IPC4010, -11, -12

Fault Detectors

IPC4010 (-4011 and -4012) is a fault detector for overcurrent and earth faults with integrated remote terminal unit functionality. The binary I/O and system interface makes it suitable for typical secondary substations. Powerful relays enable direct operation of switching devices.

The communication interfaces are

- **IPC4010: IEC 60870-5-101 (RS485)**
- **IPC4011: IEC 60870-5-101 (Optical fiber)**
- **IPC4012: IEC 60870-5-104 (Ethernet)**

MANUAL

1 Contents

Protrol AB
Ullevigatan 19
411 40 Göteborg

Tel: 031- 45 82 00
internet: www.protrol.se
e-mail: info@protrol.se

2 Schematic Overview

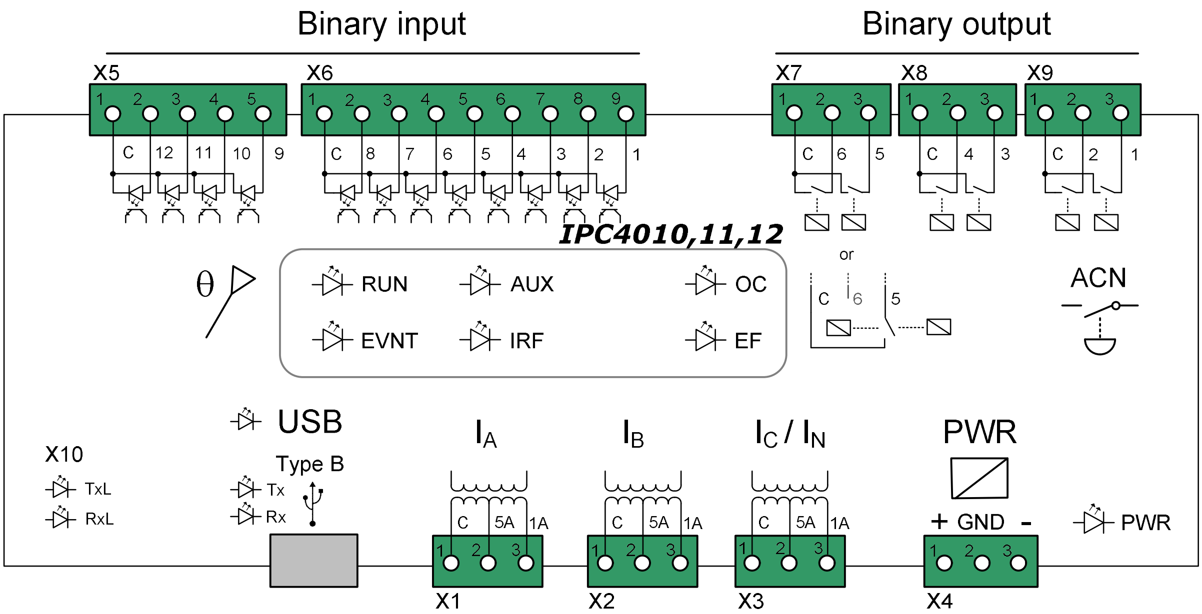


Figure 1. IPC Overview. Not shown is the system interface ports (RS485, optical fiber, RJ45) of the different units.

3 Safety Information

- The device should be grounded to ground terminal.
- If the cover is removed, avoid contact with the main circuit board and terminals. The unit is powered by 24 VDC but the wires to binary inputs and outputs are designed for higher signal voltages.
- If the unit is disconnected and the cover is removed, make sure that proper precautions are made to protect the unit from electrostatic discharges.
- When connecting and disconnecting the current terminals always short-circuit the current path to avoid open circuits!
- Short circuiting the current terminals when the earth fault detector is enabled is likely to be interpreted as an apparent earth fault. If the EF detector has no binary input qualification enabled the IPC unit should either be switched off or pluggable connectors in X7-X9 should be disconnected.

  Hint: This "feature" can be used for example in a test situation when the whole chain from IPC to the SCADA system should be verified. When the IPC40x0 is in operation and there is a normal load current it is usually possible to activate the earth fault detector by shortening one phase on the terminal screws with a short cable.

4 Functional Description

4.1 Detector Function

True Fault Pass Through Earth Fault Detection

Protrol's patented Fault Pass Through earth fault detection is suitable for all indirectly earthed networks. It is capable of detecting high impedance and arcing earth faults. It analyses the transient nature of phase and neutral currents and points reliably out the fault direction with respect to the measurement point. Note that no voltage measurement is necessary for good selectivity at very low currents. The sensitivity is comparable with that of a directional earth fault protective relay.

At an earth fault the detector will set itself into **Trig** state and will evaluate if the fault is upstream or downstream the unit. If the fault is downstream, it will switch to **Start** state. In this mode, the detector evaluates the I_N current until the *Operation Delay* has passed. If the criteria for Trip is valid after the set time, the detector will enter **Detect** state.

Note that both a **Start** and a **Detect** indication means that an earth fault has occurred downstream the detector. A **Start** without a subsequent **Detect** indication means that either the fault current is too low, or the fault was of transient type. Thus, the **Start** object, available remotely, can be used as an early indication of an incipient fault.

Some periods after the disturbance on the line has vanished, the detector returns to its normal state.

Non-directional Earth Fault Detection

Since Protrol's sensitive earth fault detection method requires prefault currents from a non-faulty feeder, a supplementary wattmetric non-directional earth fault stage can be activated. It will react if there is an existing fault when the feeder is energized.

To ensure that the non-directional earth fault stage does not react on faults in reverse direction, the operate level must be set higher than the capacitive current in the measurement point. The operate time delay is 100 ms.

Overcurrent Detection

The IPS unit features two overcurrent stages that can be configured individually.

Auto-reclose Detection

The IPS unit has the capability to remember prefault currents in order to detect if an earth fault is present after an upstream disconnection with a subsequent auto-reclose operation. In this way, it is possible to verify if the fault has vanished or not.

Fault Disconnection

Powerful relays of the IPC detector enable direct operation of switching devices. Thus, it is possible to disconnect faults before the protection in the distribution substation reacts, minimizing the consequences for the users upstream the fault.

It is possible to use a binary input for external qualification of the trip output.

Auto-reclosing Function (optional)

As option, IPC can be equipped with one auto-reclosing operation after a disconnection.

Self-healing Grid (optional, available for IPC4011 only)

Automatic fast power restoration is possible when circuit breakers are present in the secondary substations.

When a fault occurs in the loop, the respective IPC -unit will send information if the fault has passed (earth fault or overcurrent), both to the operations center via remote protocol and to the nearest IPC -unit. This enables automatic power restoration within 200 ms (at the blink of an eye), i.e., so fast so that the protection in the distribution substation will not be activated. The subscribers will thereby see only a very short “dip” (< 0.2 s).

In the station with two outgoing cables (top right), IPS2 will block the automatic power restoration at faults downstream the radial and trip its circuit breaker selectively.

Special Logic (optional)

The IPC software can be customized with special customer logic (Soft PLC function) when required.

4.2 Remote Terminal Unit Function

The IPC includes a Remote Terminal Unite (RTU) function that can employed to share Start and Trip information as well as to control switching devices such as circuit breakers and disconnectors. The I/O is optimised for a typical secondary substation.

Binary objects

The status of the 12 binary inputs of the IPC unit can be transmitted to the remote control center (Single Point / Double Point). In addition, there are four (4) objects for Start and Trip for OC and EF respectively.

The IPC unit has six (6) outputs that can be remotely controlled (Single Cmd / Double Cmd), and one (1) object for remote acknowledge.

Analogue objects

Four (4) analogue objects, local temperature and three phase currents, can be transmitted for supervision/ information purposes.

Protocols

The available protocols that can be specified at order are:

- IPC4010: IEC 60870-5-101 and RP570/571/07 (RS485)
- IPC4011: IEC 60870-5-101 and RP570/571/07 (optical fiber)
- IPC4012: IEC 60870-5-104 (Ethernet)

5 Hardware

5.1 IPC401x Main Printed Circuit Board Rev A

Pluggable Terminal Blocks

The main printed circuit board is common for IPC4010, IPC4011 and IPC4012. Most of the external wires are attached to this part of the IPC using pluggable blocks.

Also, the service port which has a USB type B connector can be found on the lower side of this board.

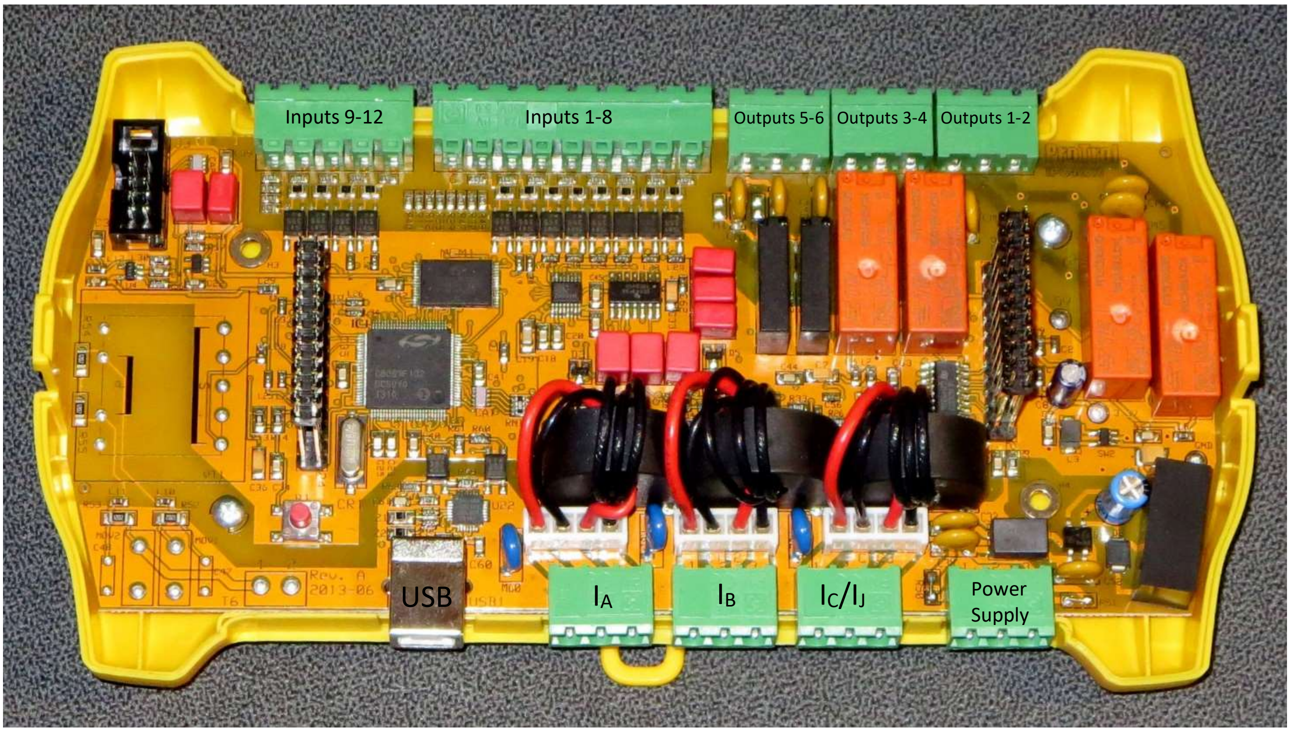


Figure 2. IPC401x Main PCB. For more information about each conductor in the contacts, please refer to the Schematic Overview. Note: Output relays 5 and 6 can be replaced by a bi-stable relay at order. In that case only Output 5 can be used.

5.2 IPC4010 Top Printed Circuit Boards

The top printed circuit board for IPC serves as local HMI and communication interface for signal cable (IEC 60870-5-101 using RS485), optical cable (IEC 60870-5-101 using 1300 nm single mode fibre) and Ethernet (IEC 60870-5-104).

Termination of RS485 modem for IPC4010

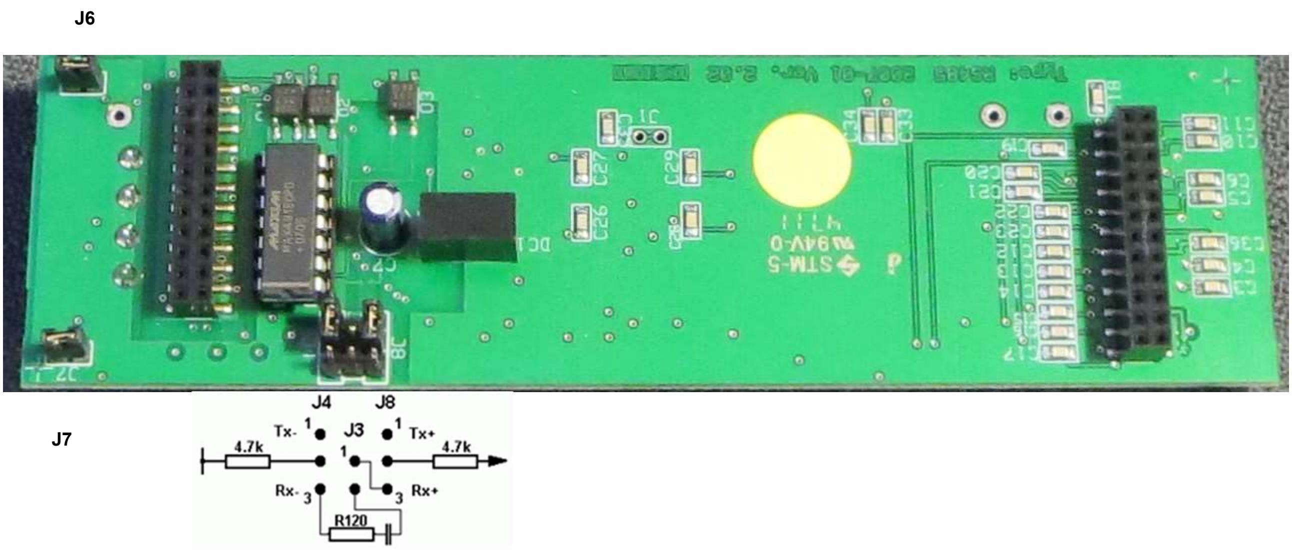


Figure 3. Jumpers on the bottom side of the signal cable interface / HMI.

