magnetizing characteristic with the Rogowski coil, because it is an air-core coil with no saturation characteristics.
5.5.4 Voltage sensor

The polarity of the voltage sensor, which is a resistive precision voltage divider, is checked as shown in the following diagram. The correct polarity of the voltage is measured by applying an appropriate DC voltage (e.g. 24V/DC) to the secondary terminals. The auxiliary voltage source can also be used if the transformation ratio is very high. The transformation ratio of the resistive divider is checked at the same time.

![Diagram of Voltage Sensor](image)

**Figure 19:** Polarity test of voltage sensors (resistive splitter)

5.6 Testing the measured value recording

Proper functioning of the transformers and sensors is important for proper functioning of the REF542plus. The measured-value processing of the unit and the set rated values must be tested for this reason.

The phase currents and phase voltages must be taken as measured input quantities. All other measured values are quantities derived from them.

Test as follows:

Check whether the set rated values match the rated values required by the user (in the order documentation).

If necessary, load the application into the PC from the REF542plus.

Select the menu item Main Menu/Settings/Connections/Analog Inputs in the configuration program. The rated values are shown in the dialog window that appears and, if necessary, changed.

Test the wiring of the transformers or sensors

Disconnect the transducers or sensors from the REF542plus. The current transformers must be short-circuited, combination sensors disconnected.

Connect the test set to the REF542plus. The relevant current and voltage signals are applied to the analog inputs.

Set the required rated values on the test set

<table>
<thead>
<tr>
<th>Transducer/sensor</th>
<th>Rated value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current transformer</td>
<td>1A or 5A</td>
</tr>
<tr>
<td>Voltage Transformer</td>
<td>100V</td>
</tr>
<tr>
<td>Rogowski coil</td>
<td>150 mV</td>
</tr>
<tr>
<td>Voltage sensor</td>
<td>2V</td>
</tr>
</tbody>
</table>

**Table 11:** Rated values of the current and voltage signals
To test the phase sequence, set every phase separately to the rated value and then check the value on the LC display screen. At the end reset the phase to zero.

Generate one symmetrical system each for current and voltage with the rated values.

Check the calculated values. A three-phase current and voltage tester is recommended to test the power. By changing the phase angle between the current and the voltage system the calculation of reactive and effective values and of $\cos \varphi$ can be checked.

### 5.7 Testing the protective functions

To ensure that no damage has been caused by transport or setup and installation of the protection equipment and systems, secondary tests are run on the REF542plus protection and control unit with the configured protective functions.

**Warning!** Always observe the applicable safety regulations when conducting the secondary test with an appropriate test set.

**Caution** When testing ensure that the limit values of the measuring inputs and the auxiliary voltage supply are not exceeded.

Secondary function tests are recommended during commissioning of the protective functions.

The activated and configured automatic auto reclosure and also other functions of the complete system and the power circuit-breaker should be tested to ensure safe operation of these functions.

The following points are particularly important for protective functions that must work in connection with a set direction or energy flow quantity.

- Checking the sensor and transformer connections and wiring check of the station circuit diagram
- Determining the transformer direction
- Connection and documentation of the test set
- Testing and documentation of the measured value recording
- Setting parameters for the protective functions
- Recording the test settings

To monitor the test of the correct direction of the specific protective functions in comparison with the measured power and power factors in the event of a later primary test, the following information should be documented in the secondary tests:

- Directional setting of the test set
- Measurement of the effective and reactive power and of the $\cos \varphi$ factor
- Directional setting of the measurement and protective functions
6 Troubleshooting

In this chapter you will find information on

Self test of the Central unit

Self test of the HMI

By means of the self test the proper function of the REF542plus can be checked. It is to be recommended that the self test is done in uninstall condition of the REF542plus. At least no connection to the primary system should be left. Beside that, the upgrade the firmware will also be described.

6.1 Safety Information

If there is any doubt regarding the treatment of a message, please check with our service representative.

6.2 Required devices and facilities

6.2.1 Sinusoidal generator

The generator must have the following features in case of using the analog inputs of the REF542plus with current and voltage transformers:

- Accuracy class: 0.5
- Current output: 1 respective 5 A 50 Hz AC minimum
- Voltage output: 100 V 50 Hz AC minimum
- Voltage output: 2 VRMS 50 Hz AC

The generator must have the following features in case of using the analog inputs of the REF542plus with current and voltage sensors:

- Accuracy class: 0.5
- Current output: 150 mV 50 Hz AC minimum
- Voltage output: 2 VRMS 50 Hz AC minimum

6.2.2 Adjustable power supply

with the following features:

- Voltage output: 30 – 240 V DC
- Power: 500 VA
- Accuracy class: 5, <12% ripple

6.2.3 Personal computer

The PC (usually laptop) must be provided with at least one RS232 port for serial communication respectively data transfer. Two RS232 ports will give better operation condition. Thereby, the following software must be installed:

- REF542plus official released configuration software (example V4B01)
- Tera Term Pro software

6.2.4 Tera Term Pro

Tera Term Pro is a freeware terminal program for communication between the PC and the hardware of the REF542plus, the Central Unit or the HMI Local Control Unit,
The setting for the communication with the Central Unit can be seen in the next figure, which can be stored e.g. using the file name MCTERM:INI. This setting file can be used later, if a communication with the Central Unit is necessary.

![Figure 20: Setting of the communication to the Central Unit](image1)

The above figure shows the setting for the communication to the HMI Local Control Unit and can be stored e.g. as RHMITERM.INI.

### 6.2.5 Connection cables

The next figure show the set up for trouble shooting. There are several cables needed to link the PC and the REF542plus:

![Figure 21: Setting of the communication to the HMI](image2)
6.2.5.1 RS232 cable

This standard serial communication cable is needed for the communication between the PC and the Central Unit. The connector on the central unit for this purpose is X72.

6.2.5.2 REF542plus optical cable.

The HMI must be interfaced to a PC through the ABB RS232 optical cable. The optical converter must be plugged in the connector situated on the front side of the HMI. By using this interface the configuration file can be downloaded or uploaded from the local PC, which hosts the configuration tool, to the REF542plus central unit. Besides that, protection and operation events and the value of the measurement quantities stored in the REF542plus can be uploaded from the local PC for monitoring purpose.

6.2.5.3 RS 485 Cable

This cable is normally used for the connection between the HMI as Local Control Unit and the Central Unit in the LV compartment. This cable is connected to the connector X73 on the Central Unit.

