REF 542plus

Multifunction Protection and Switchgear Control Unit

Operator's manual
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1. **Introduction**

1.1. **This manual**

Before attempting any operation with REF 542plus, read this manual carefully first.

This manual describes how to use the interface of REF 542plus (LD HMI, Local Detached Human Machine Interface). Note that HMI views and pictures are to be considered exemplary.

Do not make any changes to the REF 542plus configuration unless you are authorized to do it and familiar with REF 542plus and its Operating Tool. This might result in malfunction and loss of warranty.

1.2. **Use of symbols**

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

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

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

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

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

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

1.3. **Intended audience**

This manual is intended for operators, supervisors and administrators to support normal use of the product.
1.4. Product documentation

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1.5. Document revisions

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| A | | 28.02.2006 | Document updated
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  | | | * layout |
| B | 2.5 | 30.09.2006 | Updated to software version V4E03x |
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| D | 2.5 SP3 | 14.02.2008 | Updated |
| E | 2.6 | 19.12.2008 | Updated to software version V4F06x |
| F | 2.6 | 01.07.2009 | Updated |
| G | 3.0 | 15.02.2010 | Document updated |

Applicability

This manual is applicable to REF 542plus Release 3.0, software version V4F08x.
2. Safety information

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

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

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

National and local electrical safety regulations must always be followed.

The frame of the device has to be carefully earthed.

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

The REF 542plus is shown in Fig. 3.-1. This HMI features a back-illuminated LCD, 8 push buttons, several LEDs and an electronic key sensor. This new international HMI is a part of the product release of REF 542plus, starting from release 2.5.

The resolution of the display is 320x240 (QVGA) and the display supports full Unicode character set. Consequently, all languages, for example Chinese, can be displayed clearly. With this HMI two different languages can be handled simultaneously. The local language can be defined as the first language with the related operating tool. Then, the second language becomes automatically English. The language on the HMI can be changed from one to the other very easily.

![Fig. 3.-1 REF 542plus HMI](image)

The LCD in the SLD view provides a graphical representation of the primary objects controlled or monitored by REF 542plus in the switchgear. The right half of the LCD is for plain text visualization such as measurements and protection events. The contrast level is automatically controlled for an optimum reading, it can also be adjusted as wanted.

The HMI panel is organized in three main areas.

3.1. Control area

The left side of the HMI panel is for primary objects control. The command buttons and the information related to the switchgear control are placed on this area.
This section of the display shows the Single Line Diagram (SLD) of the controlled panel and the measurement bars. Text can be added in this section to improve the understanding of SLD.

- **Command buttons**

The Primary Object Control can be performed with the following push buttons to allow operating the primary objects if configured as “selectable”. The command push buttons for local operation of the switching devices are:

- **Open**: to open the selected object.
- **Close**: to close the selected object.
- **Select**: to select the object. The selected object appears highlighted.

- **CB Fast Opening**: to allow opening of the circuit breaker independently from the selected control mode. When pressed simultaneously with the normal open button, this button allows opening the circuit breaker independently from the selected control mode. This feature must be enabled in the unit with the Operating Tool.

- **E-Keys Sensor**: this is the sensor for the electronic keys. The sensor automatically detects which key has been inserted. The two keys are usually labelled “Protect” and “Control” to distinguish them.

- **Protection key**: is specialized to the protection environment allowing changing of parameters and other functions related to the protection.

- **Control Key**: this is dedicated to the control modes. It allows changing the operating mode of REF 542plus. The different operating modes discipline the access to the primary objects by the different REF 542plus interfaces (HMI and SCADA). When required, a Super User key to access both modes can be
provided. The Super User key is also needed to access the commissioning test mode. The password codes stored in the key can be customized in each REF 542plus for access restriction purposes.

- SLD view: this is the graphical part of the LCD. This part shows the single line diagram of the switchgear. The status of the primary objects is dynamically updated after every operation. If for example the circuit breaker has been opened, its representation will reflect it.

### 3.2. Info and Menu area

The right side of the HMI LCD is for information and menu browsing. The buttons to navigate through the menus and to change items are placed on this area.

![Fig. 3.2.1 Info and Menu area](image)

- **Menu Navigation:** these push buttons allow navigation through the REF 542plus menus.

  - **Pressing this button, the unit goes back to the former menu.**
  - **The up direction push button.**
  - **The down direction push button.**
  - **The enter push button to enter into the selected menu or to select the highlighted submenu.**

The following menus are available in the main window:

- **Commands:** this menu shows the configured FUPLA commands.
- **E-Key status:** to display and change the unit modes with the electronic keys.
- **Alarms:** it displays the indication LED’s status.
- **Measurements:** it displays the available measurements.
- **Resets:** to acknowledge alarms and other quantities.
• Events: to display protection starts and trips events.
• Protection: it displays the protection functions installed in the unit, and allows displaying and changing their settings.
• Control: it displays the control functions list installed in the unit and allows displaying and changing their settings.
• Service: relevant information on the HW and SW configurations and basic setting of REF 542plus.
• Tests: to access the test mode for the HMI and the primary objects.

Access to a few submenus is allowed only in some modes.

• LED bars: The three LED bars are available to show the most relevant measurements acquired by REF 542plus for a quick inspection of the switchgear load situation. The three bars are marked M1, M2, and M3. Each bar is composed of twelve LEDs, ten green and two red ones. The ten green LEDs are normally dedicated to display between 0% and 100% of the nominal value of the configured measurement. Each LED corresponding then to 10% of the nominal value. The two red LEDs indicate an overload condition of 20%. The measurements displayed by the bars are set with the Operating Tool.
• Indication LEDs: 8 freely programmable, three-color LEDs are available for indications. There are 4 pages of these LEDs. As a result, a total of 32 indication options can be programmed for events and status regarding protection, control, monitoring, binary inputs and so on. The assignment of the LED to a specific condition is done with the Operating Tool.
• Infrared (IrDa) interface: This is the IrDa serial interface port to connect REF 542plus to a personal computer. By using the appropriate cable and the Operating Tool, the following actions are possible:
  • Download a configuration into the unit.
  • Upload the current configuration from the unit.
  • After a fault, upload the fault recorder data. This is possible only if the fault recorder has been previously enabled with the Operating Tool.

Upload other information (measurements, binary inputs status, binary output status).

Do not make any changes to the REF 542plus configuration unless you are familiar with REF 542plus and the Operating Tool. This might result in malfunction and loss of warranty.
3.3. REF 542plus status information area

Fig. 3.3.-1 Status Information area

1. Ready: Operation status of the unit
2. IBB Error: Network communication status
3. Alarm: Indication according to the programmed alarm condition
4. Interlocking: Indication for inadmissible control action

The HMI shows the following status information:

- Ready. This green LED is turned on when the unit is in the operational state. The LED is switched off when the auxiliary power is not present or when the unit is not operational (FUPLA is not running).

- IBB(interbaybus) Error. This LED is meaningful only when the REF 542plus is equipped with a communication module. When the configured communication module is detected the LED turns on to green. If the module is not detected or fails, the LED turns red. When a Modbus communication module is installed, the LED becomes orange if the communication error rate increases. It becomes red when the communication error rate prevents good communication. The LED comes back to green when no communication errors occur or by resetting the module status registers (see the Modbus technical reference). When there is no communication module, the LED is always switched off.

- Alarm: this LED turns to red when the user defined alarms become true. Several arbitrary alarm conditions can be defined and configured with the Operating Tool. Alarm conditions could be the trip of a protection function, loss of SF6 in the circuit breaker and so on. When this LED is on, it is not possible to close the circuit breaker or to download a new configuration. The alarm must be acknowledged first.

- Interlocking Error: this LED is usually green. It turns temporarily to red when the user attempts an operation that would violate the programmed interlocking conditions; for example switching a disconnector with the circuit breaker in closed position.
4. Behavior at power up

Before energizing the switchgear, verify that the REF 542plus protection functions are properly set and that the unit is properly working (READY LED green).

At power up, the HMI unit shows on the LCD for a few seconds the following:

![Abb.Upload configuration](image)

Fig. 4.-1 REF 542plus LCD during power up

After that, the LCD left part shows the switchgear single diagram while the right part shows the default menu. When the initialization is completed and the unit is operational, the ready LED is on.
5. Changing the language displayed

The international HMI version V5 can support up to two different languages. The first one can be used to display the local language. Due to the high QVGA resolution, it is possible to display, for example, Chinese on the HMI. Then the second language becomes English. If no local language is defined, the language used is always English, which is the default one.

The following Fig. 5.-2 shows how to change the active language on the HMI. The prerequisite is that there is a local language defined. Do as follows:

- Go to the main menu by pressing MENU.
- Press UP and DOWN simultaneously to get to the Language page.
- Press ENTER to execute the language change.

**Fig. 5.-1 Display of Chinese as first language**

The following Fig. 5.-2 shows how to change the active language on the HMI. The prerequisite is that there is a local language defined. Do as follows:

- Go to the main menu by pressing MENU.
- Press UP and DOWN simultaneously to get to the Language page.
- Press ENTER to execute the language change.
The former HMI of the REF 542plus (HMI Version V4) can still be applied together with the base unit having the new firmware of release 2.5. provided the firmware of the HMI is upgraded accordingly. After upgrading the firmware the HMI V4 behaves almost the same as the new international HMI V5. Due to the low resolution of the LCD on the former HMI, the displaying certain languages, such as Chinese, is not possible. Other languages, such as Russian with cyrillic characters, can be used as the first language.

Starting from release 2.5 SP1, an optional Ethernet module for the IEC 61850 communication protocol can be applied. Therefore, new menu items appear on the HMI display. Because of the limitation of the existing memory, the use of the HMI version V4 is not reasonable and it is not recommended anymore.

The design of the new international HMI V5 has been improved by extending the existing memory on the related mainboard. The information files for both languages are stored on the HMI after the download of the configuration file by the operating tool. The display of the language file is immediately available after the language change. In case of HMI V4 the language files are stored in the base unit. If the
display shall be changed, the relating language file must first be uploaded. After reset of the LCD the requested language will be displayed.
6. Control modes

6.1. Available control modes

Local Control

It is possible to control the circuit breaker and other primary objects from the HMI using the object control buttons. Open and close operations are possible only if the interlocking logic programmed into the unit allow them. Remote control from the SCADA is inhibited. Uploading and downloading the configuration via the optical interface is possible.

Remote Control

The control of the circuit breaker and other primary objects from the HMI is inhibited. The control is possible only remotely. Uploading and downloading the configuration via the optical interface is possible.

No Control

It is not possible to control the circuit breaker and other primary objects both from the HMI and remotely. Any kind of operation apart from the protection trip is inhibited. Uploading and downloading the configuration via the optical interface is possible.

Local and Remote Control

Both the local control and remote control from HMI are possible. Uploading and downloading the configuration via the optical interface is possible.