The pull-up and pull-down resistors connected to pin 2 on jumpers **J4** and **J8** should be connected to avoid an undefined state of the communication wire.

2-wire signal cable (J6 and J7 connected)

1 IPC + approximately 10% of the total number of IPCs along the wire shall be terminated as follows.

J4: 1-2

J8: 1-2

As a rule of thumb one can set the corresponding jumpers in the master modem and the most remote IPC.

4-wire signal cable (J6 and J7 open)

1 IPC + approximately 10% of the total number of IPCs along the wire shall be terminated as follows.

J4: 1-2 (TxD)

J8: 1-2 (TxD)

As a rule of thumb one can set the corresponding jumpers in the master modem and the most remote IPC.

1 IPC + approximately 10% of the total number of IPCs along the wire shall be terminated as follows.

J4: 3-2 (RxD)

J8: 3-2 (RxD)

As a rule of thumb one can set the corresponding jumpers in the master modem and the second most remote IPC.

The BUS TERMINATION jumper **J3** should be connected on the most remote IPC and on the corresponding termination at the master modem.

5.3 IPC4011 Top Printed Circuit Board

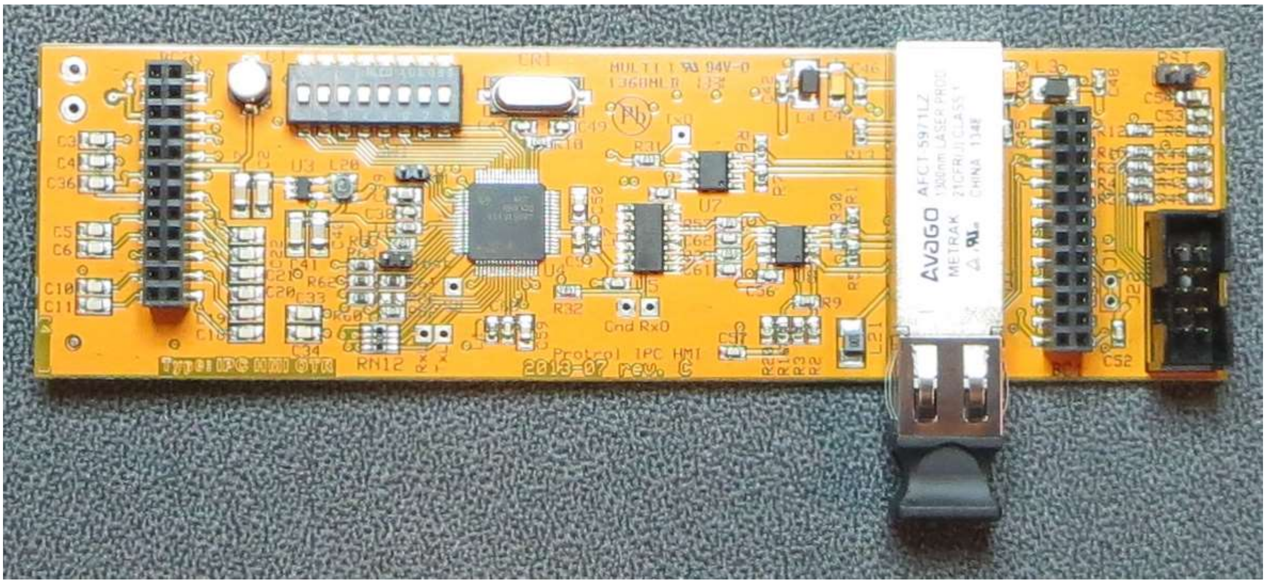


Figure 4. Dip switches on the bottom side of the optical cable interface / HMI.

The dip switches of IPC4011 are for internal use and should not be altered.

5.4 IPC4012 Top Printed Circuit Board

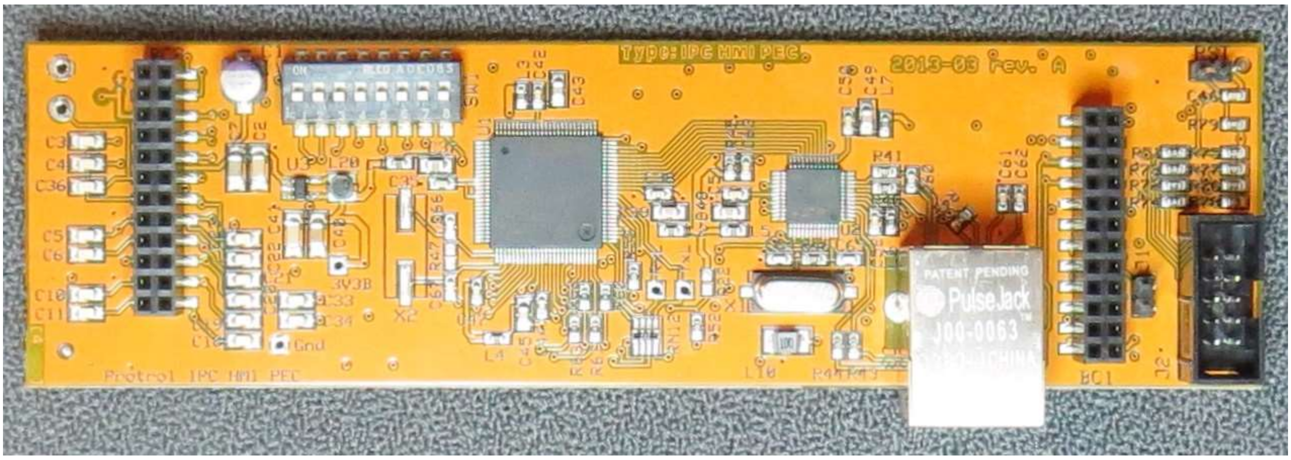


Figure 5. Dip switches on the bottom side of the Ethernet interface / HMI.

The dip switch to the left in Figure 5 is used for factory settings. If the unit is powered off and restarted with this dip switch in position 1, the communication board uses factory settings. See Section 7.1 for more details.

5.5 The IPC Human Machine Interfaces

The IPC Human Machine Interfaces comprises Light Emitting Diodes (LED) and an acknowledge button. The yellow numbers in Figure 6 are explained in the following.

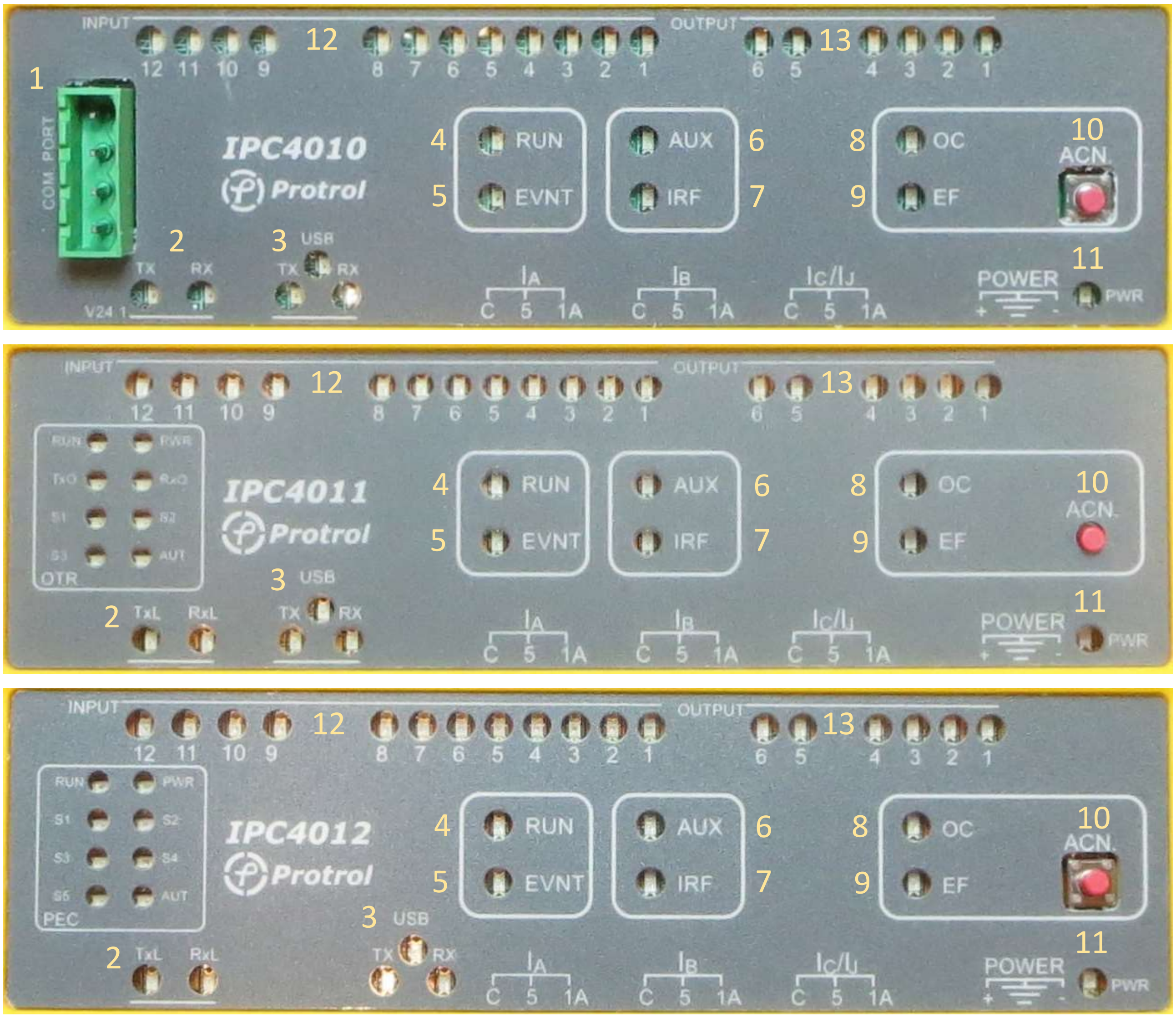


Figure 6. IPC4010, IPC4011 and IPC4012 local HMIs.

1. RS485 system interface port (IPC4010 only). Eight data bits, even parity, one stop bit. Pin numbers from top to bottom in picture.
    a. 2-wire:
        1. RxD-/TxD- (Data B)
        2. RxD+/TxD+ (Data A)
        3. RxD-/TxD- (Data B)
        4. RxD+/TxD+ (Data A)
    b. 4-wire:
        1. RxD-
        2. RxD+
        3. TxD-
        4. TxD+
2. Transmit and receive data for system interface.
3. Transmit and receive data for USB service interface.
4. RUN is a ½ Hertz flashing LED indicating correct operation.
5. EVNT LED indicates buffered telegram.
6. AUX LED is for special applications.
7. IRF LED indicates internal errors, configuration missing or calibration needed.
8. OC LED indicates a detected but unacknowledged overcurrent.
9. EF LED indicates a detected but unacknowledged earth fault.
10. Acknowledge switch for LEDs.
11. PWR is lit when power is applied.
12. Green indication LEDs for binary inputs.
13. Yellow indication LEDs for control relay outputs.

5.6 USB Service Port

A USB Type B service port is used together with any computer that runs the Windows software Protrol-Tool. This is a service tool described more in details in the following chapter.

6 IPC Toolbox in Protrol-Tool

Protrol-Tool is available for Windows XP/7/8.1 and can be downloaded from Protrol's web page (www.protrol.se). A Type B USB standard cable is needed to communicate with IPC units.

6.1 Main Window

The toolbox contains five major services:

- TFR, Transient Fault Recorder
- Settings dialog for the IPC detector
- Configuration dialog for the remote protocol
- Site Manager for commissioning
- Documentation

For the advanced user, it is also possible to use the IPC Toolbox for firmware updates.