6.3 Self test of the Central Unit

By means of the self test the functionality of the REF542plus Central unit can be proved.
6.3.1 Behavior after cold start

To see the behavior after cold start the following condition is to be prepared:

- The PC must be connected via the serial interface RS232 to the connector X72.
- The Tera Term Pro software is running and configured with the setting file MCTERM.INI.
- The related power supply voltage must be connected to connector -X10.
- The HMI Local Control Unit must not be connected to the Central Unit.

After the central unit starts up, the software Tera Term Pro shows messages as displayed in the following figure.

![Correct start up sequence of Central Unit displayed by Tera Term Pro software](image)

The REF542plus is after the indication “system running” in operation again. If the HMI Local Control Unit is connected, then on the LCD screen the single line diagram and the menu will be displayed.
6.3.2 Enter REF542plus self test

If a self test should be performed, press a key on the PC keyboard within a couple of seconds after the Central Unit is powered on again. The TeraTerm Pro software will display the following messages on the PC:

![Tera Term Pro display for entering the self test of the Central Unit](image1)

Type the proper password and press ‘enter’. Ask for the password from the authorized personnel in your local ABB representative. After typing the correct password, the following sub-menu will be shown:

![Display on Tera Term Pro Window after entering the right password](image2)

To verify the functionality the following test can be performed:
6.3.2.1 RAM test

Press ‘r’

2 Mbyte RAM is being tested

Test result is shown on the terminal

![Figure 11: Display of the result after RAM test](image)

6.3.2.2 Program flash memory test

Press ‘p’

16 Mbit flash is being tested. This test will destroy the actual application firmware on the program flash. Application firmware must be downloaded afterwards by ‘d’ command.

Test result is shown on the terminal.

6.3.2.3 Configuration flash memory test

Press ‘c’

16 Mbit flash is being tested. This test will destroy the actual configuration (if any) on the data flash.

Test result is shown on the terminal

6.3.3 Calibration of the Analog Input

The calibration of the REF542plus is normally not necessary, because the related calibration data are stored in the memory of the analog input board itself. But if e.g. one of the CT or VT on the analog input board is removed or substituted, a re-calibration has to be done. For this reason the so called factory test mode must be entered by typing ‘f’ after entering the self test mode. After some seconds, a menu with possible operations is shown on the PC terminal. The following commands are available:
Table 12: All available commands on the factory test mode

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>s</td>
<td>set time to RTC</td>
</tr>
<tr>
<td>a</td>
<td>set A/D calibration parameter</td>
</tr>
<tr>
<td>p</td>
<td>display A/D calibration parameter</td>
</tr>
<tr>
<td>w</td>
<td>test DSP watchdog</td>
</tr>
<tr>
<td>f</td>
<td>test fast I/O and DSP trip interrupt</td>
</tr>
<tr>
<td>g</td>
<td>GPS IRIG-B test</td>
</tr>
<tr>
<td>b</td>
<td>test binary I/O board</td>
</tr>
<tr>
<td>k</td>
<td>enter DSP calibration mode</td>
</tr>
<tr>
<td>r</td>
<td>read communication board version</td>
</tr>
<tr>
<td>u</td>
<td>show DSP RAM test result</td>
</tr>
<tr>
<td>h</td>
<td>show help (e.g. the present table)</td>
</tr>
</tbody>
</table>

As can be seen from the table the calibration mode can be entered by selecting the command k. In this mode the offset errors of the signal conditioning chain for the further processing of the analog input signals in the REF542plus unit can be compensated. Moreover the connections to the connector X80 can be defined. Afterwards the calibration data are stored on the EEPROM on the Analog Input Board.

- The calibration procedure needs the following preparation:
- Sinusoidal generator as already mentioned in chapter 6.2.1.
- Put in the jumper X12, which is located near to the back plane connector.

6.3.3.1 Transformer Input Board

The board must be supplied at X80 connector with:

- 1A, 50 Hz with accuracy class 0.5 at the 1A current inputs pins
- 0.2A, 50 Hz with accuracy class 0.5 at the 0.2A current inputs pins, normally on input channel 7 and/or 8
- 100 V RMS, 50 Hz. with accuracy class 0.5 at the voltage inputs

Note: During the calibration procedure all signals used calibration must be in phase!

6.3.3.2 Sensor Input Board

The board must be supplied at the X81…X88 connectors at the same time with signals of 2V, 50 Hz with an accuracy class 0.5

Note: During the calibration procedure all signals used calibration must be in phase!
6.3.3.3 Mixed Input Board

In this case the board must be supplied at

- X80 current inputs with 1A, 50 Hz with accuracy class 0.5
- X80 voltage inputs with 100V, 50 Hz. with accuracy class 0.5
- X81..X86 with 2 V, 50 Hz accuracy class 0.5

**Note**
During the calibration procedure all signals used calibration must be in phase!

6.3.3.4 Calibration procedure

Before starting the calibration procedure, the protection unit housing must be grounded. Beside that, the shielding screw on the analog input board must also be in.

**Caution**
Before starting the calibration procedure, the jumper X12 must be put in

After switching on all the input signals for running the calibration procedure can be started. For each possible analog input channel (from 1 to 8) the following selection must be done:

- `c`, if the input is a current transformer (1A).
- `v`, if the input is a voltage transformer (100V).
- `s`, if the input is a sensor (2V)
- `x`, if you like to skip the calibration for the channel.

After entered 8th channel input settings the calibration procedure starts automatically the calculation of calibration factors and after some seconds, it ends. The report shows at the corresponding input lines the calibration result with channel accuracy. In case of wrong connections to the input a phase error will be reported. The following figure shows the returned messages of the calibration procedure in case of phase error.
At the end of the calibration procedure it must be verified that all the configured channels has been configured and the phase error check reports no errors.

**Caution** At the end of the calibration phases the Jumper X12 must be removed.

### 6.4 Remote HMI self test

The following test procedure is applicable since the implementation of the software version 4B 01. To carry out the test the following steps must be done:

Connect the power supply to the connector X10. Take care of the voltage level of the HMI.

Switch on the power supply of the HMI Local Control Unit.

The connection to the Central Unit shall be removed.
When the RHMI is not connected to the protection unit shows the following screen:

![RHMI software version: V4B.01](image)

**PROTECTION UNIT NOT RESPONDING OR COMMUNICATION CORRUPTED**

< ' to test RHMI

**Figure 26:** Display on the LCD screen after switching on the power supply

By pressing the return key a “Stand alone” mode on the LCD display is shown. The test can be run individually or all together in sequence by selecting the corresponding menu line. In this case the e-key with the ABB code must be inserted in its plug and loop back cable must be inserted in X20 and in the optical interface in advance.

