



## IPC40x0 operation manual



The IPC40x0 is a secondary substation fault detector with RTU functionality and a Soft PLC option. All settings and configurations are done through the software “Protrol\_Tool”.

## Table of contents

1	Hardware.....	3
1.1	External screw termination interfaces.....	3
	The IPC40x0 basic PCB ver. 2.01 .....	3
1.2	Hardware jumpers on IPC40x0 basic PCB .....	4
	The IPC40x0 basic PCB ver. 2.01 .....	4
1.3	The HMI RS485 modem.....	5
	The IPC40x0 top card ver. 2.02 .....	5
1.4	The IPC40x0 HMI .....	6
1.5	USB communication connector .....	6
2	IPC40x0 Toolbox.....	7
2.1	IPC Transient Fault Recorder .....	8
	File handling .....	9
2.2	IPC Detector Settings.....	10
	Value scaling.....	11
	Over current detection.....	11
	Earth fault detection.....	11
	Acknowledgement .....	12
	Texts.....	12
	Version information .....	12
	Temperature .....	12
	Time .....	13
	Read and write settings .....	13
	File Save and File Open.....	13
2.3	Protocol configuration .....	14
	Communication.....	14
	Protocol configuration .....	15
	Read and write the configuration.....	15
2.4	Site Manager .....	17
2.5	Documentation.....	19
2.6	FirmWare download .....	21

# 1 Hardware

## 1.1 External screw termination interfaces

### The IPC40x0 basic PCB ver. 2.01

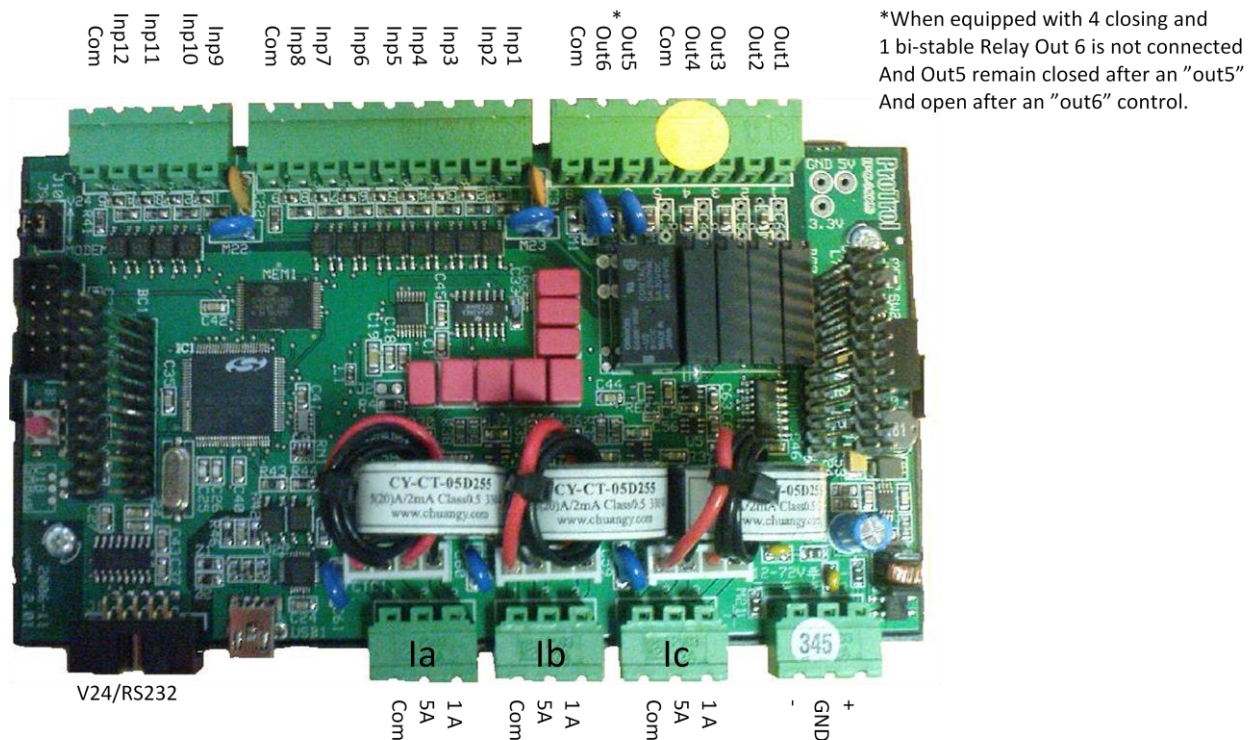


Fig. 1.1 IPC40x0 Basic I/O

- STOP** When connecting and disconnecting the current terminals always short-circuit the current path to avoid open circuits!
- STOP** 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 IPC40x0 should either be switched off or the earth fault detection should temporarily be disabled. *On the other hand 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.*

## 1.2 Hardware jumpers on IPC40x0 basic PCB

### The IPC40x0 basic PCB ver. 2.01

On this board there are only 2 jumpers (J9 and J10). These are for selecting whether the primary protocol communication line should be directed to the top card modem or to the IDC\_10 connector J1 (V24/RS232).