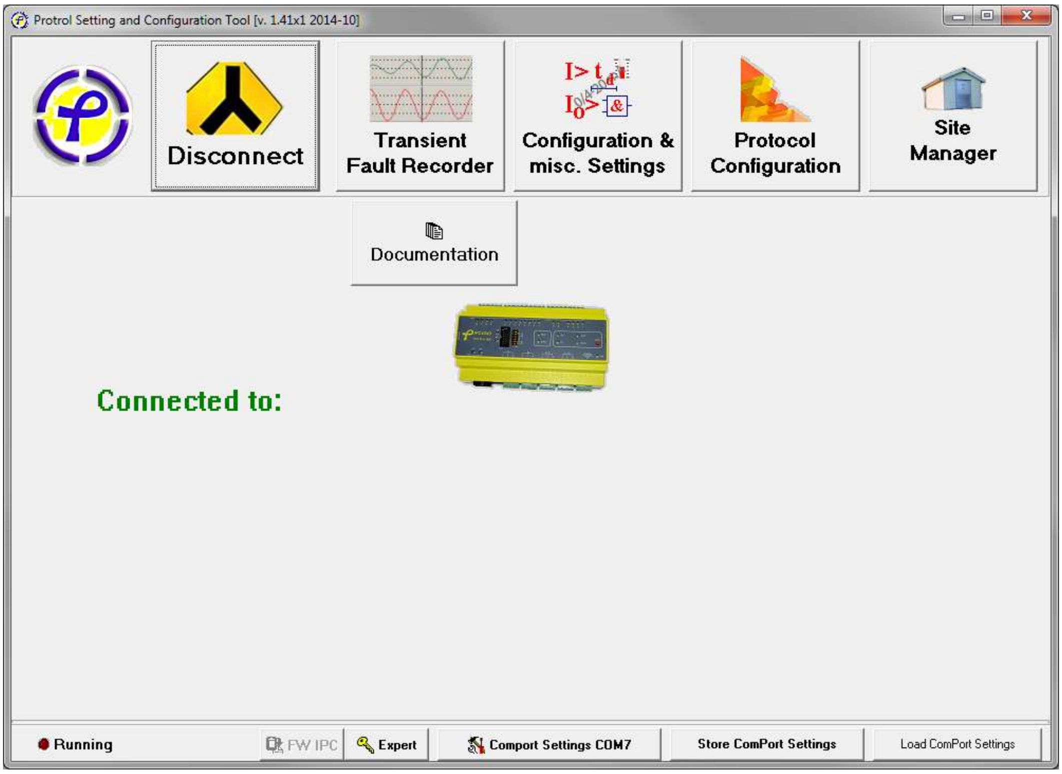


Figure 7. Protrol-Tool main window.

Protrol-Tool uses the serial port of the engineering workstation. However, this has in most computers been replaced by the more common USB interface. Before using Protrol-Tool for the first time, the corresponding serial port - USB driver must be installed in your computer. If it will not be automatically installed by your operating system, a link is available at www.protrol.se in the download section. When starting the IPC Toolbox for the first time, verify that the COM-port settings are correct, see Figure 8. The *Port* shall be any available port on the engineering workstation.

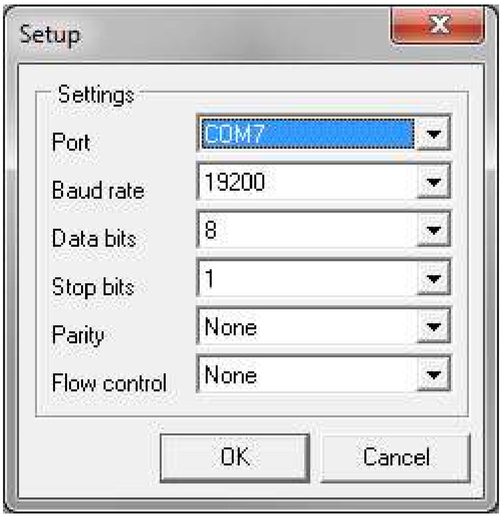


Figure 8. COM-port settings pop-up. Important: Select an available port on your computer!

Connect a USB cable between the USB Type B connector of the IPC and a USB-port on your engineering workstation.

Acknowledge by pressing *OK* and then try to connect by pressing *Connect*. If the dialog LED *Running* is flashing, connection has been established.

Communication settings can be stored in the Registry by pressing the *Store ComPort Settings* button. Next time Protrol-Tool is started the selected port is opened automatically.

6.2 IPC Transient Fault Recorder

The IPC detector has a built-in transient fault recorder which can be accessed from Protrol-Tool for further analysis of the recordings.

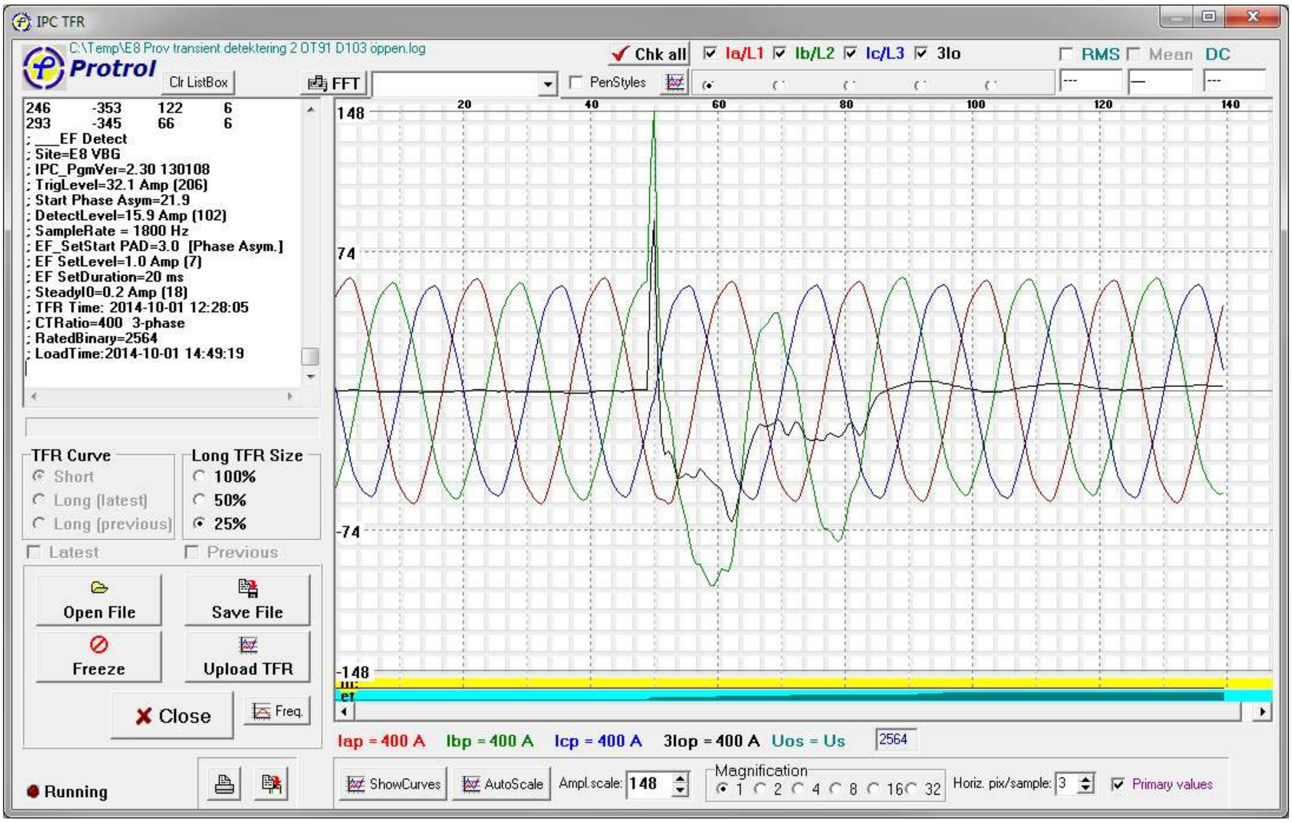


Figure 9. The Transient Fault Recorder

If the IPC detector has registered a fault, the Transient Fault Recordings, TFR, for the last faults can be uploaded by pressing the *Upload TFR* button. By default this button uploads a *Short* TFR which covers seven power frequency cycles. Also, the last two long curves can be uploaded. A 100 % long curve is two seconds with approximately 60 ms prefault data. If less than two seconds is of interest it is also possible to select one (*50 %*) or 0.5 seconds (*25 %*) TFR length.

Figure 10. The TFR length radio buttons.

By pressing the *ShowCurves* or *AutoScale* buttons, the TFR data will be displayed in the oscillogram. If *Primary values* is checked the curves are scaled to primary values, otherwise they represent unscaled binary values.

If *AutoScale* is not pressed the amplitude scale can be selected arbitrarily by changing the *Ampl.scale* field shown in Figure 11 . Magnification of the amplitude axis is done in the *Magnification* field while *Horiz. pix/sample* zooms in on the time axis.

Figure 11. The amplitude and time scaling fields.

The *Phase* checkboxes above the oscillogram is used to *display* the signals graphically, while the radio buttons below each signal are used for *phase selection*.

Figure 12. Checkboxes and radio buttons for graphical display options.

It is possible to *trace* a single curve. Select the curve of interest with the phase selection radio buttons above the graph, then push the left mouse button on the graph and drag the cursor horizontally along the time axis until the marker is at the desired location.

Each sample value is displayed numerically together with the time tag to the right of the phase selection radio buttons. If the *RMS* checkbox is checked the corresponding RMS value for one cycle ahead of the cursor is shown instead of the sample value.

Instead, if the right mouse button is pressed anywhere along a signal, all sample values at a given time are displayed in a popup, see Figure 13.

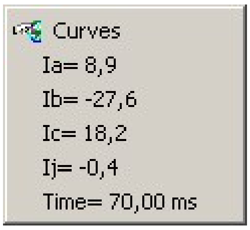


Figure 13. Sample popup.

A useful feature of the transient fault recorder is the possibility to make a snapshot of the actual phase currents by pressing the *Freeze* button and then the *Upload TFR* button. The *Freeze* button is not available unless any registered faults have been *Acknowledged* (see Sections 4.2 and 5.5)! Observe that a manually initiated TFR replaces the last saved TFR – it is therefore recommended to upload any recordings of interest **before** a snapshot is made.

Please notice the scroll box to the left containing the samples as a numerical table. It also contains meta information that describes the conditions when the recording was made. It is possible to add additional observations or notes to the scroll box by starting each row with a “;”.

A Harmonic Analyzer is located in the upper left corner of the graph. By pressing the *FFT* button, frequencies up to the 7th harmonic are calculated using the data from the **selected** curve. In Figure 14, an example where the harmonics when Ia is selected are displayed.

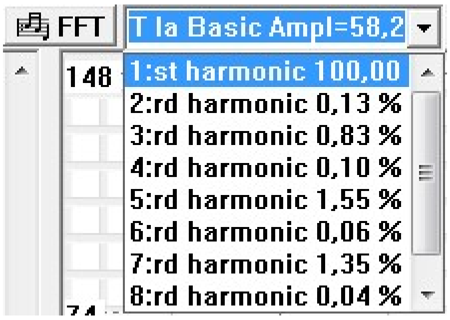


Figure 14. Harmonic Analyzer output. In this case, phase L2 has been selected and analyzed.

Note: The real harmonics above the third are somewhat higher than shown due to internal low pass filtering.

File Handling

When uploading a TFR from the IPC a question dialog is displayed asking for saving the file. This can also be done later by pressing the *Save File* button. Saved files can be retrieved later by pressing the *Open File* button.

6.3 IPC Detector Settings

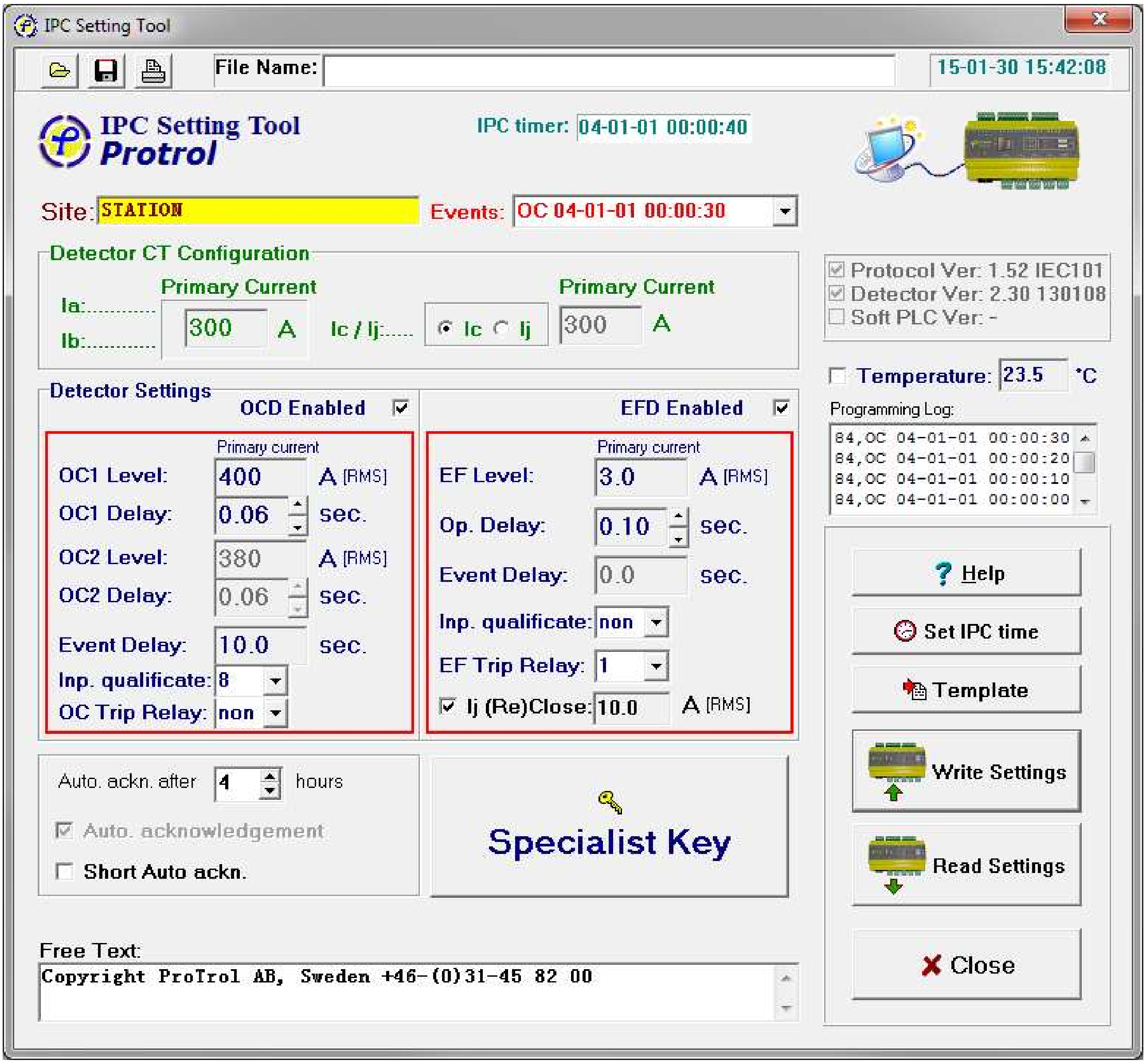
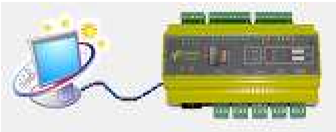
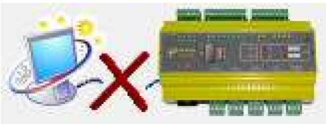


