Protrol

IPC4020/IPC4022

Fault Detector and RTU

IPC4020 and IPC4022 are fault detectors for over current and earth fault, both with integrated remote terminal unit functionality.

This user's manual describes the interfaces and management of the devices. This includes:

- **Overview**
- **Connection using the service port**
- **Configuration, reset and upgrade**
- **System interface**
- **Detector functions**
- **Event list, Site manager and transient fault recorder**
- **Commissioning and testing**

M A N U A L

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1 Safety Information

Only certified electricians are allowed to perform installation work.

National and local security guidelines must be followed.

Always short circuit the secondary conductors of the current transformers during maintenance or testing.

If the secondary circuit of the CT's are opened or if their earthing point is missing or removed while the primary side is energized, high voltages can be generated. In worst case these voltages can be deadly and damage isolation material. Energization of the CT's primary side is not permitted as long as the secondary side is open or not earthed.

Dangerous voltages can be present on the terminals, also when power is removed from the device.

Violation against the security guidelines can lead to fatalities, personal injury or considerable damage to equipment.

Avoid removing the cover of the IPC402x devices. If it is removed, ensure that all electronic components are protected against electrostatic discharge, ESD, by proper earthing of both the device and the personnel performing maintenance.

The device should be connected to protective earth at terminal X4.2.

2 Abbreviations

IPC401x	Previous generation fault detectors – IPC4010, -11 and -12
IPC402x	IPC4020, IPC4020exp or IPC4022
ASDU	Application Service Data Unit
COMTRADE	Common Transient Data Exchange
DHCP	Dynamic Host Configuration Protocol
EF	Earth Fault
ESD	Electro Static Discharge
OC	Overcurrent
RTU	Remote Terminal Unit
NTP	Network Time Protocol
TFR	Transient Fault Record(-er)

3 Firmware

Some of the functions described in this document were introduced in firmware version 1-0.6.8.

4 Overview

IPC402x consists of two or three printed circuit boards; base board, front board and, if applicable, an expansion board. Overview pictures of IPC4020/IPC4020exp and IPC4022 are shown in Figure 1 and Figure 2. More detailed descriptions of the devices can be found in the datasheet for each device [1][2].

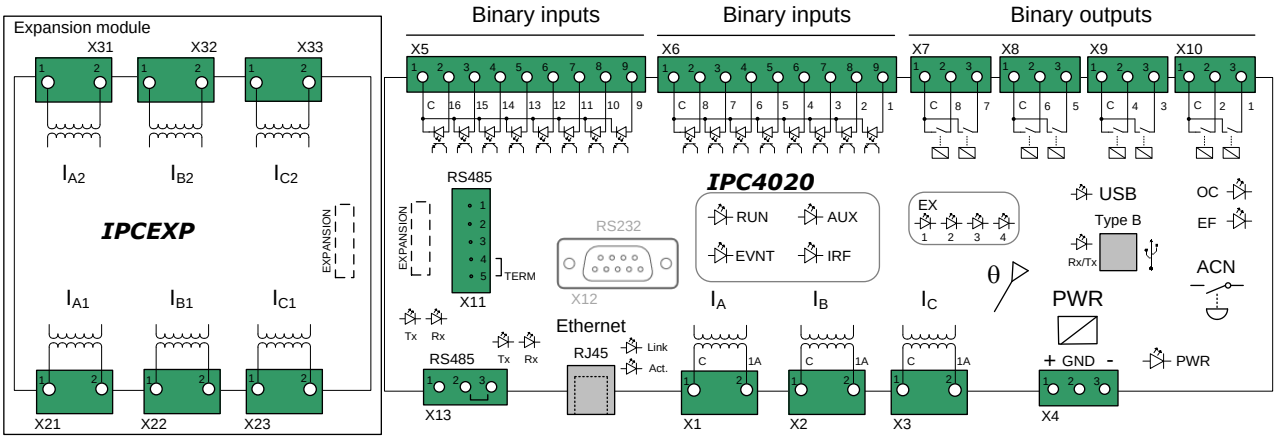


Figure 1. Overview IPC4020 with expansion for two extra detector functions (to the left). The outputs of contacts X8 and X10 are routed to more powerful relays.

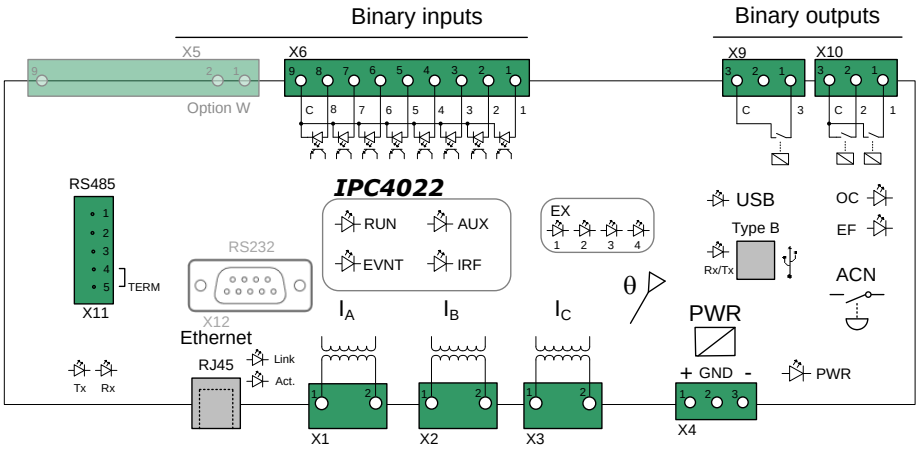


Figure 2. Overview IPC4022. The outputs on contact X10 are routed to more powerful relays.

The only normal reason to remove the front cover of the devices is to check the identification stickers that are located on the printed circuit boards. Each circuit board has a unique identity with the following format, see example beneath.

Manufacturing year and week: 1906

Batch identity: 46539

Sequence number: P0098

The sticker of the front board is located on the rear side of the board. It is not necessary to remove the front board to be able to see the identity number when needed during support cases or reclaims.

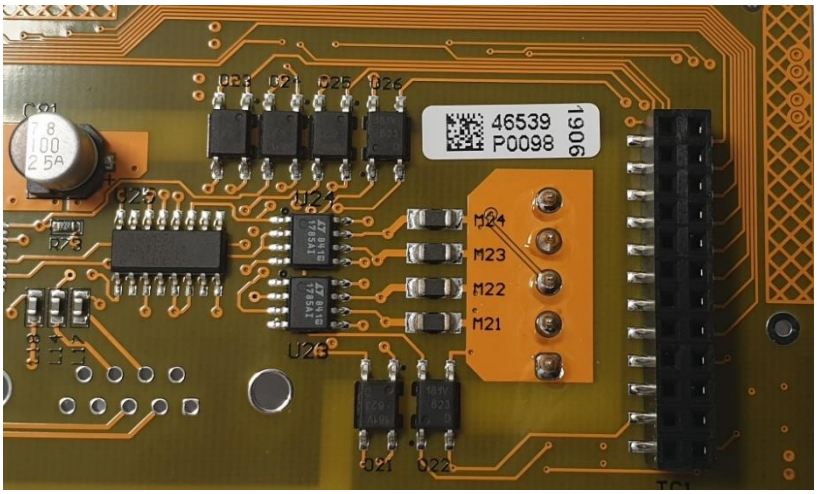


Figure 3. Example board identity.

4.1 Front Panel – HMI

LED Indicators

There are various LED indicators on the front panel for inputs, outputs, communication ports and status purposes.

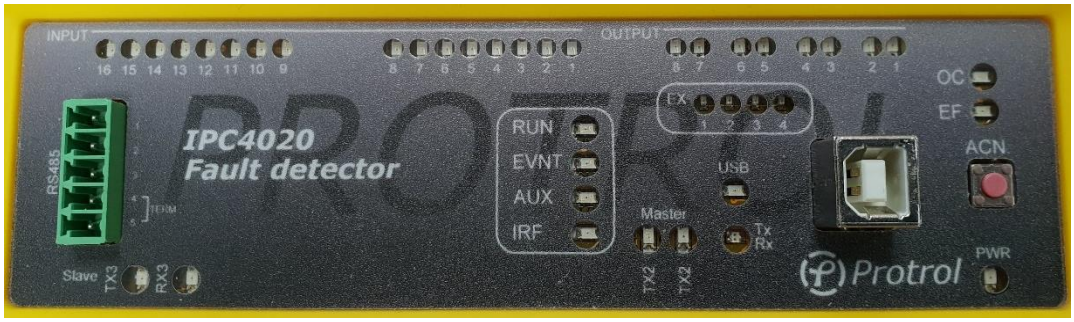


Figure 4. Front panel of IPC4020.

Each binary input and output have a LED above its screw terminal and reflects the position of the input/output. Voltage on an input activates the LED. Closed relay output activates the LED.

The table beneath describes the other LED indicators on the front panel.

LED	Description
PWR	Green diode indicating that the device is powered up
RUN	Green diode normally flashing at 0.5 Hz frequency
EVNT	Yellow diode indicating that there is an unsent telegram in the queue for slave transmission on the system interface
AUX	Yellow diode that normally indicates that the device is handling a frequency deviation
IRF	Red diode that indicates internal fault
USB	Yellow diode indicating a connected USB port
OC	Red diode indicating that an overcurrent has been detected
EF	Red diode indicating that an earth fault has been detected
TX2	Yellow diode indicating that a telegram is being sent on the serial master interface
RX2	Yellow diode indicating that a telegram is being received on the serial master interface
TX3	Yellow diode indicating that a telegram is being sent on the serial slave interface
RX3	Yellow diode indicating that a telegram is being received on the serial slave interface
Tx/Rx	Dual-coloured green-red diode which alternates when there is traffic on the USB port.
EX1	Yellow diode indicating that Detector 1 has identified a fault
EX2	Yellow diode indicating that Detector 2 has identified a fault – applies to expanded device
EX3	Yellow diode indicating that Detector 3 has identified a fault – applies to expanded device
EX4	Yellow diode that in normal configuration indicates start fault detection

Some LEDs, such as AUX and EX1-4, can have other functionality for certain option choices.

Push-button for Local Acknowledge

There is a push-button, ACN, on the far right of the front panel for local acknowledge of the overcurrent and earth fault indications. Remote acknowledge from the dispatch center and automatic self-acknowledge after a configurable time delay are described in a separate chapter of this text manual.

4.2 Startup

After a restart of the device, i.e., if there has been a disturbance in DC supply or a restart has been ordered from remote, inputs and outputs are updated with the current status. Any outputs that were activated before the restart, return to inactive position unless the conditions for activation are valid.

4.3 Internal Supervision

Internal check of hardware and software modules is performed at startup.

- Memory check – activates IRF
- Flash memory check – activates IRF
- Expansion board check – activates IRF
- Execution of software modules – activates IRF
- Supervision of external interfaces – rapported in Event Log

Supervision of expansion boards and execution of software modules are being made continuously.

4.4 Interfaces

4.4.1 RS485/RS422 port for IEC 60870-5-101 Slave

IPC402x has a signal interface on the left of the front panel for connection to the remote control center using the communication protocol IEC 60870-5-101.

This port supports both 4-wire (full-duplex) and 2-wire (half-duplex) communication.

It is factory set to 8-E-1, i.e., 8 data bits, even parity and 1 stop bit.

There is built-in protection for surge voltages. However, cables for communication that may be subjected to overvoltage must have a primary protection, for example Protrol OVP. As a rule of thumb, one can say that cables that leave the building / station must be supplemented with a primary protection.

Termination:

The first (master) and last device (last slave) on the communication line should be terminated. This is done on IPC402x by short-circuiting X11:4 and X11:5.

The port has built-in bias adjustment which means that there are no need for any ”pull-up/down” configuration.

Terminals:

Terminal/pin	Short name	Description
X11:1	TX+	Sender (plus)
X11:2	TX-	Sender (minus)
X11:3	RX(TX)+	Receiver (plus), (also sender when 2-wire)
X11:4	RX(TX)-	Receiver (minus), (also sender when 2-wire)
X11:5	TERM	Termination for receiver. Connect to X11:4 for activation

The terminals X11:3 and X11:4 are used for 2-wire communication. Configuration according to Chapter 7.2.

4.4.2 RS485-port för IEC 60870-5-101 Master (option)

IPC4020 has another terminal X13 on the left lower side, where additional units that communicate with IEC 60870-5-101 can be connected. The port only supports 2-wire communication (half duplex). It is factory set to 8-E-1, i.e., 8 data bits, even parity and 1 stop bit. This function and port are not available on IPC4022.

Note that the IEC 60870-5-101 Master function is an option and is ordered separately, see datasheet [1].

There is built-in protection for surge voltages. However, cables for communication that may be subjected to overvoltage must have a primary protection, for example Protrol OVP. As a rule of thumb, one can say that cables that leave the building / station must be supplemented with a primary protection.

Termination:

The first (master) and last device (last slave) on the communication line should be terminated. This is done on IPC402x by short-circuiting X13:2 and X13:3.

The port has built-in bias adjustment which means that there are no need for any ”pull-up/down” configuration.

Terminals:

Terminal/pin	Short name	Description
X13:1	RX/TX+	Sender/Receiver (plus)
X13:2	RX/TX-	Sender/Receiver (minus)
X13:3	TERM	Line termination. Connect to X13:2 for activation.