The selection of this control mode requires caution, because operations are allowed both from the HMI and remotely.

6.2. Changing the control modes

The next figure shows how to change the control mode. At first the menu E-Key must be selected. Then the control key must be placed in the electronic key sensor. Select then the desired control mode by using UP and DOWN until it is highlighted. Confirm the selection by pressing ENTER. After pressing ENTER, the E-key status menu will appear again. Verify that the required control mode has been properly set in the unit looking in the lower left corner of the HMI. A text string there indicates the currently selected control and protection mode.
Fig. 6.2.1  Changing the control mode by using the control key
7. Operating the primary objects

The primary objects can be operated from the HMI when the selected control mode is local or local and remote. The Object control push buttons allow operating the primary objects.

Press \( \text{A} \) to step through the available objects until the desired object is selected (it will appear highlighted in the SLD). The object remains highlighted until the open or close push button is pressed or the time-out has elapsed.

Press \( \text{O} \) to open the selected object.

Press \( \text{I} \) to close the selected object.

Only primary objects controlled directly by REF 542plus can be selected. For example, REF 542plus will show the correct position of a manual disconnect switch after an operation, but it will not be possible to select it.
8. Viewing and resetting alarms

8.1. Viewing alarms

The presence of an alarm, when latched, is indicated by the alarm LED turned on or by one of the 8 x 4 pages user programmable LED’s turned on to red. The conditions or the events that generate an alarm are defined and programmed with the Operating Tool.

When an alarm is active, the corresponding LED is turned on to red. Select the alarm menu with the navigation buttons. Then, this menu displays the text associated to the alarm condition. The displayed text is defined with the Operating Tool.

There are four pages of alarms and each page reports eight alarms at most. Use the navigation button to browse through the pages.

8.2. Resetting alarms

At first, the reset menu must be selected. Select the reset menu with the navigation buttons. Highlight the reset alarm line in the menu and then press ENTER .
Some alarms might not be reset before the cause that generated it has been removed. For example, an alarm due to an error in the tripping circuit (coil supervision) cannot be reset before the tripping coil is replaced. Whereas an alarm generated by a trip of a protection function is normally reset with this procedure.

Fig. 8.2.-1   Resetting alarms
9. Viewing measurements

REF 542plus offers complete measurements set to the user. To view the measurements, select the measurement menu with the navigation button. Use the UP ▲ and DOWN ▼ buttons to browse the measurement pages.

The available measurements depend upon the unit configuration. In the maximum configuration, the following measurements are displayed:

- IL1, IL2, IL3, in A; line currents, measured values
- U1E, U2E, U3E, in kV; phase to earth voltages, measured values
- UL12, UL23, UL31, in kV; phase-to-phase voltages, computed values.1)
- IL1 mean, IL2 mean, IL3 mean, in A; mean currents in the observation period, computed values
- IL1 max, IL2 max, IL3 max, in A; maximum peak currents in the observation period, computed values
- Frequency, in Hz; measured values
- Active power, in kW; reactive power in kVAr, apparent power in kVA, computed values
- Power factor, computed value
- Active energy in MWh, reactive energy in Mvarh; computed values
- Operating hours, in hours. This is the total working hours of the unit
- Switch cycle, number the circuit breaker close-open cycles
- Added switched current, in kA; sum of the interrupted currents by the circuit breaker
- THD (total harmonic distortion)

The observation period is set with the Operating Tool. It can be from 0 minutes up to 30 minutes. If the observation period is set to 0, the corresponding measurements are disabled.

The refresh time for the displayed measurements is about half second.

1) REF 542plus can also use phase-to-phase voltage transformers. When used, phase-to-phase voltages are measured and phase to earth voltages are computed.
The available measurements depend upon the analogue input module type and the unit configuration.
10. Viewing events

REF 542plus records the last 30 protection events (start, trips, block and other). This internal memory is managed as a circular buffer, for example the 31st event overwrites the 1st oldest one. In case of a power loss, events are kept because they are stored in the non-volatile memory.

For each event, the following information is recorded: involved protection function, event type, relevant measurement (current, voltage, frequency), date and time (up to milliseconds). Events are displayed using the full screen; the single line diagram is thus not visible.

To display the protection events, select the Start/Trip menu with the navigation buttons. Use UP ↑ and DOWN ↓ to browse through the events.
11. Viewing and changing the protection settings

11.1. Viewing the protection settings

The protection functions currently installed in the unit can be seen in the menu protection functions. Select the menu protection functions with the navigation push buttons.

![Submenu: PROTECTION *](image)

**Fig. 11.1.-1** Viewing the installed protection functions

Use UP ↑ and DOWN ↓ to highlight the desired protection function and press ENTER ⏎. Then, the protection parameters will be displayed in one or more pages.

11.2. Changing the protection settings

11.2.1. Changing the protection key mode

Two different modes are available for the protection functions:

- **Set**: It is possible both to visualize and to change the protection settings.
- **Operational**: It is possible to visualize the protection settings but it is not possible to modify them.

In both modes, the protection functions are active.

In the operational mode, parameterization of the protection functions is also possible by a SCADA when present. In the set mode, parameterization from a SCADA is inhibited.
The procedure to change the protection mode is identical to changing the control mode. At first, the menu E-Key must be selected. Then the protection key must be placed in the electronic key sensor. Select then the required protection mode by using UP and DOWN until it is highlighted. Confirm the selection by pressing ENTER. After having pressed ENTER push button, the E-key status menu will appear again. Verify that the required protection mode has been properly set in the unit, looking in the HMI lower left corner.

Fig. 11.2.1.-1 Changing the protection mode by using the protection key

11.2.2. Changing the protection parameters

Select the menu protection functions with the navigation push buttons and highlight the desired protection function. Press ENTER to select it. Press ENTER again and the cursor will automatically go to the first parameter. Use Up or Down buttons to modify the parameter as wished. After completed, press ENTER and use Up and Down button to select the next parameter to change.

Repeat the procedure for all the parameters that need to be modified. Then press to go back to the list of currently installed protection functions. Repeat the procedure for every protection function that needs to have the setting modified.
Press again to leave the protection functions menu. The unit will then ask what to do with the changes:

The following screen will appear:

**Fig. 11.2.2.-1  Changing protection parameters**

**Fig. 11.2.2.-2  Unit right screen after protection parameters modification**
Select the desired choice with Up ↑ or Down ↓ and then press ENTER → to confirm it. The meaning of the choices is as follows:

Store permanently: The new parameters are stored in the unit internal memory. They will be used immediately and for all the next starts.

Save temporarily: The new parameters are used immediately but are not saved in the unit internal memory. Next starts will use the old parameters.

Discard changes: The new parameters are discarded. There are no effects.

Do not switch off the Base Unit power supply during parameter storing. The whole unit configuration might be corrupted and a new configuration download might be necessary.

11.2.3. Changing the active parameter set

Most of the protection functions have two different parameter sets to cope with different plant situations. This menu allows seeing and changing the active parameter set.

Changing the active parameter set is possible only with the protection in the set mode.

Select the active set page menu and press ENTER → to make the change.

Fig. 11.2.3.-1 Changing the protection active parameter set
11.2.4. Viewing and changing control parameters

Select the Control menu with the navigation push buttons and highlight the desired control function. Press ENTER to select it. Press again and the cursor will automatically go to the first control parameter. Use the Up or Down button to modify the parameter as wished. After the modification, press and use Up Down to select the next parameter to change.

Repeat the procedure for all the parameters that need to be modified. Then press to go back to the list of currently installed protection functions. Repeat the procedure for every control function that needs to have the setting modified.

Fig. 11.2.4.-1 Control parameters page
12. Setting the time and date

During commissioning, the internal time and date of the unit should be set to the current values. There are a few differences according to the unit configuration.

Standalone unit: The internal time of the unit has to be set to the current value. To do it, select the service menu and then the MC time submenu with the navigation buttons.

![Diagram of menu options with Service, Statistics, Versions, HW Identification, Communication, Char. map, LCD contrast, Load flow dir., Time, Internal clock, Select time, to edit, Select value labels]

Fig. 12.1 Setting the time

The time is edited by using UP ▲, DOWN ▼ and then ENTER → to confirm. The complete date and time must be inserted: year, month, day, hour, minutes and seconds.

Unit connected to a master clock:

- When the unit is connected via IRIG-B to a master clock, only the year can be set. The clock typically receives its signal from a GPS and sends it to the main module by an optical connection. The remaining part of the date and time is received from the master clock.
- When the unit is connected via SNTP to a master clock, a clock which typically receives its signal from a GPS and makes it available to the main module or Ethernet module via the Ethernet interface, the setting of the time and date form the HMI is inhibited.

Unit connected to a SCADA system:
Usually, the SCADA transmits to the unit the time and date according to the used protocol services. There are some differences depending on the used protocol.

- IEC 60870–5–103 protocol: The IEC 60870–5–103 module is the time master. Setting the time and date from the HMI is inhibited.
- LON LAG 1.4 protocol: The LON module is the time master. Setting the time and date from the HMI is inhibited.
- SPA bus and MODBUS protocol: usually, the SCADA sets the time and date, and setting the time and date from the HMI is inhibited.
13. **Command page**

From this page, it is possible to access the HMI command objects configured in the application software of REF 542plus. For more information on these objects, refer to Operating Tool user manual.

![Command page diagram](image)

*Fig. 13.-1 Command page*

By selecting the desired command and pressing ENTER the command is executed.
14. REF 542plus commissioning mode

The commissioning test mode allows accessing all the digital and analogue inputs and outputs of REF 542plus. This mode is independent of the REF 542plus application. This working mode has been designed to make easier the wiring verification.

The super user key is required to enter this mode.

Entering this mode STOPS the execution of the protection and control functions. The application software is not running. However, it is not deleted from the permanent memory of the unit. The commissioning test mode should be entered when the switchgear is de-energized and in a safe state.

To switch on this mode the following actions have to be performed in sequence.

- Switch off the REF 542plus Base Unit.
- Place the super user key on the e-key sensor and keep it contacted.
- Switch on the Base Unit.

When the Base Unit starts the e-key is detected. The commissioning mode is entered. Verify this reading on the start-up status line “COMMISSIONING MODE”. When this text is visible, the e-key can be unplugged from the e-key sensor.

This mode allows driving directly the binary outputs of the Base Unit. If they are connected to primary objects, operations are thus possible. The interlocking functions are disabled. Before accessing this mode, put the switchgear in safe conditions.

When entering the commissioning mode, the following screen is displayed.
14.1. Binary input commissioning page

This page displays the current status of the binary input channels on the binary IO modules. There are 14 binary inputs per module available. For the binary inputs numbering see Section 19.2. Binary inputs and outputs.