Figure 15. The Configuration & Misc. Settings window when connected to an IPC.

When connected to an IPC the information stored in the IPC is uploaded when the *Configuration & Misc. Settings* button is pressed on the Protrol-Tool main window. Please note that if the setting dialog remains open while switching to another IPC, it is necessary to push the *Read Settings* button to display the actual settings.

Note the status image in the upper right corner:

Service communication OK: 

Service communication error: 

Value Scaling

To be able to make settings in primary values the current transformer ratio must be set. Since the current terminations are designed for either 1 or 5 A secondary current it is only necessary to fill in the rated *primary current*. **From here on, all values are primary values!**

The detector uses the three phase currents and the residual current. The default measuring method is three phase currents, while the residual current is calculated internally. If the measurement is carried out by two phase currents and the residual current Ij this radio button should be selected. Please note that the residual current must be connected to the Ic / Ij input, no matter which phase current it replaces, see Figure 16. Be aware that using a cable current transformer and two phase current transformers will **reduce the sensitivity of the earth fault detector.** The reason for this is the different characteristics of the two transformer types.

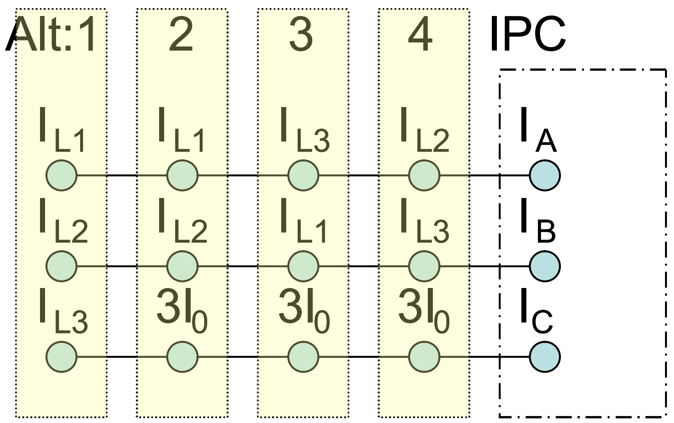


Figure 16. Connection alternatives.

The OC and EF detector can be *enabled* or *disabled* by the checkboxes in the Detector Settings panel.

Overcurrent Detection

The overcurrent *OCx Levels* are based on steady state RMS current values. The *OCx Delay* is the time which the fault current must remain above the setting level before the detector reacts by setting the **OC Detect** signal. *The event delay* is a signal hold time that ensures that user defined logic reacts on the input conditions, see Figure 17 for more information about the built-in logic. If the *inp. qualificate* is set to none or if the chosen input is high, the OC Detect signal will be transmitted to the dispatch centre. If an *OC Trip Relay* is selected the corresponding output relay will be closed for 0.2 s. This time is adjustable.

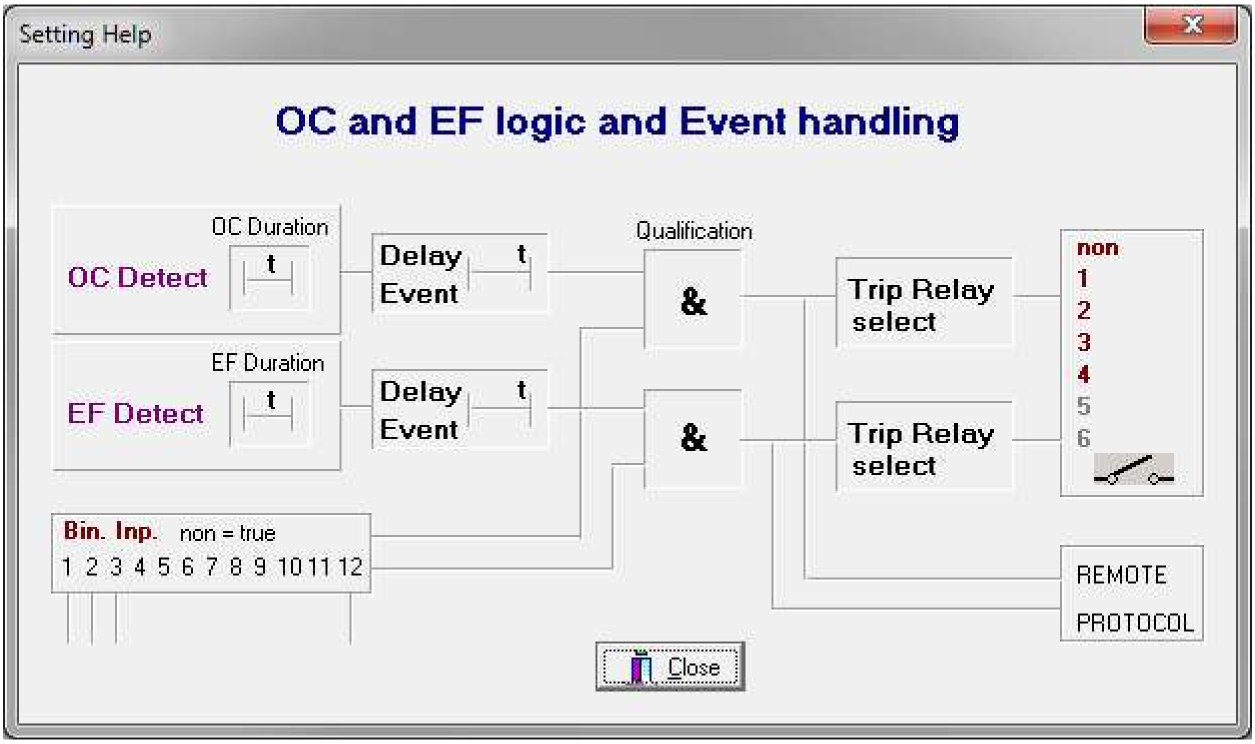


Figure 17. Pressing the ? Help button displays the OC and EF logic.

Earth Fault Detection

The earth fault settings are similar to the overcurrent settings. The *EF Level* is selected with respect to the expected current levels for earth faults with a specific fault resistance. The value represents the steady state RMS level. It is also used to **trig** (default: √2 of the RMS value) the **start** evaluation phase of the EF detector. In this phase, the detector determines if there is a downstream fault, i.e., if the detector is situated between the transformer and the fault location.

Note: If the EF level is set too low this will be indicated by the EF LED which will flicker with a week light when the detector is triggered. This type of frequent trigging indicates that the EF level must be increased.

It is possible to inspect and verify trigs in the TFR window by pressing *Freeze* and then *Upload TFR*.

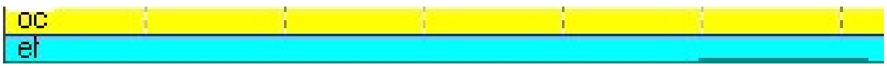


Figure 18. The state bar. The ef signal represents states where the first level is Trig, the second is Start, third and fourth are evaluation states, and the fifth is EF Detect.

As seen in the state bar in Figure 18, there is an **ef** trig which lasts about half a cycle before it is released. One spurious trig is not a key issue, but if it occurs frequently the setting is too sensitive. With the *Specialist Key* it is possible to change the *EF Trig Level* so that it is not related to the *EF Level* described above. Contact your supplier to receive a specialist key code!

The *Operation Delay* setting is the time between a confirmed **start** and the check of the steady state residual current $3I_0$. Normally, there is no requirement to use a long operation time. The residual current must be above the *EF level* for the internal **EF Detect** signal to be set. *Inp. qualificate* and *EF Trip Relay* are used in the same way as for the OC detection.

It is possible to activate a temporary non-directional earth fault stage for switch-onto-faults conditions. This is done by ticking the Ij (Re)Close box and entering a current threshold. The non-directional earth fault stage is activated during 100 ms after the line is energized.

Acknowledgement

It is always possible to acknowledge OC or EF Detect with the physical *ACN button* on the HMI panel of the IPC. It is also possible to enable *automatic acknowledge* after a settable time. If the time is set to zero, the auto-acknowledge function is disabled.

Texts

There are two text fields. The first is the *Site* field where the physical location can be entered with up to 30 characters. In the bottom of the dialog there is another field for *Free Text* of up to 80 characters.

Version Information

In the upper right corner of the settings panel the programs executed in the IPC are displayed with version index and creation date.

Temperature

The internal temperature of the IPC is shown in the *Temperature* field. The value can be calibrated by entering the correct temperature and then checking the box to the left of the temperature, before *Write Settings* is pressed. The temperature displayed must not necessarily represent inside of the IPC, it could as well be a different temperature if there is some temperature relation to the IPC. Therefore, it is possible to measure the temperature elsewhere and enter this temperature. Note: This recalibration should be done when the IPC has been in service and can be considered to be in steady-state conditions.

Time

Normally time is set from the remote control center. However, it is possible to transfer PC time to the IPC using *Set IPC time*. The IPC timer accuracy is ±30 ppm. The IPC time will be lost when power is disconnected.

Read and Write Settings

Pressing the *Read Settings* button transfers the settings from the IPC to Protrol-Tool. This transfer is also initiated when the setting dialog is opened. If successful, a “happy” sound is heard, otherwise there will be an “unhappy” sound.

Pressing the *Write Settings* button activates a dialog where the setting transfer to the IPC must be confirmed to avoid mistakes. If successful, a “happy” sound is heard, otherwise there will be an “unhappy” sound.

File Save and File Open

The settings can be saved to and retrieved from a file in IntelHex format by pressing the top toolbar buttons. Note that data does not contain pure settings. The setting levels may be identical for different IPC´s, but the CT ratios or Site names may differ.

6.4 Remote Protocol Configuration

A Remote Terminal Unit and its protocol have to be configured before use. Basic configuration includes link address, communication speed, response delay and timeouts. Standard communication settings are 8 bit data, even parity and stop bit, and does not need to be configured.

In addition, to be able to exchange information with the Master control, the RTU have to be configured with objects, blocks or channels with unique identifiers which makes sense for the Master. Such configuration is unique for each protocol and site.