![Test menu](image)

**Figure 12:** “Stand alone” Test Page
At the end of each test display line a place is left for the test result. The test result can be:

**DONE** (for LCD and LEDs tests)

**FAIL** or **OK** (for Keyboard, E-Key and Serials tests)

Each time the HMI Test Page (each of the two type) is accessed the place for the result is set to blank. After a test is run the corresponding result is shown. If the menu option “Run all tests” is selected, all tests results will be displayed.

The following paragraphs describe the performing of single test.

### 6.4.1 LCD test

This test consists in the following four parts. Each part has a corresponding page and there is a 2 seconds delay between one test and the following one.

A manual verification by the test operator is needed to check the test result.

#### 6.4.1.1 Texts writing test

LCD page is displayed

1 second delay

The LCD page is cleared

The test is carried out. It writes the text as shown in the next figure.

![Diagram of Text Writing Test]

**Figure 27:** LCD Display during Text Writing test

2 seconds delay. After the delay time is expired the following next test will be started automatically:

#### 6.4.1.2 Graphic writing test

The LCD page is displayed

1 second delay

The LCD page is cleared
Test carried out. It writes the text as shown in the next figure.

![Graphic Writing Test Diagram]

**Figure 28:** LCD display during Graphic Writing test.

2 seconds delay. After the delay time is expired the following next test will be started automatically:

### 6.4.1.3 Back-light test

The LCD Page is displayed

![Backlight Test Diagram]

**The LCD backlight will be turned OFF and then ON again**
Figure 13: Back-light Test Page

2 seconds delay
Back light off
1 second delay
Back light on
2 seconds delay. After the delay time is expired the following next test will be started automatically:

6.4.1.4 LCD contrast test

The following LCD page is shown

Figure 14: LCD Contrast Test Page

2 seconds delay
Contrast varied from minimum to maximum (in a total time of 2 seconds) and then restored to previous value
2 seconds delay. After the delay time is expired the HMI Test menu will be displayed automatically:
6.4.2 LEDs test

This test consists of the following steps:

The LCD page for for the LED Test is displayed

1 second delay

Then the test carried out, in which the LED's will be switched on and the colors will be cyclic changed

After finishing the test, the HMI test page will be displayed again automatically.

6.4.3 Keyboard test

This test consists of the following steps:

The keyboard test page is displayed on the LCD

Each keyboard buttons has to be pressed one by one, no matter the order. When a button is pressed the “PRESSED” string is displayed in the corresponding page line.

When all buttons have been pressed, after 1-second delay, the test ends with OK result.

If after 15 seconds not all buttons have been pressed, the test ends with FAIL result.

After finishing the test, the HMI test page will be displayed again automatically.
6.4.4 E-Key test

This test consists of the following steps:

The LCD display for the E-Key Test Page is shown in the following figure:

![E-Key Test Page](image)

**Figure 16: E-Key Test Page**

The so called ABB-key must be inserted within 5 seconds. Afterwards the test will end with OK result. Otherwise, the result is FAIL.

6.4.5 Serial ports test

This test is performed by connecting the loop-back cable, cable that is normally used for the connection between PC and HMI Local Control Unit, between the port X20 and the optical connector on the HMI front panel.

![RHMI serial ports test](image)

**Figure 17: RHMI serial ports test**
Figure 18: Loop-back cable for the RHMI serial ports test

The test will consist in the following steps:

The LCD page for the serial ports test is displayed according to next figure:

Figure 19: Serial Ports Test Page

RS485 to RS232 communication test
10 telegrams will be sent to the optical port.
RS232 to RS485 communication test
10 messages are sent to the RS 485 port.
Test result shown in the page (“TEST OK” or “TEST FAIL”)
2 seconds delay.
After finishing the test, the HMI test page will be displayed again automatically.
7 Firmware upgrade

In the following the upgrade of the firmware is described. The possibility of upgrading the firmware is to be asked to the authorized personnel to your local ABB representative.

7.1 Upgrade the Firmware of the Central Unit

Use the RS232 port X72 on the Central Unit of the REF542plus.

Connect to the serial RS232 port on the PC with the TeraTerm Pro software with the set up file MCTERM.INI.

Turn on the power supply for the Central Unit and press a key on the PC keyboard within a couple of seconds

Type the proper password and press ‘enter’

Type “d” and at prompt answer yes by pressing “y”

From the menu File in Tera Term Pro select “send file”

Select the new main-board firmware to download and click “Open”

After the download is completed, the Central Unit should reset itself and run the new firmware.

7.2 RHMI firmware upgrade

Set Tera Term Pro software with the set up file RHMITERM.INI.

Connect the RHMI to a PC through the optical cable

Turn ON the power supply for the HMI Local Control Unit and press “enter button” on the PC within a couple of seconds (if not, the RHMI application starts normally)

Select the "Send File..." item on TeraTerm "File" menu

Choose the firmware file. "Binary" option should be DISABLED

Wait until the file has been uploaded to HMI (one or two minutes)

At the end of the upload, the newly uploaded firmware version starts

Note

Only HMI with software version 4B01 can be uploaded with this boot loader
8 Decommissioning and Storage

In this chapter you will find information
On decommissioning the unit
Storing the REF542plus after decommissioning or before commissioning.

8.1 Decommissioning

Please observe the following directions when decommissioning the unit:
Isolate the bay
Transfer the configuration from the REF542plus to the PC and save it on data media
Switch off the REF542plus auxiliary supply voltage
Switch off the remaining miniature circuit breakers as well
If applicable, isolate all current transformers
Disconnect the REF542plus from the measuring circuits
Remove all plug connectors
Remove the unit
Check the unit for damage.
Pack the REF542plus properly; preferably in the original packaging
Store the unit on its side beforehand as specified.
It is not necessary to decommission the configuration program. If you wish to uninstall
the configuration program, follow the relevant directions.

8.2 Storage

Please observe the following minimum requirements for optimum storage:
Units with standard packaging or without packaging
Dry and well ventilated storage space, conditions in accordance with DIN VDE 0670
Part 1000/IEC 60694,
If packaging is used, it must be undamaged or
units without packaging must be well covered with protective sheets; however, ensure
sufficient air circulation to prevent corrosion.
Check the unit regularly for condensation.
9 Technical data

9.1 Analog input channels

Accuracy for measurement including the current/voltage sensors class 1.
Accuracy for protection class 3

9.1.1 With current and voltage transformer:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated current In</td>
<td>1A or 5A</td>
</tr>
<tr>
<td>Rated voltage U_n:</td>
<td>100V (also suitable for 110V)</td>
</tr>
<tr>
<td>Rated frequency f_n:</td>
<td>50 Hz / 60 Hz</td>
</tr>
</tbody>
</table>