Line description: "Channel descriptor" "Channel number ": "Values"
- Channel descriptor: Binary input
- Channel number: x-yy. Where x addresses the binary IO slot, yy is the binary input number. 1 means X20 slot and so forth.
- Values: 0 → input is not active. Applied voltage is below the activation threshold.
  1 → input is active. Applied voltage is above the activation threshold.
14.2. Binary output commissioning page

On this page, it is possible to force the status of the binary outputs. All the outputs can be driven with the exception of the watchdog.

**Line description:**

"Channel descriptor" "Channel number": "Values"

**Channel descriptor:** Binary output

**Channel number:** x-yy. Where x addresses the binary IO slot, yy is the binary output number. 1 identifies the X21 connector and so forth.

**Values:**

0 → output is opened. The relay is not energized.
1 → output is closed. The relay is energized. Normally opened contacts are closed.
14.3. Analog input commissioning page

This page shows the analog measurements acquired by the analog input module. The shown values are independent on the rated primary current or voltage of the primary sensors. The measurements are reported in absolute values taking into consideration as nominal values of the secondary windings 1 Amp and 100 V. If the 5 Amp current inputs are connected applying the nominal rated current, it will be shown 1 A.
Line description: “Channel descriptor” “Channel number”: “Values”

Channel descriptor: Analog input
Channel number: x, where x addresses the analog input channel.
Values: CT (1.5 A) → Rated secondary current related to the current input.
CT (0.2 A) → Rated secondary current.
VT (100 V) → Rated secondary voltage (Volt).
Sensor → Voltage output of the sensor (Volt).

Fig. 14.3.-1  Analog inputs commissioning page for the 3CT, 3VT, 1VT, 1CT module

With sensor inputs, the displayed values are the voltages read by the analog channels. For example, by using the voltage divider 10.000/1 applying 20 kV on the sensor, the measurement will show 2 Volt. For the current sensor 80 A/150 mV, applying 80 Amp on the sensor the measure will be 0.150 Volt.
14.4. Analog output 4-20 mA commissioning page

This page allows setting the value of the analog channels in the 4-20 mA module.

Line description: "Channel descriptor" "Channel number": "Values"
Channel descriptor: Analog Output
Channel number: x. Where x addresses the analog output channel.
Values: 0/4 mA to 20 mA, step 1 mA. The value can be set with UP or DOWN.
14.5. Analog input 4-20 mA commissioning page

From this page, it is possible to read the analog measurements of the Analog Input 4-20 mA module. The shown measurements will be depending on the connected sensor type. In case of a general 4-20 mA sensor, the value of the applied current to the channel is displayed. In case of a SF6 Trafag sensor, the density and the temperature are displayed.
### 4-20 mA analog inputs commissioning page

This page displays the status of the analog inputs on the main module. This mode is available only with main modules equipped with the analog inputs (1VCF751021R0803, X74 only and 1VCF751021R0801 for all).

**Channel descriptor**: General 4-20 mA sensor → General sensor Trafag → Density, Temperature

**Channel number**: x. Where x addresses the analog input channel.

**Values**: General Sensor → 4-20 mA, for Trafag the density and the temperature.

<table>
<thead>
<tr>
<th>Channel descriptor</th>
<th>Channel number</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>General sensor</td>
<td>1</td>
<td>mA</td>
</tr>
<tr>
<td>Density Trafag</td>
<td>1</td>
<td>kPa</td>
</tr>
<tr>
<td>Temperature Trafag</td>
<td>1</td>
<td>°C</td>
</tr>
<tr>
<td>General sensor</td>
<td>2</td>
<td>mA</td>
</tr>
<tr>
<td>Density Trafag</td>
<td>2</td>
<td>kPa</td>
</tr>
<tr>
<td>Temperature Trafag</td>
<td>2</td>
<td>°C</td>
</tr>
<tr>
<td>General sensor</td>
<td>3</td>
<td>mA</td>
</tr>
<tr>
<td>Density Trafag</td>
<td>3</td>
<td>kPa</td>
</tr>
<tr>
<td>Temperature Trafag</td>
<td>3</td>
<td>°C</td>
</tr>
</tbody>
</table>

![Figure 14.5.-1](image.png)

**Fig. 14.5.-1** 4-20 mA analog inputs commissioning page

### Optical inputs commissioning page

This page displays the status of the optical inputs on the main module. This mode is available only with main modules equipped with the optical inputs (1VCF751021R0803, X74 only and 1VCF751021R0801 for all).

**Channel descriptor**: Optical Input

**Channel number**: x. Where x addresses the optical Input channel.

1: X74 (time synch input)
2: X75
3: X76

**Values**: 0: Optical input is off (no light is present).
1: Optical input is on (light is present).
This page allows driving the optical output on the main module (only type 1VCF751021R801).

Line description: "Channel descriptor" "Channel number ": "Values"
Channel descriptor: Optical output
Channel number: x. Where x addresses the optical output channel.
Values: 0: Optical output is off (light not present). 1: Optical output is on (light present).

The value can be selected with UP ▲, DOWN ▼.
OPTICAL OUTPUTS

Optical output 3: 0

UP or DOWN to move, <- to edit

Optical output 3: 1

UP or DOWN to change

Fig. 14.7.-1 Optical output commissioning page
15. Connection to PC

15.1. Infrared (IrDa) to RS232 converter cable

A special cable with an optical infrared (IrDa) interface is needed to connect REF 542plus to a serial port of a PC. This cable is available from ABB.

![REF 542plus serial cable with optical infrared (IrDa) interface](image)

Fig. 15.1.-1 REF 542plus serial cable with optical infrared (IrDa) interface

![Interface on the HMI for the serial cable with optical infrared (IrDa)](image)

Fig. 15.1.-2 Interface on the HMI for the serial cable with optical infrared (IrDa)

15.2. Null-modem cable

If there is no HMI applied or a direct connection to the base unit is preferred, a standard null-modem cable can be used to connect the base unit via the so called RS 232 service interface (X72) to the PC.
15.3. Ethernet TCP/IP cable

A standard Ethernet cable can be used to connect the base unit via the TCP/IP port interface to the PC.

15.4. Downloading a configuration

When the connection is set up with the appropriate cable, it is possible to download the configuration into REF 542plus with the Operating Tool. Connect the infrared (IrDa) converter to the foreseen connector on the HMI and the D-sub connector to the PC or connect the base unit to the TCP/IP port of the PC with an Ethernet cable. Start Operating Tool on the PC and configure the serial port or the TCP/IP port to be used inside the program.

15.5. PC communication properties

REF 542plus Configuration Tool is able to configure the REF 542plus device connected via a serial port RS232 or an Ethernet TCP/IP port. To configure the communication port (serial RS232 or TCP/IP) of the computer to be used to transmit the configuration for the application, the corresponding applicable dialog must be edited. After starting the Configuration Tool software, open Main menu > Connect > Port configuration. The opening dialog window has three tabs.
On the first tab it is possible to select the communication port. The other two tabs are for configuring the serial port and TCP/IP settings.

**General tab**

The first tab is used to select the type of connection of REF 542plus to the PC. The connection can be Serial or TCP/IP. The type of communication must be selected before configuring it in the other tabs of the window. A section with a description of all the current settings regarding both serial port and the TCP/IP port is also provided.

If a serial port or a TCP/IP port is not available, the serial or TCP/IP port configuration tabs are not displayed. In the General tab, an empty value is displayed instead.

Fig. 15.5.-1  **PC communication properties**
15.5.1. **Serial port settings**

To configure the serial port (RS232) of the computer, the applicable Serial tab must be activated.
Fig. 15.5.1.-1 Serial port properties

The tab has five option fields where the settings for the computer serial port can be made.

Select the COM port where the RS232/Infrared (IrDa) cable or RS232 null-modem cable is plugged in.

Apply the following settings:

Application with the new international HMI V5 or connection with a null-modem cable directly to the base unit:

- Baud rate: 115,200
- Data bits: 8
- Stop bits: 1
- Parity: None
Baud rate 19,200
Data bits 8
Stop bits 1
Parity Even

After the download of the configuration file by using the service or the debug port, press ENTER to end the download process.

Base Unit slave address: This number can be from 1 to 254. When several Base Units are connected to the same HMI, this number uniquely identifies the Base Unit. The default address is 99. To configure or change the Base Unit slave address, there are two methods:

- Open the application file with the Operating Tool and change it in the hardware settings.
- Via the HMI menu > Service page > Communication > HMI PORT
Fig. 15.5.1.-3 Changing the Base Unit address from the HMI

Please note:

When the ALARM LED is on, the download is inhibited.

The configuration download starts as soon as the relevant push button on the Operating Tool is clicked.

The previous configuration inside REF 542plus is destroyed and overwritten by the new one.

REF 542plus is fully operational during the download. After the download, REF 542plus starts to write the new configuration in the non-volatile with a low priority task in background. This task might take several seconds.

Do not switch off Base Unit power supply during the storing. The whole unit configuration might be corrupted and a new configuration download might be necessary.

The download is possible in all control modes, provided the status of the protection is switched by the corresponding electronic key in operational mode.

Communication to the SCADA system is operational during the download.

After the download, REF 542plus automatically starts with the new configuration.
When the download is completed, the unit may change the operational status of the output relays due to the new logic configured in the application file. It is strongly recommended to put the switchgear in safe conditions before performing the download.

15.5.2. **TCP/IP port settings**

To configure the TCP/IP port of the computer to be used to transmit the configuration file of the application, the applicable TCP/IP tab must be edited. In this tab it is also possible to set the IP address of the REF 542plus unit involved in the TCP/IP communication.

![TCP/IP port properties](image)

*Fig. 15.5.2.-1 TCP/IP port properties*

The "Remote device" section allows setting the IP address of the REF 542plus unit involved in a direct communication with Configuration Tool.

The "Local Network Properties" section shows a list of the Ethernet adapters currently installed in the PC. Once an Ethernet adapter is selected, the related TCP/IP parameters are shown as read-only:
Both the REF 542plus unit and the PC must be connected to the same network.

To adjust the IP parameters of the PC Ethernet adapter so that it is in the same subnet or in general to modify other TCP/IP parameters, a utility is provided in the TCP/IP settings tab.

To change the parameters of a PC Ethernet adapter:

- select the adapter from the list
- select "Change network configuration settings"

The **Change Settings** button becomes available.

**Fig. 15.5.2.-2** Enabling PC for TCP/IP change
Click **Change Settings** to open the TCP/IP dialog window to enter the new settings.

**Fig. 15.5.2.-3 Changing the TCP/IP settings of the PC**

If the new parameters are correct, the **Save Settings** button becomes available.

- Click **Save Settings** to start the renewing of the PC Ethernet card.

The settings can be changed also outside Configuration Tool.

