Distributed busbar protection REB500
Commissioning Manual
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Conformity

This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2006/95/EC). This conformity is the result of tests conducted by ABB in accordance with the product standards EN 50263 and EN 60255-26 for the EMC directive, and with the product standards EN 60255-1 and EN 60255-27 for the low voltage directive. The product is designed in accordance with the international standards of the IEC 60255 series.
Safety information

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

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

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

National and local electrical safety regulations must always be followed.

The frame of the IED has to be carefully earthed.

This is a class A ITE product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

Whenever changes are made in the IED, measures should be taken to avoid inadvertent tripping.

The IED contains components which are sensitive to electrostatic discharge. Unnecessary touching of electronic components must therefore be avoided.
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Section 1 Introduction

1.1 This manual

The commissioning manual contains instructions on how to commission the IED. The manual can also be used by system engineers and maintenance personnel for assistance during the testing phase. The manual provides procedures for checking of external circuitry and energizing the IED, parameter setting and configuration as well as verifying settings by secondary injection. The manual describes the process of testing an IED in a substation which is not in service. The chapters are organized in chronological order in which the IED should be commissioned.

1.2 Intended audience

This manual addresses the personnel responsible for commissioning, maintenance and taking the IED in and out of normal service.

The commissioning personnel must have a basic knowledge of 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 IED.

1.3 Product documentation

<table>
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<tr>
<td>Product Guide</td>
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1.4 Symbols and conventions

1.4.1 Symbols

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

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

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

The information icon alerts the reader of important facts and conditions.

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

Although warning hazards are related to personal injury, it is necessary to understand that under certain operational conditions, operation of damaged equipment may result in degraded process performance leading to personal injury or death. Therefore, comply fully with all warning and caution notices.
1.4.2 Document conventions

A particular convention may not be used in this manual.

- Abbreviations and acronyms in this manual are spelled out in the glossary. The glossary also contains definitions of important terms.
- Push button navigation in the LHMI menu structure is presented by using the push button icons, e.g.:
  
  To navigate the options, use \( \text{[left] and [right]} \).
- HMI menu paths are presented in **bold**, e.g.:
  
  Select **Main menu/Settings**.
- LHMI messages are shown in **Courier font**, e.g.:
  
  To save the changes in non-volatile memory, select **Yes** and press .
- Parameter names are shown in **italics**, e.g.:
  
  The function can be enabled and disabled with the *Operation* setting.
- The * character after an input or output signal name in the function block symbol given for a function indicates that the signal must be connected to another function block in the application configuration to achieve a valid application configuration.
2.1 Preconditions

It is assumed that the REB500 protection system is already installed and all input and output signals that have been configured are also wired and the optical fiber cables are run and tested.

It must also be assumed that the busbars or sections of them are in operation and that circuit-breakers and isolators are in the process of being installed or maintained.

The commissioning engineer requires the operating instructions and the station diagrams prepared by the respective engineering department.

The protection system may only be commissioned by trained commissioning personnel.

The greatest care must be taken when testing a busbar protection system on busbars in operation, as the consequences of unexpected operation in due process of the commissioning can be extremely serious.

The REB500 protection system is equipped with an extensive, continuous self-supervision and diagnosis feature. All functions are constantly monitored by the system software. The overall system has been extensively tested by ABB before releasing the product. It is therefore not necessary to re-test the internal protection algorithm by secondary injection. This manual is therefore restricted to verifying the correct connection to the primary process.
2.2 Commissioning procedure

2.2.1 Overall procedure

The following overall procedure has proven as best practice. Some items listed might not be applicable depending on the substation architecture.

Checks prior to energizing on the IED

1. Record the equipment data
2. Visually inspect for transport damage
3. Visually inspect the external wiring and cables
4. Check the grounding of cubicles and other units
5. Check the auxiliary DC battery supply
6. Check the settings
7. Check the CT circuits
   Polarity, ratio and wiring
8. Check the VT circuits

Checks after energizing the IED

9. Comparison with the layout of the primary system.
10. Secondary injection tests using the test set
11. Check the binary input signals
12. Check auxiliary contacts on the isolators and circuit-breakers and the “CLOSE” command
13. Check the control signal and alarm circuits
14. Check the tripping circuits
15. Check the stability factor
16. Set the system time

17. Record traceability data

18. Final test and inspection

Since the methods to perform the above mentioned procedure should be well known to the commissioning engineer, a detailed explanation is omitted. The following paragraphs focus on items specific to the REB500

2.2.2 Commissioning with a partial system

In order to operate, the REB500 protection system requires signals from the isolators and circuit-breakers indicating their status. If one or several positions are unknown, the protection system starts incompletely. The system is only fully operational and standing by when all the position signals are available.