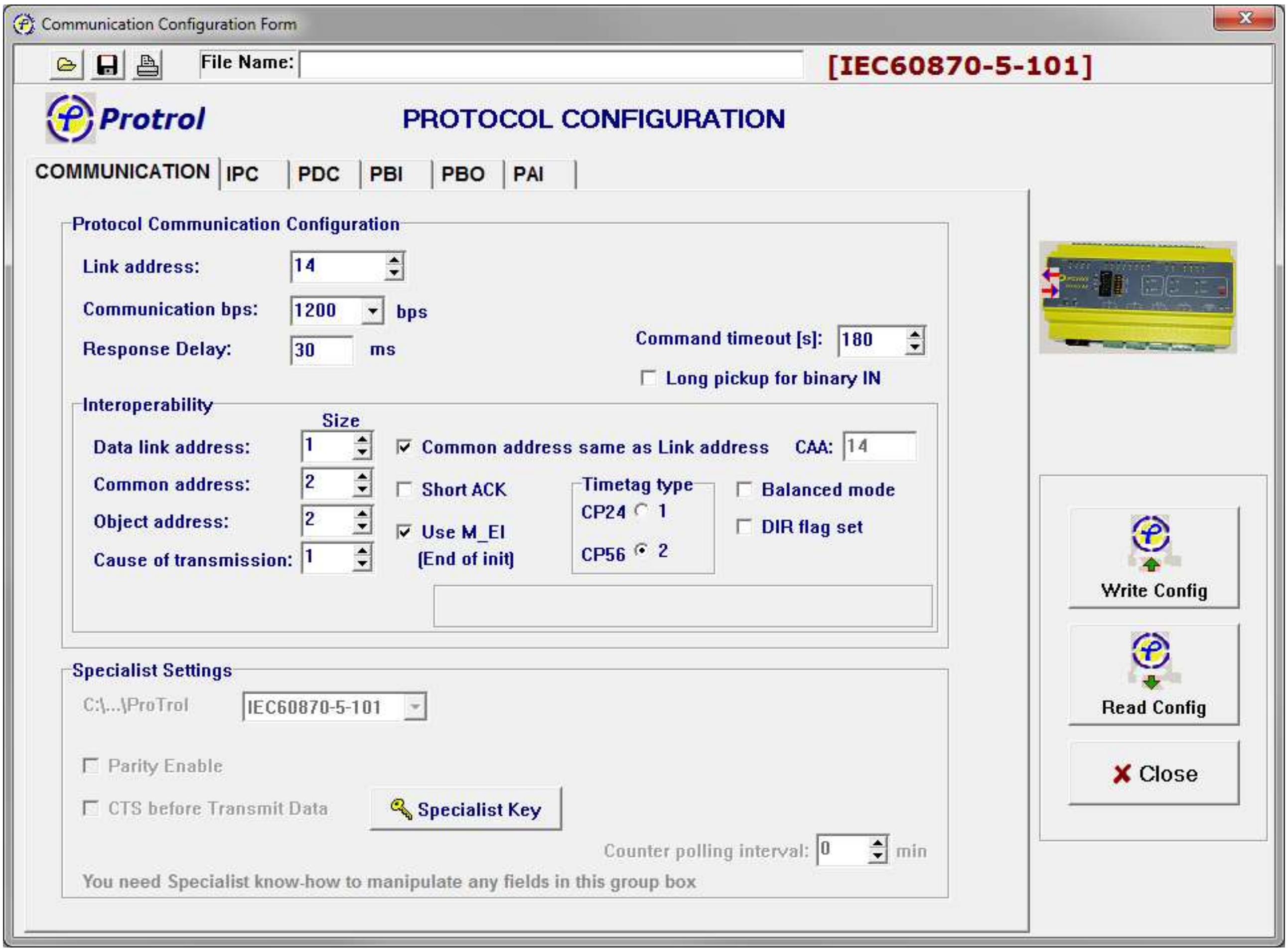


Figure 19. The Protocol Configuration panel, in this example with settings for IEC60870-5-101.

Link Address

The link address of the IPC must be unique on the same multi-drop communication line.

Communication Speed

The speed can be chosen from a number of different standard speeds expressed in bits per second (bps/baud).

Response Delay

Although the IPC can respond to within a few milliseconds, the Master is sometimes not able to apprehend a quick response since it needs time to change from transmit to receive mode. This time is at least the time required to transfer one character. For 1200 bps, 8 bit data, parity bit and one start and stop bit the transfer time is approximately 10 ms. With a safety margin, 20 ms becomes a reasonable *Response Delay*. The response delay can be set in the range from 0 to 255 ms.

Note that link address, communication speed and response delay are not applicable for IPC4012.

Command Timeout

Selection of an object is reset after the *Command timeout*.

Long Pickup

Check the box *Long Pickup for binary IN* to employ basic pickup filtering, 50 ms, of the binary input signals.

Interoperability (IEC 60870-5-101/104)

The *Size* scroll-boxes are used to define the size in octets. *CAA* is the Common ASDU Address. If the *Short Ack* is checked a single character is used to acknowledge. To use the End of Init telegram, check the *Use M_EI* box. The *Timetag type* is the selection of short or long timetag format. To use the non-standardized *Balanced mode*, check the box, and check the *DIR flag set* box if required.

Information Object Configuration (IEC 60870-5-101/104)

Object configuration data is defined on the IPC tab, see Figure 20. The address fields represents the first octet and the second two octets. If less than three octets have been defined to be the size of the object address, only the *Address fields* to the right needs to be entered.

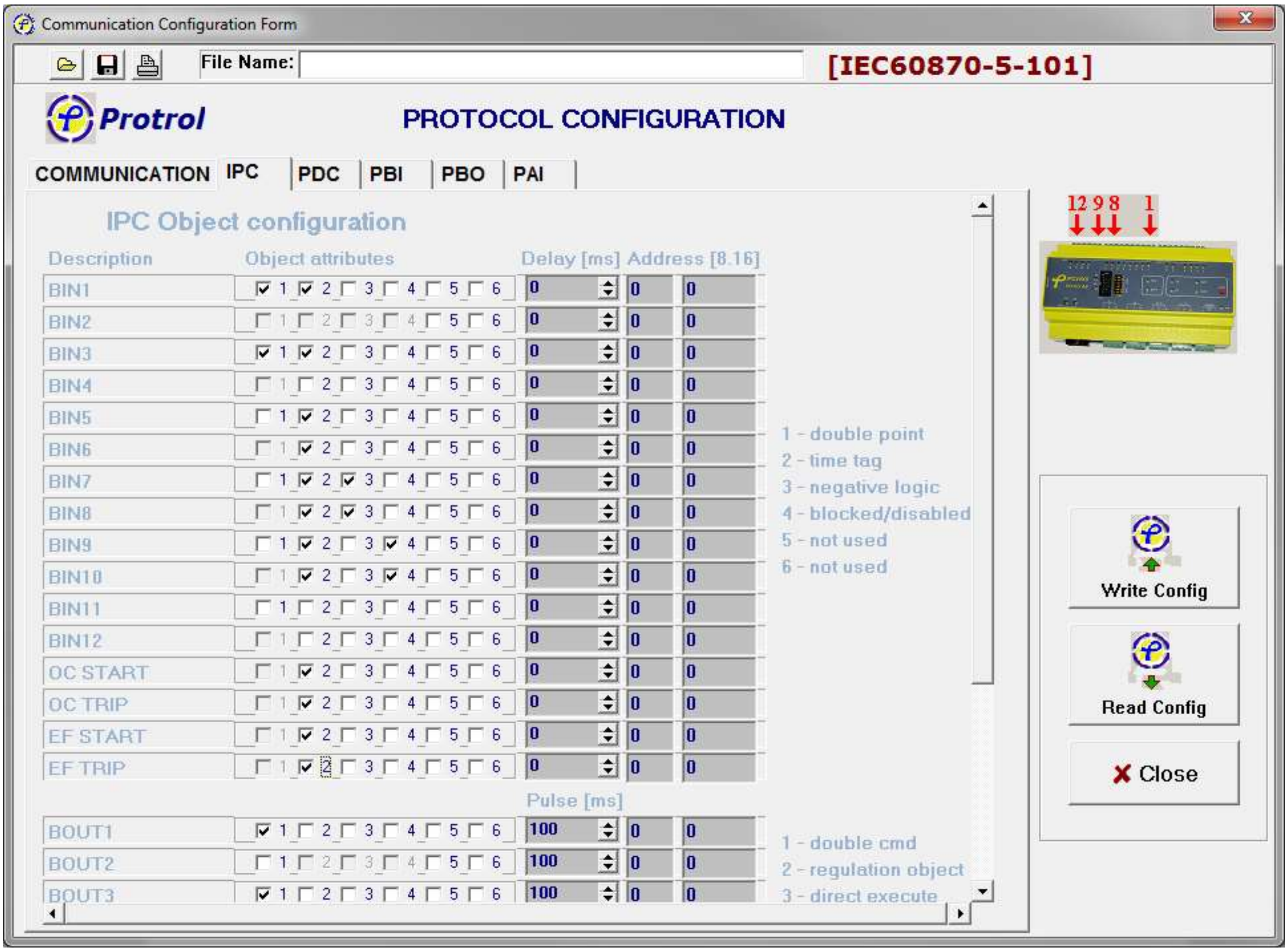


Figure 20. Information Object Configuration.

The status of up to 12 binary inputs of the IPC unit can be transmitted to the remote control center. Also, Start and Trip (Detect) for OC and EF respectively can be transmitted. A pickup *Delay* can be employed for all the transmitted signals. The following objects attributes can be set.

1. Single or Double Point (Binary inputs only). If Double Point is checked, the even binary input object attributes will be greyed out since they are not applicable.
2. Time Tag. Included if checked.
3. Negative Logic. Invert the input signal if checked.
4. Blocked/Disabled. The signal will not be transmitted.

It is possible to remotely control six output objects, and to acknowledge the Trip flags of the IPC. A *Pulse* length of a minimum of 100 ms must be specified for the binary output objects. The following objects attributes can be set.

1. Single or Double Point (Binary outputs only). If Double Point is checked, the even binary output object attributes will be greyed out since they are not applicable.
2. Regulation Object.
3. Direct Execute. If checked, executed directly when selected.
4. Blocked/Disabled. The command will not be executed.

Four analogue objects can be transmitted for supervision/ information purposes, temperature and the three input currents. A *Deadband* must be specified for the analogue objects. The following objects attributes can be set.

1. Scaled value. If checked, the current value is scaled (rated current corresponds to the value 4 000). Otherwise, it will be normalised (rated current corresponds to the value 32 767). If the transmitted signal is a temperature it is scaled to a value that is 10 times the temperature.
2. Time Tag. Included if checked.

For detailed information about configuration of the remote protocol, please refer to the protocol description of choice.

Read and Write Configuration

Pressing the *Read Config* button transfers the protocol configuration from the IPC to Protrol-Tool. This transfer is also initiated when the setting dialog is opened. If successful, a “happy” sound is heard, otherwise there will be an “unhappy” sound.

Pressing the *Write Config* button activates a dialog where the configuration transfer to the IPC must be confirmed to avoid mistakes. If successful, a “happy” sound is heard, otherwise there will be an “unhappy” sound.

File Save and File Open

The configuration can be saved to and retrieved from a file by pressing the top toolbar buttons. The configuration is stored in the same IntelHex format as the settings.

6.5 Site Manager

The commissioning process for an IPC includes installation followed by local and remote control integration. These steps are normally done at different locations. To facilitate this process, Protrol-Tool includes a Site Manager panel which is a local test and verification tool.

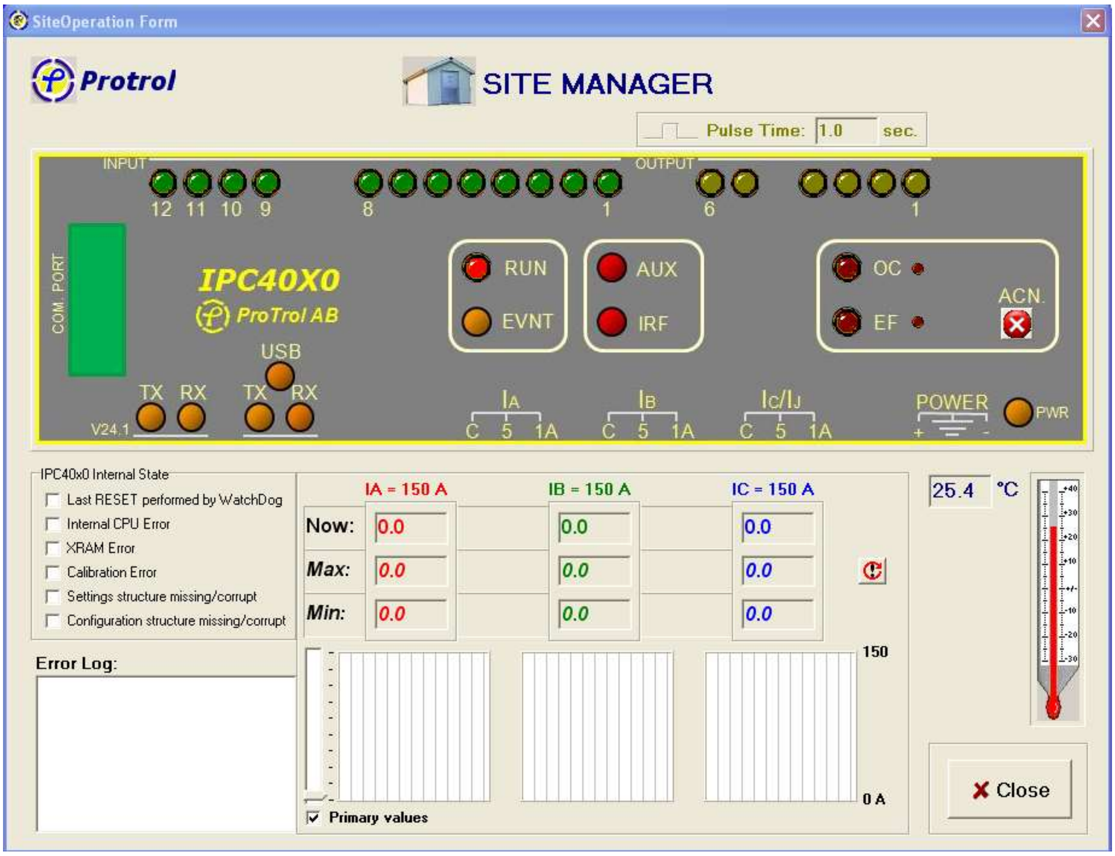


Figure 21. The Site Manager panel.