4.4.3 Ethernet Interface for IEC 60870-5-104 and Service Port

There is an Ethernet interface, RJ45 10/100Base - TX Full Duplex, for communication via IEC 60870-5-104 and the remote control center.

This interface is also used as a service port, i.e., for connecting a service computer using TCP / IP and accessing the built-in web interface of IPC402x.

4.4.4 USB Port

IPC402x is equipped with a service port for USB Type B. The port is located on the right of the front panel next to the local acknowledge push-button, ACN.

4.4.5 Secondary Current Inputs

Current terminals for phase current transformers are found in the following locations:

- Detector 1: Terminals X1-X3 between the RJ45 connector for Ethernet and the terminal for power supply.
- Detector 2: Terminals X21-X23, lower side of the expansion module (left side of IPC4020exp).
- Detector 3: Terminals X31-X33, upper side of the expansion module (left side of IPC4020exp).

4.4.6 Power Supply

IPC402x requires an external power supply of 24-48 VDC which is connected to terminal block X4. The connection is not polarity sensitive.

The unit must be connected to protective ground via X4.2.

5 Service Interface

The built-in web server in IPC402x gives authorized access to all settings, status information, file transfer and event lists, either via Ethernet RJ45 or USB type B. Protrol recommends using Chrome or Firefox web browsers.

5.1 Connecting using Ethernet

The prerequisite for connecting via Ethernet is that the service computer has IP settings that match, i.e., the same subnet and subnet mask, with those of the IPC device that you want to connect to.

An IPC402x is supplied either with factory settings or with order-specific settings. The factory settings are as follows:

Parameter	Value
IP address	192.168.0.31
Net mask	255.255.255.0
Standard gateway	192.168.0.1

The above settings mean that the IPC is accessible via computers with addresses within the 192.168.0.x range, or redirected addresses via the gateway / router.

5.2 Connecting using USB

It is also possible to connect using USB type B. to do so, a separate software, Protrol USB Bridge for Windows 7/10, is needed. This is available on Protrol's website, together with a link to download necessary drivers. Below is a brief description of how to connect via the program.

1. Start Protrol USB Bridge.
    a. If an IPC402x is found by the program, the current COM port is displayed. See the left image in Figure 5.
2. Click on ***Open serial port***.
    a. If the connected, the other buttons will light up. See the right image in Figure 5.
3. Open the default browser by clicking ***Open web browser***.
    a. To start the web browser manually, please enter *127.0.0.1:20080/* in the address bar.

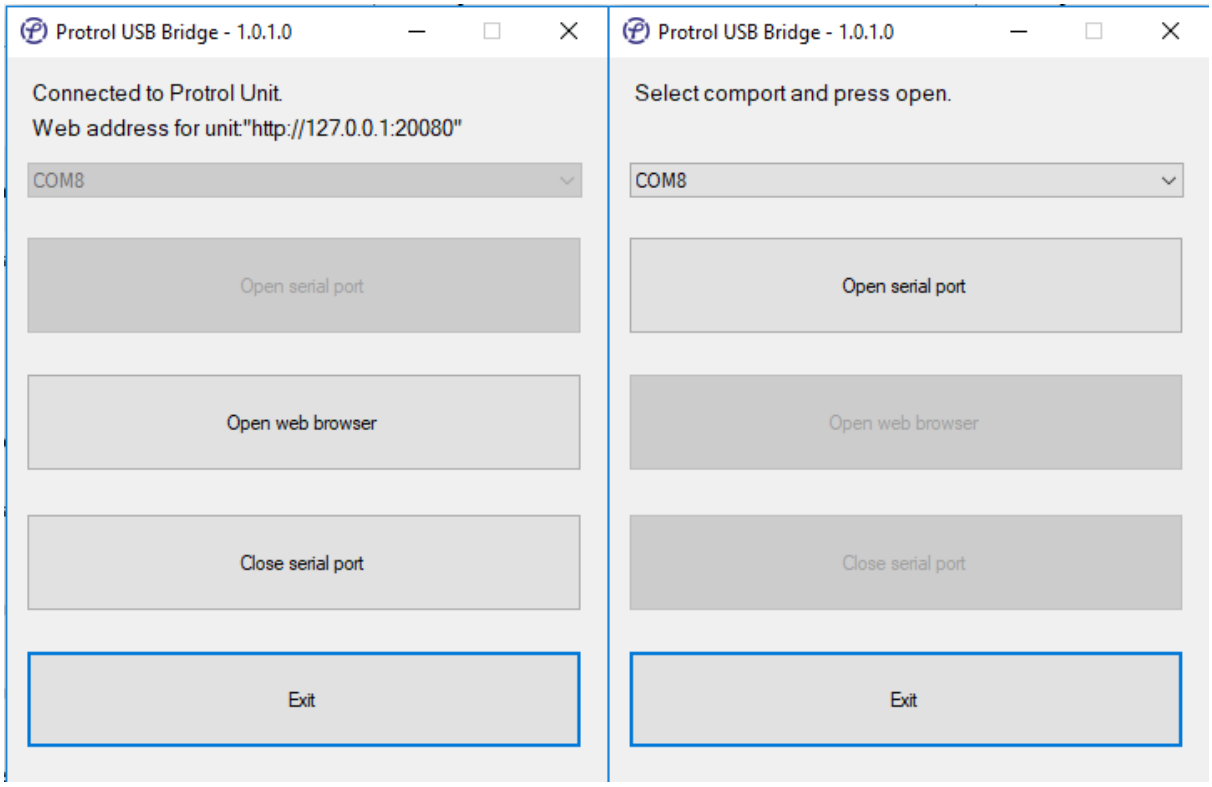


*Figure 5. When starting Protrol USB Bridge, the left picture is displayed. Select the proposed COM port and click **Open serial port**. After this, it is possible to open the default browser by pressing **Open web browser** (right image).*

5.3 Login

After connecting to the Protrol device, a login screen is displayed. This includes information about the connected Protrol device and the input field for logging in.

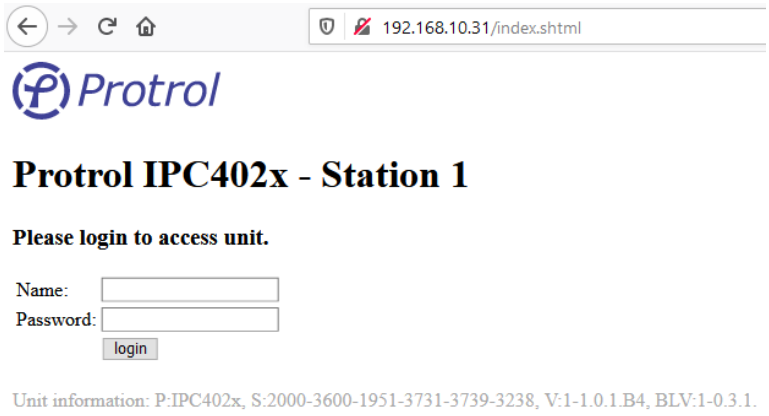


Figure 6. The login field of the web server.

The following standard users can be selected:

User	Password	User properties
status	status	Displaying settings Download of disturbance files
config	config	Display / change of normal settings Download of disturbance files Firmware upgrade
admin	availability	Same as *config*, and in addition user administration and password Display / change of special settings

5.4 Start Tab and Device Information

After logging in, the Start tab is displayed. This includes status and information about the connected device, as well as tabs for other functions.

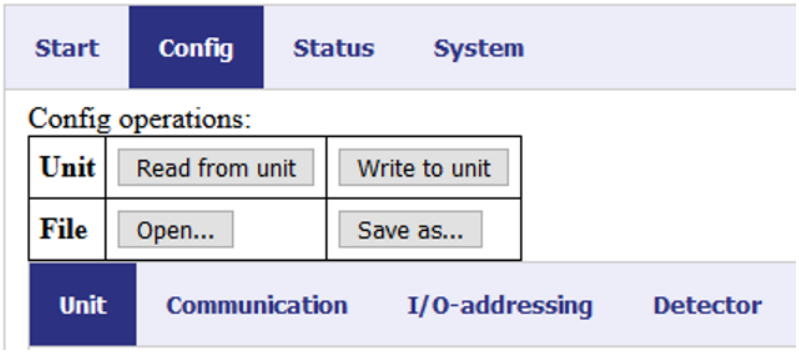
At the bottom of all web pages, even on the login page, there is the unit's unique ID number and version on software, see Figure 6. Copy the information field and attach it to the support case or complaint.

The service interface has a built-in timeout, which means that automatic logout is done after a period of inactivity.

6 Configuration and Settings

Configuration is done using the web interface. See chapter 4 for details on connection to the device and its web interface.

All settings can be found on the ***Config*** tab:



Save settings:

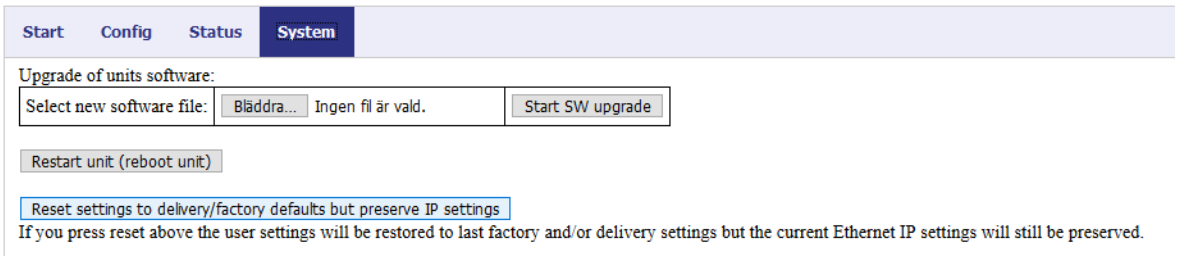
- When new settings are to be saved and activated in the IPC unit, press the ***Write to unit*** button.
- The settings are then transferred to the device and it then restarts automatically.
- You may need to reconnect and login after the restart.
- The settings can also be saved to a local file using the ***Save as…***. button.

Read settings:

- If settings are to be reread from the unit, press the ***Read from unit*** button.
- Settings saved on file are loaded using the ***Open…***. button.

Reset settings:

- IPC402x is delivered either with Protrol's *factory defaults* or with specific customer settings (*delivery defaults*) according to agreement between Protrol and the customer.
- Reset to *factory* / *customer settings* is made on the ***System*** tab.



Note that passwords for the different login levels are also reset.

Internet settings, the device's IP address, etc., are not reset.

This also applies to IP addresses for IEC 60870-5-104.

- Complete reset to *factory* / *customer settings*:

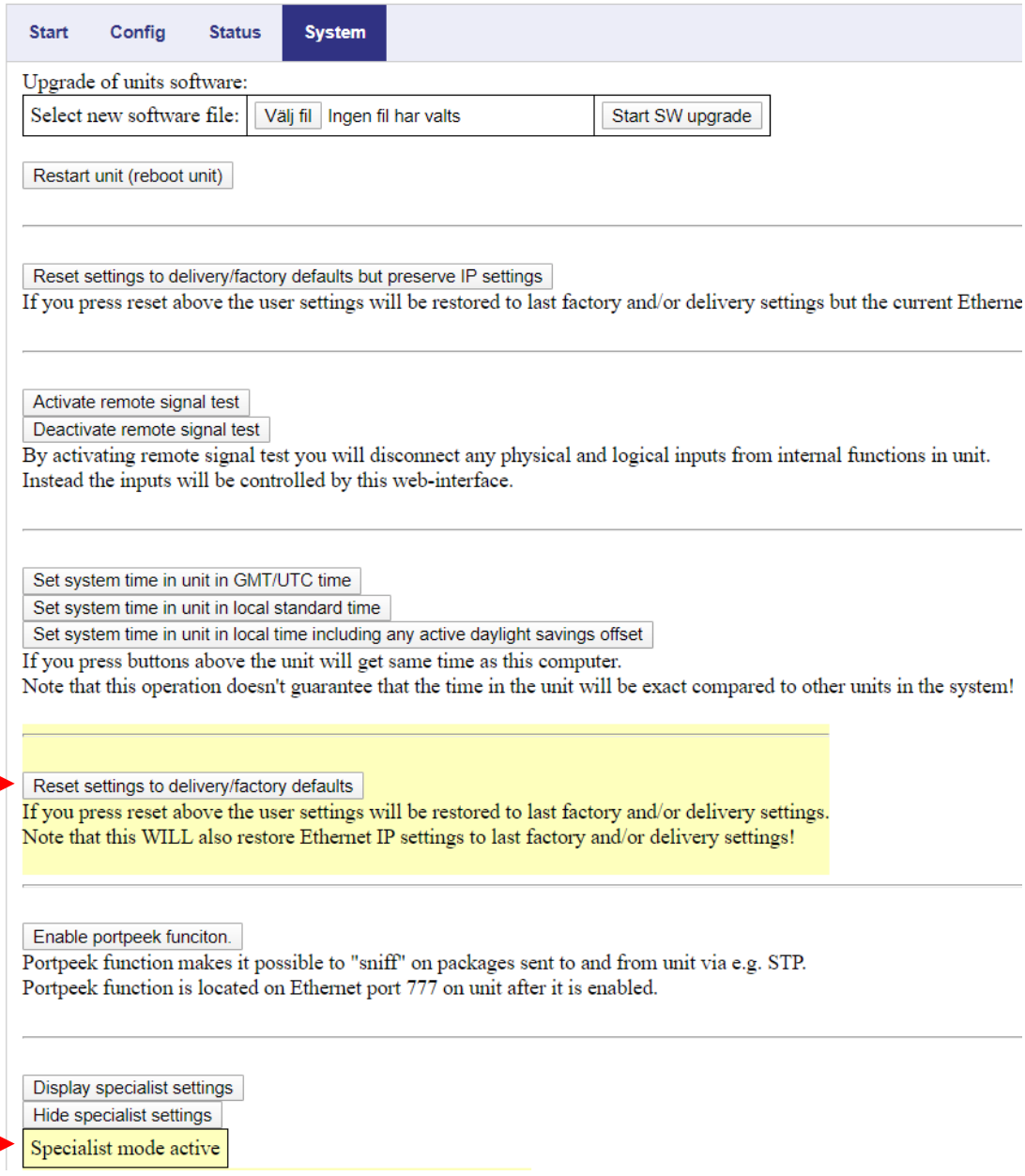
  A complete reset, including all Internet settings, can be done in two different ways:

  1. From web interface.

     Note that there is a great risk of losing the ability to remotely connect to the device after the reset, depending on the changed IP address and other internet settings!