At the beginning of commissioning, these signals are frequently incorrectly wired or the supply for the auxiliary contacts is unavailable. To enable commissioning of the protection system to proceed in spite of this, the positions of the isolators and circuit-breakers have to be simulated. This can be achieved either using jumpers at the terminals or by simulating optocoupler positions in the test mode.

The checks described in this document assume a system in a stable stand-by mode, i.e. no alarms with the exception of “Test generator active” may be active.

2.2.3 Comparison with the layout of the primary system

In order to operate correctly, the REB500 process image needs to reflect the actual setup of the primary equipment in the substation. It is therefore important to verify the correct engineering at the beginning and make sure that not yet installed parts are masked accordingly.

The easiest way to verify this is by checking the layout in HMI500 using the “Single-line diagram” in the “View” menu.

Check that the locations of the CTs in the single-line diagram conforms with the actual primary system. This check is essential if an end fault protection is installed, as it influences the tripping logic and most tests do not disclose an incorrect location.
2.2.4 Checking the analog inputs (CTs)

Using a test set, inject a secondary current into each of the CT inputs.

The CT connections can be checked in one of the following ways:

- Reading the injected currents on the local HMI
  (Note: The readings are referred to the primary values.)
- Reading the injected currents via HMI500 by selecting “Analog input measurements” in the “View” menu
- Reading the injected currents via HMI500 by selecting “Protection zone measurements” in the “View” menu
- Reading the injected currents via HMI500 by selecting “Single-line diagram”
- Increasing the currents until a protection function picks up.

2.2.5 Checking the analog inputs (VTs)

Using a test set, inject a secondary voltage into each of the voltage transformer inputs.

The checks can be executed in different ways:

- Reading the injected currents on the local HMI
- Reading the injected currents via HMI500 by selecting “Analog input measurements” in the “View” menu.

Primary values of phase-to-neutral voltages are displayed.

2.2.6 Checking the binary input signals (optocoupler inputs)

Check the proper function of every binary optocoupler input by exciting the signal source.

The binary inputs can be checked in one of the following ways:

- Reading the status on the local HMI
Section 2
Commissioning

- Reading the statuses via the HMI500 by selecting “Binary input/output status” in the “View” menu
- Checking the events generated in the event list.

Besides showing the correct operation, the event list also provides a mean to check the correct functional assignment of the input.

2.2.6.1 Wiring for auxiliary contacts

The standard wiring of the N/C auxiliary contacts on L1, L2 and L3 phases of isolators and circuit-breakers is in series and the N/O contacts in parallel.

This is reversed in case of the special version “not OPEN = CLOSED”.

![Diagram of ABB principle for isolator switching sequence](image)

**Figure 1** Switching sequence of auxiliary contacts
Inverting the logic means that local events are generated while a bay unit is starting that signal a change of input status that did not take place. Correct operation is nevertheless unimpaired.

### 2.2.6.2 Checking the isolator and circuit-breaker auxiliary contacts

Check the timing sequence of the isolator auxiliary contacts by inspecting the construction of the isolator or assessing it from the respective data sheet.

Verify the operation of the “CLOSED” and “OPEN” contacts

1. According to the circuit diagram and

2. by physically opening and closing the isolator. A check can be done in one of the following ways

   - Menu item “View \rightarrow Switchgear objects”
   - Menu item “View \rightarrow Binary input/output status”
   - Menu item “View \rightarrow Single-line diagram”.

### 2.2.6.3 Checking the manual “CLOSE” command

The local HMI is the best way of checking the circuit-breaker “CLOSE” command, because the signal is generated only briefly and the local HMI is refreshed the quickest. The corresponding menu item is “Measurements/Inputs”.

Alternatively the circuit-breaker “CLOSE” command can be temporarily configured as an event and its operation observed in the HMI500 event list.

### 2.2.7 Checking the binary output signals

Test operations of circuit-breakers and isolators require the permission of the user and all the prescribed safety precautions must be observed. Avoid unnecessary switching operations.

All binary inputs are tested by setting them appropriately in the test mode. Select “Test mode” from the “Testing” menu and clock on “Unblock all relays” in the test mode dialog.

In the test mode, select “Binary input/output status” in the “View” menu to view the outputs of a binary module. The status of an output can be changed by double-clicking on the corresponding field, which then changes to yellow.
Check that the correct circuit-breaker tripping coil is tripped by the correspondingly configured tripping output. Repeat the procedure for the separate alarm contacts.