Thermal load capacity

<table>
<thead>
<tr>
<th>Path</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current path</td>
<td>250 I_n (peak value) dynamic, 100 I_n for 1s, 4 I_n continuous,</td>
</tr>
<tr>
<td>Voltage path</td>
<td>2 U_n /√3 continuous.</td>
</tr>
</tbody>
</table>

Consumption

<table>
<thead>
<tr>
<th>Path</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current path</td>
<td>≤ 0.1 VA with I_n</td>
</tr>
<tr>
<td>Voltage path</td>
<td>≤ 0.25 VA with U_n</td>
</tr>
</tbody>
</table>

9.1.2 With current and voltage sensor

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated current I_i</td>
<td>150 mV (rms)</td>
</tr>
<tr>
<td>Rated voltage U_i:</td>
<td>2V (rms)</td>
</tr>
<tr>
<td>Rated frequency f_i:</td>
<td>50 Hz / 60 Hz</td>
</tr>
</tbody>
</table>
### 9.2 Binary inputs and outputs

Each binary I/O board has the following number of inputs and outputs:

#### 9.2.1 With mechanical relays (1 BIO version 3)

<table>
<thead>
<tr>
<th>Inputs/Outputs</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 inputs (BI 1 to 14)</td>
<td>For auxiliary voltage range: 20 to 90 V DC (threshold 14 V DC) or 80 to 250 V DC (threshold 50 V DC) Each input has a fixed filter time of 1 ms. Extension can be freely programmed.</td>
</tr>
<tr>
<td>5 power outputs (BO 1,2,3,4 and 5) respectively 6 (Relay contact of BO6 is link together with relay contact of BO5)</td>
<td>Maximal Operation voltage 250V AC/DC Make current 20 A Load current 12 A Breaking capacity 300 W at L/R = 15 ms Operation time 9 ms</td>
</tr>
<tr>
<td>2 signal outputs (BO7 and 8) and 1 Watchdog output (WD)</td>
<td>Operation voltage 250 V AC/DC Load current 2 A Operation time 5 ms</td>
</tr>
<tr>
<td>1 Static output (optionally BO7)</td>
<td>Maximal Operation voltage 250 VDC Operation time 1 ms</td>
</tr>
<tr>
<td>1 coil supervision circuit (BO2)</td>
<td></td>
</tr>
</tbody>
</table>

#### 9.2.2 With static outputs (1 BIO version static)

<table>
<thead>
<tr>
<th>Inputs/Outputs</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 inputs (BI 1-14)</td>
<td>for auxiliary voltage range 48 to 265 VDC (Threshold 35 VDC) Each input has a fixed filter time of 1 ms. Extension can be freely programmed.</td>
</tr>
<tr>
<td>3 power outputs (BO1,2 and 7)</td>
<td>Operation voltage 48 to 265 VDC Make current 70 A for t ≤ 10 ms Load current 12 A for t ≤ 30 s Operation time 1 ms</td>
</tr>
<tr>
<td>4 power outputs (BO3 to 6)</td>
<td>Operation voltage 48 to 265 VDC Make current 16 A for t ≤ 10 ms Load current 10 A for t ≤ 30 s Operation time 1 ms</td>
</tr>
<tr>
<td>2 Signal outputs and 1 Watchdog output</td>
<td>Operation voltage 48 to 265 V DC Make current 0.3 A Operation time 1 ms</td>
</tr>
<tr>
<td>2 coil supervision circuit (BO1 and 2)</td>
<td></td>
</tr>
</tbody>
</table>
9.3 Interface

9.3.1 HMI Control Unit:
Optical/electrical standard interface RS 232 to the Notebook PC (at the front)
Electrical isolated standard interface RS 485 to the Central Unit (at the rear)

9.3.2 Central Unit:
Electrical isolated standard interface RS 485 to the HMI
Electrical standard interface RS 232 for updating the firmware

9.4 Analog output board (optional)
Four channel 0 to 20 mA respectively 4 to 20 mA

9.5 Communication (optional)
SPABUS, electrical interface with standard RS232 or optical interface with snap-in type connector for plastic fiber respectively standard FMA connector for glass fiber (multi mode)
LON (according to LAG1.4), optical interface with standard ST connector for glass fiber (multi mode)
IEC 60870-5-103 with extension according to VDEW guidelines for controlling, optical interface with standard ST connector for glass fiber (multi mode)
MODBUS RTU, electrical interface with two standard RS485 or optical interface with two standard ST connector for glass fiber (multi mode)

9.6 Power supply

9.6.1 Central Unit

<table>
<thead>
<tr>
<th>Rated voltage</th>
<th>110 VDC (-15%, +10%), 220 VDC (-15%, +10%) or 48 to 220 VDC (-15%, +10%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power consumption</td>
<td>≤ 18 W (base version with 1 BIO)</td>
</tr>
<tr>
<td>Inrush current</td>
<td>≤ 10 A peak value</td>
</tr>
</tbody>
</table>

9.6.2 RHMI Control Unit

<table>
<thead>
<tr>
<th>Rated voltage:</th>
<th>For auxiliary voltage in the range of: 48 ... 110 VDC (-15%, +10%) or 110 ... 220 VDC (-15%, +10%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power consumption</td>
<td>≤ 6 W</td>
</tr>
</tbody>
</table>
9.7 **Temperature range**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation</td>
<td>-5..+ 55°C</td>
</tr>
<tr>
<td>Transport and storing</td>
<td>-20..+70°C</td>
</tr>
</tbody>
</table>

9.8 **Degree of protection**

9.8.1 **Central Unit**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Housing</td>
<td>IP 20</td>
</tr>
</tbody>
</table>

9.8.2 **RHMI Control Unit**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Front</td>
<td>IP 54</td>
</tr>
<tr>
<td>Rear</td>
<td>IP 22</td>
</tr>
</tbody>
</table>
## 10 Type Test

### 10.1 Protection Function

All relevant tests according to the standard IEC 60255.