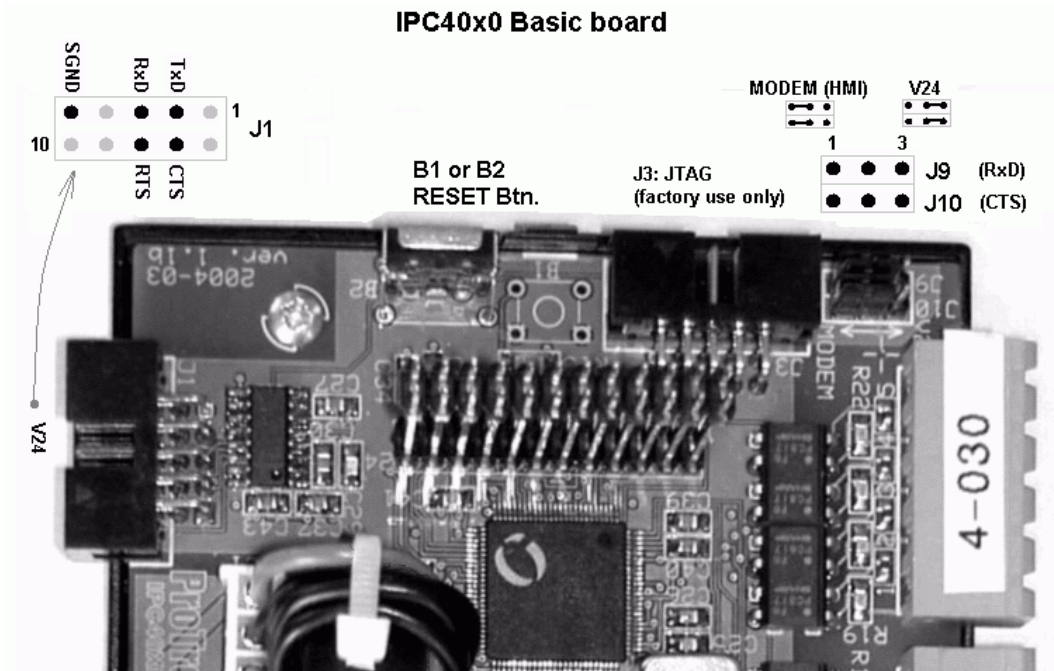


Fig. 1.2 Jumpers on the IPC40x0 Basic PCB

When the **J9** and **J10** are connected to the top card modem [between 1 and 2], the TxD (the transmitted data from the IPC40x0) is also available at the V24 **J1** connector. The **J1** V24/RS232 port TxD can be used if one wants to listen to protocol messages sent by the IPC40x0 to the Master. When the **J9** and **J10** are connected between 2 and 3 the communication is directed to J1 (V24/RS232). When the top modem can't be used the IPC40x0 can communicate through any modem connected to **J1**. The V24/RS232 port uses the handshake signals RTS and CTS. Upon a protocol request expecting an answer from IPC40x0 the RTS is enabled prior to transmission and the reply telegram is not sent before the CTS is enabled by the modem. If the RTS and CTS are not used they have to be connected to each other in the cable. If the modem has a known transmit activation time the response can be delayed by selecting an appropriate "Response Delay" in "Protrol\_Tool/Protocol Configuration". When using the top card modem which is instantaneously fast it is a good advice to have at least a Response Delay of approximately 20 ms because most Gateways are slow in switching between transmit and receive.

## 1.3 The HMI RS485 modem

### The IPC40x0 top card ver. 2.02

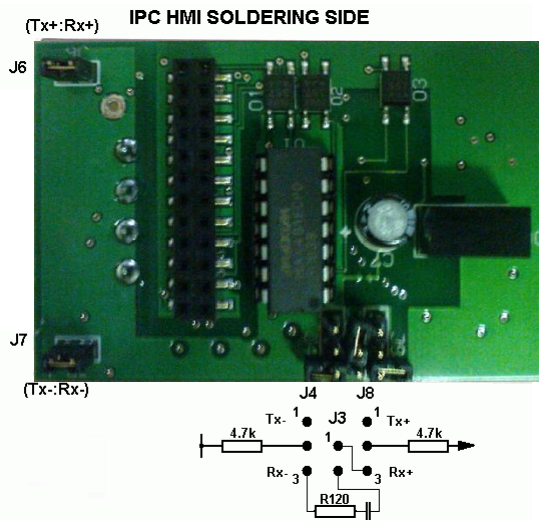


Fig. 1.3 Jumpers on the bottom side of the HMI RS485 board

How should the RS485 modem be terminated?

The pull-up and pull-down resistors connected to pin 2 on **J4** and **J8** should be connected to avoid an undefined state on the communication wire. This is of importance when there is no transmitter “owning” the line as for example in a half-duplex situation when the “owner” is changing all the time. When an “owner” leaves the line to someone else there is normally a short time where the line is “floating” and having an undefined state. However, as a general assumption one can say that:

#### 2-wire connection (J6 and J7 connected)

1 IPC + ~10% of the connected IPCs should be terminated **J4** and **J8 1:2**. As a thumb rule one can set the corresponding jumpers in the master modem and the most remote IPC40x0.

#### 4-wire connection (J6 and J7 open)

1 IPC + ~10% of the connected IPCs should be terminated **J4** and **J8 1:2** (TxD)

1 IPC + ~10% of the connected IPCs should be terminated **J4** and **J8 3:2** (RxD)

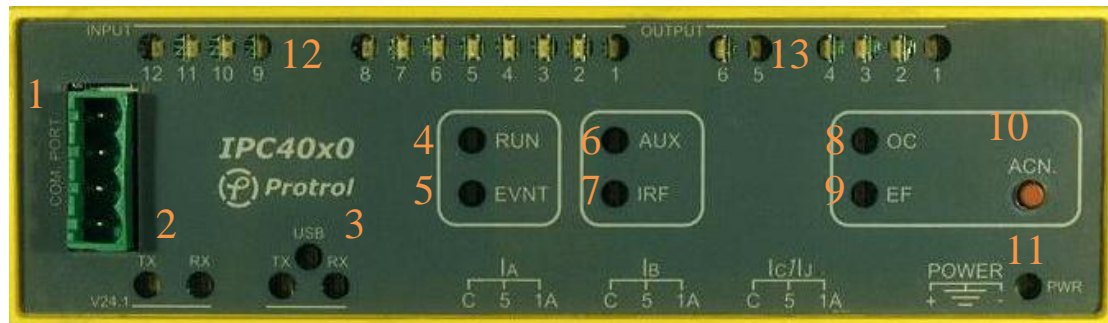
As a thumb rule one can set the corresponding jumpers in the master modem and the most remote IPC40x0.

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



## 1.4 The IPC40x0 HMI

The IPC Human Machine Interface comprises Light Emitting Diodes (LED) and an acknowledge button.



1. RS485 communication port
2. Transmit and receive data for protocol communication
3. Transmit and receive data for service communication via USB
4. RUN is a ½ Hertz flashing LED showing correct operation
5. EVNT LED showing that there is a protocol message pending
6. AUX LED is free for use in IPC4020 Soft PLC
7. IRF LED is showing internal errors or that the IPC is not configured.
8. OC LED is showing an unacknowledged over current detection
9. EF LED is showing an unacknowledged earth fault detection
10. Acknowledge button for OC and EF LED's
11. PWR indicates internal power
12. Green indication LED's for binary inputs
13. Yellow indication LED's for control relay outputs

## 1.5 USB communication connector

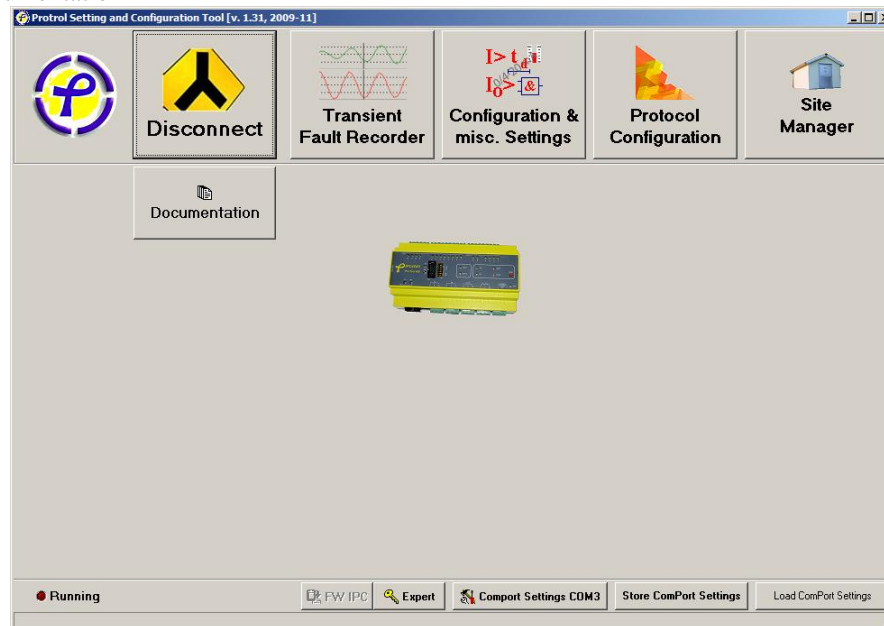
The USB connector is used together with Protrol\_Tool. This is a service port for:

- Setting the detector
- Configure the protocol
- Upload and inspect TFR
- Installing IPC40x0 on site (Site Manager)
- Local and remote firmware update
- Documentation of settings on site in a catalogue structure with document title copied from the Site name

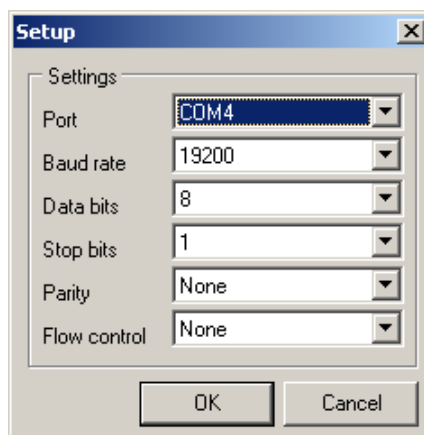
## 2 IPC40x0 Toolbox

The toolbox contains six major services:



- TFR, Transient Fault Recorder
- Setting dialog for the detector
- Configuration dialog for the protocol objects and blocks
- Site Manager for commissioning
- Firmware update
- Documentation



Connect the USB cable between the USB mini connector on bottom of the IPC40x0 and a USB-port on your PC/Laptop. Before using the USB-connection the USB-driver must be installed in your computer. When starting the Toolbox the first time, check that the COM-port settings are correct! They should be set as follows:

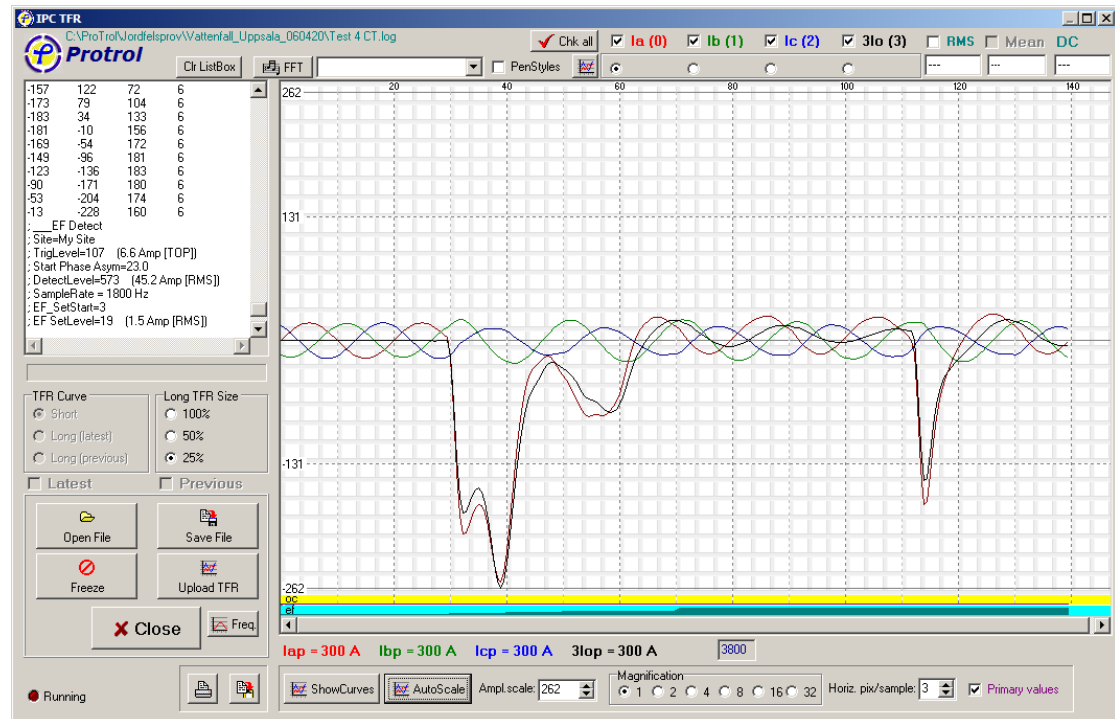


**Note: Select an available port on your PC!**


Press the OK-button and then try to connect by pressing the Connect button. If the dialog LED  **Running** is flashing, the connection has been established. The first time the Protrol\_Tool is running on a computer, the settings can be stored in the Registry by pressing the  button. Next time the Protrol\_Tool is started the selected COM-port is opened automatically.




## 2.1 IPC Transient Fault Recorder

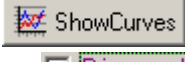
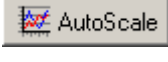


If the IPC4010 detector has “seen” a fault, the TFR for the last faults are stored and

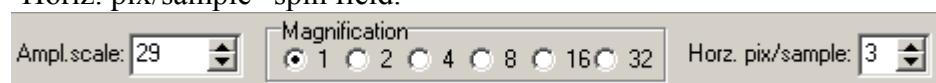
can be uploaded by pressing the  button. By default this button is referred to the short TFR which covers 7 power frequency cycles. By another selection in the “radio group TFR Curve” the latest 2 long curves can be uploaded. A long curve is 2 seconds with approximately 60 ms prefault. If less than 2 seconds is of interest it is also possible to select 1 or 0.5 seconds TFR length. It is also possible to take a



snapshot of the actual load currents by pressing the  button and the “Upload TFR” button. The Freeze button does not work if the IPC is not **acknowledged**! Notice the scroll box to the left containing the samples as a numerical list. The scroll box also contains information of the time when the TFR was captured, the cause of the TFR, “trip” levels etc. The scroll box can also be used to add additional observations or notes by starting each row with a “;”.

By pressing the  or  button the TFR data will be displayed in the graph. If the ☒ **Primary values** is checked the curves are scaled to primary values, else they are pure binary values.

If AutoScale is not pressed the amplitude scale can be selected arbitrarily by changing the amplitude scale spin editor field below. The time axis can change by changing the “Horiz. pix/sample” spin field.





It is possible to “trace” each single curve. Select curve with the radio buttons above the graph, by pushing the left mouse button on the graph and drag the cursor along the time axis (horizontally). Each sample value is displayed numerically together with the time tag in the upper right corner of the dialog. If the RMS checkbox is checked the corresponding RMS value for one cycle ahead of the cursor is shown underlined in the numerical field.

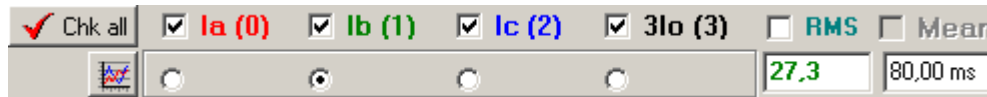
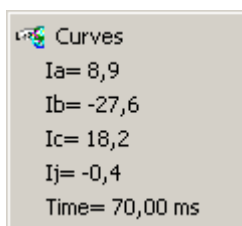
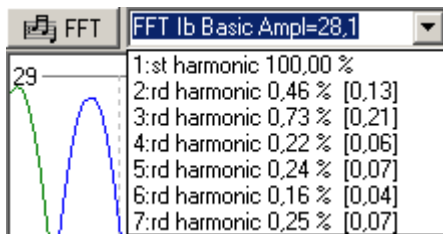


Fig 2.1 Checkboxes and radio buttons for various graphical display options.