2.2.8 Checking protection stability

The stability check verifies that all CTs are connected with the correct polarity and have the correct ratio. All feeder and bus-tie breaker CTs must be connected, otherwise the correct operation of the protection cannot be guaranteed.

Wherever possible the stability should be checked before the busbar is energized, because the risk of a busbar fault is especially high when it is being energized for the first time (flashovers, grounding isolators still closed etc.).

2.2.8.1 Checking through-fault stability with de-energized busbars

Inject a current from a primary injection test set (25% of the CT rated current is recommended) into two feeders (a reference feeder and one other feeder). Any feeder can be used as reference. Compare each of the other feeders and bus-tie breaker with the reference feeder.

If a bus-tie breaker is only equipped with one set of CTs, note that they are used by two busbar sections.

Figure 2 Through-fault stability by primary injection (two feeders)
In case of a bus-tie breaker equipped with two sets of CTs, make sure that the set of CTs assigned to the busbar section under test is checked. The simplest way of ensuring this is to short-circuit the CTs belonging to the section not under test directly at the CTs or as close as possible to them.

Figure 3 Through-fault stability by primary injection (bus-tie breaker)

The feeder currents and the differential current can be read using HMI500.

The comparison with the reference feeder has to be conducted for phase and neutral currents for protection schemes that evaluate the neutral current.

2.2.8.2 Checking through-fault stability with de-energized busbars

Where protection stability cannot be tested before the busbar is energized or in the case of an extension to an existing system, it has to be tested using load current.

For this test, either tripping by the protection has to be blocked or the tripping circuits have to be interrupted before the currents are applied to the protection.
In order to carry out the test, all the amplitudes and directions of the primary currents must be known. Perform one of the following:

a) Short-circuit the CTs and isolate them from the protection.

b) Use the test mode to simulate that all the isolators are open (this is the simpler method).

In the case of a), connect the infeeds one by one, or in the case of b), simulate the closure of the isolators one by one. Whichever method is chosen, check that the differential current increases as each infeed is connected (either HMI500 or the local HMI in the central unit). Repeat this procedure with the loads and the differential current must reduce as each feeder is connected.

In the case of systems, that evaluate the neutral current, the differential current of the neutral measurement must be checked as well. A neutral current has to be simulated in a symmetrical power system in order to perform the stability test.

Figure 4  Testing the through-fault stability of the neutral circuit.

Any other protection devices in the same CT secondary circuit must not be influenced in any way (e.g. transformer differential protection or ground fault relays).
Section 3  Maintenance

3.1  Periodic Maintenance

Depending on the ambient conditions, we recommend removing the dust (e.g. with a vacuum cleaner) and wiping the front of the LCD with a damp cloth (perhaps with a little washing up liquid) from time to time. Do not use petrol or cleaning agents containing alcohol.

The REB500 includes continuous and comprehensive self-supervision and diagnosis of the software and hardware components. Since the protection functions are implemented and computed in software, they do not require any periodic maintenance.

The protection equipment, however, is only part of the overall protection system, we recommend periodically checking all the parts that are not automatically supervised.

The following components have to be tested periodically:

- all external circuits (e.g. tripping, BFP starting, CT and VT, etc.)
- all external switching devices (circuit-breakers and isolators)
- all REB500 tripping and signaling contacts
- all REB500 optocoupler inputs
- all REB500 analog inputs
- the local HMI

3.2  Replacing units

The best time to replace assemblies is when the station is out of operation, but even in this case, care must be taken that no unintentional operation of switchgear can take place (danger to persons close to the item of plant).

While the station is in operation, care must be taken that the station is still adequately protected when REB500 is switched off.
Most importantly, communication parameters, such as the IP-address within the internal process-bus, have to be set on the replacement device.

Incorrect addresses or settings will prevent the bay unit from starting and can disable the entire protection system.

The setting procedure is as follows:

1. Re-establish all external links and cabling to the device
2. Power on the device
3. When prompted to enter the maintenance menu, press the enter key.
4. Navigate to the LAN_IF_2 address by using the arrow keys and press the enter key.
5. Adjust the IP-address as follows:
   
   \[
   IP \ 192.168.175.xx
   \]
   
   192.168.175 first to third octet → same values for all devices
   xx fourth octet → Device Id of the unit
   
   In order to get a complete list of Device Ids the HMI500 shall be opened → Menu item
   “Tools/Reports/Device Id allocation”
6. Confirm the new address by pressing the enter key
7. Leave the maintenance menu by navigating to Exit and pressing the enter key

After installing the new hardware, all components that are not included in the self-supervision have to be checked according to the normal commissioning procedures.
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