     In order to be able to make a complete reset via the web interface, the user must log in as the administrator ***admin***.

     On the ***System*** tab you first activate specialist mode, by pressing the button ***Display specialist settings.*** After that the button for full reset is displayed, ***Reset settings to delivery / factory defaults.***



2. Using ACN button.

   A full reset can also be done using the *acknowledge* button (ACN) on the front card by following these steps:

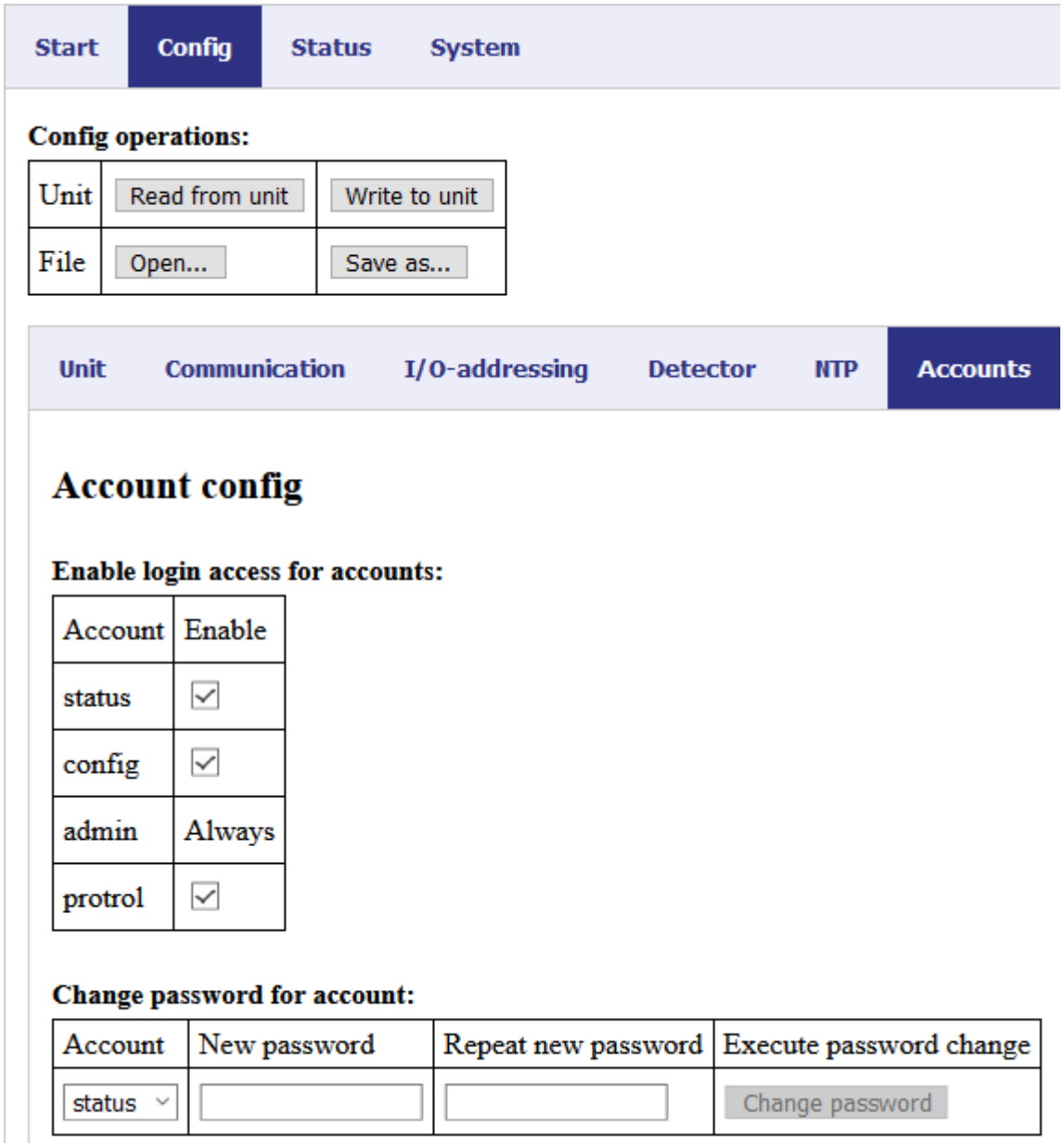
   - Restart the device by turning power off and then on again.
   - Press and hold the ACN button when the first LEDs light up (IRF etc.).
   - Tiden While the EX LEDs are "counting down", release them before "clearing".

     - It is possible to repent by just keeping the ACN button pressed until the device is in normal operation.

   - The unit now resets the settings and then restarts.

User administration:

Activation/deactivation of users and replacement of passwords are made on the ***Config/Accounts*** tab.



*Figur 1: Administration of accounts can be done when the user is logged in as **admin**.*

The administrator can activate/deactivate all accounts except for the admin account. Please observe that the passwords can only to consist of capital letters, lower case letters and the numbers 0-9. Special characters and other national characters are not allowed.

6.1 Settings – *Unit*

The IPC device has general settings on the ***Unit*** subtab, listed in the table beneath. The *Watchdog* relay closes when all is normal. If there is an internal fault, the relay opens. If power supply is missing, the relay will remain open.

Parameter	Description	Range	Factory value	Unit
Unit information:				
Site	Site reference	-	Default	-
FreeText	Free text for extra information	-	-	-
Wathdog output:				
Enable	Activation of the Wathdog feature	Yes or No	No	-
Watchdog relay	Choice of relay output	1..8	1	-

6.2 Settings – *NTP*

IPC402x has support for time synchronization using NTP. Settings can be found on the ***Config/NTP*** tab.

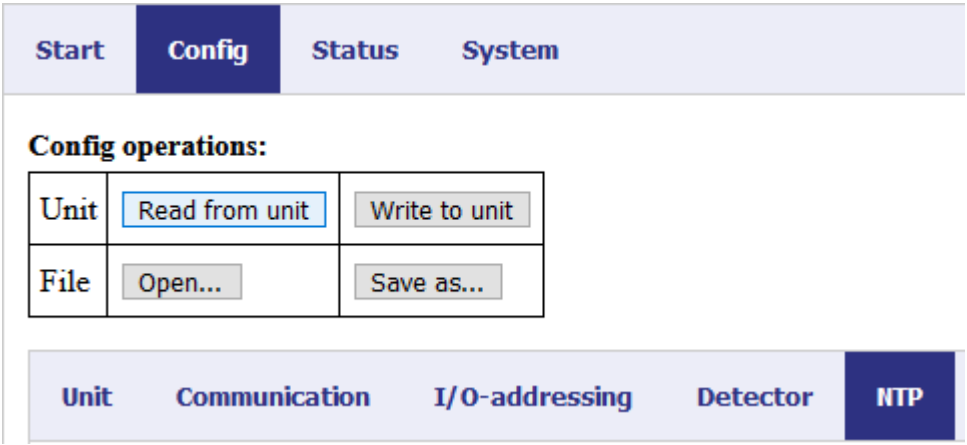


Figure 7. Configuration of NTP.

Parameter	Description	Range	Factory value	Unit
Enable NTP	Activation of NTP	Yes or No	No	-
UTC offset	Adjustment, offset, of time	-60..60	0	min
IP address primary NTP	Primary NTP server	-	0.0.0.0	-
IP address secondary NTP	Secondary NTP server	-	0.0.0.0	-

7 Remote Control Interface

IPC402x includes an integrated RTU (Remote Terminal Unit) function.

All physical binary and analog inputs can be configured to communicate values to a remote control system. Physical outputs can be set up to be controlled from remote.

Also events from detector functions as well as various objects for activation (e.g. *Autoreclosure*) and objects for acknowledgment can be assigned to a remote control system.

IPC402x supports the communication protocols IEC 60870-5-101 and IEC 60870-5-104.

In addition, there is an option which makes it possible to use IPC4020 as a local -101 Master. With this option it is possible to connect several -101 slaves to IPC4020 and access them in the remote control center.

Please observe that IEC 60870-5-101 Master is optional and must be ordered separately, refer to the datasheet [1].

IEC 60870-5-101:

- Physical interface for IEC 60870-5-101 is RS485 (X11) or RS232 (X12 DSUB9, optional).
- Both 2 and 4 wire communication is supported for RS485 communication.
- Terminate RS485 by short-circuiting inputs 4 and 5 on the X11 terminal. Only the last device should be terminated if there additional IPC402x on the same RS485 loop.

IEC 60870-5-104:

- Physical interface for IEC 60870-5-104 is RJ45 10/100Base – TX Full Duplex.

IEC 60870-5-101 Master - OPTIONAL:

- Physical interface for IEC 60870-5-101 Master is 2 wire communication via RS485 (X13).
- Refer to kapitel 4.4.2 for detailed information regarding the physical connection.
- Please observe that IEC 60870-5-101 Master is optional, refer to the datasheet [1].

For more information regarding settings for communication, objects and more, see the following chapters.

A general description on how to configure IPC402x can be found in Chapter 6.

7.1 Events, Queues and Interrogation

Status changes of physical binary inputs and internal logical events are timestamped upon detection with a time resolution of 1 ms. If the status change is shorter than 1 ms, the event is suppressed. Events are added to internal queues and sent in the order of creation. The EVT LED on the device is active when events are waiting to be transported on the system interface.

For analog signals, changes larger than the deadbands result a message which is added to the internal queues. See Section 7.5 Analog Inputs (I/O-addressing – Analog Inputs) for detailed information about configuration. Only the last analog message is kept in the buffers.

The queues are using the principle FIFO – *First In First Out* and can buffer a maximum of 500 events. When a queue is full, the oldest event is discarded to make place for the last event. As long as the event queues are not full, all status changes will generate time stamped event messages and no information is lost.

There are functions that will limit the creation of events when an input changes status too often. See chapter 7.3.1 Binary Inputs – Input 1-16 for more information.

When a communication link has been initiated by the master inferface, events are transmitted according to the chosen protocol and a prioritized order (class 1 and 2 for IEC 60870-5-101/104). For IEC 60870-5-104, the events are sent immediately when they have been added to the queues. If IEC 60870-5-101 is used, the events are transmitted after requests from the master interface.

At general interrogation, events are created for all objects defined in the device. The current status of all input signals, physical and logical, are collected and added to internal queues with no delay. The events are sent in the order they have been added to the queues.

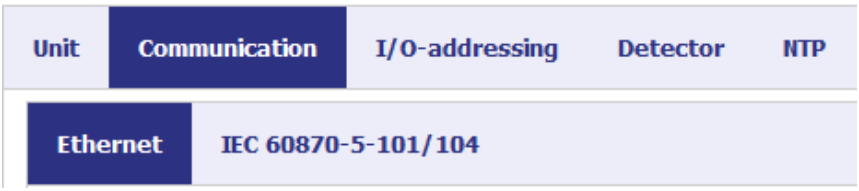
If the IPC device is acting master for other slaves, it will collect events from all active slaves and transmit them to the remote control center. Due to speed limitations in the master-slave transmission there will be a delay until all status updates are sent to the control center.

7.2 General Settings – *Communication*

This section describes the configuration settings for remote communication; IP addresses, and general settings for IEC 60870-5-101 and IEC 60870-5-104, slave and master functions.

7.2.1 Communication – Ethernet

The settings for *Ethernet* are found on the ***Config/Communication/Ethernet*** tab*:*

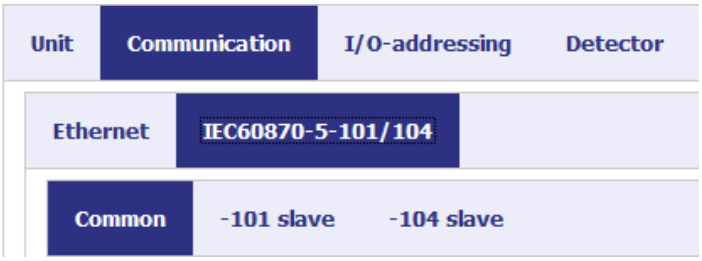


Settings - *Ethernet*:

Parameter	Description	Range	Factory value	Unit
Settings for unit:				
Enable static IP	Fixed or dynamic IP address (via DHCP).	Yes or No	Yes	-
IP address	Fixed IP address for the device.	[1]	192.168.0.31	-
Netmask	Netmask	[1]	255.255.255.0	-
Gateway	IP address for network gateway	[1]	192.168.0.1	-
Trusted IP addresses for IEC 60870-5-104:				
IP address n	Address for n IEC 60870-5-104 master	[1]	192.168.0.10n	-
Enable n	Accept connection from this address. If no address is specified, connection is accepted from all addresses.	Yes or No	No	-

7.2.2 Communication – IEC 60870-5-101/104

There are three sub-tabs under the ***IEC 60870-5-101/104*** tab.