<table>
<thead>
<tr>
<th>ANSI Code</th>
<th>Protection Function and the Setting Parameters</th>
<th>Test Procedure</th>
</tr>
</thead>
</table>
| 68        | Inrush stabilization (Only in connection with I>> and I>)  
N = 2.0 … 8.0  
M = 3.0 … 4.0  
Time = 220 … 100.000 ms | IEC 60255-3 |
| 67        | Overcurrent directional high  
I>> = 0.05 ... 40 In  
t = 70 ... 300.000 ms | IEC 60255-12 |
| 67        | Overcurrent directional low  
I > = 0.05 ... 40 In  
t = 220 ... 300.000 ms | IEC 60255-12 |
| 50        | Overcurrent instantaneous  
I>>> = 0.10 ... 40 In  
t = 15 ... 300.000 ms | IEC 60255-3 |
| 51        | Overcurrent high  
I>> = 0.05 ... 40 In  
t = 40 ... 300.000 ms | IEC 60255-3 |
| 51        | Overcurrent low  
I > = 0.05 ... 40 In  
t = 40 ... 300.000 ms | IEC 60255-3 |
| 51        | IDMT  
Normal-, Very-, Extremely- or Longtime- inverse time characteristic  
Ie = 0.05 ... 40 In  
K = 0.05 ... 1.5 | IEC 60255-3 |
| 51N       | Earth fault high  
IE>> = 0.05 ... 40 In  
t = 70 ... 100.000 ms | IEC 60255-3 |
| 51N       | Earth fault low  
IE> = 0.05 ... 40 In  
t = 70 ... 100.000 ms | IEC 60255-3 |
| 67N       | Earth fault directional high  
IE>> = 0.05 ... 40 In  
t = 40 ... 100.000 ms  
forward- / backward direction  
isolated (sin ϕ) and earthed (cos ϕ) | IEC 60255-12 |
| 67N       | Earth fault directional low  
IE> = 0.05 ... 40 In  
t = 40 ... 300.000 ms  
forward- / backward direction  
isolated (sin ϕ) and earthed (cos ϕ) | IEC 60255-12 |
<table>
<thead>
<tr>
<th>ANSI Code</th>
<th>Protection Function and the Setting Parameters</th>
<th>Test Procedure</th>
</tr>
</thead>
</table>
| 67N       | Earth fault directional sensitive<br>
|           | $I_E > = 0,05 \ldots 2 \text{ In}$<br>$t = 120 \ldots 100.000 \text{ ms, for- / backward}$<br>$\text{Slope angle } \alpha = 0 \ldots 20^\circ$<br>$\text{Slope angle } \delta = - 180 \ldots 180^\circ$<br>$U_{NE} > = 0,05 \ldots 0,7 \text{ Un}$ | IEC 60255-12 |
| 51N       | Earth fault IDMT<br>
|           | Standard, very, extremely or long time inverse time characteristic,<br>$I_e = 0,05 \ldots 40 \text{ In}$<br>$k = 0,05 \ldots 1,5$ | IEC 60255-3 |
| 59        | Overvoltage instantaneous<br>$U_{>>>} = 0,10 \ldots 3 \text{ Un}$<br>$t = 20 \ldots 300.000 \text{ ms}$ | IEC 60255-3 |
| 59        | Overvoltage high<br>$U_{>>} = 0,10 \ldots 3 \text{ Un}$<br>$t = 70 \ldots 300.000 \text{ ms}$ | IEC 60255-3 |
| 59        | Overvoltage low<br>$U_{> } = 0,10 \ldots 3 \text{ Un}$<br>$t = 70 \ldots 300.000 \text{ ms}$ | IEC 60255-3 |
| 27        | Undervoltage instantaneous<br>$U_{<<<} = 0,10 \ldots 1,2 \text{ Un}$<br>$t = 50 \ldots 300.000 \text{ ms}$ | IEC 60255-3 |
| 27        | Undervoltage high<br>$U_{<< } = 0,1 \ldots 1,2 \text{ Un}$<br>$t = 70 \ldots 300.000 \text{ ms}$ | IEC 60255-3 |
| 27        | Undervoltage low<br>$U_{< } = 0,1 \ldots 1,2 \text{ Un}$<br>$t = 70 \ldots 300.000 \text{ ms}$ | IEC 60255-3 |
| 59N       | Residual overvoltage high<br>$U_{NE} >> = 0,05 \ldots 3 \text{ Un}$<br>$t = 40 \ldots 300.000 \text{ ms}$ | IEC 60255-3 |
| 59N       | Residual overvoltage low<br>$U_{NE} > = 0,05 \ldots 3 \text{ Un}$<br>$t = 40 \ldots 300.000 \text{ ms}$ | IEC 60255-3 |
| 49        | Thermal overload protection (thermal equation 1st order with complete memory function)<br>$T_n = 50 \ldots 400 \text{ °C (nominal temperature at In)}$
|           | $I_{n (Mot)} = 1 \ldots 10000 \text{ A (primary value of the nominal motorcurrent)}$
|           | $T_{ini} = 50 \ldots 120 \% T_n \text{ (initial temperature at power on)}$
|           | $\tau_{cool} = 10 \ldots 20.000 \text{ s (time constant at I< 0.1 In and n = 0)}$
|           | $\tau_{warm} = 10 \ldots 20.000 \text{ s (time constant normal)}$
|           | $\tau_{warm} = 10 \ldots 20.000 \text{ s (time constant at I > 2 In)}$
|           | $T_{max} = 20 \ldots 400 \text{ °C (maximal temperature)}$
|           | $T_{warn} = 20 \ldots 400 \text{ °C (warn temperature)}$
<p>|           | $T_{envi} = 50 \ldots T_{ini} \text{ (environment temperature)}$ | IEC 60255-8 |</p>
<table>
<thead>
<tr>
<th>ANSI Code</th>
<th>Protection Function and the Setting Parameters</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>51</td>
<td>Motor start protection (adiabatic characteristic)</td>
<td>IEC 60255-3</td>
</tr>
<tr>
<td></td>
<td>( I_e = 0.3 \ldots 1.2 , I_n ) (motor current)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( I_s = 1.00 \ldots 20 , I_e ) (start value)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( t = 70 \ldots 300.000 , \text{ms} )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( I_&gt; = 0.6 \ldots 0.8 , I_s ) (motor start)</td>
<td></td>
</tr>
<tr>
<td>51LR</td>
<td>Blocking rotor (definite time characteristic)</td>
<td>IEC 60255-3</td>
</tr>
<tr>
<td></td>
<td>( I_e = 0.3 \ldots 1.2 , I_n ) (motor current)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( I_s = 1.00 \ldots 20 , I_e ) (start value)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( t = 70 \ldots 300.000 , \text{ms} )</td>
<td></td>
</tr>
<tr>
<td>66</td>
<td>Number of starts</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( n(\text{warm}) = 1 \ldots 10 ) (number of warm starts)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( n(\text{cold}) = 1 \ldots 10 ) (number of cold starts)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( t = 1.02 \ldots 7200 , \text{s} )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( T(\text{warm}) = 20 \ldots 200 , ^\circ \text{C} ) (temperature limit warm start)</td>
<td></td>
</tr>
<tr>
<td>21+79</td>
<td>Distance protection with autoreclosings</td>
<td>IEC 60255-16</td>
</tr>
<tr>
<td></td>
<td>System earthing = high/low ohmic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ct – grounding = line side, bus bar side</td>
<td></td>
</tr>
<tr>
<td></td>
<td>with/without earth start</td>
<td></td>
</tr>
<tr>
<td></td>
<td>switching onto faults = normal, overreach zone, trip after start</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Signal comparison overreach scheme time set = 30 \ldots 300.000 , \text{ms}</td>
<td></td>
</tr>
<tr>
<td></td>
<td>U / I- Start characteristic:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( I_&gt; ), ( I_E&gt; ) and ( I_F&gt; ) = 0.05 \ldots 4 , I_n</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( U&lt;_n ) = 0.05 \ldots 0.9 , U_n</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Phase selection = cyclic/acyclic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Earth factor: ( k = 0.00 \ldots 10.00 )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \phi (k) = -60 \ldots 60^\circ )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 Impedance- and 1 overreachstage:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( R = 0.05 \ldots 120 , \Omega ) (secondary values)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( X = 0.05 \ldots 120 , \Omega ) (secondary values)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( t = 20 \ldots 10.000 , \text{ms} )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 directional stage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Direction 0 \ldots 90 bzw.-45 \ldots 135°</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( t = 25 \ldots 10.000 , \text{ms} )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 non directional stage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( t = 25 \ldots 10.000 , \text{ms} )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 shots AR with short/long time reclosing</td>
<td></td>
</tr>
<tr>
<td>87</td>
<td>Differential protection</td>
<td>IEC 60255-13</td>
</tr>
<tr>
<td></td>
<td>Transformer group = 0 \ldots 11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Transformer earthing = primary and or secondary side</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nom. current ( I_n ) on the primary/secondary side of the transformer = 0.00 \ldots 100.000A (prim value)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Threshold current = 0,10 \ldots 0,50 , \text{In}</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unbiased region limit = 0,50 \ldots 5 , \text{In}</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Slightly biased region threshold = 0,20 \ldots 2 , \text{In}</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Slightly biased region limit = 1,00 \ldots 10,0 , \text{In}</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Slope = 0,40 \ldots 1,00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Trip with ( I_d&gt; ) = 5,00 \ldots 40 , \text{In}</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blocking by ( 2^{nd} ) harmonic = 0,10 \ldots 0,30 , \text{In}</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blocking by ( 5^{th} ) harmonic = 0,10 \ldots 0,30 , \text{In}</td>
<td></td>
</tr>
</tbody>
</table>
### ANSI Code | Protection Function and the Setting Parameters | Test Procedure
--- | --- | ---
46 | Unbalance load<br>\[ I_s = 0.05 \cdots 0.3 \, I_n \text{ (start value of the negative phase sequence)} \]<br>\[ K = 2 \cdots 30 \]<br>\[ t_{\text{Reset}} = 0 \cdots 200 \, s \]<br>\[ \text{Timer decreasing rate} = 0 \cdots 100\% \] | IEC 60255-3
32 | Directional power<br>\[ \text{Nominal real power} \, P_n = 1 \cdots 1000.000 \, \text{kW (primary values)} \]<br>\[ \text{Max. reverse load} \, P_r> = 1 \cdots 50 \% \, P_n \]<br>\[ t = 1.02 \cdots 1000 \, s \] | IEC 60255-12
37 | Low load<br>\[ \text{Nominal real power} \, P_n = 50 \cdots 1000.000 \, \text{kW (primary values)} \]<br>\[ \text{Minimal load} \, P_< = 5 \cdots 100\% \, P_n \]<br>\[ \text{Minimal current} \, I_< = 2 \cdots 20 \% \, I_n \]<br>\[ t = 1 \cdots 1000 \, s \] | IEC 60255-12
81 | Frequency monitoring<br>\[ \text{Start at} \, \Delta f = 0.04 \cdots 5 \, \text{Hz} \]<br>\[ t = 1.02 \cdots 300 \, s \] | IEC 60255-3
25 | Synchronism check<br>\[ \Delta U = 0.02 \cdots 0.4 \, U_n \]<br>\[ t = 0.52 \cdots 1000 \, s \]<br>\[ \Delta \phi = 5 \cdots 50^\circ \] | IEC 60255-12
| Fault recorder<br>\[ \text{Recording time} = 1000 \cdots 5000 \, \text{ms} \]<br>\[ \text{Pre fault time:} = 100 \cdots 2000 \, \text{ms} \]<br>\[ \text{Post fault setting} = 100 \cdots 4900 \, \text{ms} \]<br>\[ \text{Max. 5 records} \] | IEC 60255-24
55 | Power factor controller<br>\[ \text{Power factor} = 0.70 \cdots 1.00 \]<br>\[ \text{QC}_0 = 1.000 \cdots 20000.000 \, \text{kVAR} \]<br>\[ \text{Series of banks} = 1:1:1:1 \cdots 1:2:4:8 \]<br>\[ \text{Number of banks} = 1 \cdots 4 \]<br>\[ \text{Insensitivity} = 105 \cdots 200 \% \, \text{QC}_0 \]<br>\[ \text{Threshold} = 0 \cdots 100 \% \, \text{QC}_0 \]<br>\[ \text{Switching program} = \text{sequential/circuit switching} \] | IEC 60255-12
10.2 **Electro Magnetic Compatibility**