If, instead, the right mouse button is pressed on the graph, each sample value is displayed as a popup menu:



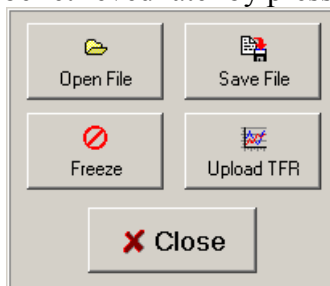
The harmonic analyzer is located in the upper left corner of the graph. By pressing the FFT button, frequencies up to the 7th harmonic are calculated using the data from the entire selected curve. The harmonics for the example where Ib(1) is selected will be displayed if the combo box is dropped down:



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

## File handling

When uploading 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.





## 2.2 IPC Detector Settings

IPC Setting Form

File Name: \_\_\_\_\_ 09-12-15 18:29:42

**IPC40x0 Setting Tool** IPC40x0 timer: 04-01-01 01:12:26

Site: **My Site** Events: \_\_\_\_\_

**Detector CT Configuration**

Ia: ..... Primary Current Ib: ..... 150 A Ic / Ij: ..... Ic Ij 150 A

**Detector Settings**

OCD Enabled ☐ EFD Enabled ☒

OC Level: 150 A [RMS] EF Level: 1.0 A [RMS]

Op. Delay: 0.30 sec. Op. Delay: 0.10 sec.

Event Delay: 0.0 sec. Event Delay: 0.0 sec.

Inp. qualificate: non Inp. qualificate: non

OC Trip Relay: non EF Trip Relay: non

☐ Ij (Re)Close: 5.0 A [RMS]

Auto. ackn. after 0 hours

☐ Auto. acknowledgement

☐ Short Auto ackn.

**Specialist Key**

Free Text:  
Copyright ProTrol AB, Sweden +46-(0)31-45 82 00

Protocol Ver: 1.5 IEC101  
Detector Ver: 2.21 091117  
Soft PLC Ver: -

Temperature: 25.4 °C

Programming Log:  
50,2564  
51,0  
52,150  
53,150

? Help

Set IPC time

Template

Write Settings

Read Settings

Close

When connected to an IPC4010 / 4020 the information stored in the IPC is uploaded to the dialog when the “Detector Settings”-button is pressed on the main tool menu. Note, 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 figure in the upper right corner to check the communication status:

Service communication Ok:




Service communication error:



## Value scaling

To be able to “think” in primary values these should be set first. As the current terminations are either 1 or 5 Amp and both relate to the rated current it is only necessary to fill in the primary rated current. **From now on, values are primary values!**

The detector uses 3 currents which are Ia, Ib and Ic or Ij. If the measurement is carried out by 2 phase currents and the residual current Ij the proper radio button should be selected. The default measuring method is 3 phase currents . 


**OCD Enabled** ☐ **EFD Enabled** ☐

The OC and EF detector can both be enabled or disabled by the checkbox in the detector setting panel.

## Over current detection

The over current setting level is based on steady state RMS current values. A tool tip text is shown when the mouse pointer is placed above the value field. The setting range is up to 2.5 times the rated current. The duration is the time for which the fault current must be above the setting level after a start. The event delay is the time for which the detector “signal” should be remembered before it is “shown” for the communication protocol. If the detector has recognized an over current, the signal will be hidden during the event delay time. When the event delay has elapsed the “signal” will be “displayed” to the protocol if the input qualification is “none”. If not “none” the corresponding digital input will be tested and if “high” the detection “signal” will be “displayed” to the protocol. At the same time as being “displayed” to the protocol the OC Trip Relay is tested. If an output is selected the corresponding output relay will be closed for 1 second.

## Earth fault detection

The earth fault settings are very similar to the over current settings. The EF level is selected with respect to the grounding and expected current levels for earth faults with a fault resistance. The value is based on steady state RMS levels. The value will also be used as a “trig” value (default:  $\sqrt{2}$  of the RMS value) which initiate the “starting stage” of the EF detector. In the start stage the detector calculates if there is a fault, or in other words, if the detector is situated between the transformer and the fault location. Tip: If the set value is too low this will be indicated by the EF LED which will “flash” with a weak light when the detector is triggered. This type of frequent triggering indicates that the setting level should be increased. One can inspect and verify trigs in the TFR by pressing the  button and then upload the TFR.

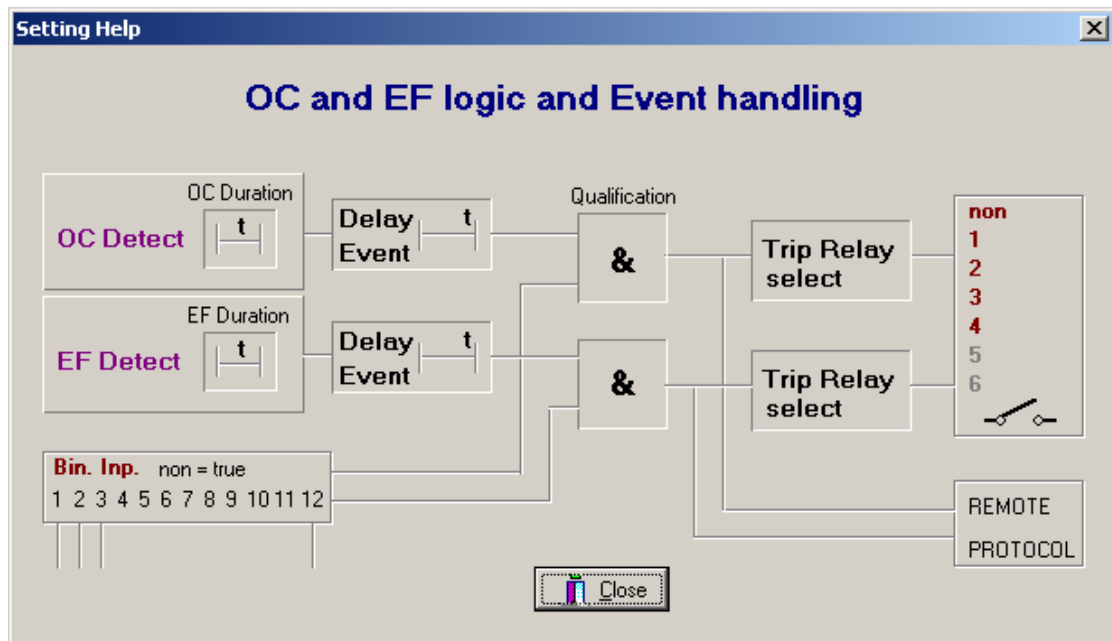


As seen in the “bar” above there is an “ef” trig which will last about half a cycle before it is released. One spurious trig is not a key issue, but if it happens frequently the setting is too sensitive. With the specialist authority it is possible to manipulate the trig level separately from the RMS setting. Contact your supplier to receive a specialist key code!

  
**Specialist Key**

The duration setting is the time between the start and when the steady state residual current (3Io) is checked. Normally there is no requirement to utilize a long duration time (after the start requirement has been fulfilled). The residual current must be present before the internal “EF signal” is enabled. If the EF detector has noticed an earth fault it will proceed in the same way with input qualification and EF Trip Relay as for the OC detection.

There is a Help button which displays the logic for the detectors:



## Acknowledgement

Acknowledgement with the physical “ACN”-button (on the front panel of the IPC) is selectable between push button acknowledge or acknowledge by push button / automatic acknowledge after the time set in hours in the spin editor.