The Site Manager can be used before any protocol configuration has been done. However, it is an advantage if the Master (remote control or gateway) is connected to be able to verify that the communication works at the same time as the installation is verified.

Control

The green LEDs illustrated in Figure 21 reflect the input signals in the same way as the LEDs on the HMI panel of the IPC. The yellow LEDs illustrate the relay outputs, but they also work as controls. When approaching a yellow LED with the mouse pointer the pointer it will change from an arrow to a hand, and the LED will change to RED colour.

Figure 22.   Moving the mouse pointer near an output LED makes it change colour which means that it is selected.

By pressing the left mouse button the corresponding output relay will close for the chosen pulse time and the LED will switch to bright yellow.

Internal State Supervision

On the left side of the dialog there is a panel displaying the internal state of the IPC.

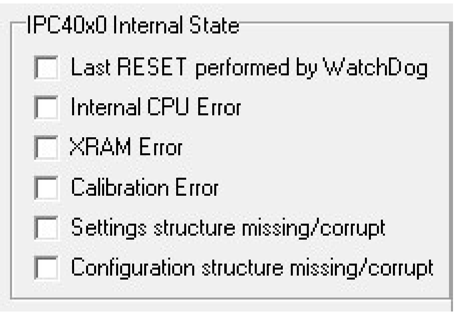


Figure 23.   The Site Manager can provide information about internal error flags.

Normally none of the checkboxes should be checked. The possible errors are as follows:

- The software was stalled or not working properly and the Watchdog has made a reset.
- Internal CPU error, most likely indicates a missing clock.
- Problems with the external memory identified.
- Calibration of the analogue inputs is needed.
- The settings structure is missing or corrupt. The information in the setting panel is not available to the IPC, thus no detectors are available.
- The configuration structure is missing or corrupt and the protocol will not work properly.

Analogue Values

Analogue values measured by the current transformers are displayed as RMS values and are updated every second in the oscillographs beneath the illustration of the HMI panel.

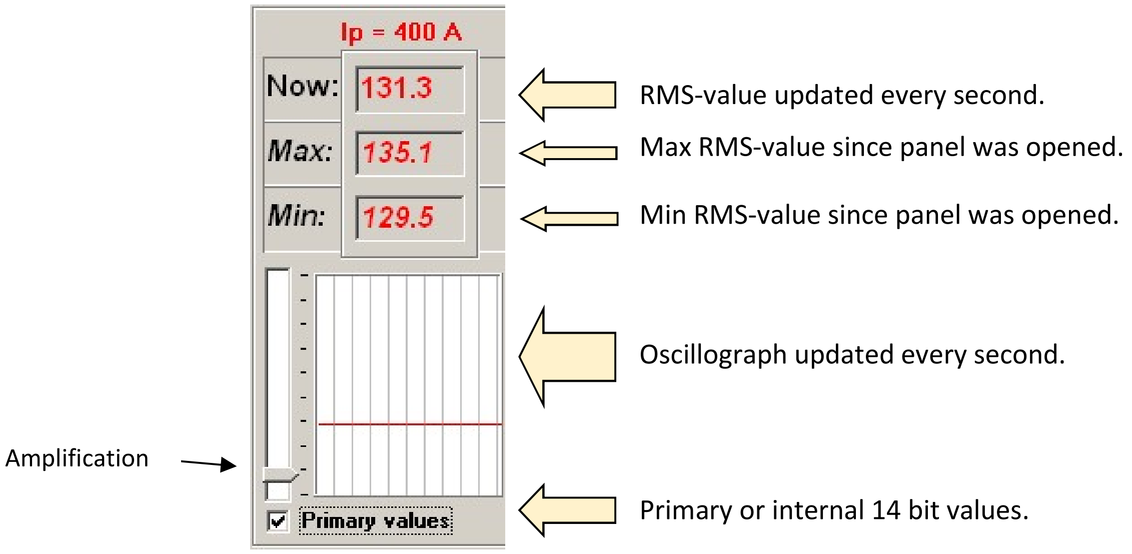


Figure 24. Current measurements.

Clear max and min values: 

Detector Status

The detector status is illustrated by four LEDs. When the OC or EF detector is started/triggered the corresponding LED shines with less brightness. This can be difficult to see on the screen, therefore the Site Manager panel features a small diode to show if any detector attempts to start/trig, see Figure 25.

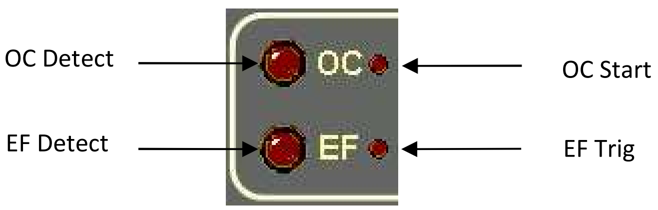


Figure 25. The left LEDs illustrate bright shining diods, the right LEDs diods shining with less intensity.

Soft acknowledge button: 

(Same function as the push button on the IPC)

6.6 Documentation

Protrol-Tool has a built-in function that helps organising the documentation of a system with a number of IPC and/or PDC installed. The default folder for documentation is C:\Protrol_Documentation.

To change from the default folder, check the *Edit Path* checkbox, enter the new path manually in the *Path* field and press the *Documents* button beneath.

Press *Yes* to the question Change existing Path. This new path will now be remembered the next time Protrol-Tool is restarted. The name in the *Subfolder* field is copied from the *Site* field for the connected IPC. When pressing *OK* the path and the subfolder are created and the latter is filled with data from the connected IPC. When the next IPC is documented the file structure is already created and the new site name is suggested as the next subfolder.

In each subfolder the detector settings and configuration files are saved together with a text document that contains a summary of the most important settings.

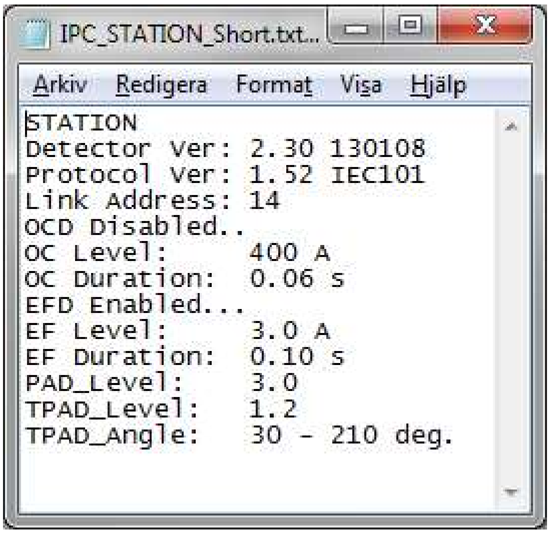


Figure 26. The generated text document contains a short summary of detector and protocol settings of an IPC.

6.7 Firmware Download

A new version of firmware can be downloaded to the device locally or remotely. Press *Expert* to enter the password. Enter the password and press the *FW IPC* button.

The firmware in IPC consists of two separate files; the Detector / RTU software and the Communication protocol. These can be updated/changed independently.

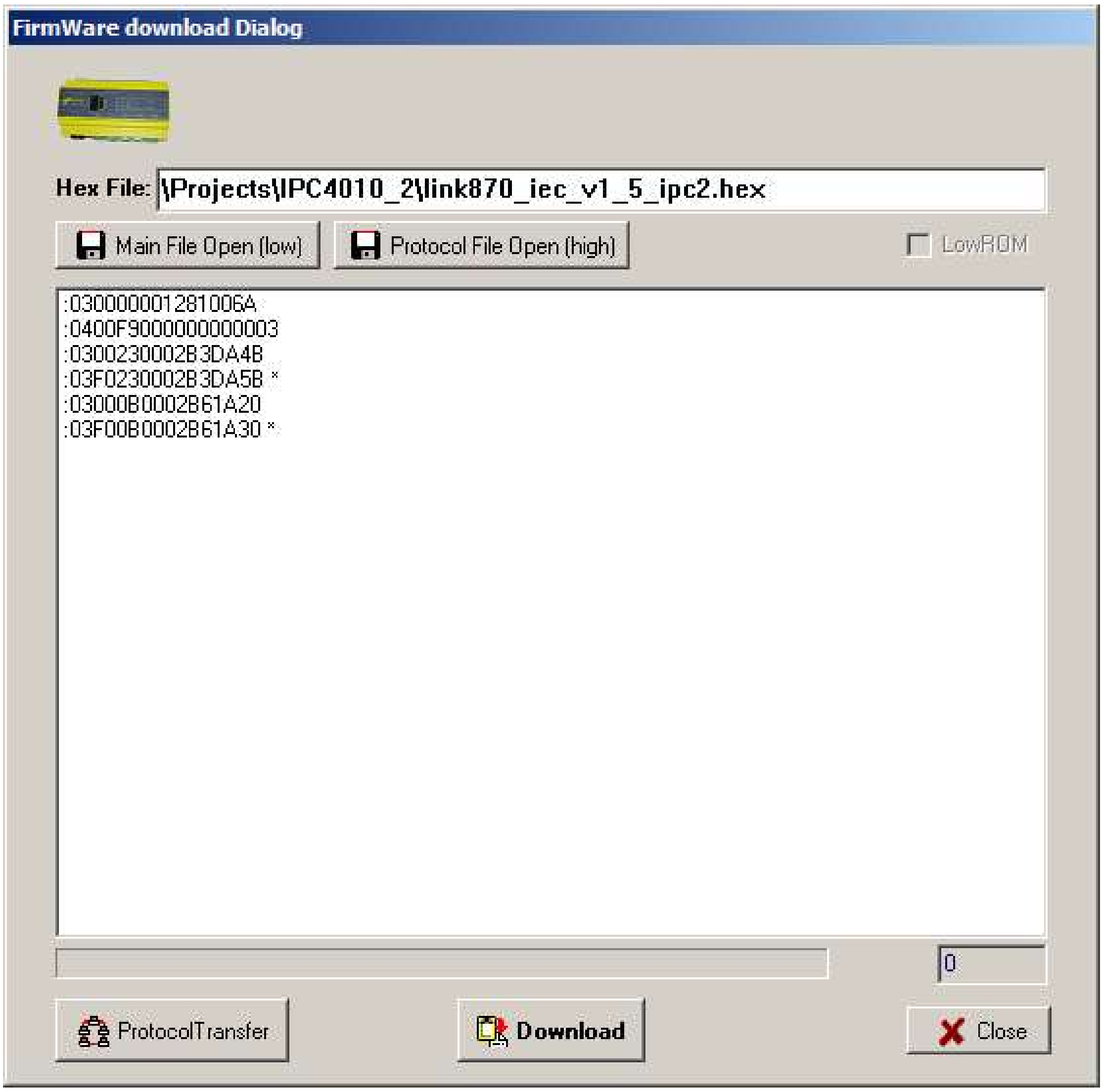


Figure 27. The Firmware download dialog can be used to transfer firmware locally and remotely.

When pressing the *Download* button, the firmware is transferred to the connected IPC using the USB service port. In the situation where many IPCs are to be updated, it is possible to do this remotely by connecting the service PC/Laptop to a modem and update all connected IPCs at the same time by pressing the *Protocol Transfer* button. The dialog for remote protocol transfer is shown below:

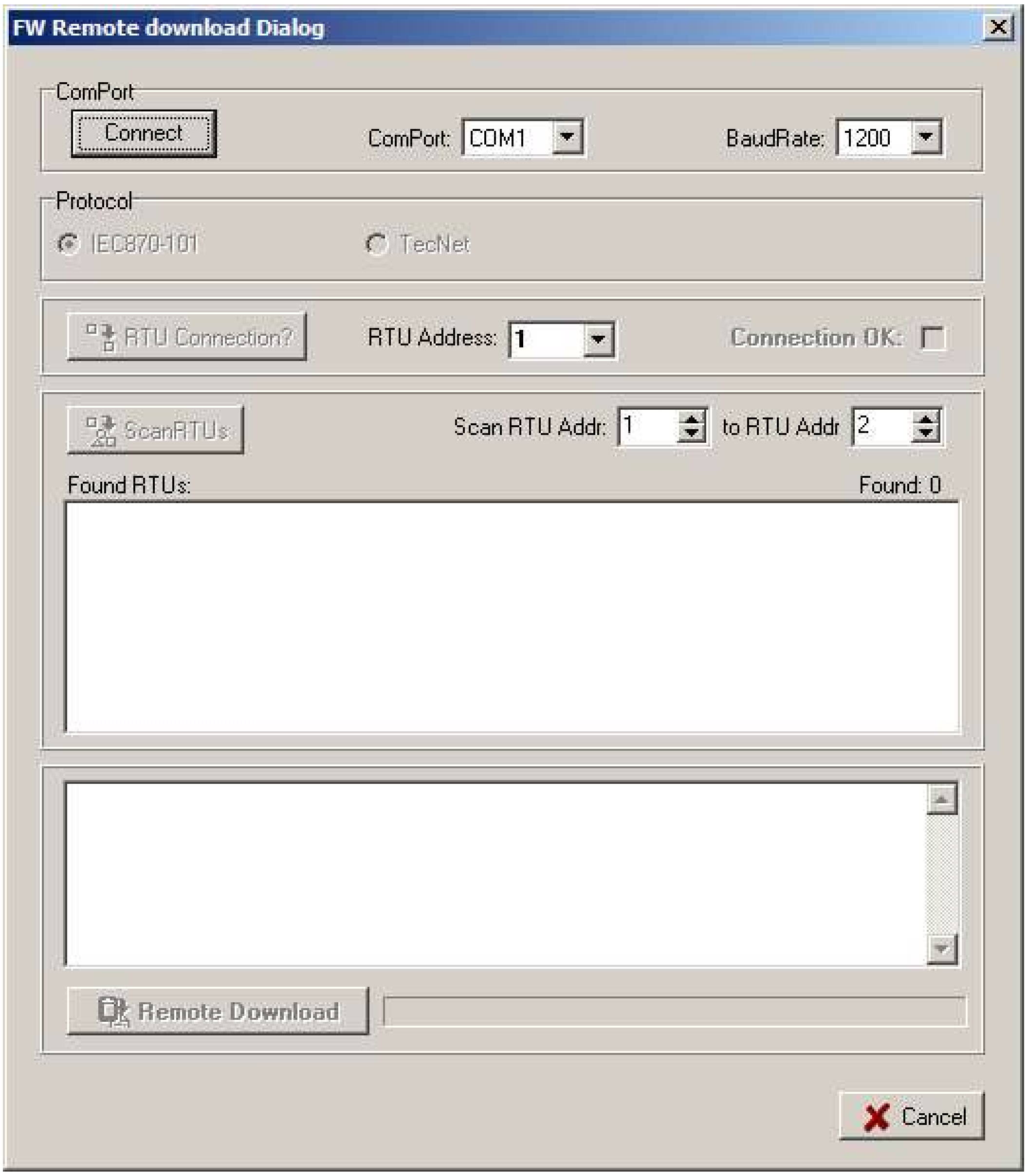


Figure 28. Additional settings for remote download.