Each tab and its settings are described in the following chapter.

[1] Range according to common notation (4 bytes in decimal form, 0..255). Observe that the address 0.0.0.0 is not allowed.

7.2.2.1 IEC 60870-5-101/104 – Common

Settings – *Common*:

Parameter	Description	Range	Factory value	Unit
Common address (CA)	Common ASDU address. Can have range 1 octet or 2 octets.	1..254 1..65534	1	-
Use end of init (M_EI)	The device shall send a startup message.	Yes or No	Yes	-
Slave interface to use	Choice of remote control interface	No slave, -101 slave, -104 slave	-104 slave	-
Select timeout	Specifies how long to wait for the Execute command after an object has been Selected. If no Execute command arrives within the set time, the order will be interrupted.	1..3600	30	s

Option				
Master interface to use	Choice of interface to sub-slaves	No master, -101 master	No master	-

7.2.2.2 IEC 60870-5-101/104 – -101 slave

Settings - *101 slave*:

Parameter	Description	Range	Factory value	Unit
Protocol settings:				
Link address (LA)	Link address (RTU address). Can have range 1 octet or 2 octets.	1..254 1..65534	1	-
Common address (CA)	RTU address. Configured on the tab *Common*.	-	-	-
Time tag type	Specifies what type of time format IPC402x uses.	- [1]	CP56	-
Link address (LA) size	Size of link address.	0..2	1	octets
Common address (CA) size	Size of RTU address.	1..2	2	octets
Object address (OA) size	Size of Object address	1..3	3	octets
Cause of transmission (COT) size	Size of ”COT”.	1..2	2	octets
Port settings: [2]				
Port type	Choice of physical interface: 1. 2 wire RS-485 2. 4 wire RS-422 3. RS-232 (without hand shake) 4. RS-232 (with hand shake)	1..4	1	-
Baudrate	Communication speed.	1200, 2400, 4800, 9600	9600	Bit/s

[1] This is for information only and cannot be changed by the user

[2] The port is set to 8-E-1, i.e., 8 data bits, even parity and 1 stop bit.

7.2.2.3 IEC 60870-5-101/104 – -104 slave

Settings - *104 slave*:

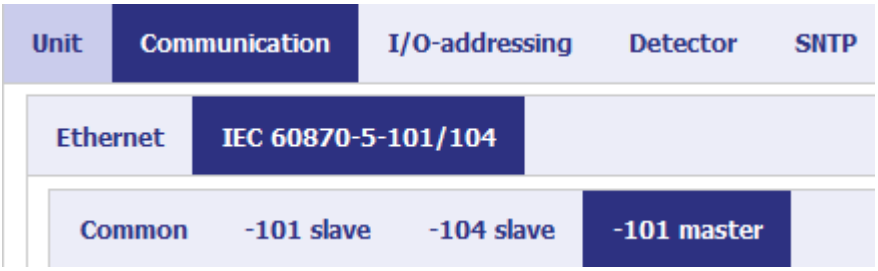
Parameter	Description	Range	Factory value	Unit
APDU timeout (t1)	Time limit for sent unconfirmed message. If the time has expired, communication is closed.	1..3600	15	s
ACKN timeout (t2)	Deadline for received unconfirmed messages. Confirmation (ackn) is sent no later than this time.	1..3600	10	s
TEST timeout (t3)	Test message timeout. Test message is sent no later than this time.	1..3600	30	s
k unackn I format ASDU	Maximum number of unconfirmed messages (I format). If exceeded, communication is closed.	1..255	12	-
w ackn I format ASDU	Maximum number of unconfirmed received messages (I format). Confirmation (ackn) will be sent no later than this number.	1..255	8	-
Command timetag timeout	Maximum difference between local time in the unit and time marking on an order. If the telegram does not arrive in time, the order is not allowed.	1..3600	30	s
Time tag type	Specifies the type of time format IPC402x uses.	- [1]	CP56	-
Common address (CA) size	Size of the RTU address, number of octets.	- [1]	2	Octet
Object address (OA) size	Size of the object address, number of octets.	- [1]	3	Octet
Cause of transmission (COT) size	Size of ”COT”, number of octets.	- [1]	2	Octet

[1] This is for information only and cannot be changed by the user

7.2.2.4 IEC 60870-5-101 master - OPTIONAL

IPC4020 can be obtained with the option *IEC -101-master for IPC402x*. With this option, IPC4020 can act local IEC-101 master, which enables the user to connect an additional number of local -101 slaves. This means that only one RTU is visible in the remote control center.

The settings are found on the ***Communication/IEC 60870-5-101/104/-101 master*** tab.



General instructions:

- The link adresses of the slaves must be in rising order.
  Only the first slave adress is specified in the master. See the first parameter in the table.
- Link and RTU addresses must be identical in each -101 slave.
- Size settings (parameters 4-7 in the table) must be the same as those used by the SCADA system (-101 or -104 slave).
- Keep in mind that all objects in all slaves must have unique object addresses. The SCADA system interpretes data as objects coming from the same RTU, i.e., the IPC4020 which acts -101 master.
- To forward commands from remote control the highest object address octet must be identical to the link/RTU address. See the following example:
  - Binary output no 3, in the second slave, shall be controlled from the SCADA system.
  - The second slave has the RTU address (and link address) = 2 (if factory settings are used).
  - Binary output no 3 has normally the object address 21003 according factory settings for IPC402zx. This must be changed to 2.21003 for the slave (structured address according to service interface, which is address 152075 in decimal notation.
- If contact with a slave is lost, all objects belonging to that slave are sent to the remote control center with the Invalid flag set. This is only done if an interrogation prevously has been made from this specific slave.

Settings - *101 master*:

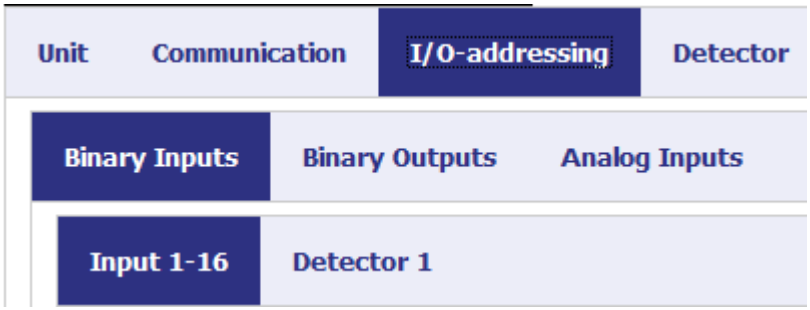
Parameter	Description	Range	Factory value	Unit
Protocol settings:				
First slave link address (LA)	Link address and RTU address.	1..254	1	-
Number of slaves	Number of connected slave devices.	1..10	1	-
Time tag type	Specifies the type of time format IPC402x uses.	- [1]	CP56	-
Link address (LA) size	Size of link address.	1..2	1	octet
Common address (CA) size	Size of RTU address.	1..2	2	octet
Object address (OA) size	Size of Object address	1..3	3	octet
Cause of transmission (COT) size	Size of ”COT”.	1..2	2	octet
Port settings: [2]				
Port type	2-tråds RS-485	- [1]	-	-
Baudrate	Communication speed.	1 200, 2 400, 4 800, 9 600	9 600	Bit/s

[1] This is for information only and cannot be changed by the user

[2] The port is set to 8-E-1, i.e., 8 data bits, even parity and 1 stop bit.

7.3 Binary inputs (I/O-addressing – Binary Inputs)

Communication settings for all binary inputs are found under ***Config – I/O-addressing – Binary Inputs***.



On the tab ***Input 1-16*** all physical and system signals are listed.

The ***Detector m*** tab contains binary objects for the detector functions. Up to three detectors can be used for IPC4020exp, the settings are identical.

All binary inputs can be setup in the same manner. Beneath is a general description.

For more information on each specific object, please refer to the chapter that describes it.

Parameter	Description	Range	Unit
Description	Brief descriptive name for the object.	-	-
Type	Type of indication; Single or Double[1].	Single point, Double point	-
Settings – Blocked	The signal is blocked, i.e. no value / status is sent to the remote end. Also applies to "interrogation" (status request).	Yes or No	-
Settings – Negative	The signal is inverted, i.e. a high signal is transmitted with status low to remote end.	Yes or No	-
Settings – Time tagged	The signal is timestamped upon change. The time is also sent to the remote end.	Yes or No	-
Delay	Number of milliseconds that the signal should be changed before a message is sent to the remote end. Applies to a positive change state change (0 -> 1). When Settings – Negative has been chosen, the opposite applies.	0 … 65 535	ms
Address 8	Upper octet of the address. Decimal.	0 … 255	-
Address 16	Lower octets of the address. Decimal.	0 … 65 535	-

[1] If Double point is used, this means for indication <OFF> that input *n* is high and input *n+1* is low. Input *n* low and input *n+1* high results corresponingly in indication <ON>.

7.3.1 Binary Inputs – Input 1-16

Settings for binary objects connected to physical inputs on the device, ACN and IRF.

Limitation of events from binary inputs that change status often kan be made using the parameter ***Delay***, see description in the section on the previous page.

Only specific settings and differences to the normal are described below. See chapter 7.3 for a general description of the various configuration options.

The objects have the following factory settings:

- ***Type*** - *Single point*
- ***Settings - Blocked*** - No
- ***Settings - Negative*** - No
- ***Settings – Time tagged*** - Yes
- ***Delay*** - 0 ms

Settings – *Input 1-16*:

Parameter	Description	Factory value address
Ack button	Object linked to the ACN button on the front panel. Can only have the type *single indication*.	100
Input *n*	Object connected to physical input *n*.	10*n*
Input 16	Objects connected to physical input 16. Can only have the type *single indication*.	116
IRF	Indication for internal error. Can only have the type *single indication*.	117

7.3.2 Binary Inputs – Detector *m*

Binary object settings associated with detector functions.

Only specific settings and differences to the normal are described below. See chapter 7.3 for a general description of the various configuration options.

None of the indications can be of *double* type.

The objects 1-10 have the following factory settings:

- ***Type*** - *Single point*
- ***Settings - Blocked*** - No
- ***Settings - Negative*** - No
- ***Settings – Time tagged*** - Yes
- ***Delay*** - 0 ms

The objects 11-13 have the following factory settings:

- ***Type*** - Logical input 1: *Double point*
  - Logical input 2: *Single point*
  - EF Trip (reignition): *Single point*
- ***Settings - Blocked*** - Yes
- ***Settings - Negative*** - No
- ***Settings – Time tagged*** - No
- ***Delay*** - 0 ms

For more information regarding detector functions and their specific signals, refer to chapter 8.

Settings – *Detector m*:

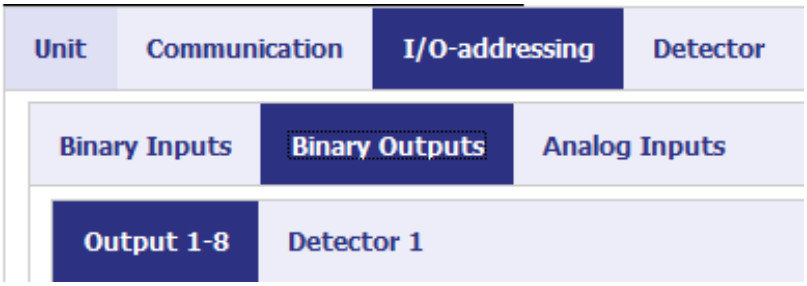
Parameter	Description	Factory value address lower octets[1]
OC Start	Overcurrent – START indication	*m*20
OC1 Trip	Overcurrent – TRIP indication, level 1	*m*21
OC2 Trip	Overcurrent – TRIP indication, level 2	*m*22
EF Start	Earth fault – START indication	*m*23
EF Trip	Earth fault – TRIP indication	*m*24
EF Start (non dir.)	Earth fault, non-directional – START indication	*m*25
EF Trip (non dir.)	Earth fault, non-directional – TRIP indication	*m*26
Phase break	Indication for phase break	*m*27
OC Trip Ind	Indication mirroring the LED OC Trip.	*m*28
EF Trip Ind	Indication mirroring the LED EF Trip.	*m*29
Logical input 1[2]	Logical object 1, from additional software functions.	0 (Not activated)
Logical input 2	Logical object 2, currently not used	0 (Not activated)
EF Trip (reignition)	Earth fault – TRIP indication at arcing earth fault.	0

[1] *m* = 1, 2 or 3 depending on the detector. Factory settings for the upper octet are always 0.

[2] Option: RECL OFF/ON, Auto reclosure inactive / activated.

7.4 Binary outputs (I/O-addressing – Binary Outputs)

Settings for all binary outputs are available in the ***Config – I/O-addressing – Binary Outputs*** subtabs**.**



On the ***Output 1-8*** tab all physical outputs are listed.

Detector m contains binary outputs for the detector functions.

All binary outputs have the same parameter settings. Below is a general description.

For more information on each individual item, see the following chapters.