- From **Control Panel > Network Connections**, select the Ethernet adapter whose parameters need to be modified.
- Click **Properties** and select from the list "Internet Protocol (TCP/IP)."
Fig. 15.5.2.-4 Changing the PC TCP/IP settings and properties from Control Panel

- Click Internet Protocol to open a dialog window that allows making changes to the TCP/IP parameters.
Fig. 15.5.2.-5  Internet Protocol properties

The PC Ethernet port is configured to communicate with the address 192.168.2.234 and with the subnet 255.255.255.0. The subnet value must match the subnet value set in the REF 542plus unit, while only the first three digits of the IP address must match the ones of the REF 542plus unit with the fourth digit being different. After that, it is possible to verify a remote connection with a ping command.

15.6. Uploading the configuration

With the Operating Tool, it is possible to upload the current configuration inside REF 542plus. Set the Operating Tool and the PC as for the download and click the menu Transfer/load from REF 542plus.

Please note:

The uploaded configuration overwrites the current one inside the Operating Tool.

The upload is possible in all control modes and does not affect the functioning of the unit.
15.7. Uploading other information

With the Operating Tool, other information can be uploaded from REF 542plus. Different data can be uploaded:

- The fault recorder file
- The binary input status
- The binary output status
- The measurements
- The software version

All this data is accessible with the Operating Tool from the transfer menu. Refer to the Operating Tool manual for more details.
16. Troubleshooting

16.1. Error messages

Base Unit not responding, communication corrupted or wrong slave address

When the HMI is not able to communicate with the Base Unit, the following information appears on the LCD:

![HMI Software version: V4E03a
BASE UNIT NOT RESPONDING
COMMUNICATION CORRUPTED
OR WRONG SLAVE ADDRESS

↓ to test HMI
OR CHANGE SLAVE ADDRESS](image)

Fig. 16.1.-1 HMI is not able to communicate with the Base Unit

Solution:

Check that the Base Unit is powered and regularly working. Look at the status LED on the connector panel (Slot X7).

The LED close to the analog inputs is related to the watchdog. When the Base Units is working this LED is on with a weak light.

The other LED is related to the communication with the HMI. When the communication is properly working, this LED is blinking. When the communication is not working, the LED can be either ON or OFF. It depends on when the communication is interrupted.

Check that the connection cable between the HMI and the Base Unit is inserted both in the HMI and in the Base Unit (Base Unit connector X73 and HMI connector X20) and properly tighten.

Check the slave address of the connected Base Unit to be polled. The address is configured in the application file. If you do not know you can enter the following page by pressing ENTER.
**Power Up Operations**

After pressing the key the Power Up Operation menu is shown as in the following Fig. 16.1.-2.

![POWER UP OPERATION](image1)

Fig. 16.1.-2 Menu for Power Up Operations for HMI V5

If the older version of the HMI V4 is used, the menu of the Power Up Operations is slightly different in accordance to the menu in the former release 2.0. The menu is as shown in the following Fig. 16.1.-3.

![POWER UP OPERATION](image2)

Fig. 16.1.-3 Menu for Power Up Operations for HMI V4

Select **HMI <-> Base Unit address scanning** menu item and press ENTER.

The HMI will start polling all the addresses to find the connected Base Units. When a unit is found, its address and the feeder name are reported.
Fig. 16.1.-4  **HMI is polling the Base unit addresses**

Select the **HMI <-> Base Unit address** to change the address to be polled.

Fig. 16.1.-5  **Changing the Base Unit address to be polled.**

### HMI Self Test

Only with the older version of the HMI V4, the HMI can be tested without connection to the base unit. The test must be done by using the foreseen menu item on the Power Up Operations. The HMI V5 must only be tested in connection to the base unit and by using the related test menu after reaching the ready status.

Press ENTER to start the test for the HMI.
**Base Unit not configured**

REF 542plus is without configuration when the following message appears:

![BASE UNIT NOT CONFIGURED](image)

... Waiting for new configuration ...

**Configuration not loaded**

The following message appears when the downloaded configuration has not been saved inside the unit due to an internal error.

**Solution:**

Download the configuration into the unit by using the serial cable and the Operating Tool.
Fig. 16.1.-8  REF 542plus configuration is not stored in the unit internal memory

Solution:

Try to download the configuration again. If after two or three attempts the error remains, contact ABB.

Wrong configuration

The following message appears when a not correct configuration has been downloaded in the Base Unit. This message can also appear when the configuration contains protection functions that exceed the unit functionality level.

Fig. 16.1.-9  REF 542plus with wrong configuration

The WRONG CONFIGURATION can also be caused by other reasons. The error handling will be described in Appendix D, where the Self Supervision is explained.
16.2. Clearing the configuration inside the unit

In some cases, there might be the need to delete the configuration stored inside the REF 542plus. For example, when the RED alarm is on, it is not possible to download a new configuration inside REF 542plus. The following procedure deletes the configuration inside REF 542plus:

- Switch off the Base Unit power supply (disconnect the X10 connector from the Base Unit).
- Press simultaneously the UP and DOWN buttons on the HMI and keep them pressed.
- Switch on the Base Unit again.

After this procedure, REF 542plus is without configuration. Download a new configuration in the unit.

This procedure deletes the configuration stored inside REF 542plus. The configuration cannot be recovered. Upload the configuration and save it before deleting it from the unit.
16.3. **Primary objects incorrect visualization**

The primary object status is usually acquired by REF 542plus with two distinct contacts: one that is closed when the object is closed and another that is opened. When the object is opened, the same two contacts with two different positions are needed.

The primary object is visualized in open position with a dotted line when both contacts are opened (REF 542plus has no voltage at both contact inputs).

![Diagram](image1)

*Fig. 16.3.-1 REF 542plus has no voltage at both inputs indicating the primary object position*

The primary object is visualized both in open and closed positions when both contacts are closed (REF 542plus has voltage at both its contact inputs).

![Diagram](image2)

*Fig. 16.3.-2 REF 542plus has voltage at both inputs indicating the primary object position*

**Solution:**

Check the wiring of the primary object. Verify that REF 542plus connectors are properly inserted and tightened.
Note: When the primary object in such an undefined positions, issuing an open command will activate the open coil on the circuit breaker. The open operation is never blocked. The close operation with the object in the undefined position is blocked. A close command will be discarded and will turn the interlocking error LED on.
## Terminology

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethernet</td>
<td>Physical communication network to transfer Internet data of the REF 542plus to the PC and back.</td>
</tr>
<tr>
<td>Modbus</td>
<td>By extension, communication board implementing the Modbus protocol for REF 542plus.</td>
</tr>
</tbody>
</table>
### Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO</td>
<td>Binary input and output board</td>
</tr>
<tr>
<td>CAN</td>
<td>Controller area network</td>
</tr>
<tr>
<td>CB</td>
<td>Circuit-breaker</td>
</tr>
<tr>
<td>CT</td>
<td>Current transformer</td>
</tr>
<tr>
<td>EEPROM</td>
<td>Electrically Erasable Programmable Read-Only Memory</td>
</tr>
<tr>
<td>FUPLA</td>
<td>Function block programming language; Functional programming language; Function plan; Function chart</td>
</tr>
<tr>
<td>GPS</td>
<td>Global positioning system</td>
</tr>
<tr>
<td>HMI</td>
<td>Human-machine interface</td>
</tr>
<tr>
<td>HW</td>
<td>Hardware</td>
</tr>
<tr>
<td>IBB</td>
<td>Interbaybus</td>
</tr>
<tr>
<td>ID</td>
<td>Identifier; identification</td>
</tr>
<tr>
<td>IEC</td>
<td>International Electrotechnical Commission</td>
</tr>
<tr>
<td>IP</td>
<td>Internet protocol</td>
</tr>
<tr>
<td>LCD</td>
<td>Liquid crystal display</td>
</tr>
<tr>
<td>LD</td>
<td>Logical device</td>
</tr>
<tr>
<td>LED</td>
<td>Light-emitting diode</td>
</tr>
<tr>
<td>LON</td>
<td>Local operating network</td>
</tr>
<tr>
<td>MC</td>
<td>Micro controller</td>
</tr>
<tr>
<td>PC</td>
<td>Personal computer</td>
</tr>
<tr>
<td>RAM</td>
<td>Random access memory</td>
</tr>
<tr>
<td>SCADA</td>
<td>Supervision, control and data acquisition</td>
</tr>
<tr>
<td>SLD</td>
<td>Single-line diagram</td>
</tr>
<tr>
<td>SNTP</td>
<td>Simple Network Time Protocol</td>
</tr>
<tr>
<td>SPA</td>
<td>Data communication protocol developed by ABB</td>
</tr>
<tr>
<td>TCP</td>
<td>Transmission Control Protocol</td>
</tr>
<tr>
<td>VT</td>
<td>Voltage transformer</td>
</tr>
</tbody>
</table>
Appendix A: Connection diagrams

The pictures below show the connections plate for REF 542plus both in the wide and standard housing versions. The wide housing version can house three binary input and output modules; the communication module, the analog output module or alternatively the analog 4-20 mA input module. The standard housing version can house at most two binary input and output modules and alternatively the communication or the analog output module.

The connectors meaning is explained in the following.

⚠️ Do not operate a switchgear unless the REF542plus connections are properly done and verified by an expert electrician and tightened.

![Connection Diagram](image)
Table 19.-1 summarizes the connectors.

<table>
<thead>
<tr>
<th>Connector</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>X10</td>
<td>Base Unit power supply</td>
</tr>
<tr>
<td>X20</td>
<td>First BIO, input</td>
</tr>
<tr>
<td>X21</td>
<td>First BIO, output</td>
</tr>
<tr>
<td>X30</td>
<td>Second BIO, input</td>
</tr>
<tr>
<td>X31</td>
<td>Second BIO, output</td>
</tr>
<tr>
<td>X40</td>
<td>Third BIO, input</td>
</tr>
<tr>
<td>X41</td>
<td>Third BIO, output</td>
</tr>
<tr>
<td>X50</td>
<td>4-20 mA analog outputs, 4-20 mA analog inputs</td>
</tr>
<tr>
<td>X51</td>
<td>4-20 mA analog input RS 232 service interface</td>
</tr>
<tr>
<td>X52</td>
<td>4-20 mA analog CAN service interface</td>
</tr>
<tr>
<td>X60</td>
<td>Modbus RS 485, channel 2; COM L-COM I TX; SPABUS RX</td>
</tr>
<tr>
<td>X61</td>
<td>Modbus RS 485, channel 1; COM L-COM I RX; SPABUS TX</td>
</tr>
<tr>
<td>X62</td>
<td>Modbus optical, RX channel 1</td>
</tr>
<tr>
<td>X63</td>
<td>Modbus optical, TX channel 1</td>
</tr>
<tr>
<td>X64</td>
<td>Modbus optical, RX channel 2</td>
</tr>
<tr>
<td>X65</td>
<td>Modbus optical, TX channel 2</td>
</tr>
<tr>
<td>X66</td>
<td>Optical LC connector on the Ethernet module</td>
</tr>
<tr>
<td>X67</td>
<td>Optical LC connector on the Ethernet module</td>
</tr>
<tr>
<td>X68</td>
<td>Electrical RJ-45 connector on the Ethernet module</td>
</tr>
<tr>
<td>X69</td>
<td>Electrical RJ-45 connector on the Ethernet module</td>
</tr>
<tr>
<td>X70</td>
<td>Ethernet 10 Mb/s RJ-45</td>
</tr>
<tr>
<td>X71</td>
<td>CAN Open ISO11898 connector</td>
</tr>
<tr>
<td>Connector</td>
<td>Meaning</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>X72</td>
<td>Mainmodule RS232 service or debug interface</td>
</tr>
<tr>
<td>X73</td>
<td>HMI connection</td>
</tr>
<tr>
<td>X74</td>
<td>Time synch input</td>
</tr>
<tr>
<td>X75</td>
<td>HSTS Input</td>
</tr>
<tr>
<td>X76</td>
<td>HSTS Input</td>
</tr>
<tr>
<td>X77</td>
<td>HSTS Output</td>
</tr>
<tr>
<td>X80</td>
<td>Analog inputs</td>
</tr>
<tr>
<td>X81</td>
<td>Sensor 1</td>
</tr>
<tr>
<td>X82</td>
<td>Sensor 2</td>
</tr>
<tr>
<td>X83</td>
<td>Sensor 3</td>
</tr>
<tr>
<td>X84</td>
<td>Sensor 4</td>
</tr>
<tr>
<td>X85</td>
<td>Sensor 5</td>
</tr>
<tr>
<td>X86</td>
<td>Sensor 6</td>
</tr>
<tr>
<td>X87</td>
<td>Sensor 7</td>
</tr>
<tr>
<td>X88</td>
<td>Sensor 8</td>
</tr>
</tbody>
</table>