## Texts

There are 2 text edit fields. The first field is the Site field where the physical location can be written with up to 30 characters. In the bottom of the dialog there is another edit field for free texts up to 80 characters.

## Version information

In the upper right corner of the dialog the respective programs executed in the IPC are displayed with version No. and date of creation.

## Temperature

The registered temperature inside the IPC is shown in the Temperature edit field. The value read from the IPC can be calibrated by writing the correct temperature and then check the checkbox to the left of the temperature before “Write Settings” is performed. The temperature displayed must not necessarily be from inside of the IPC, it could as well be a different temperature if there is some temperature relation to

where the IPC is located. Therefore it is possible to measure the temperature elsewhere and “program” this temperature by giving it a temperature offset.

## Time

Normally the time is set from the remote control, but it is possible to “copy” the PC time down to the IPC. The IPC-timer accuracy is  $\pm 30$  ppm. The IPC-time will be lost when the power is disconnected.

## Read and write settings

With these buttons the settings can be read from the IPC40x0 or written to the IPC40x0.



Pressing the Write Settings button activates a dialog where the setting transfer to the IPC must be confirmed to avoid mistakes. If successful, there will be a “happy” tone, otherwise there will be an “unhappy” tone in the PC speaker.



Pressing the Read Settings button reads the settings from the IPC. This button is automatically pressed when the setting dialog is opened. If successful, there will be a “happy” tone, otherwise there will be an “unhappy” tone in the PC speaker.

## File Save and File Open



The settings can be saved and retrieved from a file in IntelHex-format by pressing the top toolbar buttons. A **warning** must be expressed of using these possibilities as there are not just pure settings stored in the same information structure. The setting levels may be identical for different IPC:s, but the CT's or Site name etc. may differ. Saving the settings in IntelHex format makes it convenient for merging with code which is “burned” down to the micro processor flash memory before delivery.





## 2.3 Protocol configuration

An RTU (Remote Terminal Unit) and its protocol have to be configured before use. The basic configuration has to do with the serial communication enabling the RTU to have the same speed and data format as the master collecting information from the RTU. In addition, to be able to exchange information, the RTU normally have to be configured with “objects”, “blocks” or channels with unique identifiers which could be understood by the master system. These configurations will, though similarities, be different for each protocol. What is included in the configuration is dependent on the particular substation. When the Protrol\_Tool is connected to an IPC4000 - 4020 the information stored in the IPC is uploaded when the protocol configuration dialog is opened.

## Communication

### Communication speed

The speed is selectable amongst a number of different standard speeds expressed in bits per second.

Communication Bps:

## Response delay

Though the IPC can respond to a protocol question within a few milliseconds, the master is normally not able to apprehend a quick response as some time is required to change from “transmit” to “receive” mode. If the master is a PC or based on PC-hardware the communication circuitry normally requires some time to switch from “transmit” to “receive”. This time is at least the time required to transfer one character. For 1200 bps, 8 bit data, parity and one start and stop bit the transfer time is about 10 ms. The response delay in this case should be 10 ms with margin, say 20 ms. When the RS485-modem is used, no time is required to switch from “receiving data” to “transmitting data”. Other modems, as for example V23 needs about 30 ms to enable the pilot tone.

When using “slow” modems, connected to **J1** on the basic board, there is normally no need to set any delay when the modem hand shake is used. When the IPC wants to respond it always starts with setting the RTS hand shake signal high. The data transmission starts when it receives a CTS hand shake signal from the modem. If there is no useful CTS signal one can use the response delay as CTS-delay. In this case the CTS should be wired to RTS or disabled (not checked as described below). The response delay can be set in the range from 0 to 255 ms.

## Specialist Settings

Here it is possible to select protocol. The IPC40x0 can handle a number of SCADA protocols and the selection is done in the Driver Combo box.

## Parity and handshake

Protocols normally specify the parity and data format. However, some modems do not accept more than 8 bit data why an additional 9th parity bit cannot be used. It is therefore possible to override the protocol specification. This possibility should be used with care and is intended for future Protrol specific solutions.

The CTS requirement can be disabled if the CTS signal is not available. Manipulation of this handshake signal could be used together with the Response Delay time or in pure test situations when the IPC is connected directly to a PC COM-port. By default the IPC require high CTS to be able to respond to a protocol question.

## Protocol configuration

For detail information about configuration of the protocol reference to respective protocol description.

## Read and write the configuration

When the configuration is ready it can be written to the IPC and/or saved to a file.



Write the configuration to the IPC. The configuration is written to the IPC after a confirmation dialog. If successful there will be a “happy” tone, otherwise there will be an “unhappy” tone in the PC speaker.



Read the configuration from the IPC. This button has the same effect as when the configuration dialog is opened. If successful there will be a “happy” tone, otherwise there will be an “unhappy” tone in the PC speaker.

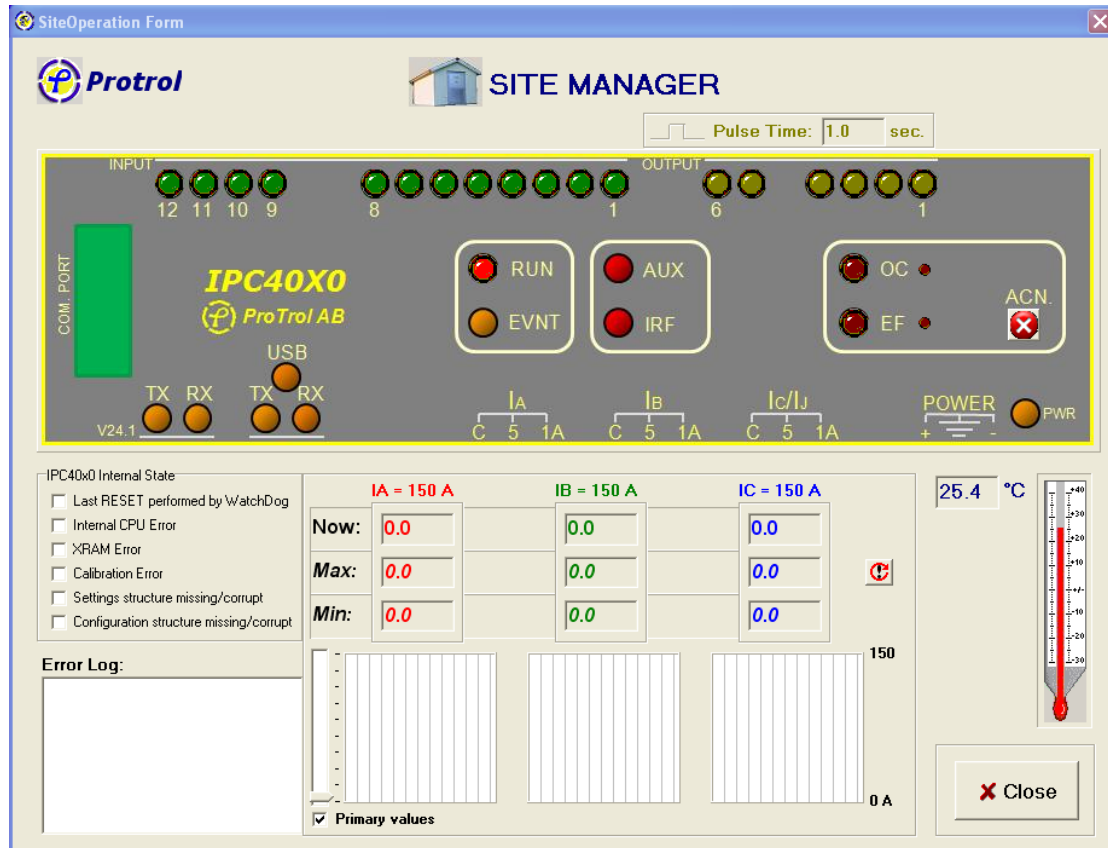


Open and save the configuration from or to a file. The configuration is stored in the same IntelHex format as the settings.