Parameter	Description	Range	Unit
Description	Brief descriptive name for the object.	-	-
Type	Type of object; *Single* or *Double*[1].	Single command, Double command	-
Settings – Blocked	The signal is blocked, i.e. no order or command is executed.	Yes or No	-
Settings – Direct Excute	The order is executed directly, ie no *select* is needed.	Yes or No	-
Pulse time [ms]	Number of milliseconds that the output signal should be high.	0 … 65 535	ms
Address 8	Upper octet of the address. Decimal.	0 … 255	-
Address 16	Lower octets of the address. Decimal.	0 … 65 535	-

7.4.1 Binary Outputs – Output 1-8

Settings for binary objects connected to physical outputs on the device, as well as the ACN button.

Only specific settings and differences to the normal are described below. See the beginning of this chapter for a general description of the various configuration options.

From factory, all objects are set as *single command* and the sequence *selected / executed*.

The objects have the following factory settings:

- ***Type*** - *Single command*
- ***Settings - Blocked*** - No
- ***Settings - Negative*** - No
- ***Pulse time*** - 100 ms

[1] For Double command <OFF> this means that output relay *n* is closed and output relay *n*+1 is opened. The command <ON> opens output relay *n* and closes output relay *n*+1.

Settings – *Output 1-8*:

Parameter	Description	Factory value address lower octets
Ack	Object connected to the ACN button on the front panel. Can only have the type *single command*. Pulse time cannot be changed, fixed time of 100 ms.	21000
Output *n*	Objects connected to physical output *n*.	2100*n*
Output 8	Objects connected to physical output 8. Can only have the type *single command*.	21008

7.4.2 Binary Outputs – Detector *m*

Settings for binary outputs linked to customer specific functions.

IPC402x has a number of logical outputs that can be used to activate and control various customized functions. In the standard version, there are no functions associated with these objects. However, they are visible via the web interface and a brief general description is therefore made here.

See the beginning of this chapter for a general description of the various configuration options.

From factory, all objects are set as a *single command* and the sequence *selected / executed*.

The objects have the following factory settings:

- ***Type*** - Logical output 1: *Double command*
- Logical output 2-13: *Single command*
- ***Settings - Blocked*** - Yes
- ***Settings - Negative*** - Yes
- ***Pulse time*** - 100 ms

Since the items are not used, they are set to ***Blocked*** on delivery.

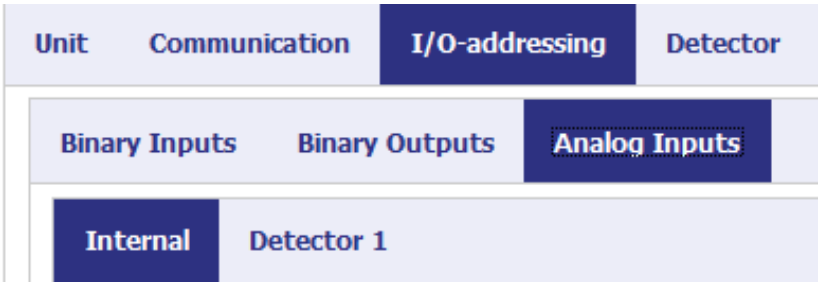
Inställningar – *Detector x*:

Parameter	Description	Factory value address lower octets[1]
Logical output *n*	Logical object for controlling customized functions.	21*m*0*n*

[1] *m* = 1, 2 or 3 depending on the detector.

7.5 Analog Inputs (I/O-addressing – Analog Inputs)

Settings for all analog inputs can be found in the ***Config - I / O addressing - Analog Inputs*** subtabs:



The ***Internal*** tab contains internal analogue system signals.

Detector m lists analog signals from the detector functions.

All analog signals have the same setting options. Below is a general description.

For more information on each individual item, see the following tab descriptions.

Parameter	Description	Range	Unit
Description	Brief descriptive name for the object.	-	-
Type	Type of analogue object; Different formats and scaling. [1]	Normalized [0–100 %], Normalized [0–120 %], Floating point [SI], Scaled [SI*1], Scaled [SI*10], Scaled [SI*100]	-
Settings – Blocked	The signal is blocked, i.e. no value / status is sent to the remote end. Also applies to "interrogation" (status request).	Yes or No	-
Settings – Timetagged	The signal is timestamped upon change. The time is also sent to the remote end.	Yes or No	-
Deadband [%]	Deadband - indicates how much change is needed for a new value to be sent to the remote end. [1)]		%
Address 8	Upper octet of the address. Decimal.	0 … 255	-
Address 16	Lower octets of the address. Decimal.	0 … 65 535	-

[1] For a detailed description of what the different types provide regarding format, scaling and how the deadband is defined, see descriptions in the following text.

7.5.1 Analog Inputs – Internal

Settings for internal analog objects of the device.

Only specific settings and differences to the normal are described below. See Chapter 7.5 for a general description of the configuration options.

Settings – *Internal*:

Parameter	Description	Factory value address lower octets
Unit temperature	Temperature measurement inside the device. Default: - Type: Float [SI] - Blocked: No - No time stamp - Deadband: 5.0 %	3001

Type and Deadband – *Internal*:

Object	Type / Deadband	Description
Unit temperature	Normalized [0-100 %]	Normalized to 100 degrees Celsius.
	Normalized [0-120 %]	Normalized to 120 degrees Celsius.
	Float [SI]	Floating point corresponding to Celsius degrees.
	Scaled [SI*1]	Integers corresponding to Celsius degrees.
	Scaled [SI*10]	Integers corresponding to 0.1 Celsius degrees
	Scaled [SI*100]	Integers corresponding to 0.01 Celsius degrees.
Unit temperature	Deadband [%]	Set as a percentage of 100 degrees Celsius.

7.5.2 Analog Inputs – Detector *m*

This subtab contains settings for analog inputs connected to detector functions.

See chapter 7.5 for a general description of the various configuration options.

All objects are set to the ***Normalized [0-100%]*** type, except ***Fault Phase***, and a 10% deadband from factory.

Current values are given as primary values.

For more information on the detector functions and the various signals see chapter 7.

Settings – *Detector m*:

Parameter	Description	Factory value address lower octets[1]
L1 Current	Measured current (rms) at input L1 / Ia.	3*m*01
L2 Current	Measured current (rms) at input L2 / Ib.	3*m*02
L3 Current	Measured current (rms) at input L3 / Ic.	3*m*03
LN Current	Calculated residual current 3I0 (rms).	3*m*04
Max Fault Current	Maximum fault current (rms), I>/I>>	3*m*05
Max Current	Maximum current (rms).	3*m*06
Avg Current Period	Average current value (rms), 15 min.	3*m*07
Fault Phase	Faulty phase / phases. The following values can be sent: - 0,1,2,3,12,13,23,123 Can only be of the types: - "Float [SI]" or "Scaled [SI * 1]"	3*m*08

[1] *m* = 1, 2 or 3 depending on the detector.

Type and deadband – *Detector n*:

Object	Type / Deadband	Description
Lx Current	Normalized [0-100 %]	Normalized primary current according to CT ratio. Example: CT ratio = 300/1 Value 0 ⇔ 0 A Value 1.0 ⇔ 300 A
	Normalized [0-120 %]	Normalized primary current according to CT ratio times 1.2. Example: CT ratio = 300/1 Value 0 ⇔ 0 A Value 1.0 ⇔ 360 A
	Float [SI]	Primary current in Amperes, as floating point.
	Scaled [SI*1]	Primary current in Amperes, as integer.
	Scaled [SI*10]	Primary current in 0.1 Amperes, as integer
	Scaled [SI*100]	Primary current in 0.01 Amperes, as integer
Lx Current	Deadband [%]	Set as a percentage of CT ratio. Example: CT ratio = 300/1 1 % ⇔ 3 A
LN Current	Type	Identical to ”Lx Current”
LN Current	Deadband	Identical to”Lx Current”
Max Fault Current	Normalized [0-100 %]	Normalized primary current according to CT ratio times 10. Example: CT ratio = 300/1 Värde 0 ⇔ 0 A Värde 1.0 ⇔ 3000 A
	Normalized [0-120 %]	Normalized primary current according to CT ratio times 12. Example: CT ratio = 300/1 Värde 0 ⇔ 0 A Värde 1.0 ⇔ 3600 A
	Float [SI]	Primary current in Amperes, as floating point.
	Scaled [SI*1]	Primary current in Amperes, as integer.
	Scaled [SI*10]	Primary current in 0.1 Amperes, as integer
	Scaled [SI*100]	Primary current in 0.01 Amperes, as integer
	Deadband [%]	Set as a percentage of CT ratio times 10. Example: CT ratio = 300/1 1 % ⇔ 30 A
Max Current	Type	Identical to ”Lx Current” ovan.
Max Current	Deadband	Identical to ”Lx Current” ovan.
Avg Current Period	Type	Identical to ”Lx Current” ovan.
Avg Current Period	Deadband	Identical to ”Lx Current” ovan.
Fault Phase	Float [SI]	Faulty phase, as floating point.
	Scaled [SI*1]	Faulty phase, as integer.
Fault Phase	Deadband	Not used.

8 Detector Functions

8.1 General

IPC402x contains the following detector functions:

- Overcurrent - detects short circuit or overload
- Earth fault Protrol - patented method for sensitive detection of solid and intermittent earth faults
- Earth fault non-directional – residual current based detection
- Phase break - for detection of the loss of a phase

The fault detector measures the phase currents. Isolation between detector and the secondary current circuit of the primary current transformer is provided by current transformers. The sampling frequency of the phase currents is 2 kHz.

Protrols method for earth fault detection is of transient measuring nature, which means that it is both fast and sensitive. Fast means that the method works safely for both high impedance as well as transient and arcing faults. The method is based on analysing the change of the phase currents when an earth fault occurs. Detection of an earth fault means that the fault is downstream of the measuring point in a radial network, or that a fault current has passed the measuring point, i.e., true fault pass-through detection. Indirectly, this means that the direction of the fault can be identified by measuring phase currents only, without the need of polarizing zero-sequence voltage.

The method works very safely for all types of networks from directly grounded to isolated. In particular, this means that for an impedance grounded network, the compensation degree has no significance, and for an isolated network, the natural unbalance between the phases in principle can be infinite. It works just as well.

8.2 Detection states

The earth fault detection sequence goes through discrete states. These states can be seen in the transient fault recording (chapter 10). For each state, an evaluation is made if certain conditions are met to proceed to the next state. If these conditions are not met, a controlled return to the basic state is made.

0 IDLE – This is the basic state. The detector continuously evaluates any changes in the residual current, I_N.

2 TRIG – An earth fault somewhere in the network is triggered by detecting a sudden change of I_N. The size of the change is related to the sensitivity, the smaller the change, the higher the impedance of the earth fault. During a short period after TRIG, the nature of the error is evaluated. Depending on the result, the state changes to either RESET, EVAL-T, or EVAL-A.

3 EVAL-T – In this state, supplementary calculations are made especially for high impedance faults. From this state, the detector always continues to EVAL-A.

4 EVAL-A – State to determine whether the detector should go to START or RESET.

5 START – Here, a timer for the set time delay is started. The detector proceeds to the DETECT or TRIP states if the changed I_N exists after the set time. The state will return to RESET if the condition is not met.

6 DETECT/TRIP – This state means that a fault has been detected. Controlled return to IDLE via RESET will follow.

8 REIGNITION – This state means the same as DETECT but indicates that the fault is reigniting or arcing.

1 RESET – The detector will temporarily and as short as possible be in this state for the return to IDLE to be controlled.

Similar states also exist for overcurrent, non-directional earth fault and phase interruption. Only the overcurrent detection states are displayed in the transient fault recording:

0 IDLE

2 START

4 DETECT/TRIP

The *State* signal in the transient fault recording file contains information on the state of both earth fault and overcurrent. The state signal is an 8-bit value where the lower nibble indicates the state of the earth fault detector and the upper one indicates the state of overcurrent one. For example, the value 34 decimals (22 hexadecimal) means that ground fault has state 2-TRIG and overcurrent 2-START.

Evaluation of Earth Faults

See the example below showing a solid earth fault and the corresponding state changes during the evaluation process.