Select the communication port. If a single IPC is to be reprogrammed, choose the *RTU* link *Address*. Verify the connection by pressing *RTU Connection*. If the IPC link address is unknown or multiple units are to be programmed, scan for all connected IPCs/RTUs. The found RTUs will appear with a checkbox under Found RTUs. It is possible to deselect specific RTUs by clicking their associated checkboxes.

Press *Remote Download*. The list box above the *Remote Download* button and the bar to the right shows information about the download process.

7 Ethernet and IEC 60870-5-104 Configuration (IPC4012)

This section applies to IPC4012 only. A separate tool, Protrol Settings and Config Tool 2, is available to configure the IPC4012 Top Printed Circuit Board, which is the IEC 60870-5-104 interface. All IEC 60870-5-104 configuration is done by accessing the IPC4012 unit using the service address. If locally accessed using an Ethernet cable only, a cross-over cable is necessary unless the Ethernet interface of the service computer is auto-MDI-X. If a switch is connected in between the service computer and the IPC unit, the cross-over functionality is resolved by the switch.

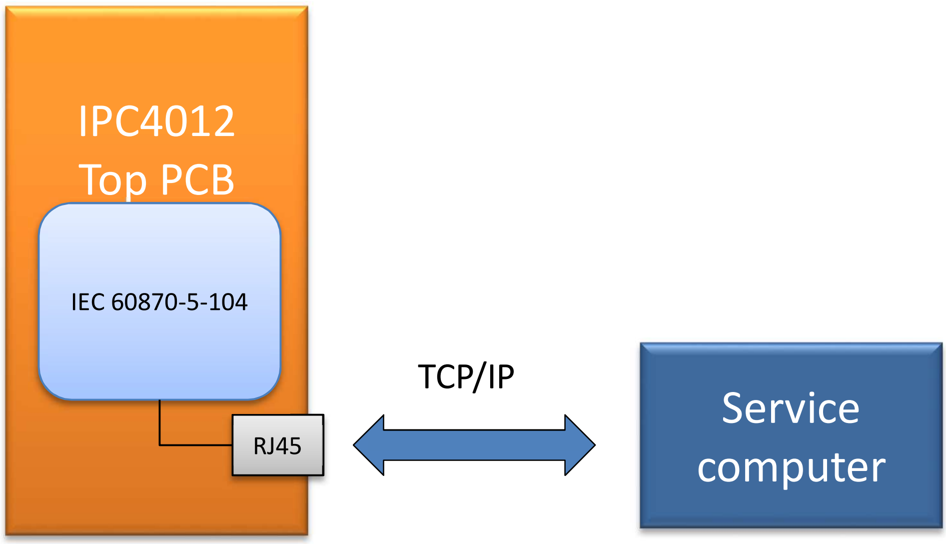


Figure 29. Settings are adjusted by connecting an Ethernet cable between the service computer and the IPC4012.

IPC4012 requires a unit specific IP address, and can be configured to communicate with up to four alternative devices with unique IP addresses. For communication between the service computer and the IPC, their IP addresses must match the settings in the IPC and in the service tools listed above.

The IP address of the service computer must match that of one of the four devices that are defined in the IPC4012 unit. Changing the IP address of the service computer is not described in details in this document. The *Fourth destination address* is default for service operations.

7.1 Protrol Settings and Config Tool 2

It is possible to edit and transfer settings to the target IPC using a stand-alone tool for Windows. This tool is used for basic configuration and allows the user to download/upload communication settings to/from an IPC4012, and to save and load this information to/from disk. A screenshot of the configuration tool with factory settings is shown in Figure 30.

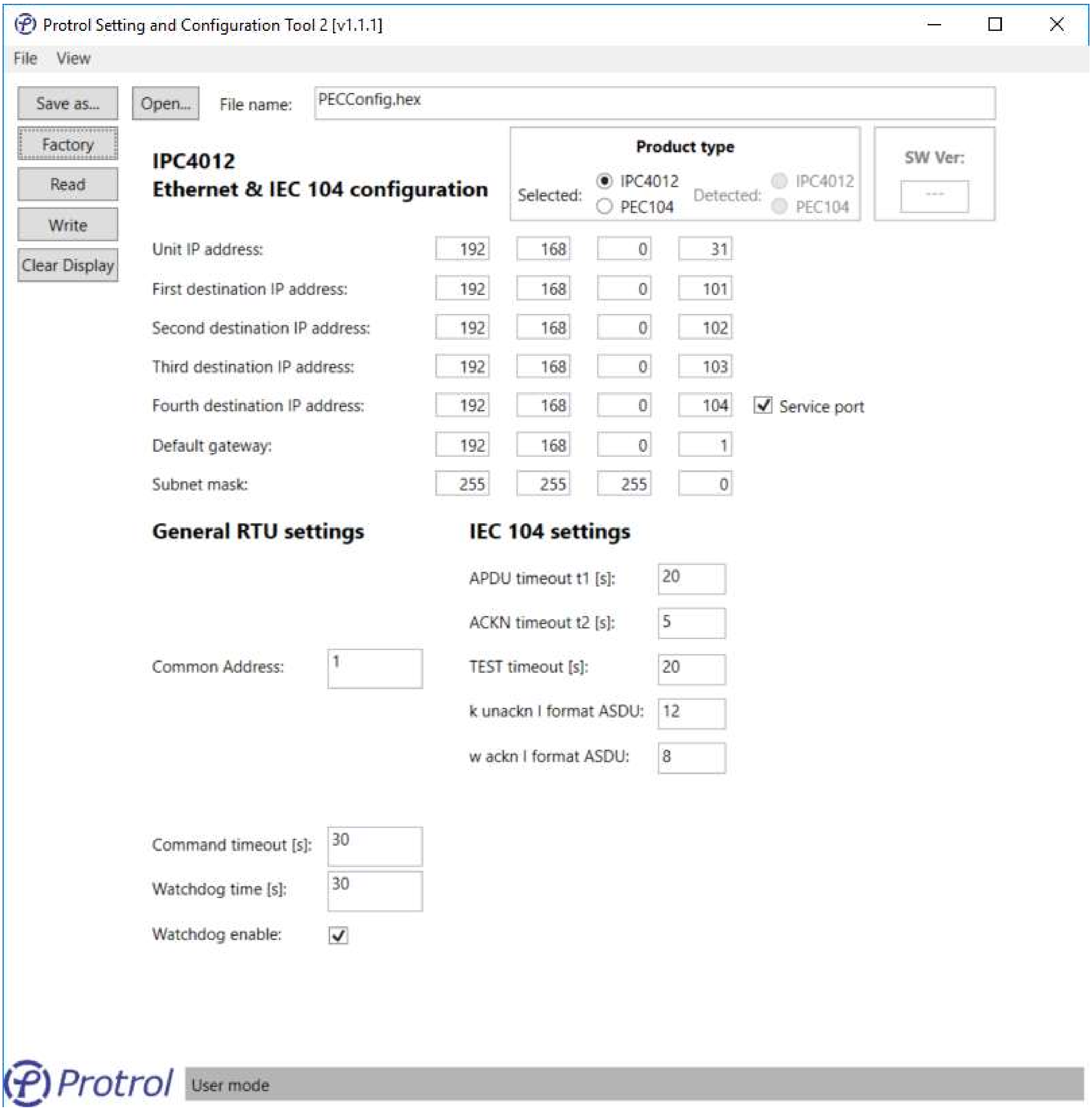


Figure 30. The Protrol Settings and Config Tool 2 with factory settings.

Clear Display

It is possible to clear all settings in the configuration tool by pressing the *Clear Display* button.

Factory Defaults

It is possible to reset all settings in the configuration tool to factory defaults by pressing the *Factory* button.

Open Configuration File

Previously saved settings can be reloaded to the configuration tool by pressing the *Open* button. A dialog opens and it is possible to browse and choose the desired configuration file. Press *Open* to read the file.

Edit Configuration Data

After the *Factory* or *Open* buttons have been pressed it is possible to adjust configuration data. Please note that the First, Second and Third IP address uses port 2404 (IEC60870-5-104 port) only, and that the default port value of the Fourth address is 23 (Service port).

Save Configuration File

The current settings can be save by pressing the *Save* button. A dialog opens and it is possible to adjust the file name before *Save* is pressed a second time.

Communication Settings

It is possible to use the configuration tool to edit settings offline, but before writing- and reading files to/from the IPC the communication settings must match those of the IPC. Each IPC is delivered with factory settings, unless otherwise has been agreed upon order. This means that the original IP address of the IPC is 192.168.0.31 (*Unit IP address*).

Before contact with the IPC can be established the IP settings of the service computer that is used for changes must match those of the IPC. When using factory settings, this means that the service computer shall have IP settings 192.168.0.104.

Choose *View -> Read/Write settings* to edit the current IP address of the IPC4012, see Figure 31. Please note that this only applies to the tool – changing the IP address of the IPC requires that configuration is written to the device, see section below. Also, choose which *Port* that will be used. There are two port options available:

- 23 – Service port
- 2404 – IEC60870-5-104 port

The default port is 23 (*Service port*).

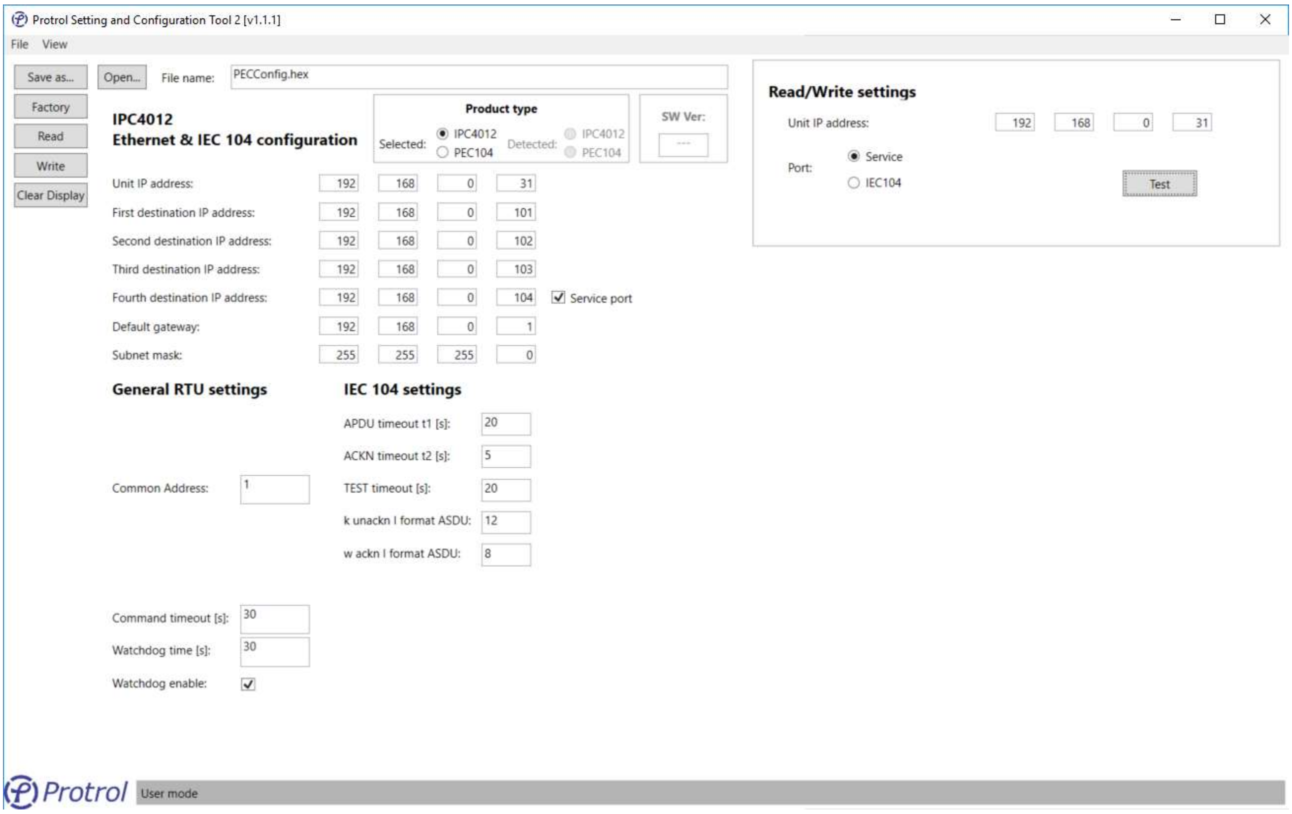


Figure 31. The Read/Write settings must match the IPC unit. Choose View -> Read/Write settings to edit these settings.