All relevant tests according to the standard IEC 60255, EN 61000 respectively to the new product standard EN 50263

### 10.2.1 Emission test

<table>
<thead>
<tr>
<th>Port</th>
<th>Frequency range</th>
<th>Limits</th>
<th>Basic standard</th>
<th>Test procedure</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enclosure</td>
<td>30 - 230 MHz</td>
<td>40 dB(µV/m) quasi peak, measured at 10 m distance</td>
<td>EN 55022</td>
<td>EN 55022</td>
<td>See note 2</td>
</tr>
<tr>
<td></td>
<td>230 - 1000 MHz</td>
<td>47 dB(µV/m) quasi peak, measured at 10 m distance</td>
<td>EN 55022</td>
<td>EN 55022</td>
<td>See note 2</td>
</tr>
<tr>
<td>Power Supply</td>
<td>0.15 - 0.5 MHz</td>
<td>79 dB(µV) quasi peak, 66 dB(µV) average</td>
<td>EN 55022</td>
<td>EN 55022</td>
<td>See note 1</td>
</tr>
<tr>
<td></td>
<td>0.5 - 5 MHz</td>
<td>73 dB(µV) quasi peak, 60 dB(µV) average</td>
<td>EN 55022</td>
<td>EN 55022</td>
<td>See note 1</td>
</tr>
<tr>
<td></td>
<td>5 MHz - 30 MHz</td>
<td>73 dB(µV) quasi peak, 60 dB(µV) average</td>
<td>EN 55022</td>
<td>EN 55022</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE 1** The test procedure given in EN 55022 will be superseded by that given in EN 60255-25 when it is published.<br>
**NOTE 2** May be measured at other distances. When this is done the test report should record the distance and the circumstances of the measurement. For test site measurements, an inverse proportionality factor of 20 dB per decade should be used to normalise the measured data to the specified distance for determining compliance.
### 10.2.2 Immunity tests - enclosure port