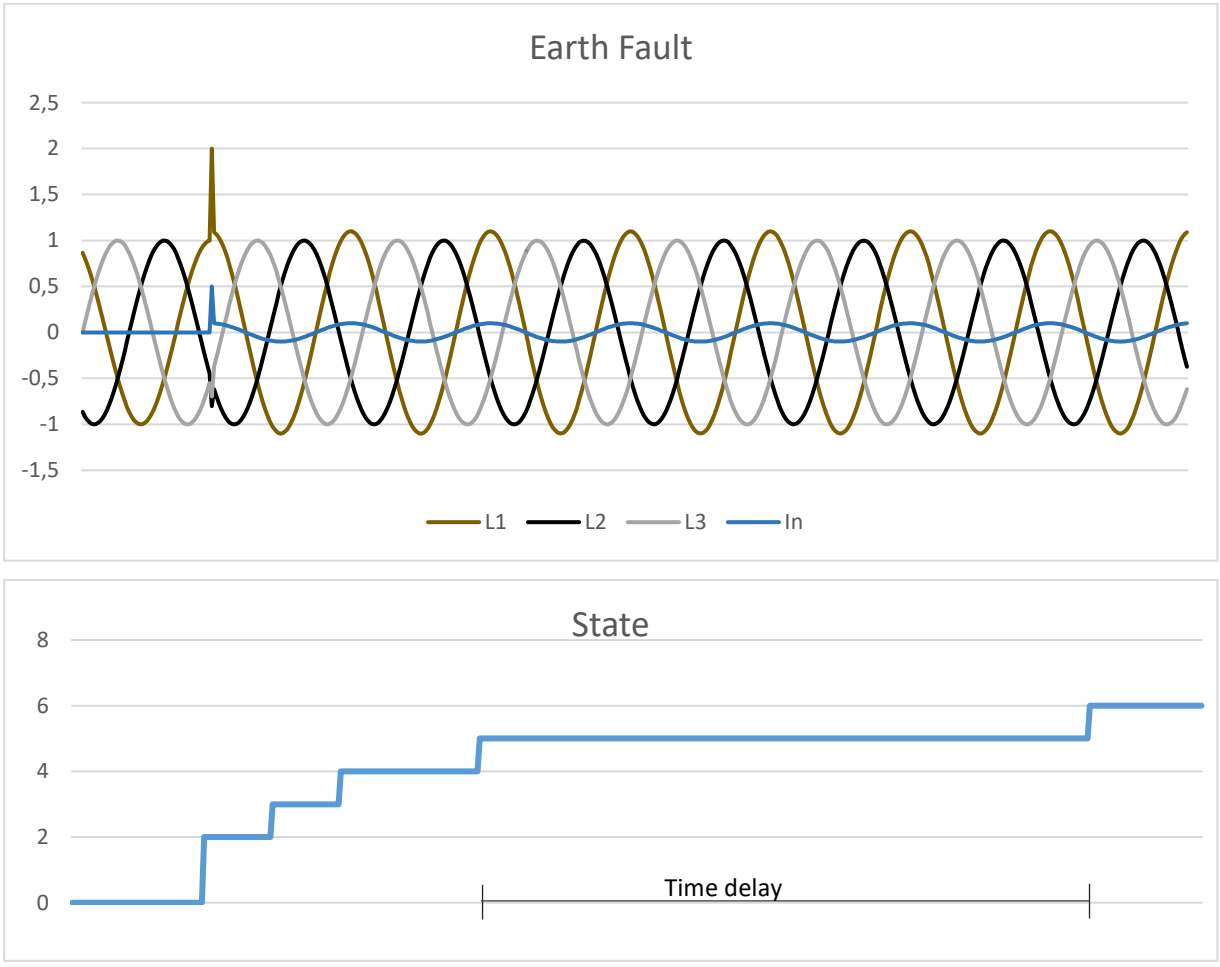


Figure 8. States during the evaluation of a solid earth fault.

Evaluation of Transient and Arcing Faults

An arcing earth fault is characterized by its transient nature. It extinguishes and then returns with a new transient after a certain time or with a certain frequency. If the time delay is short enough, a single transient may be sufficient for the detector to go to the *TRIP* state. If an error occurs and the detector reaches the *START* state, the *reignition* timer is started. If the fault returns within the set reignition time, the detector will indicate *TRIP* immediately when the *START* state is reached. Thus, it does not wait for the normal time delay between *START* and *TRIP* to expire. Two consecutive starts within a certain time is evaluated as an arcing fault. The method ensures that an arcing error does not start and reset repeatedly.

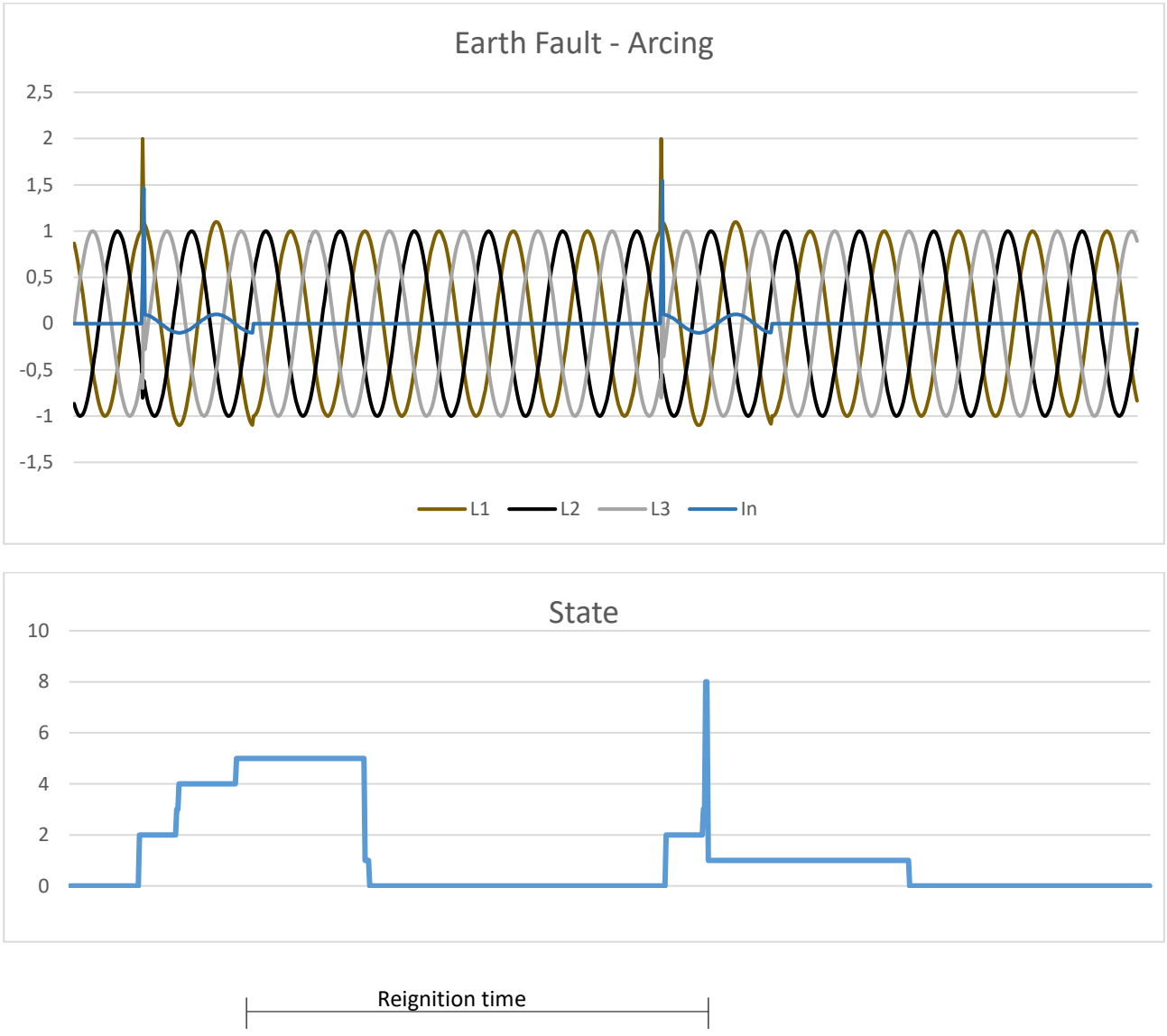


Figure 9. *Earth fault with arcing characteristics – after the second "START" the detector progresses immediately to state TRIP.*

8.3 Settings - *Common*

Detector function settings can be found on the website on tab ***Config/Detector***. Here are two or four subtabs with expansion found, Common, ***Detector 1, Detector 2*** and ***Detector 3.***

*Figure 10. Settings for the **Detector** functions.*

Settings – *Auto acknowledge*

Parameter	Description	Range	Factory value	Unit
Enable	Activation of automatic acknowledge.	Yes or No	Yes	-
Auto ack delay	Time for automatic acknowledge after fault detection.	0..48	4	h

The function for transient fault recordings is described in detail in chapter 10. There are limitations in the number of transient fault recordings that can be stored in runtime memory. If there is a need to ensure that there is always space for a new disturbance recording, the parameter ***Enable immediate ack*** can be checked. Observe that previous recordings can be deleted if the detector restarts due to new events.

Inställningar – *TFR functions*

Parameter	Description	Range	Factory value	Unit
Enable immediate ack	Activation of automatic acknowledge of TFR.	Yes or No	Nej	-
Pretrigger	Time for the first data point of the record.	1..1 000	140	ms

Specialist	Description	Range	Factory value	Unit
Post Trip Blocking Time	Time for blocking of detector functions after fault detection	0..1 000 000	2 000	ms
Test qualifier	Parameter for test	0..4294967295	0	-

8.4 Settings – *Detector n*

8.4.1 Current Transformer

Settings – *Current transformer*

Parameter	Description	Range	Factory value	Unit
Ia/Ib/Ic	Primary current or ratio	1..2000	300	A[1]

Specialist	Description	Range	Factory value	Unit
Rated Binary	Internal resolution – units per Ampere	0..1000000	313000	-

8.4.2 Overcurrent

IPC402x has two overcurrent steps that operate independently of each other. Overcurrent ***Enable*** means that both steps are activated. The start signal is common. This means that *START* overcurrent is generated by either step 1 or step 2 starting. The overcurrent function measures the RMS value of all phases. Inverse time characteristics can be activated for step 1 using the parameter ***Enable***.

The *START* signal is generated if the current in a phase exceeds the set levels, ***Level 1*** or ***Level 2***. *TRIP* overcurrent is generated after the set time delays, ***Delay 1*** or ***Delay 2***. If the setting ***Input qualifier*** is selected to any input, 1-16, no *TRIP* output signal and message to remote control will be created until there is voltage on the selected input within set time, ***Event delay***. However, the internal event is always generated.

If inverse time characteristics is used, ***Delay 1*** is ignored and is replaced with a calculated delay time according to IEC 60255,

$$t = TMS \times \left(\frac{k}{\left(\frac{I}{I_{Level\ 1}} \right)^{\alpha} - 1} \right)$$

Where ***TMS*** is a parameter of own choice and *k* och α are defined by the choice of inverse curve according to the following table.

Curve type	k	α
Standard inverse	0,14	0,02
Very inverse	13,5	1
Extremely inverse	80	2
Long inverse	120	1

[1] Omsättning Primär-/Sekundärström

Settings – *Overcurrent*:

Parameter	Description	Range	Factory value	Unit
Enable	Overcurrent steps activated.	Disabled Definite Standard inv Very inv Extremely inv Long inv	Disabled	-
Level 1	Overcurrent level step 1	0..10000.0	500.0	A
Delay 1	Time delay between *START* and *TRIP* step 1	0..10000	40	ms
TMS 1	Time multiplier at inverse time step 1	0.05..1.00	0.05	-
Level 2	Overcurrent level step 2	0..10000.0	10 000.0	A
Delay 2	Time delay between *START* and *TRIP* step 2	0..10000	10 000	ms
Event delay	Time delay for *TRIP* interlocked with input	0..25000	0	ms
Input qualifier	Input for release of *TRIP*	0..16	0 (non)	-
Trip relay	TRIP output relay	0..8	0 (non)	-
Relay pulse	Pulse length of *TRIP* output signal	100..10000	500	ms
Level 1 - set point address[1]	Address for *Set point command* in accordance with IEC 60870-5-101/-104.	0..16 777 214	0	-
Delay 1 - set point address	Adress för *Set point command* in accordance with IEC 60870-5-101/-104.	0..16 777 214	0	-

8.4.3 Earth Fault, General

The IPC402x devices have two types of earth fault detectors; Protrol's patented method, and a complementary non-directional earth fault function that can be employed when switching onto faults. The non-directional function can also be used to detect fault connection, that a phase is missing or that one phase is connected with the wrong polarity. Both methods work independently of each other. Both will set the indication earth fault *START*.

8.4.4 Earth Fault Protrol

IPC402x initially triggers a ground fault detection sequence on a change in the zero-sequence system. The current ***Level*** corresponds to the zero-sequence current measured by the detector.

A *START* signal is generated if the detector reaches State 5, according to Section 8.2. Ground fault *TRIP* is generated after set time ***Delay*** or if immediately without delay if the reignition timer has been started by a previous transient. If the setting ***Input qualifier*** is selected to any input, 1-16, no TRIP output signal and message to remote control will be created until there is voltage on the selected input within set time, ***Event delay***. However, the internal event is always generated.

[1] Enheten startar om 10 s efter senaste Set point-kommando.

Settings – *Earth Fault Protrol*:

Parameter	Description	Range	Factory value	Unit
Enable	Protrol earth fault function activated	Yes or No	No	-
Level	Earth fault current level	0.1..100.0	2.0	A
Delay	Time delay between *START* and *TRIP*	0..10 000	100	ms
Event delay	Time delay for *TRIP* interlocked with input	0..25 000	0	ms
Input qualifier	Input for release of *TRIP*	0..16	0 (non)	-
Trip relay	*TRIP* output relay	0..8	0 (non)	-
Relay pulse	Pulse length of *TRIP* output signal	100..10 000	500	ms
Reignition enable	Reignition feature activated	Yes or No	Yes	-
Reignition delay	Time window for reignition to be identified	0..25 000	2 500	ms
Level 1 - set point address[1]	Address for *Set point command* in accordance with IEC 60870-5-101/-104.	0..16 777 214	0	-
Delay 1 - set point address	Adress för *Set point command* in accordance with IEC 60870-5-101/-104.	0..16 777 214	0	-

Specialist				
Trig level	Trig level for earth fault – not possible to set	0.0..100.0	90% of Level	A
Asym level	Asymmetry level	1.0..1000.0	3.0	-
TPAD level	Alternative asymmetry level	1.0..1000.0	1.5	-
TPAD angle 1	Angle restriction 1	0.0..100.0	30.0	deg
TPAD angle 2	Angle restriction 2	90.0..270.0	150.0	deg
Early start	Alternative for the reignition function	0..2	0	-
Fast reset	Deactivation of fast reset i r.*0.2.3*	0..1	0	-
Minimum arcing time	Shortest time for reignition/arcing fault	0..25 000	0	ms

8.4.5 Non-Directional Earth Fault

Activation of non-directional earth fault can be selected as ***Always*** or only after closing of the circuit breaker, ***Only at Close***. Closing or energization is detected using an input indicating ON, specified by the parameter ***Input qualifier***, or by using the current change. The two alternative ways of detecting a closed circuit breaker work in parallel. The earth fault function is activated during a set time, parameter ***Event delay***.