19.1. Analog Inputs

REF 542plus can have a maximum of 8 analog input channels. These inputs are divided into three measurement groups:

- Measurement Group 1: channel 1, channel 2, channel 3
- Measurement Group 2: channel 4, channel 5, channel 6
- Measurement Group 3: channel 7, channel 8

Group 1 and group 2 have to be homogeneous, which means they can measure 3 currents or 3 voltages. For example, measurements of 1 current and 2 voltages are not allowed.

Group 3 can get any type of signals: 2 currents, 2 voltages, 1 current and 1 voltage and so on. Group 1 and group 2 can be used for homogeneous current or voltage measurements both from instrument transformers and non-conventional sensors. Group 3 can be used in a heterogeneous way.

Channel 7 and 8 in group 3 can be used for earth-fault current with CT type input; residual voltage, or for the synchrocheck function with VT or sensor type input.

The input CT 0.2A is commonly used with a toroidal transformer for sensitive earth-fault current measurement.

Instrument current transformers can have secondary windings ratio /1 A or /5 A. The primary nominal current (for example 400 A) is selected with the Operating Tool. The secondary current (for example /5 A) is automatically selected connecting the right wire to the analog input module.
The Rogowsky coil can be used for current sensing. The correct ratio of the
Rogowsky coil is selected with the Operating Tool. The resistive divider can be used
for voltage sensing. The ratio is selected with the Operating Tool. The physical input
on the unit is the same both for voltage and current sensing, the selection is done via
the Operating Tool. Therefore, it is possible for example to use 6 Rogowsky coils, 6
voltage dividers, or 3 Rogowsky coils and 3 voltage dividers.

To detect which analog input module is present inside the unit, look in the
identification label stick on the unit itself, or on the HMI service page under the HW
identification submenu.

![Connector for sensors analog input module](image1)

Fig. 19.1.-1 Connector for sensors analog input module

The analog input for sensor is the same both for voltage and current sensing. To find
out whether an input is for current or for voltage, the Operating Tool is needed. X81
corresponds to analog input 1 (sensor 1 in the Operating Tool), X82 to analog input
2 (sensor 2 in the Operating Tool) and so forth.

![Connector for conventional instrument transformers](image2)

Fig. 19.1.-2 Connector for conventional instrument transformers

The connector for conventional instrument transformer has twenty-four pins. The
following Table 19.1.-1 defines which input is connected to what:

<table>
<thead>
<tr>
<th></th>
<th>VT (100-110/)</th>
<th>CT (1-5A)</th>
<th>CT (0.2A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>T5/B</td>
<td>T5/2</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>T3/B</td>
<td>T3/2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>T1/B</td>
<td>T1/2</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>T8/B</td>
<td>T8/2</td>
<td>T8/A</td>
</tr>
<tr>
<td>5</td>
<td>T5/R</td>
<td>T5/1</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>T3/R</td>
<td>T3/3</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>T1/3</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>T8/R</td>
<td>T8/3</td>
<td>T8/B</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>T5/3</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>T3/1</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>T1/R</td>
<td>T1/1</td>
<td></td>
</tr>
<tr>
<td>Pin</td>
<td>Description</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>--------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>T8/1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>T4/3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>T2/B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>T6/3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>T7/B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>T4/B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>T7/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>T6/B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>T7/R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>T4/R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>T2/R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>T6/R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>T7/1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B: Black wire for voltage transformer.

R: Red wire for voltage transformer.

1: 1 A input for current transformer.

2: Common input for current transformer.

3: 5 A input for current transformer.

Example:

To determine the pins for the analog input module 1VCF750170R0817: 3CTs, 3VTs, 1CTs; used with transformers with 1 A on the secondary windings.

The following connection must be done:

Analog input 1; the current transformer for phase 1 must be connected on pins 11 and 3 (common).

Analog input 2; the current transformer for phase 2 must be connected on pins 22 and 14 (common).

Analog input 3; the current transformer for phase 3 must be connected on pins 10 and 2 (common).

Analog input 4; the voltage transformer for phase 1 to earth must be connected on pins 21 and 17.

Analog input 5; the voltage transformer for phase 2 to earth must be connected on pins 5 and 1.

Analog input 6; the voltage transformer for phase 3 to earth must be connected on pins 23 and 19.

Analog input 7, for the toroidal transformer for the residual current must be connected on pins 24 and 16 (common).
Fig. 19.1.-3  Connector for mixed analog input module

The picture above shows the connector for the mixed analog input module when both sensors and conventional instrument transformers are used. To find out which connector is used for what, identify the module code from the identification label stick on the unit and see Table 19.1.-1.

19.2. Binary inputs and outputs

Binary input and output modules use the following connectors:

X20 (inputs), X21 (outputs) for the first module.

X30 (inputs), X31 (outputs) for the second module.

X40 (inputs), X41 (outputs) for the third module, available with the wide housing only.

REF 542plus can be equipped with two different types of binary inputs and outputs modules: static or with electromechanical relays.

19.2.1. Static

In the static module, digital inputs are implemented with optocouplers and digital outputs are implemented with power transistors. Two different module types are available, with control coil continuity and without.

Each module features: 14 digital inputs, 3 power outputs, 4 normal outputs, 2 signal outputs, 1 watchdog output and optionally 2 coil supervision circuits. For more information, refer to the REF 542plus Technical Reference Manual.
19.2.2. Electromechanical

In the electromechanical module, digital inputs are implemented with optocouplers and digital outputs are implemented with electromechanical relays.

REF 542plus can be equipped with electromechanical module type BIO3.

19.2.2.1. BIO3

Twelve different types of BIO3 are available depending upon the supply voltage and other features.

<table>
<thead>
<tr>
<th>BIO3 Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1VCF750132R0801</td>
<td>Binary I/O3 - 19..72 V DC/ 14 V DC Standard</td>
</tr>
<tr>
<td>1VCF750132R0803</td>
<td>Binary I/O3 - 19..72 V DC/ 14 V DC Standard with Static Channel</td>
</tr>
<tr>
<td>1VCF750161R0801</td>
<td>Binary I/O3 - 19..72 V DC/ 14 V DC Standard with interconnected '-' on inputs</td>
</tr>
<tr>
<td>1VCF750161R0803</td>
<td>Binary I/O3 - 19..72 V DC/ 14 V DC with Static Channel and with interconnected '-' on inputs</td>
</tr>
<tr>
<td>1VCF750132R0802</td>
<td>Binary I/O3 - 88..132 V DC/ 50 V DC Standard</td>
</tr>
</tbody>
</table>
### BIO3 Code Description

<table>
<thead>
<tr>
<th>BIO3 Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1VCF750132R0804</td>
<td>Binary I/O3 - 88..132 V DC/ 50 V DC Standard with Static Channel</td>
</tr>
<tr>
<td>1VCF750161R0802</td>
<td>Binary I/O3 - 88..132 V DC/ 50 V DC Standard with interconnected '-' on inputs</td>
</tr>
<tr>
<td>1VCF750161R0804</td>
<td>Binary I/O3 - 88..132 V DC/ 50 V DC Standard with Static Channel and with interconnected '-' on inputs</td>
</tr>
<tr>
<td>1VCF750132R0805</td>
<td>Binary I/O3 - 88..132 V DC/ 72 V DC Standard</td>
</tr>
<tr>
<td>1VCF750132R0806</td>
<td>Binary I/O3 - 88..132 V DC/ 72 V DC Standard with Static Channel</td>
</tr>
<tr>
<td>1VCF750132R0807</td>
<td>Binary I/O3 - 176..264 V DC/ 143 V DC Standard</td>
</tr>
<tr>
<td>1VCF750132R0808</td>
<td>Binary I/O3 - 176..264 V DC/ 143 V DC Standard with Static Channel</td>
</tr>
</tbody>
</table>

**Fig. 19.2.2.1.-1** 2 BIO3 modules with interconnected inputs and the static output

### 19.3. Other connections

#### 19.3.1. Analog outputs 0/4-20 mA

The 4 analog outputs, when present, are available at connector X50 accordingly to the following diagram (see Fig. 19.3.1.-1). The not used pins, including the shielding of the cable are connected to ground.
**19.3.2. Analog inputs 4-20 mA**

When present, the 4-20 mA analog input module uses connector X50. Sensor’s connections are shown in Fig. 19.3.2.-1 X51 and X52 are service interfaces of no use for the user. The output contact BO1 is for the future use.
19.3.2. - 4-20 mA analog inputs

Only passive sensors, for example those that are powered from the loop, can be connected to the 4…20 mA analog input module.

19.3.3. Communication module

The communication module uses connectors from X60, X61, X62, X63, X64 and X65 depending on the physical media type (RS 845, glass or plastic fiber).

19.3.4. Power supply

Power supply for the Base Unit is X10.

19.3.5. Time synchronization

The optical input for time synchronization is X74.
Fig. 19.3.6.-1  
**HMI connectors**

Fig. 19.3.6.-1 shows the back side of the HMI. The connector for the HMI power supply is X10, which is located on the right-hand side of the Fig. 19.3.6.-1. The serial cable for the connection to the base unit is to place on the other connector X20 on the left-hand side.