<table>
<thead>
<tr>
<th>Environmental phenomena</th>
<th>Test specification</th>
<th>Units</th>
<th>Basic standard</th>
<th>Test procedure</th>
<th>Acceptance criteria</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiated radio frequency electromagnetic field, Amplitude modulated</td>
<td>80 – 1000 MHz 10 80 V/m (unmod, rms) % AM (1 kHz)</td>
<td>EN 61000-4-3</td>
<td>EN 61000-4-3</td>
<td>See note 1</td>
<td>See note 2</td>
<td></td>
</tr>
<tr>
<td>Radiated electromagnetic field from digital radio telephones, Pulse modulated</td>
<td>900 ± 5 MHz 1890 ± 5 MHz 10 50 200 V/m (unmod., rms) Duty cycle % Rep. Frequency Hz</td>
<td>EN 61000-4-3</td>
<td>EN 61000-4-3</td>
<td>See note 1</td>
<td>See note 1</td>
<td></td>
</tr>
<tr>
<td>Electrostatic discharge</td>
<td>6 (Cont. discharge)</td>
<td>kV (charge voltage)</td>
<td>EN 61000-4-2</td>
<td>EN 60255-22-2</td>
<td>EN 60255-22-2</td>
<td>See EN 60255-22-2, applicability of contact and air discharge test.</td>
</tr>
<tr>
<td></td>
<td>8 (Air discharge)</td>
<td>kV (charge voltage)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power frequency magnetic field</td>
<td>50 30 300 additional 500 continuous Hz A(rms)/m (continuous) A(rms)/m (1 to 3 sec) A(rms)/m</td>
<td>EN 61000-4-8</td>
<td>EN 61000-4-8</td>
<td>See 15.2</td>
<td>See note 3</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE 1** The test procedure given in EN 61000-4-3 and the acceptance criteria given in 7.2 will be superseded by that given in EN 60255-22-3 when it is published.

**NOTE 2** Except for the ITU broadcast frequency bands: 87 MHz - 108 MHz, 174 MHz - 230 MHz, and 470 MHz – 790 MHz where the level is 3 V.

**NOTE 3** Applicable only to apparatus containing devices susceptible to magnetic fields, e.g. Hall elements, magnetic field sensors, etc.
### 10.2.3 Immunity tests - power supply port

<table>
<thead>
<tr>
<th>Environmental phenomena</th>
<th>Test specification</th>
<th>Units</th>
<th>Basic standard</th>
<th>Test procedure</th>
<th>Acceptance criteria</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conducted disturbance induced by radio-frequency fields, amplitude modulated</td>
<td>0.15 – 80 10 80 150</td>
<td>MHz V (unmod., rms) % AM (1 kHz) ohms Source impedance</td>
<td>EN 61000-4-6</td>
<td>EN 61000-4-6 See note 1</td>
<td>See 15.2 and note 1</td>
<td>See note 2</td>
</tr>
<tr>
<td>Fast transients</td>
<td>5/50 5 2 2/2.5</td>
<td>Tr/Th ns kHz repetition frequency kV (peak) kV/kHz</td>
<td>EN 61000-4-4</td>
<td>IEC 60255-22-4</td>
<td>IEC 60255-22-4</td>
<td></td>
</tr>
<tr>
<td>1 MHz burst</td>
<td>1 75 400 200 1 2.5</td>
<td>MHz frequency Tr ns Hz repetition frequency ohms Source impedance kV (peak) kV (peak)</td>
<td>IEC 60255-22-1</td>
<td>IEC 60255-22-1</td>
<td>IEC 60255-22-1</td>
<td></td>
</tr>
<tr>
<td>Surge</td>
<td>1,2/50 (8/20) 1 2</td>
<td>Tr/Th ms kV charge voltage kV charge voltage ohms Source impedance</td>
<td>EN 61000-4-5</td>
<td>EN 61000-4-5</td>
<td>See 15.2</td>
<td>See note 3</td>
</tr>
<tr>
<td>Voltage Interruption</td>
<td>100 5, 10, 20, 50, 100 and 200</td>
<td>% reduction ms interruption time</td>
<td>IEC 60255-11</td>
<td>IEC 60255-11</td>
<td>IEC 60255-11</td>
<td>See note 4</td>
</tr>
<tr>
<td>Damped oscillatory wave</td>
<td>0.1/1/10/50 1 2.5 2 or 3 5</td>
<td>MHz kV kV</td>
<td>IEC 61000-4-12</td>
<td>IEC 61000-4-12</td>
<td>See 15.2</td>
<td>See note 4</td>
</tr>
</tbody>
</table>

**NOTE 1** The test procedure given in EN 61000-4-6 and the acceptance criteria given in 7.2 will be superseded by that given in EN 60255-22-6 when it is published.

**NOTE 2** Except for the ITU broadcast frequency band: 47 MHz - 68 MHz where the level is 3 V.

**NOTE 3** Applicable only to ports interfacing with cables, the total length of which according to the manufacturer's functional specification may exceed 10 m.

**NOTE 4** 10 and 50 MHz is for GIS applications relevant

**NOTE 5** The guaranteed interruption time must be mentioned in the data sheet (REF542plus 50ms)
### 10.2.4 Immunity tests - communication ports

<table>
<thead>
<tr>
<th>Environmental phenomena</th>
<th>Test specification</th>
<th>Units</th>
<th>Basic standard</th>
<th>Test procedure</th>
<th>Acceptance criteria</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conducted disturbance induced by radio-frequency fields, amplitude modulated</td>
<td>0.15 – 80 10 80 150 MHz V (unmod., rms) % AM (1 kHz) ohms Source impedance</td>
<td>EN 61000-4-6</td>
<td>EN 61000-4-6</td>
<td>See 15.2 and note 1</td>
<td>See note 2 &amp; 3</td>
<td></td>
</tr>
<tr>
<td>Fast transients</td>
<td>5/50 5 12 kHz repetition frequency</td>
<td>EN 61000-4-4</td>
<td>IEC 60255-22-4</td>
<td>IEC 60255-22-4</td>
<td>See note 3</td>
<td></td>
</tr>
<tr>
<td>1 MHz burst</td>
<td>1 75 400 200 MHz frequency</td>
<td>IEC 60255-22-1</td>
<td>IEC 60255-22-1</td>
<td>IEC 60255-22-1</td>
<td>See note 3</td>
<td></td>
</tr>
<tr>
<td>Insulation</td>
<td>0.5 additional 2 MV/DC 1 Minute</td>
<td>IEC60255-5</td>
<td>IEC60255-5</td>
<td>IEC60255-5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Damped oscillatory wave</td>
<td>0.1/1/10/50 kHz</td>
<td>IEC 61000-4-12</td>
<td>IEC 61000-4-12</td>
<td>See 15.2</td>
<td>See note 4</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE 1** The test procedure given in EN 61000-4-6 and the acceptance criteria given in 7.2 will be superseded by that given in EN 60255-22-6 when it is published.