The non-directional earth fault function measures the residual current, ***Ia + Ib + Ic***. The measurement method can be chosen between ***RMS*** and ***Fundamental***. The latter means that only the fundamental harmonic is measured, since characteristic harmonics are suppressed.

START signal is generated when the sum current exceeds the set threshold, ***Level***. *TRIP* earth fault is generated after the set time ***Delay***.

[1] Enheten startar om 10 s efter senaste Set point-kommando.

Settings – *Non-Directional Earth Fault*:

Parameter	Description	Range	Factory value	Unit
Enable	Non-directional earth fault function activated	Never/ Always/ Only at close	Always	-
Level	Earth fault current level	0.1..500.0	10.0	A
Delay	Time delay between *START* and *TRIP*	0..10 000	100	ms
Event delay	Time delay for *TRIP* interlocked with input, alternatively time window for activation after closing of circuit breaker	0..25 000	0	ms
Input qualifier	Input for release of *TRIP*, alternatively input for ON indication for activation after closing of circuit breaker	0..16	0 (non)	-
Trip relay	*TRIP* output relay	0..8	0 (non)	-
Relay pulse	Pulse length of *TRIP* output signal	100..10 000	500	ms
Measurement type	Measurement method RMS or Fundamental	RMS/ Fundamental	RMS	-
Low level	Current level before for switch-on detection.	0.1..500.0	1.0	A
High level	Current level after for switch-on detection.	0.1..500.0	30.0	A

8.5 Phase Break

A phase break is identified as a failure of a phase without grounding. Typical scenario is the interruption due to a down fallen phase conductor that does not get in contact with ground. The following criteria must be met for phase interruptions to be detected:

- Residual current < ***Low Level***
- Current in one of the phases < ***Low Level***
- Current in the other two phases > ***High Level***

When the three criteria at the same time have been fulfilled during the set time ***Delay***, a phase break is detected. Phase breaks do not result in a start signal. Note that if a phase is missing but the two remaining have a phase difference of 120 degrees, there will be no phase break. Such a fault is indicated by a non-directional earth fault.

Settings – *Phase Break*:

Parameter	Description	Range	Factory value	Unit
Enable	Phase break function activated	Yes or No	No	-
Low Level	Max nivå för förlorad fas och summaström Max current for lost phase and residual current	0.1..1000.0	5.0	A
High Level	Min current level for healthy phases	0.1..1000.0	20.0	A
Delay	Time delay between *START* and *TRIP*	0..10 000	5 000	ms
Trip relay	*TRIP* output relay	0..8	0 (non)	-
Relay pulse	Pulse length of *TRIP* output signal	100..10 000	500	ms

8.5.1 Auto reclosing – OPTION

Auto reclosing (AR - *RECL*) means that a delayed switch-on is ordered after an initial *TRIP* has been issued by any of the Overcurrent or Earth fault Protrol protection functions. This option can be acquired for one bay only, or for all three bays.

Activation of the function can be made at the device using a binary input, or the ACN button. It can also be ordered by the remote control centre. The ACN button must be pressed 5 s before toggling takes place. Indication to and order from SCADA is configured as double point / double command, see *I/O-addressing/Binary inputs/Detector m/RECL OFF/ON* and *I/O-addressing/Binary outputs/Detector m/RECL OFF/ON,* respectively. These objects are blocked from factory.

Visual indication of AR OFF/ON can be chosen as follows:

AR for Detector 1 – no output (None), outputs 1 – 8, however, always AUX-LED
AR for Detector 2 and 3 – no output (None), outputs 1 – 8, and/or AUX-LED

After reclosure the function is always OFF. Reactivation can be done from SCADA but will always be done automatically by Acknowledge after a preset time or by pressing the ACN button. Also, a restart of the device inactivates AR. Manual switch-on of the circuit breaker blocks auto reclosure for 60 s.

The event log shows events for AR OFF/ON, AR startad and AR executed: *RECL OFF*, *RECL ON*, *RECL Started*, *RECL Executed*.

Settings – *Auto reclosing*:

Parameter	Description	Range	Factory value	Unit
Enable	Choice of function that starts auto reclosing	Disabled/ OC/EF/OC&EF	Disabled	-
Delay	Time delay for auto reclosing	500..60 000	30 000	ms
Reclosure relay	Output relay for reclosing (*ON* output)	0..8	0 (None)	-
Relay pulse	Pulse length of *ON* output signal	100..10 000	500	ms
Input ON/OFF	Input for local activation of auto reclosing	ACN, 1..16	ACN	-
Output indication	Output or LED for local indication OFF/ON	None, 1..8, AUX LED	AUX LED	-

It is strongly recommended to use the Non-directional earth fault function with activation after switch-on to ensure safe detection of a permanent earth fault after the auto reclosure operation.

9 Event log and Site Manager

9.1 Event log – *Event log*

The event registration that logs events in the device, ***Event log***, can be found in the web interface under the ***Status*** tab. Here, both internal events and events generated by detector functions are shown. An event has four different fields:

- ***Timestamp*** - time marking
- ***Type*** - type of event can be *Error*, *Warning*, *Info* or *Debug*
- ***Text*** - description of the event
- ***Extra information*** - four fields for extra information mainly for internal use

In the example in Figure 11, extra information is used. For the *EF Detected* event, the first digit tells which detector has started. In this case, it is *Detector 1*. The second digit of the *EF Detected* is the *State*. Here it is 8 which means that it was the reignition function that detected the fault. Third digit for *EF NONDIR Detected* or *EF Detected* indicates that faulty phase is L2. For overcurrent, there are also options 12, 13, 23 or 123, which show which phases are involved.

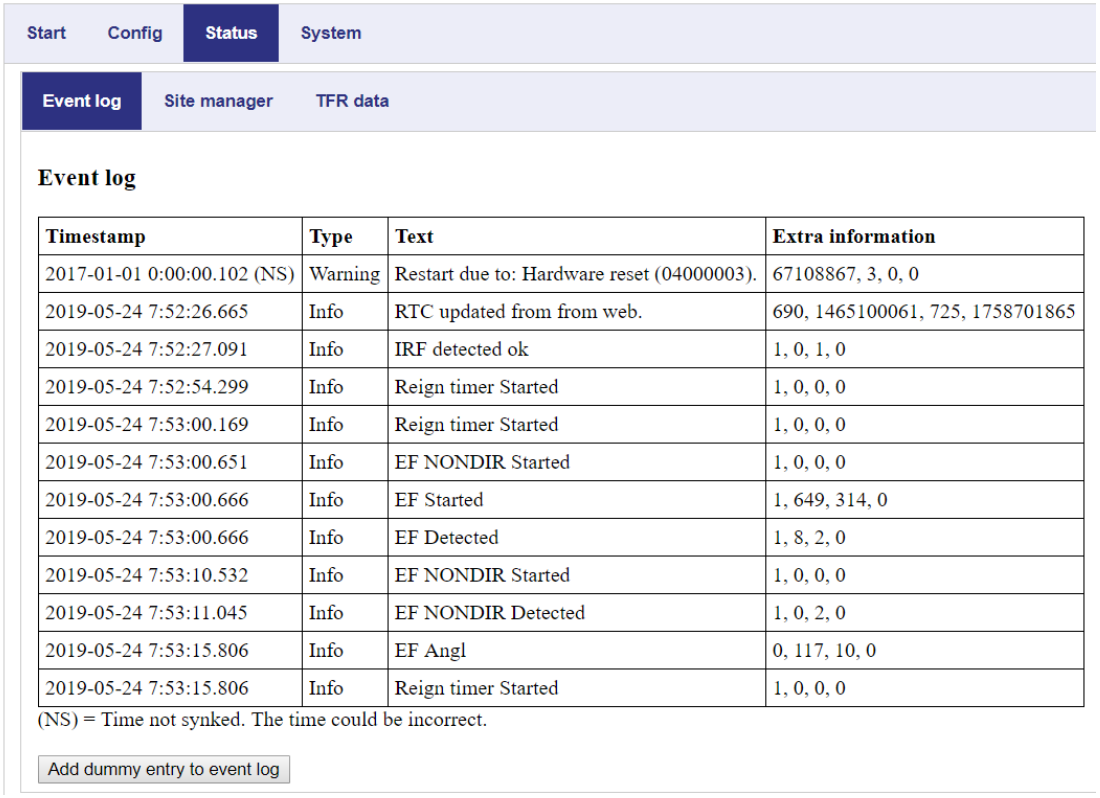


Figure 11. Event log.

At the bottom there is a button to generate a *dummy* event for test purposes.

9.2 Site Manager

Site manager is found in the web interface on the ***Status*** tab.

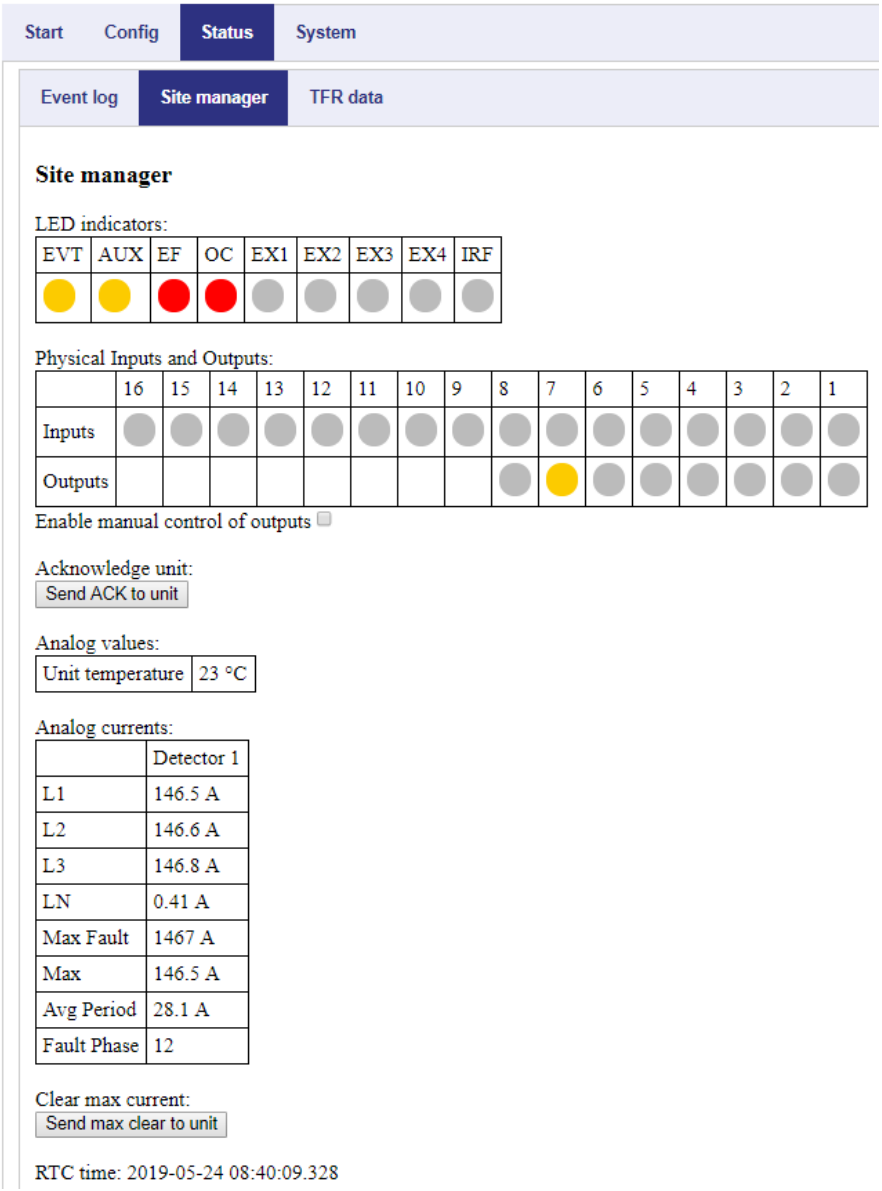


Figure 12. Site manager for IPC4020.

Please note that Site manager will adjust to the type of IPC402x device that is used and on what options that are activated.

The table below describes the indicators on the ***Site Manager*** tab.