Respect the right polarity on the HMI power supply to avoid damages to the unit.
20. Appendix B: Menu structure

This chapter illustrates the HMI menu structure with the submenus not described in the document.

To access the menu structure, press 📷.

![Diagram](image)

Fig. 20.-1 REF 542plus menu

The access to some submenus to change parameters or to reset indication depends on the actual operating modes. The operating mode is set with two different electronic keys. With the CONTROL key the following operation modes are selectable:

- No Control
- Local
- Remote
- Local & Remote

With the PROTECTION key the following mode can be achieved:

- Set local
- Operational

20.1. Commands

The command in this submenu can be activated if the active mode is Local or Local & Remote. In other modes the activation will be denied.

20.2. Reset page

From this page, it is possible to reset alarms and other quantities. Some reset actions are possible only if REF 542plus is in the proper mode. The possibility of reset in the different submenus is described in the following:
Reset alarm: the LED’s alarm indication can be reset in this submenu, independent of the active mode.

![Diagram: Menu RESETS](image)

**Fig. 20.2.-1** Attempt to resetting the fault recorder in the wrong mode

Select the quantity to reset with UP ↑ and DOWN ↓ and press ENTER → to execute.

![Diagram: Menu RESETS](image)

**Fig. 20.2.-2** Resetting a quantity in the proper mode

The quantities that can be reset are:

- Reset fault recorder
- Reset Start/Trip
- Reset max. values
- Reset Energy values
- Reset CB Cycles
- Reset counters
- Reset AR2 counter
Reset alarm: can only be reset, if there is no active alarm present anymore. An attempt to reset an alarm caused for example by an interrupted open coil is impossible as long as the coil is not replaced.

Reset max. values: this sub menu resets the maximum and mean current values in the observation period. Also the sum of switched off current is reset from here. Reset is only possible in Local or Local & Remote modes.

Reset energy values: all the energy values (active, reactive, apparent) are reset from here. Reset is only possible in Local or Local & Remote modes.

Reset CB cycles: a circuit breaker cycle is a close operation and the subsequent open operation. The unit sums the cycles. This cycle number is reset from here. Reset is only possible in Local or Local & Remote modes.

Reset fault recorder: the fault recorder data is cleared from here. Reset is only possible in Local or Set Local modes.

Reset events: the events are cleared from here, if the mode is in Set Local.

Reset counters: the unit working hours are reset from here. Reset is only possible in Local or Local & Remote modes.

20.3. Protection

The parameter of the Protection submenus, Active set page and Protection, can only be changed in mode Set Local by applying the protection electronic key.

20.4. Control

The parameter of the Control submenus can only be changed in mode Set Local by applying the protection electronic key.

20.5. Test

The test of the primary object can only be performed in local mode.

20.6. Service page

The service page menu is composed of several submenus. Browse through the submenus with UP and DOWN buttons. Press ENTER to enter the selected submenu.
The service page contains the following submenus.

### 20.6.1. Statistics

This submenu shows the FUPLA cycle time and other information related to the current configuration in the unit.

### 20.6.2. Versions

This submenu displays information on the firmware versions loaded inside the unit.
20.6.3. **Hardware identification**

This submenu shows the reference information of the hardware modules installed into REF 542plus.

**Fig. 20.6.3.-1 Hardware identification**

**Hardware information page**

To display the information select the row and press ENTER. When the information is available in the selected module, the following page will be displayed (this information is stored in a dedicated EEPROM on the module itself).
When the information from the module is not available the following page is displayed.

When the information stored on the module is corrupted, the following page is displayed.
20.6.3.-4 **Hardware information corrupted**

When the module is not present or the module is not able to publish the HW identification data, the following page is displayed.

20.6.3.-5 **Hardware information not available**

20.6.4. **Communication**

This subpage displays the information related to the communication ports available and configured in REF 542plus.
When the port is not installed or configured, the following page will be displayed.

**Fig. 20.6.4.-1 Communication subpage visualization**

When the IEC 60870-5-103 communication module is installed the following page is displayed.

**Fig. 20.6.4.-2 Communication module is not installed**

### 20.6.4.1. IEC 103 communication page

When the IEC 60870-5-103 communication module is installed the following page is displayed.
In this subpage, it is possible to block the monitoring direction of the module. For more information, refer to the Communication Module User Manual.

The IEC Test mode menu allows setting and resetting the test mode of the IEC module. For more information, refer to the Communication Module User Manual.
When the COM-L module for LON communication is installed and active, the following page displays the configured Node ID.
20.6.4.3. SPA communication page

When the SPA bus communication module is installed, the following page is displayed.

Fig. 20.6.4.3.-1 SPA bus communication module page

It is not possible to modify the SPA bus slave address of the unit on this page.

20.6.4.4. Modbus communication page

When the Modbus module is installed and properly working, the following page is displayed.

Fig. 20.6.4.4.-1 Modbus communication module page
By selecting the row related to port 1 or 2 and pressing \[\text{ ENTER} \], it is possible to change the port communication address.

20.6.4.5. **CAN communication page**

When the CAN port has been enabled the following pages display the CAN communication settings.

> The CAN communication may only be used by ABB switchgear companies.

![CAN communication port page](Image)

Fig. 20.6.4.5.-1 **CAN communication port page**

Only channel 1 is currently available. To enter the next subpage, select Channel 1 and press \[\text{ ENTER} \]. The following page is displayed.
CAN INFO subpage

This page displays the CAN status information.

CAN Commands subpage

From this page, it is possible to issue direct operation to the CAN communication subsystem. For more information, refer to the CAN Communication User Manual.
CAN setting subpage

In this page, it is possible to change the node address of the CAN communication. This setting is allowed only when the REF 542plus node is in the Pre-Operational status.
20.6.4.6. **HMI communication page**

In this page, it is possible to change the Base Unit slave address used to communicate with the HMI.

When the Base Unit address is changed, the communication with the HMI is lost. To restore it, the Base Unit address must be inserted in the HMI as well. Select the menu item Base Unit Slave Address and insert the same address of the Base Unit.
20.6.4.7. Ethernet IP page

This page shows the current settings of the Ethernet communication subsystem. Here, it is possible to visualize the IP and MAC address. The IP and MAC addresses cannot be changed from this page.

Fig. 20.6.4.7.-1 Ethernet port subpage
20.6.4.8. Ethernet communication page

When the Ethernet module is applied, the following subpages appear after you select the corresponding Ethernet communication submenu, depending on the actual condition. The following Fig. 20.6.4.8.-1 shows a case where the Ethernet board is not supported:

![Diagram of Ethernet communication page]

*Fig. 20.6.4.8.-1 Subpage if Ethernet board is not supported*

The next Fig. 20.6.4.8.-2 shows a case where there is no Ethernet module present.
In normal situation where the Ethernet module is installed, the following subpage appears when you select another submenu, as shown in Fig. 20.6.4.8.-3:
To select the desired subpage, click the UP ▲ and DOWN ▼ buttons. The subpages are divided into two categories for value settings and info.

**General Settings subpage**

The General Settings subpage displays the configuration parameters coming from the REF 542plus main module, whereas the General Info subpage displays the status values and configurations coming from the Ethernet communication module. The following two figures, Fig. 20.6.4.8.-4 and Fig. 20.6.4.8.-5, show the related subpages.

![General Settings subpage diagram](image)
Fig. 20.6.4.8.-5 General Info subpage

To move from one subpage to another click the UP \( \uparrow \) and DOWN \( \downarrow \) buttons. You can go back to the FB COM Ethernet page from each subpage by clicking the MENU \( \text{MENU} \) button.

TCP/IP subpage

The TCP/IP subpage consists of two pages for each configured communication port, port1 or port2. The following two figures Fig. 20.6.4.8.-6 and Fig. 20.6.4.8.-7 show the TCP/IP Settings subpage and the TCP/IP INFO subpage.
At the moment, you can either use port 1 or port 2. If you apply port 2, the subpages shown in the following two figures are displayed.
The SNTP subpage displays whether SNTP is enabled or disabled.
If SNTP is enabled, the related subpage consists of two different subpages, as shown in the following two figures Fig. 20.6.4.8.-11 and Fig. 20.6.4.8.-12.

Fig. 20.6.4.8.-11  SNTP Settings subpage

Fig. 20.6.4.8.-10  SNTP disabled
You can move from one subpage to another by clicking the UP and DOWN buttons. You can go back to the FB COM Ethernet subpage by clicking the MENU button.

**Protocols subpage**

The Protocols subpage consists of a page for each configured protocol on Ethernet board, IEC61850 or MODBUS TCP.

The following figure 20.6.4.8.-13 shows the Protocols subpage for the IEC61850 protocol.
The following figure 20.6.4.8.-14 shows the Protocols subpage for MODBUS TCP protocol.

The pages shown when the protocol is currently disabled are presented in 20.6.4.8.-15(IEC61850) and 20.6.4.8.-16(MODBUS TCP).
20.6.5. Char map

This page shows the active char map used by the HMI. Refer to the Operating Tool User Manual on how to change it.
The LCD screen contrast can be adapted to different light condition from this submenu.

Load flow direction

The load flow direction determines how REF 542plus computes energy and power. It is set with the Operating Tool and it is also dependent upon the current and voltage transformers (or sensors) connections in the primary parts.

- FORWARD: the power is flowing from the switchgear to the load (outgoing feeder).
- BACKWARD: the power is flowing into the switchgear (incoming feeder).
20.7. Test page

This submenu allows testing the HMI and the primary part of the switchgear.

20.7.1. Test HMI

When the test HMI is selected, all its features will be tested by switching them on and off.

HMI buttons are not available during the test. The displayed information on the HMI does not reflect the switchgear’s actual status. REF 542plus is protecting the switchgear during the HMI test. The HMI test takes a few seconds.
20.7.2. Test primary object

The circuit breaker and other switching devices can be tested from this submenu. The object control buttons are used to perform the desired tests. A warning message is displayed before leaving the test primary object mode.

In test mode, the interlockings are disabled. It is strongly recommended to de-energize the switchgear before activating the test mode.

Verify the primary object’s correct position before leaving the test mode and before energizing the switchgear. Make sure all the primary objects are back in the correct positions.
21. **Appendix C: Tripping time indication**

The example below shows and explains the information on the Events page of the HMI. It refers to events generated by Overcurrent Instantaneous protection function. The test is performed with a fault current around 10 times of the current threshold setting value, simulating a two-phase fault between phase L1 and phase L3.

![Fig. 21.-1 Start/Trip events](image)

Event number 21:

The Overcurrent Instantaneous protection function detects the system fault condition on phase L1 at the absolute time 25/05/2006, 07:45:15.859. The time stamp is indicated by arrow 1, see Fig. 21.-1.

Event number 22:

The Overcurrent Instantaneous protection function detects the system fault condition on phase L3 at the same absolute time 25/05/2006, 07:45:15.859.