Finally, press *Test* to establish contact with the connected IPC. If there is no response, the efforts to contact the IPC will be interrupted after approximately two minutes. In such case, verify that the units are physically connected, that Ethernet has link and that the IP addresses match. Please note that if the computer has several Ethernet interfaces it is advisable that all connections are closed.

Read Configuration from IPC

The current settings of the connected IPC can be upload to the Configuration tool by pressing the *Read* button. The unit should identify itself as an IPC4012. This is controlled by the dip switches described in the end of this chapter. Dip switch 7 in position ON and dip switch 8 in position OFF means IPC4012.

Write Configuration to IPC

When the Configuration tool displays the desired settings, they can be downloaded into the selected IPC. This is performed by pressing the *Write* button. A confirmation is displayed if the settings have been changed successfully.

Base settings for the Main Printed Circuit Board

The basic settings for IEC 60870-5-104 for the Main Printed Circuit Board are highlighted in red in Figure 32. Normally, these parameters are set before delivery and should not need to be adjusted. An exception is the Common address, which needs to be specified. Also, the Link address shall be equal to the least significant octet of the Common address.

Example:

Common address: 10000 = 2710h => Least significant octet: 10h = 16 => Link address = 16

The Main PCB settings require that Protrol-Tool is connected and Protocol Configuration is chosen.

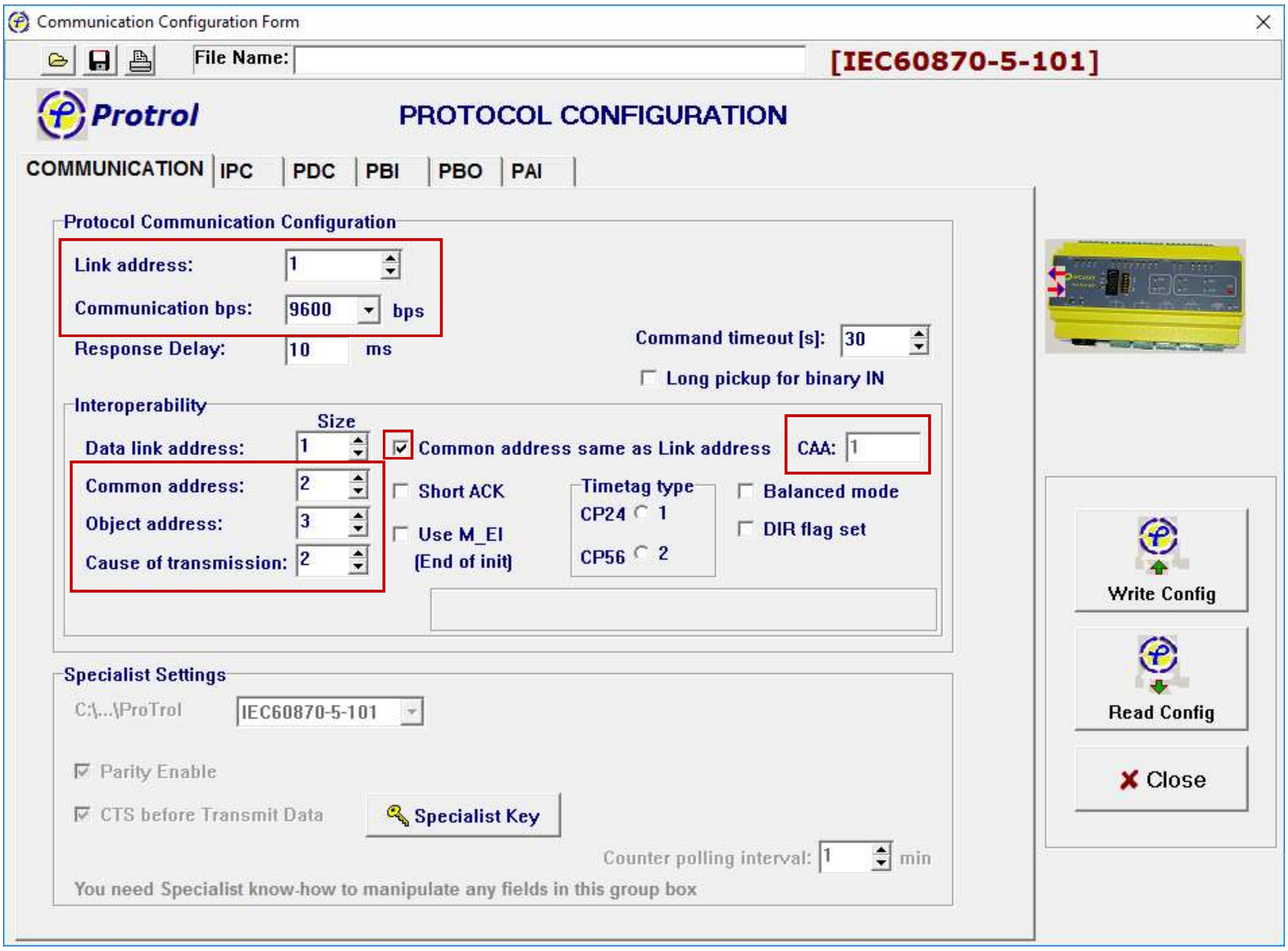


Figure 32. Basic settings for the Main Printed Circuit Board when using IEC 60870-5-104, highlighted in red.

Download Configuration to IPC using Factory settings of the device

If the user cannot establish communication with the IPC4012, factory settings must be used.

This means that the IPC unit is forced into a state with known communication parameters. If the Configuration tool uses factory settings, it is possible to download a new configuration. To set the IPC in factory settings mode, follow these steps.

1. Follow the recommendations in Section 3.
2. Switch off power to the IPC.
3. Dismount the cover of the IPC by pressing the two locks at the short ends.
4. Carefully remove the IPC4012 Top Circuit Board.
5. Turn the board upside down set dip switch position 1 (see Figure 5) to ON. The unit now uses factory settings.
6. Put the IPC4012 Top Circuit Board back in position.

Return to the Protrol IEC-104 Configuration and press the *Factory* and *Test* buttons. Verify that the Configuration tool establishes connection with the IPC. It is now possible to edit and transfer new configuration data to the IPC according to previous sections.

When the IPC unit has been reconfigured, the Top Circuit Board must be set to use station specific settings. Repeat the steps above and reset the left dip switch position 1 to OFF. Reassemble, reconnect and power on the IPC and verify that it communicates with the new settings.

8 Testing and Commissioning of IPC

Before taking an IPC into operation it can be tested either in off site or installed in the station. An IPC can be tested with a single current source for both overcurrent and earth fault functions.

8.1 Binary I/O

Test of Binary Inputs

Apply a test voltage to the binary inputs and verify that the IPC detects the signal and transmits them to the dispatch centre.

Test of Binary Outputs

Verify that signals from the dispatch centre are received by the IPC and that the correct output relays close. Use the Site Manager to test the outputs locally.

8.2 Current Injection Test

Test circuit

Connect the current source to phases A and B (or any other combination of two phases) according to Figure 33. Apply a current of 0.5 A. The measured sum of the phases shall now be zero. Verify with the built-in transient fault recorder of Protrol-Tool. See section below for details.

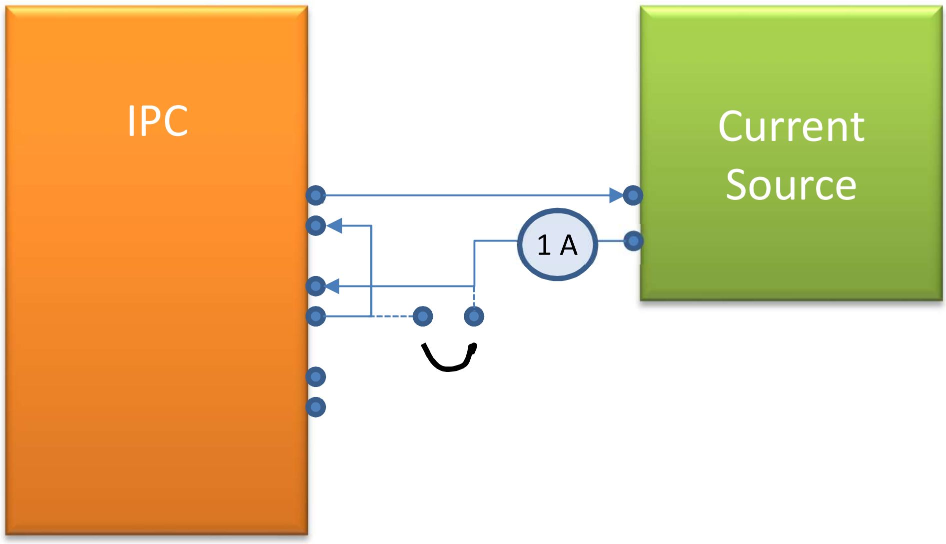


Figure 33. Current injection test.

Overcurrent Test

Increase the current of the current source until overcurrent is detected. This is indicated by the OC LED and the output relay will close for the set time, if applicable. Note: If an input is used to release the output signal this input must be set high.

Verify that the OC Start and Trip signals are transferred to the dispatch center.

Earth Fault Test

Put a short circuit over one of the phases according to the drawing above using a **short** test cord. The current in the short circuit will simulate the measured earth current, and needs to be applied longer than the set *Operation Delay*. Earth fault detection is indicated by the EF LED and closing of the output relay, if applicable. If connected to a PC, check the transient fault record using Protrol-Tool.

A typical recording from an earth fault test is shown in Figure 34.

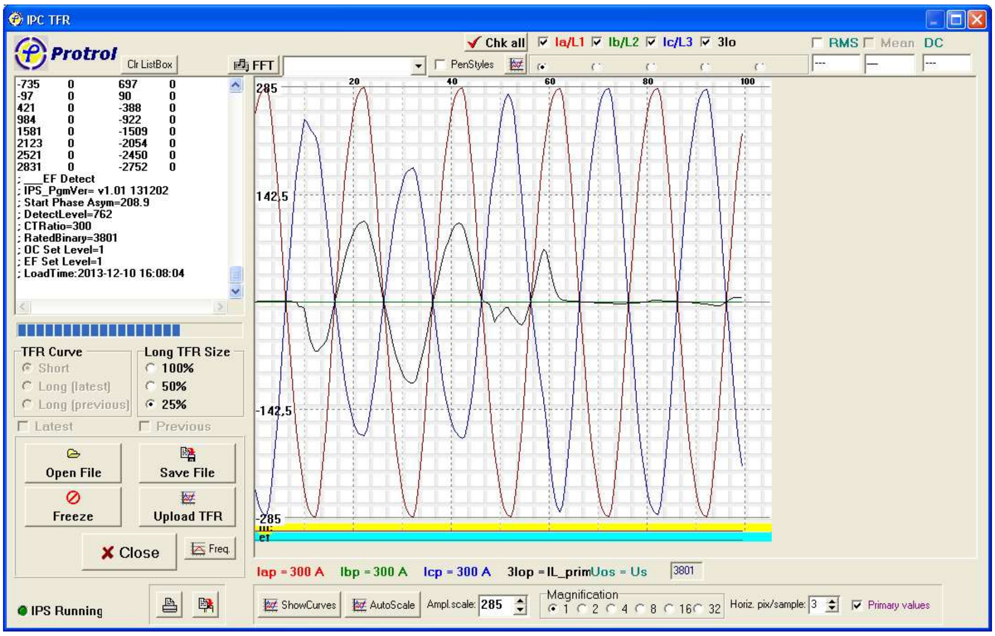


Figure 34. Typical transient fault recording after an earth fault test.

Verify that the EF Start and Trip signals are transferred to the dispatch center.

8.3 EF Trig Level Check

After connection to the current transformers, verify that the EF LED does not flicker vaguely. This indicates that the *EF Trig Level* may be set too low.

8.4 Test of IPC after Commissioning

Testing of earth fault detection is possible by simply short circuiting one of the three phases directly on the input terminal. Disconnect the output relay to avoid any unwanted actions. There must be a primary current (at least a few Amperes) in all three phases.

Protrol AB, Ullevigatan 19, 411 40 Göteborg

Tel: 031-45 82 00. E-post: info@protrol.se

www.protrol.se