## 2.4 Site Manager

The commissioning process for an IPC40x0 incorporates both site erection and, communication and remote control integration. These steps are normally done at different locations. To facilitate this process the Protrol-Tool includes a “Site Manager” which is a pure local dialog from which the installation can be tested and verified locally.



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 Site Manager is very intuitive. The green LED's reflect the corresponding input signal in the same way as the front panel of the IPC40x0. The yellow LED's show the relay output but they also work as push buttons. When approaching the yellow buttons with the cursor it will change from an “arrow” to a “hand”, and the nearest button will lit in RED color.

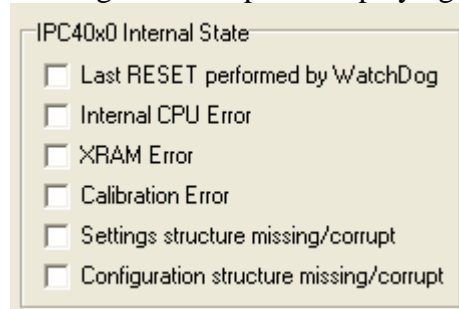


By pressing the left mouse button the corresponding output relay will close during the “pulse time” and the LED will switch to yellow bright.



## Internal state supervision

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

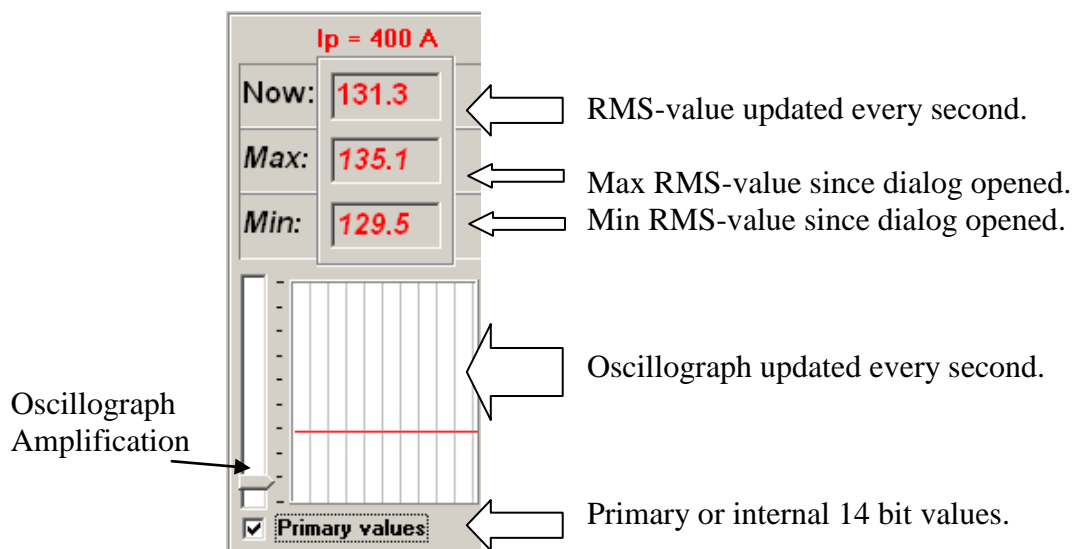


Normally none of the checkboxes should be checked. The possible errors are as follows:

- The software is hanging or not working properly as the Watchdog has made a reset.
- Internal CPU error can be many things but most likely it is a missing clock.
- XRAM error.
- Calibration of the analog inputs are needed
- The settings structure is missing or corrupt, the information in the setting dialog is not available to the IPC, and no detectors are available.
- The configuration structure is missing or corrupt and the protocol will not work properly.

## Analog values

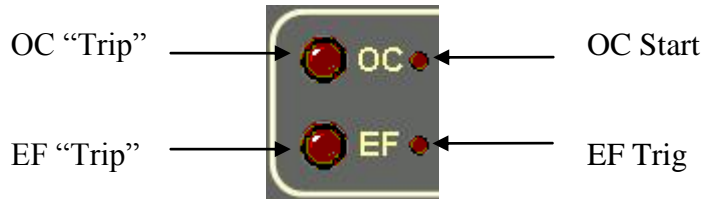
Analog values are displayed numerically or as RMS values updated every second in the tiny oscillograph connected to each analog channel.





## Detector

The Detector operation is displayed by 4 LED's. When the OC or EF detector is triggered/started the corresponding LED's lit with less brightness. This is difficult to show on the screen, therefore the "front panel" has a small diode to show if any detector attempts to start/trig.



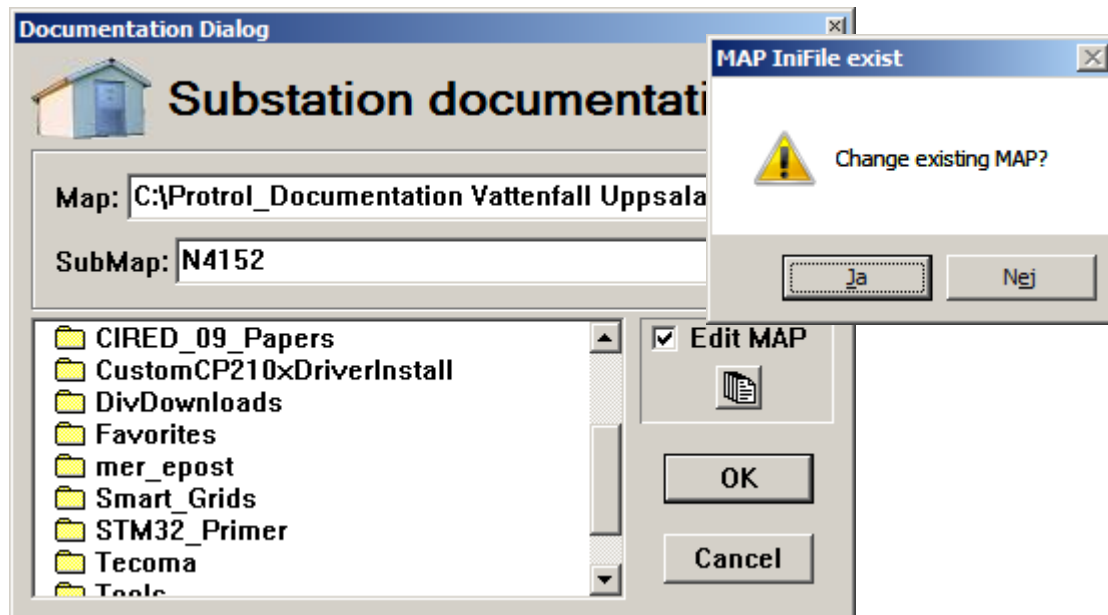
Clear max and min values:

Soft acknowledge button: (have the same function as the push button on the IPC)



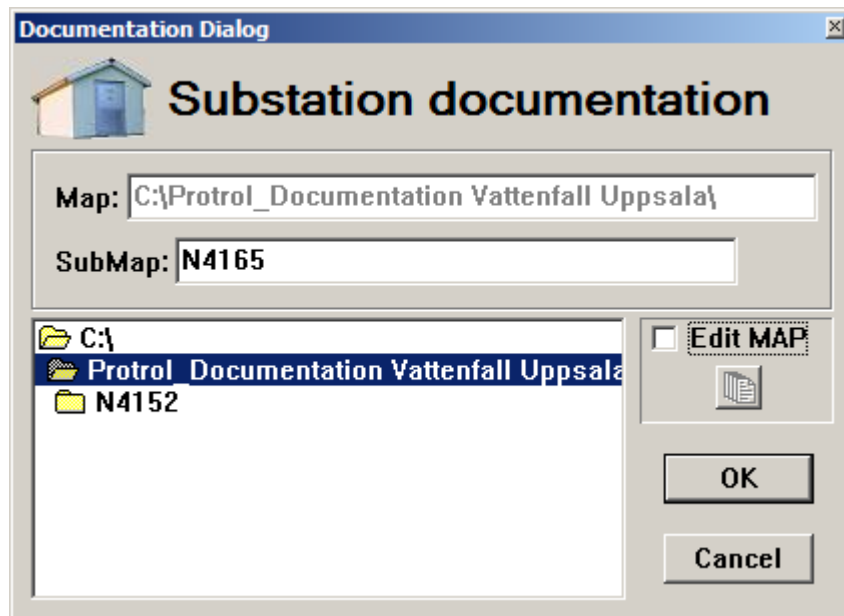
## 2.5 Documentation

In order to help organizing the documentation of a system with many IPC40x0 and/or PDC installed the tool has a function for this. First time used there is a possibility to decide the root catalogue name. Check the Edit MAP and press the button below.

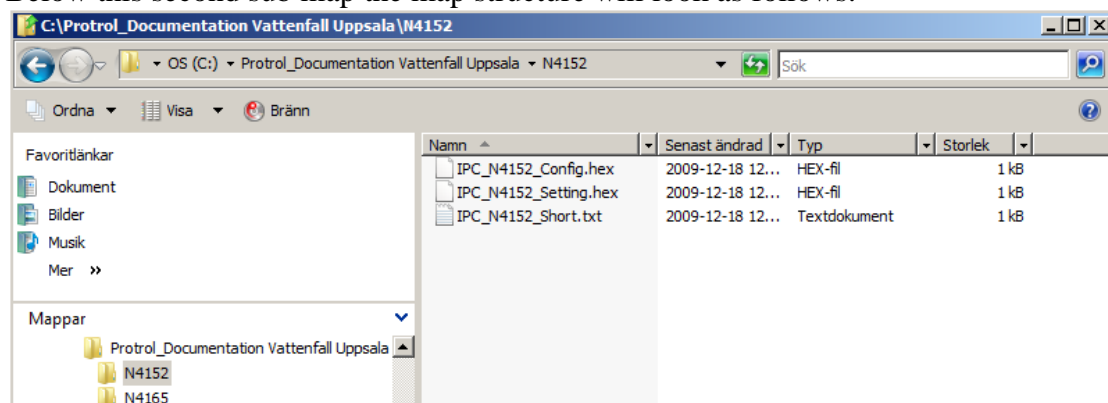


If the corresponding IniFile already exist, press "Yes" to the question "Change existing MAP". Now the Map edit line is available for change. The name in the Sub

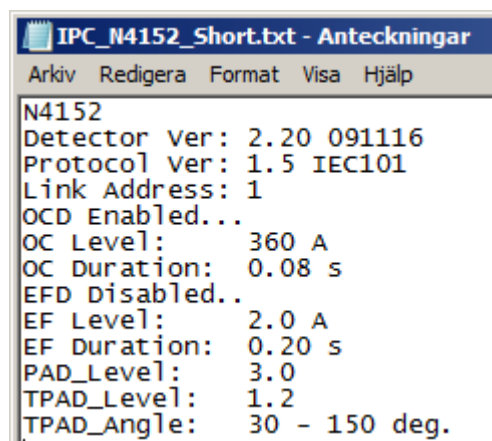
Map is read from the “Site” in the connected IPC40x0. When pressing OK in the Documentation Dialog the map and the sub map is created and the latter is filled with information read from the connected IPC. When the next IPC should be documented the file structure is already setup and the new site name is suggested as sub map.



Below this second sub map the map structure will look as follows:



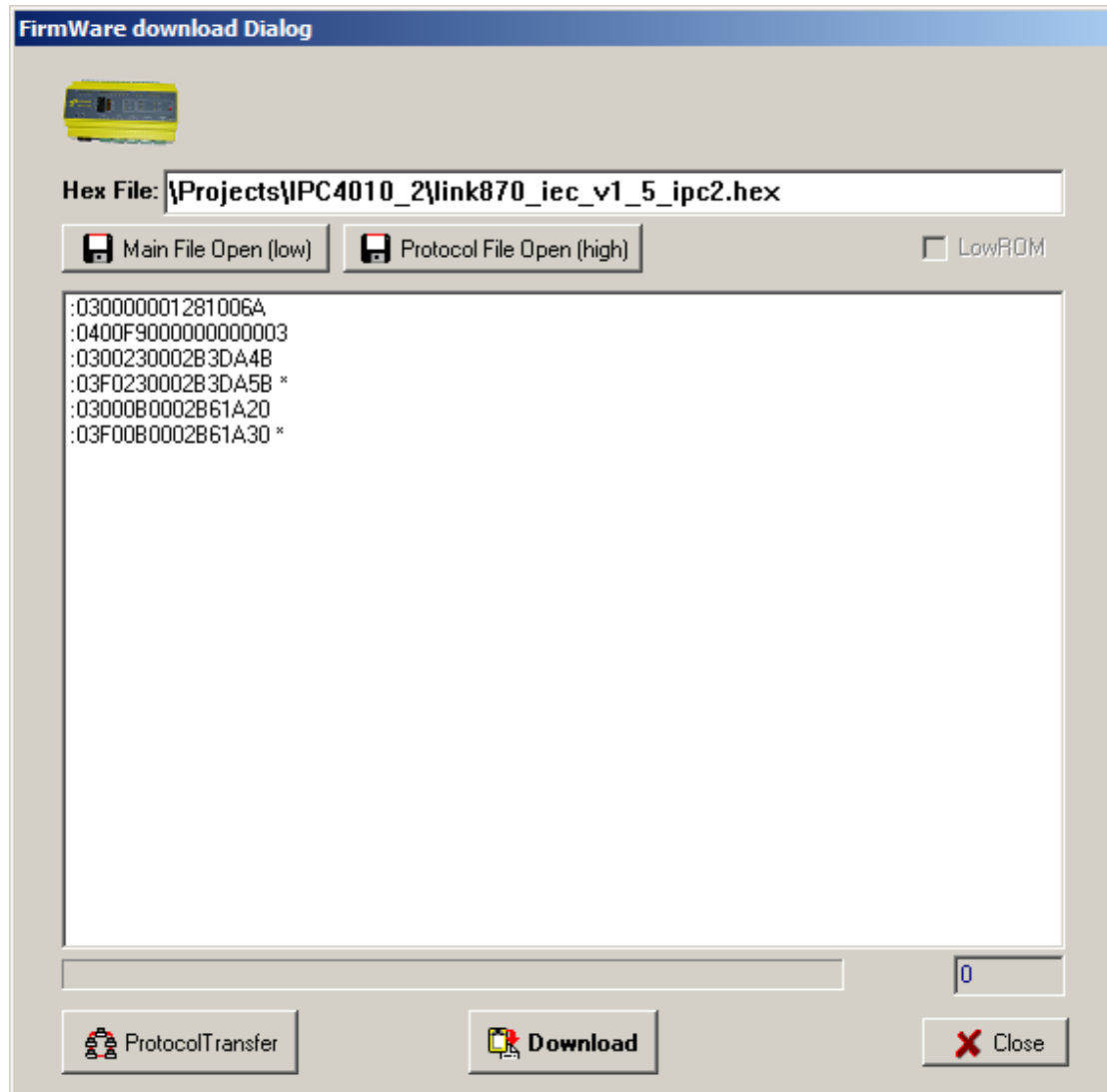
In each sub map the corresponding setting and configuration files are saved together with a text document with a fraction of the most important settings as for example:



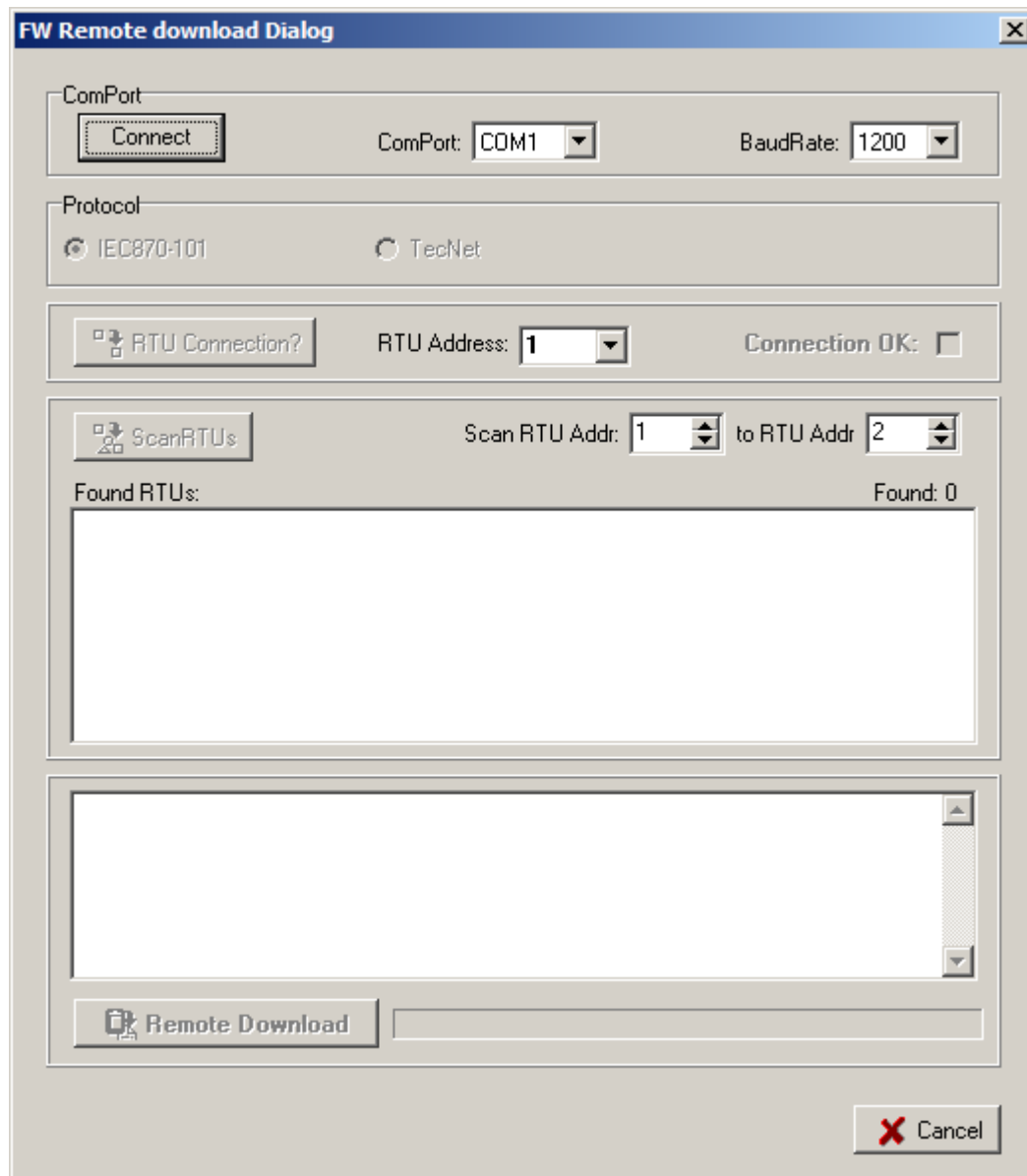


## 2.6 FirmWare download

This tool makes it possible to download new versions of firmware locally or remotely. To be able to do this the specialist key is required. The functionality will be described shortly here. The firmware in IPC40x0 consists of two “independent” programs, one is the Detector and RTU and the other is the Communication protocol. These can be updated/changed independently as shown in the dialog below:



When pressing the Download button the firmware is transferred to the connected IPC through the USB service port. In the situation where many IPCs are to be updated it is possible to do that by connecting the PC/Laptop to a modem and update all connected IPC40x0 at the same time by pressing the Protocol Transfer button. The dialog for protocol transfer is shown below:



The dialog box is titled "FW Remote download Dialog". It contains several sections:

- ComPort section:** Includes a "Connect" button, a "ComPort:" dropdown menu set to "COM1", and a "BaudRate:" dropdown menu set to "1200".
- Protocol section:** Includes two radio buttons: "IEC870-101" (selected) and "TecNet".
- RTU Connection section:** Includes a button with a download icon and the text "RTU Connection?", an "RTU Address:" dropdown menu set to "1", and a "Connection OK:" checkbox.
- Scan RTUs section:** Includes a button with a download icon and the text "Scan RTUs", a "Scan RTU Addr:" spinner set to "1", and a "to RTU Addr" spinner set to "2".
- Found RTUs section:** Includes a label "Found RTUs:", a large empty list box, and a label "Found: 0".
- Remote Download section:** Includes a button with a download icon and the text "Remote Download", and a progress bar.
- Cancel button:** A button with a red "X" icon and the text "Cancel".

First of all the COM-port must be selected (or USB – RS232 converter). When this is done, one can scan all connected IPC/RTUs. The found RTUs will appear with a corresponding checkbox in the list box “Found RTUs”. It is possible to de-select specific RTUs by clicking their associated checkbox.

When the list of RTUs is ready the download can start. This process is a combination of point to point communication with each RTU and broadcast to minimize the download time. The list box above the Remote Download button and the bar to the right shows and displays the download process with respect to success, resend and progress.