Event number 23:

The trip by the above-mentioned protection function is released at the absolute time 25/05/2006, 07:45:15.862, which is indicated by arrow 3, see Fig. 21.-1.

As long as the current is not interrupted, the start signal remains active. Arrow 2 indicates that the current is flowing for a time duration of 73 ms.
Appendix D: Self Supervision

The REF 542plus feeder terminal is provided with an extensive self-supervision system. The self-supervision system handles configuration and run-time fault situations and informs, if possible, the user of faults via the HMI and SPA event.

REF 542plus is a programmable device. The configuration is built by the configuration tool REF542CONF and is composed by the following files:

- FUPLA (functions sequence)
- WIRE (functions connection)
- LCU (HMI display configuration)
- COM (communication configuration)

REF 542plus is a scalable system. Optional modules can be used according to project requirements. The following list provides a definition of the terminology used when defining the state of an optional module:

- "Installed" indicates that the module is physically inserted in the REF 542plus housing.
- "Configured" indicates that the module has been configured in REF542CONF by a REF 542plus engineer.
- "Detected" indicates that the REF 542plus start-up procedure has made a successful detection check of the module.

Software supervision

Software faults require different kinds of handling and these can be modelled by defining a level that identifies the fault’s critical nature:

- Level 1
  Level 1 faults are irrecoverable fatal errors. After fault detection, the system is not able to guarantee safe execution of the protection and control functions. The irrecoverable fault forces REF 542plus to stop any activities and it can only be restarted after a power-switch cycle (power off/on) or after a configuration download (if possible).

- Level 2
  Level 2 faults are recoverable fatal errors. They are similar to level 1 faults except that REF 542plus, instead of stopping any activities, resets and therefore automatically restarts and signals the reset cause.

- Level 3
  Level 3 faults are errors that do not affect safe execution of the protection and control functions. In general, they are handled by signalling the fault via an HMI error message and a SPA event.
The fault can be signalled externally via the following mechanism:

- **HMI LEDs**
  - **Ready:**
    - **Black** Protection and control functions not active
    - **Green** Protection and control functions active
  - **Network communication:**
    - **Black** No communication
    - **Green** Communication works properly
    - **Amber** Some communication error on the line (handled only by MODBUS and ETHERNET module)
    - **Red** Communication error
  - **Alarm Led and Interlocking errors are handled by the programmable logics**
  - **HMI error message**
    
    If an error message has been displayed in the MMI, no other message is displayed until:
    - a local/remote reset command has been given
    - completion of a configuration download
    - SPA event

### Supervision by bootloader

REF 542plus has an on-chip bootloader that handles the software upgrade and the entering into Factory test mode. The bootloader supervises RAM (Random Access Memory) and FLASH (MC non-volatile memory) application program correctness. At normal start-up, it performs a simple RAM test that verifies the presence of the RAM chip and its memory size. The exhaustive RAM test has to be performed if the Factory test mode is activated.

If the RAM test is passed, the bootloader verifies the presence and the correctness of the application program which is stored in FLASH. The presence is verified through a pre-defined pattern check in a fixed FLASH location and the correctness is verified through application program checksum calculation.

The following table presents the bootloader fault descriptions:
### Faults/Errors Signalling Level

<table>
<thead>
<tr>
<th>Faults/Errors</th>
<th>Signalling</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAM presence</td>
<td>DEBUG port message  &quot;RAM error has been detected&quot;</td>
<td>2</td>
</tr>
<tr>
<td>RAM size</td>
<td>DEBUG port message  &quot;RAM error has been detected&quot;</td>
<td>2</td>
</tr>
<tr>
<td>&quot;RAM addressing error (?) - size too small: xx&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FLASH application program</td>
<td>DEBUG port message  &quot;No valid application found - card resetting&quot;</td>
<td>2</td>
</tr>
</tbody>
</table>

## Reset

REF 542plus performs a complete and deep analysis of the last reset cause. The reset can be the result of a normal situation or a HW/SW fault detection. A normal situation can be either of the following two:

- **Power-switch cycle**
  
  REF 542plus power is switched OFF and than ON.

- **Commissioning test end**
  
  REF 542plus is in commissioning test mode and the user exits from the commissioning test HMI menu.

The fault situations consist of the following:

- **HW watchdog**

  A HW watchdog supervises the SW execution. The required refresh time is about 80 ms (fault-time detection). This is the worst reset cause because the reset is beyond SW control which means that the real fault root cause in principle is unknown. The cause can be either SW or HW related and in any case there is no possibility to obtain a SW reference or description of the fault. The fault analysis depends on the fault reproducibility in laboratory. If the fault is not reproducible, a special REF 542plus SW can be built that is able to make a trace log of all the activities executed by the SW (interrupts, tasks switching, events, semaphore, etc.). This trace log is stored in the internal memory and can be displayed in the DEBUG port after a watchdog reset. The trace log contains the last operation performed by the system before the fault and it can be the starting point for further analysis to identify the real fault cause. That is, if the fault was HW or SW related, and, in case of SW, in which SW module the fault occurred or what sequence of events that produced the fault.

- **SW exceptions**

  The internal processor supervises all instruction executions and memory access instances. In case it detects an exception, it prepares an exception stack frame and raises a SW exception interrupt. The REF 542plus exception handler stores all the information contained in the exception stack frame in the internal memory and sets the reset cause to SW exception. The SW exception always produces a HW reset. At start-up, the SW exception is signalled through a HMI and SPA event.
Moreover, the exception stack frame data, which includes very important information needed when analysing the real root cause of the SW exception, is available on the DEBUG port.

Examples of SW exceptions are:

- access error
- address error
- illegal instruction
- Fatal errors

Fatal errors are faults detected by the internal error checking functionality that, if it fails, compromises the system reliability (e.g. RTOS errors). The REF 542 plus fatal error handler stores a fatal error description string in the internal memory. The description string contains a reference to the SW function that generated the fatal error and a description of the cause. Fatal errors always produce a HW reset. At start-up, the fatal error is signalled through a HMI and SPA event.

The following table describes signalling/handling of the reset faults:

<table>
<thead>
<tr>
<th>Faults/Errors</th>
<th>Signalling</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>HW watchdog</td>
<td>HMI event “Reset!! Watchdog”</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>SPA event “0E37”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DEBUG port command ‘4’ shows SW trace logs before reset (Special REF542 SW)</td>
<td></td>
</tr>
<tr>
<td>SW exception</td>
<td>HMI event “Reset!! SW exception”</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>SPA event “0E37”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DEBUG port command ‘1’ shows SW exception stack frame data</td>
<td></td>
</tr>
<tr>
<td>Fatal Error</td>
<td>HMI event “Reset!! Fatal error”</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>SPA event “0E37”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DEBUG port command ‘1’ shows fatal error description string</td>
<td></td>
</tr>
</tbody>
</table>

**Configuration**

The configuration is stored in FLASH. At start-up or after a configuration download, REF 542 plus makes a consistency check on it. It consists of:

- **Version checking**

  There are separate versions for protection and control functions (FUPLA) and COM configuration functions.

- **Function checking**

  Every installed function must be implemented in the firmware and must have the expected configuration data/parameters format.

- **Hardware checking**

  If a function requires a hardware component, this has to be installed and detected by the start-up procedure.
Note that all version checks are performed by REF542CONF before configuration download. Therefore, the fault can occur only after a REF 542plus firmware upgrade/downgrade or after FLASH configuration data corruption.

The following table describes signalling/handling of the configuration faults:

<table>
<thead>
<tr>
<th>Faults/Errors</th>
<th>Signalling</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>No configuration</td>
<td>HMI error message &quot;Waiting new config.&quot;</td>
<td>1</td>
</tr>
<tr>
<td>Incompatible Version</td>
<td>HMI error message &quot;Software changed&quot;</td>
<td>1</td>
</tr>
<tr>
<td>COM configuration file format</td>
<td>HMI error message &quot;WRONG COM CONFIG.&quot;</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>SPA event &quot;102E60&quot;</td>
<td></td>
</tr>
<tr>
<td>COM TCP-IP incompatible version</td>
<td>HMI error message &quot;WRONG TCP-IP CONFIG.&quot;</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>SPA event &quot;102E61&quot;</td>
<td></td>
</tr>
<tr>
<td>COM MOD-TCP incompatible version</td>
<td>HMI error message &quot;WRONG MODTCP CONFIG.&quot;</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>SPA event &quot;102E62&quot;</td>
<td></td>
</tr>
<tr>
<td>COM WEBREF incompatible version</td>
<td>HMI error message &quot;WRONG WEBREF CONFIG.&quot;</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>SPA event &quot;102E63&quot;</td>
<td></td>
</tr>
<tr>
<td>COM SMS incompatible version</td>
<td>HMI error message &quot;WRONG SMS CONFIG.&quot;</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>SPA event &quot;102E61&quot;</td>
<td></td>
</tr>
<tr>
<td>COM module incompatible version</td>
<td>HMI error message &quot;WRONG COMODULE CONF.&quot;</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>SPA event &quot;102E61&quot;</td>
<td></td>
</tr>
<tr>
<td>Functions checking</td>
<td>HMI error message &quot;WRONG CONFIGURATION&quot;</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>SPA event &quot;0E43&quot;</td>
<td></td>
</tr>
<tr>
<td>Hardware checking</td>
<td>Protection functions: See 2.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DSP AI20mA functions: See 2.6 AI20mA</td>
<td></td>
</tr>
</tbody>
</table>

**DSP (Digital Signal Processor)**

The DSP supervision verifies correct DSP start-up and correct DSP working status during normal operation.

The DSP start-up supervision verifies:

- **DSP version**
  
  It is used to verify communication at start-up and to check SW version compatibility.

- **DSP Analogue Inputs calibration factors**
  
  The data is retrieved from the Analogue Input module. If the data is not present or if it is corrupted, the system will be stopped because it is not able to guarantee reliable measurements and safe protection executions.

- **DSP configuration**
  
  The DSP configuration is built by the MC from the Analogue Input and Protections configuration. It is sent to the DSP that performs a consistency check on it.
The DSP normal operation supervision verifies:

- DSP SW watchdog
  It is based on a flag-toggle mechanism. The DSP is faulty if it does not toggle a flag for 1 second.

- MC-DSP communication
  The DSP is faulty if the number of consecutive fault requests reaches a predefined counter (15). Note that, during normal operation, the DSP measurements are requested every 100ms which means that the worst fault-time detection of a DSP fault is 1.5 sec.