**NOTE 2** Except for the ITU broadcast frequency band: 47 MHz - 68 MHz where the level is 3 V.

**NOTE 3** Applicable only to ports interfacing with cables, the total length of which according to the manufacturer’s functional specification may exceed 3 m.

**NOTE 4** 10 and 50 MHz is for GIS applications relevant.
### 10.2.4.1 Immunity tests - input and output ports

<table>
<thead>
<tr>
<th>Environmental phenomena</th>
<th>Test specification</th>
<th>Units</th>
<th>Basic standard</th>
<th>Test procedure</th>
<th>Acceptance criteria</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conducted disturbance induced by radio-frequency fields</td>
<td>Amplitude modulated</td>
<td>MHz V (unmod, rms) % AM (1 kHz) ohms Source impedance</td>
<td>EN 61000-4-6</td>
<td>EN 61000-4-6 See note 1</td>
<td>See 15.2 and note 1</td>
<td>See note 2</td>
</tr>
<tr>
<td>Fast transients</td>
<td>5/50 5 2 2/2.5</td>
<td>Tr/Th ns kHz repetition frequency kV (peak) kV/kHz</td>
<td>EN 61000-4-4</td>
<td>IEC 60255-22-4</td>
<td>IEC 60255-22-4</td>
<td></td>
</tr>
<tr>
<td>1 MHz burst</td>
<td>Differential mode Common mode</td>
<td>1 75 400 200 1 2 2.5</td>
<td>MHz frequency Tr ns Hz repetition frequency ohms Source impedance kV (peak) kV (peak)</td>
<td>IEC 60255-22-1</td>
<td>IEC 60255-22-1</td>
<td>IEC 60255-22-1</td>
</tr>
<tr>
<td>Surge</td>
<td>Differential mode Common mode</td>
<td>1,2/50 (8/20) 1 2 42</td>
<td>Tr/Th ms kV charge voltage kV charge voltage ohms Source impedance</td>
<td>EN 61000-4-5</td>
<td>EN 61000-4-5</td>
<td>See 15.2</td>
</tr>
<tr>
<td>Insulation</td>
<td></td>
<td>2 5</td>
<td>kV/DC 1 Minute kV impulse 1.2/50us; 0.5J</td>
<td>IEC60255-5</td>
<td>IEC60255-5</td>
<td>IEC60255-5</td>
</tr>
<tr>
<td>Damped oscillatory wave</td>
<td>Differential mode Common mode</td>
<td>0.1/1/10/50 1 2.5</td>
<td>MHz kV kV</td>
<td>IEC 61000-4-12</td>
<td>IEC 61000-4-12</td>
<td>See 15.2</td>
</tr>
</tbody>
</table>

**NOTE 1** The test procedure given in EN 61000-4-6 and the acceptance criteria given in 7.2 will be superseded by that given in EN 60255-22-6 when it is published.

**NOTE 2** Except for the ITU broadcast frequency band: 47 MHz - 68 MHz where the level is 3 V.

**NOTE 3** Applicable only to ports interfacing with cables, the total length of which according to the manufacturer’s functional specification may exceed 10 m.

**NOTE 4** 10 and 50 MHz is for GIS applications relevant.
### 10.2.5 Immunity tests - functional earth port

<table>
<thead>
<tr>
<th>Environmental phenomena</th>
<th>Test specification</th>
<th>Units</th>
<th>Basic standard</th>
<th>Test procedure</th>
<th>Acceptance criteria</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conducted disturbance induced by radio-frequency fields</td>
<td>0.15 – 80 MHz 10 80 150</td>
<td>V (unmod., rms) % AM (1 kHz) ohms Source impedance</td>
<td>EN 61000-4-6</td>
<td>EN 61000-4-6</td>
<td>See note 1 1 &amp; 3</td>
<td>See note 1 2 &amp; 3</td>
</tr>
<tr>
<td>Fast transients</td>
<td>5/50 kHz repetition frequency 5 2</td>
<td>Tr/Th ns KV (peak)</td>
<td>EN 61000-4-4</td>
<td>IEC 60255-22-4</td>
<td>IEC 60255-22-4</td>
<td>See note 3</td>
</tr>
</tbody>
</table>

**NOTE 1**  The test procedure given in EN 61000-4-6 and the acceptance criteria given in 7.2 will be superseded by that given in EN 60255-22-6 when it is published.

**NOTE 2**  Except for the ITU broadcast frequency band: 47 MHz - 68 MHz where the level is 3 V.

**NOTE 3**  Applicable only to ports interfacing with cables, the total length of which according to the manufacturer’s functional specification may exceed 3 m.
10.3 **Insulation Resistance**

Insulation resistance >100MΩhm 500V DC

10.4 **Mechanical Robustness**

Vibration test per IEC 60255-21-1
Shock response and withstand test per IEC 60068-2-2
Seismic test per IEC 60068-2-30

10.5 **Climatic Conditions**

Cold test per IEC 60068-2-1
Dry heat test per IEC 60068-2-2
Damp Heat and Cycling test per IEC 60068-2-30
11 Connection Diagram

11.1 REF542plus with mechanical binary I/O

Example of REF542plus base version with one mechanical binary I/O version 3. Extension up to two additional mechanical binary I/O version 3 possible. Other configurations of the analog input board available, e.g. mixed configuration for transformer and sensor connection.
Note: Please connect the right polarity on BO02.
Extension with second additional mechanical binary I/O version 3

Note: Please connect the right polarity on BO 10
Extension with third additional mechanical binary I/O version 3

Note: Please connect the right polarity on BO 18
11.2 REF542-plus with solid state binary I/O

Example of REF542-plus base version for sensor connection with one solid state binary I/O version 3. Extension up to two additional solid state binary I/O possible. Other configuration of the analog input board available, e.g. mixed configuration for transformers and sensors connection.

Note: Please connect the right polarity
Extension with second solid state binary I/O.

Note: Please connect the right polarity
Extension with third additional solid state binary I/O

Note: Please connect the right polarity
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