The following table describes signalling/handling of the DSP faults:

<table>
<thead>
<tr>
<th>Faults/Errors</th>
<th>Signalling</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSP version</td>
<td>HMI error message &quot;WRONG DSP VERSION&quot;</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>SPA event &quot;102E23&quot;</td>
<td></td>
</tr>
<tr>
<td>DSP Analogue Inputs</td>
<td>HMI error message &quot;CALIB. DSP FAULT&quot;</td>
<td>1</td>
</tr>
<tr>
<td>calibration factors</td>
<td>SPA event &quot;102E22&quot;</td>
<td></td>
</tr>
<tr>
<td>DSP configuration</td>
<td>HMI error message &quot;CONFIG. DSP ERROR&quot;</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>SPA event &quot;102E21&quot;</td>
<td></td>
</tr>
<tr>
<td>DSP watchdog</td>
<td>HMI event &quot;Reset!! DSP fail&quot;</td>
<td>2</td>
</tr>
<tr>
<td>DSP communication</td>
<td>SPA event &quot;0E38&quot;</td>
<td></td>
</tr>
</tbody>
</table>

**COM module (optional extension)**

The COM module is an optional module that can be installed in the REF 542plus housing. Its supervision is done only if the COM module is detected at start-up or configured by REF542CONF. The supervision verifies correct COM module configuration start-up and correct COM working status during normal operation.

The COM start-up supervision verifies:

- COM module version
- COM configuration data version
- COM module type

The COM start-up supervision verifies that the configured COM module type matches with the one detected.

The following fault situations can happen:

- The COM module type detected is different from the one configured in REF542CONF
- The COM module has been configured in REF542CONF but it is not installed in the REF 542plus housing
- The COM module has been configured in REF542CONF but it has not been detected due to an internal COM module fault (the detection timeout is 30 sec.)
- The COM module has been detected but it has not been configured
The COM normal operation supervision verifies:

- **COM module alive state**
  Based on the update of a life cycle counter. If the COM module does not update the life cycle counter for 500 ms, it is considered to be faulty. NOTE: Up to release 2.5, this mechanism is implemented by the MODBUS and ETHERNET modules.

The following table describes signalling/handling of the COM module faults:

<table>
<thead>
<tr>
<th>Faults/Errors</th>
<th>Signalling</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>COM module configuration data version</td>
<td>“Network communication” led becomes RED HMI error message “WRONG COM VERSION” SPA event “102E67”</td>
<td>3</td>
</tr>
<tr>
<td>COM module type</td>
<td>“Network communication” led becomes RED HMI error message “WRONG COMMODULE TYPE” SPA event “102E66”</td>
<td>3</td>
</tr>
<tr>
<td>COM module not installed</td>
<td>“Network communication” led becomes RED HMI error message “COMMODULE NOT INSTALL” SPA event “102E68”</td>
<td>3</td>
</tr>
<tr>
<td>COM module not detected</td>
<td>“Network communication” led becomes RED HMI error message “COMMODULE NOT DETECT” SPA event “102E69”</td>
<td>3</td>
</tr>
<tr>
<td>COM module not configured</td>
<td>“Network communication” led becomes RED HMI error message “COMMODULE NOT CONFIG.” SPA event “102E70”</td>
<td>3</td>
</tr>
<tr>
<td>COM module not alive</td>
<td>“Network communication” led becomes RED</td>
<td>3</td>
</tr>
</tbody>
</table>

**AI20mA module (optional extension)**

The AI20mA (20 mA analogue input module) is an optional module that can be installed in the REF 542plus housing. Its supervision is done only if the AI20mA module is detected at start-up or configured by REF542CONF. The supervision verifies correct AI20mA start-up and correct AI20mA working status during normal operation.

The AI20mA start-up supervision verifies:

- **AI20mA version**
  A common pre-defined pattern is used for AI20mA module detection and, if detected, an internal version number is used to perform the compatibility check.

- **AI20mA firmware**
  No, or not valid, firmware detected.

- **AI20mA HW tests**
  The initial hardware test detected an error.

- **AI20mA configuration**
The AI20mA configuration is built by the MC from the AI20mA sensors and Warnings configuration. It is sent to the AI20mA that performs a consistency check on it.

- AI20mA-MC configuration

The MC does not start normal operation if the AI20mA is configured but not detected at start-up.

The AI20mA normal operation supervision verifies:

- MC-AI20mA communication

The AI20mA sensor measurements and warnings status are requested every FUPLA cycle and so this time has to be considered as the worst fault time detection.

The following table describes signalling/handling of the AI20mA faults:

<table>
<thead>
<tr>
<th>Faults/Errors</th>
<th>Signalling</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI20mA version</td>
<td>HMI error message &quot;WRONG AI20MA VERSION&quot; SPA event &quot;102E50&quot;</td>
<td>1</td>
</tr>
<tr>
<td>AI20mA firmware</td>
<td>HMI error message &quot;AI20MA NOT READY&quot; SPA event &quot;102E52&quot;</td>
<td>3</td>
</tr>
<tr>
<td>AI20mA HW tests</td>
<td>HMI error message &quot;AI20MA NOT READY&quot; SPA event &quot;102E53&quot;</td>
<td>3</td>
</tr>
<tr>
<td>AI20mA configuration</td>
<td>HMI error message &quot;AI20MA NOT READY&quot; SPA event &quot;102E51&quot;</td>
<td>3</td>
</tr>
<tr>
<td>AI20mA-MC configuration</td>
<td>HMI error message &quot;WRONG CONFIGURATION&quot; SPA event &quot;0E43&quot;</td>
<td>1</td>
</tr>
<tr>
<td>AI20mA communication</td>
<td>HMI error message &quot;AI20MA NOT READY&quot; SPA event &quot;102E54&quot;</td>
<td>3</td>
</tr>
</tbody>
</table>

**FLASH data**

REF 542plus uses a FLASH device to store non-volatile data/configuration. The MC supervises every FLASH erase/write operation checking that the FLASH status registers. In order to protect the FLASH data against erroneous write/erase attempts, the FLASH is write-protected which means that erroneous access will raise a SW exception (address error). The write-protection is disabled only when valid FLASH write/erase has to be performed. Moreover, in order to guarantee data integrity, all data stored in FLASH is validated with size-check and checksum verification.

The following table describes signalling/handling of the FLASH faults:
<table>
<thead>
<tr>
<th>Faults/Errors</th>
<th>Signalling</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory full error</td>
<td>SPA event “102E1”</td>
<td>3</td>
</tr>
<tr>
<td>Ready error</td>
<td>SPA event “102E2”</td>
<td>3</td>
</tr>
<tr>
<td>Writing byte error</td>
<td>SPA event “102E3”</td>
<td>3</td>
</tr>
<tr>
<td>Block erase error</td>
<td>SPA event “102E4”</td>
<td>3</td>
</tr>
<tr>
<td>Vpp low error</td>
<td>SPA event “102E5”</td>
<td>3</td>
</tr>
<tr>
<td>Block locked error</td>
<td>SPA event “102E6”</td>
<td>3</td>
</tr>
</tbody>
</table>
Appendix E: Telnet protocol

Through the Telnet protocol it is possible to access an Ethernet module from a specific computer connected remotely to the same network. Telnet provides bidirectional communication, where the destination system (Ethernet module) is referred to as the Telnet server, while the specific local system (for example, PC) is the Telnet client. It is possible to connect only one Telnet client to the Telnet server at a time. The Telnet server appears to the connected Telnet client as a locally connected terminal.

Configuring the Telnet Terminal

To connect a Telnet client to the Ethernet module as the Telnet server, few operations are necessary. How to connect a common PC is shown below. Both the Ethernet module and PC must be connected to the same network. Adjust the IP parameters of the PC Ethernet port so that it is in the same subnet:

![Fig. 23.-1 Setting the IP properties](image)

In the above figure, the PC Ethernet port is configured to communicate with the address 192.168.2.203 and with subnet 255.255.255.0. The subnet value must match the subnet value set in the Ethernet module, while only the first three digits of the IP address must match with the ones of the Ethernet module, the fourth digit must be different. After that it is possible to verify a remote connection with a ping command.

To perform the ping command, select Run in the PC Start menu. Then type the ping command by specifying the Ethernet board IP address, as illustrated in the following Fig. 23.-2:
In the example above, the PC sends a ping command to an Ethernet board connected to the net with the address 192.168.2.106. If the connection is correct, the following window appears after the execution of the ping command:

![Ping Test Result](image1.png)

**Fig. 23.-2 Running a ping test**

Now, it is possible to establish a connection with the Telnet server of the Ethernet module. As before, use the Run command in the PC Start menu. After that, type the telnet command specifying the Ethernet board IP address as displayed in the following figure:

![Telnet Run](image2.png)

**Fig. 23.-3 Test result of ping command**

**Fig. 23.-4 Running a Telnet client**

The following window appears:
Fig. 23.5  Log into the Telnet shell

A connection with the Ethernet board Telnet server is now established. The Ethernet module Telnet server allows different logging levels to enable different functions and commands. You can access Telnet without any log in operation by simply pressing the Enter key twice. Note that the Telnet connection is automatically closed if it stays inactive for more than two minutes.

Access to Telnet as a basic user allows functions to monitor the Ethernet board status and general information.

**Basic shell commands**

Basic commands include:

- **h**  shows a list of the allowed commands
- **v**  prints a version of the loaded software modules
- **q**  closes the active Telnet connection

**Specific commands**

Specific commands allow getting information on:

- Ethernet connection configurations
- disks’ contents
- SNTP module state
- internal interface state
- Dual Channel state (if the option is enabled)
- Modbus TCP configuration and state
- Time configuration and state

The Ethernet connection configurations display the current Ethernet configuration. Two commands are available:
ep shows the configuration parameters of the ports:
- topology
- protocol type
- MAC address (for port1 and port2)
- IP address (for port1 and port2)
- subnet mask (for port1 and port2)
- gateway IP address (for port1 and port2)
es shows the SNTP client configuration parameters

The disks’ contents display the contents of the Flash disk (C:) and Ram disk (D:). Three commands are available:

fl allows to see the content of the selected disk (C: or D:)
fp allows to select the current disk and path to look at
fs shows the disk usage statistics for the current disk

You can check the SNTP module state by using the following five commands:

sa shows some information regarding the running SNTP algorithm
sc shows the state of the SNTP client
sk shows information regarding the SNTP clock module
ss shows the state of the SNTP server
st shows the result of the last transaction
sx shows all information reported with the previous commands

You can check the internal interface state with the command:

ih shows internal event handler information
ii shows current application state
ip shows internal SPA poller information
is shows internal interface statistics

You can also view the factory test result file with the command:

tf shows stored factory tests report

The following set of commands can be used to check the state of the Dual Channel operation modality:

da used to print out all the Dual Channel information
dc shows the current Dual Channel configuration
df shows Ethernet Controller statistics
dn shows the table list of the nodes connected
ds shows statistics about Dual Channel communication
dv shows the Dual Channel module release version

Commands related to Modbus TCP protocol are:
mc shows the Modbus TCP configuration
md shows current connections’ states and statistics for Modbus TCP server

Finally, the section Time configuration and state collects following commands:

wc shows possible time sources and current time
wm shows Ethernet Board and Main Card current time source and state
ws shows the collected time statistics