Indikator	Beskrivning
EVT	Yellow diode indicating that there is an unsent telegram in the queue for slave transmission on the system interface
AUX	Yellow diode that normally indicates that the device is handling a frequency deviation
EF	Red diode indicating that an earth fault has been detected
OC	Red diode indicating that an overcurrent has been detected
EX1	Yellow diode indicating that Detector 1 has identified a fault
EX2	Yellow diode indicating that Detector 2 has identified a fault – applies to expanded device
EX3	Yellow diode indicating that Detector 3 has identified a fault – applies to expanded device
EX4	Yellow diode that in normal configuration indicates start fault detection
IRF	Red diode that indicates internal fault
Inputs 1 - 8/10/16	Yellow indicator for active input.
Outputs 1 – 3/8	Yellow indicator for active output.

On this tab, the status of the following is displayed:

- Indications - the status of each LED is mirrored
- Temperature - measured inside the device and displayed with an offset of -15 degrees in standard design. E.g., if the unit measures 43 degrees, the value 28 is displayed
- Current values, primary values
    - Phase currents and residual current
    - Max fault current
    - Max current of indicator - resets with the ***Send max clear unit*** button
    - 15 minutes mean value of minimum phase current
- Faulty phase(s) for last registered fault
- Current time - *RTC time*

The ***Send ACK to unit*** button works just like the physical button on the device. Note that the value *Max* is not reset.

Site manager is typically used to check the device status via the Ethernet interface and in conjunction with commissioning to obtain current values. A good way to verify that all phase currents are correctly connected is, for example, to read the amplitudes. If they are equal and the sum current at the same time is small, the connection is likely to be correct.

There is a checkbox that enables activation of the outputs via the web interface. It is checked as long as you are logged in. To activate an output, simply click on the LED symbol. It then lights up and closes the relay output for 2 seconds.

10 Transient Fault Recorders – TFR

The transient fault recorder saves the current phases and *State* during 1 s with the resolution 2 000 Hz, including the time that is specified by the parameter ***Pretrigger***. See chapter 8.2. for more details on *State*. Disturbance recorder data is found under ***Status / TFR data***. If there is more than one detector, a file is always saved per detector regardless of which one that triggers the recording. To download the interference file, simply click on the button *Detector 1*, *Detector 2* or *Detector 3*. Depending on the browser settings, you can select the file name and destination for the download.

The *Type* column specifies what triggered the file to be saved. For example, the earth fault function may have started. The following events trigger the transient fault recorder:

- *START* overcurrent
- *START* earth fault
- *START* non-directional earth fault
- External trigger by binary input
- Manual trigger by pressing ***Capture active live data***. See Figure 13.

The rightmost column contains a button, ***Acknowledge***. The purpose of the function is that non-acknowledged disturbances files should not be overwritten and valuable information lost. A disturbance file can be acknowledged in several ways:

1. Press the button for the respective interference in the *TFR data* subtab. Only this specific disturbance is acknowledged.
2. Press the physical button on the IPC device. All disturbances are acknowledged.
3. By automatic acknowledgment after some time, a setting on the ***Config/Detector/Common*** subtab. All disturbances are acknowledged.
4. By sending a telegram, *single command* to the device, addressing *Acknowledge*, binary outputs. All disturbances are acknowledged.

A maximum of four disturbances are saved. Only a disturbance that is acknowledged can be discarded. When the disturbances are acknowledged, the oldest acknowledged disturbance will be next to be discarded. This means that after an acknowledgment, IPC402x is always ready to register a new disturbance record.

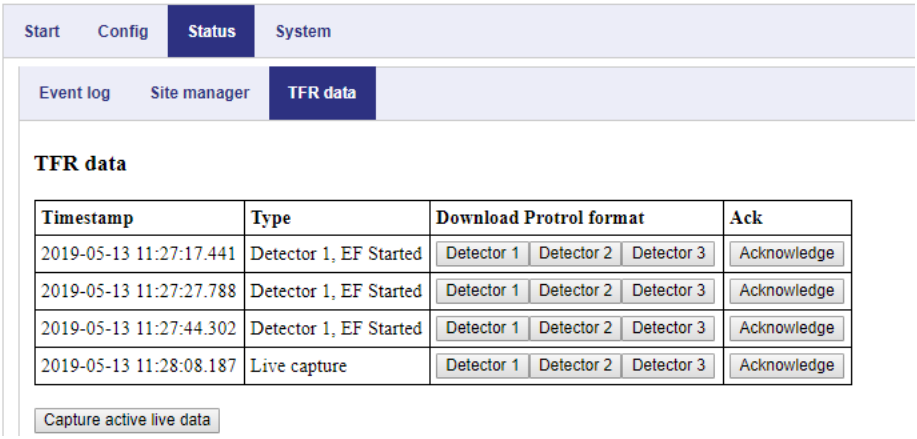


Figure 13. TFR data subtab of the web interface.

TFR data is saved in the same basic format as for IPC401x. Data can thus be displayed by the same tool, see [3]. For conversion to COMTRADE there is a special tool, available on Protrol's web page. Also, files from IPC401x can be converted.

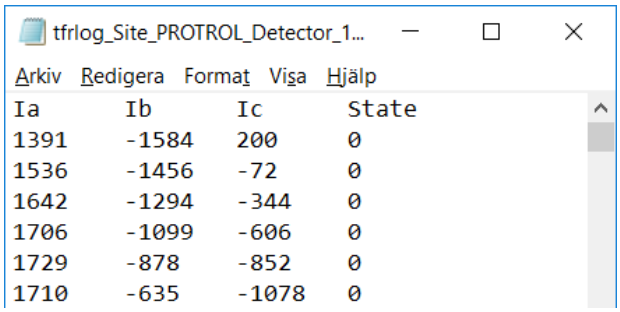


Figure 14. The log file with TFR data – phase currents and State.

At the end of the log file there is additional information to obtain traceability during error analysis. Here can be found, among other things, version number, detector type, station name and scaling information. See Figure 15.

Some of the information is necessary for the conversion to COMTRADE to work. This applies to frequency, sampling frequency, CT ratio, resolution (RatedBinary) and time stamp.

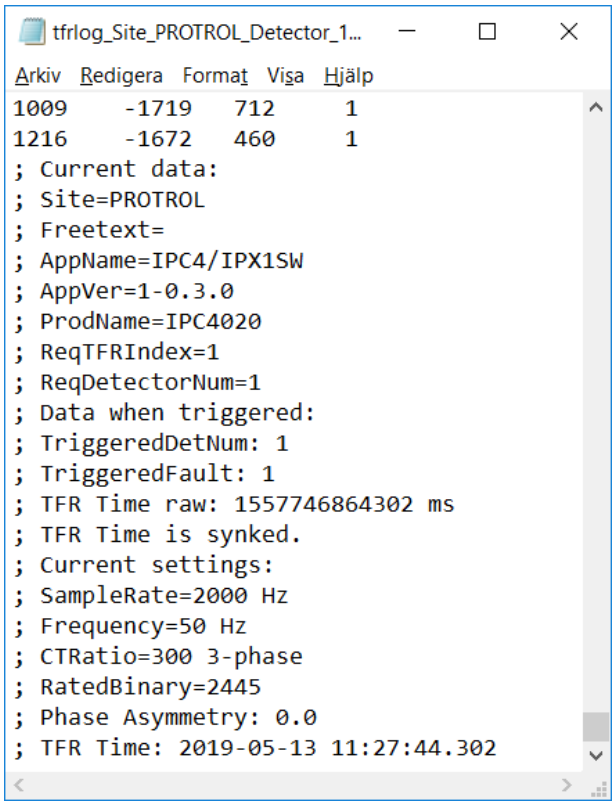


Figure 15. TFR log file – data at the end of the file.

The COMTRADE converter is shown in Figure 16 beneath.

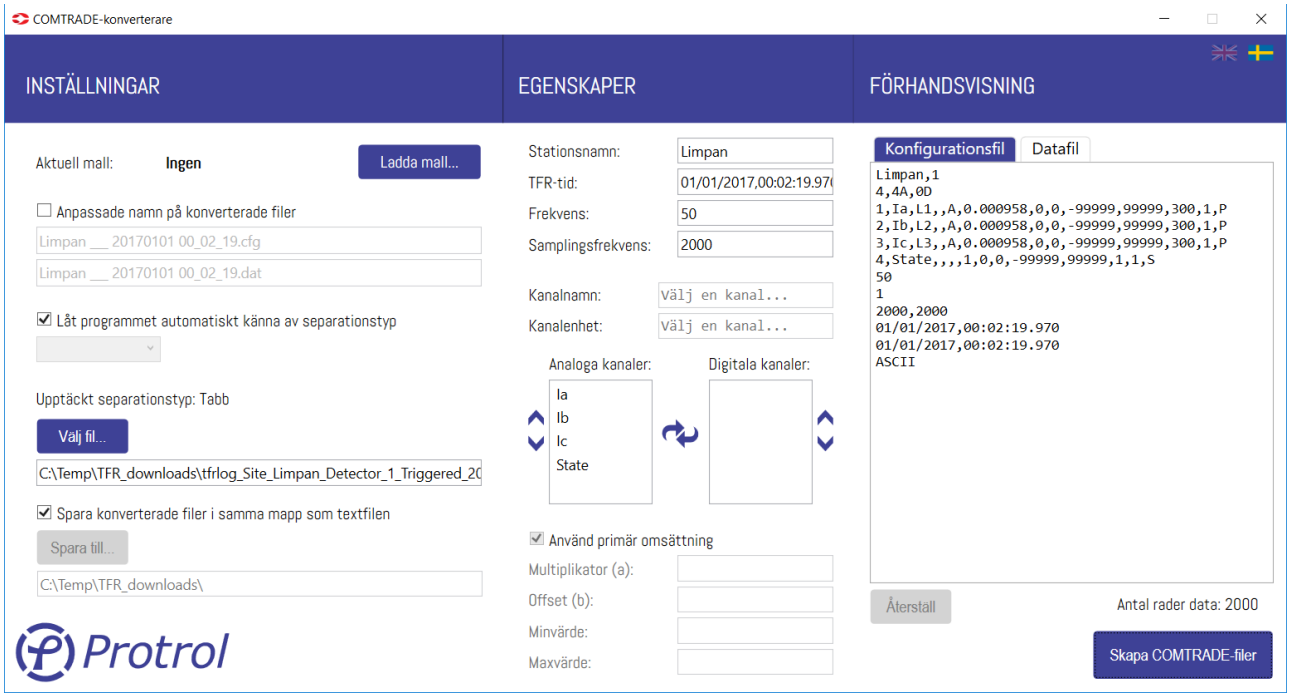


Figure 16. COMTRADE converter.

- Upload a stored TFR file from the test device or select a previously uploaded file.
- Specify where to save a converted file. By default, it is saved in the same directory as the original data. It is possible to change file names if desired. The tool recognizes the type of data separation, eg loss or comma. Separation type can also be specified.
- When the file is selected, the configuration file and data file are displayed to the right. Change any input, scaling, labels, etc., if necessary.
- Convert by clicking ***Create COMTRADE files***.

11 Upgrade of Firmware

Chose a *Bundle file* for firmware upgrade on the system tab and activate the software upgrade by pressing ***Start SW upgrade***.

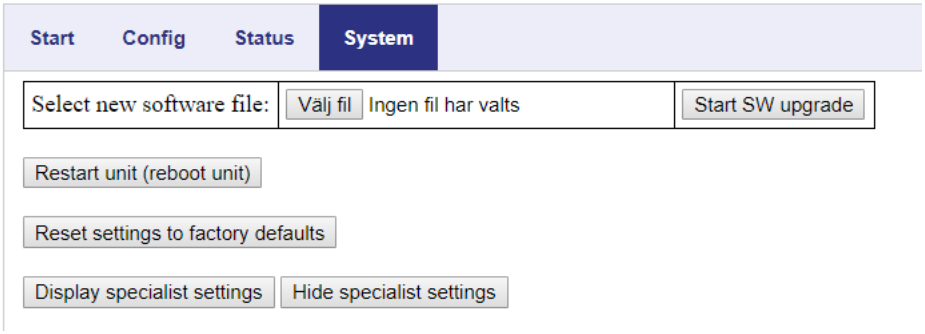


Figure 17. System tab for IPC402x.

After restart of the device, which will be performed automatically, it is recommended to check the current software version.

12 Checklist for Commissioning and Testing

1. Check the polarity and level of the auxiliary voltage before powering up the IPC402x.
2. Connect to IPC402x via the Ethernet or USB interface. Log in as ***config*** or ***admin***.
3. Open the *Site manager* subtab.
4. Test binary inputs by applying 24 VDC at one input at a time. Verify that:
    a. The correct LED on the unit lights up.
    b. The corresponding LED symbol in the ***Site manager*** is activated.
    c. Corresponding indication message is sent via the selected remote interface.
5. Check *Enable Manual control of outputs* box in *Site manager*. If required, disconnect the outputs from external objects. Verify that:
    a. The correct LED on the unit lights up when activated in *Site manager*.
    b. The correct output is activated. Measure the resistance across the output on terminal block. It should be <1 Ohm when the relay is active.
    c. If possible, activate the output via the remote interface.
6. If the station is in operation, the phase currents connected and with a measurable current, check that:
    a. The correct amplitude is displayed in the *Site manager*.
    b. The currents are symmetrically presented in *Site manager*. If the amplitudes are equal and the residual current near 0 is safe, the connection is correct.
    c. Create a disturbance file and check that the phase sequence is the expected one.
    d. Measurement values are displayed correctly in the remote control center.

7. To test overcurrent and earth fault detector functions:

   a. Inject current with a one or three phase instrument. Check the indications for each function of the front panel of the device, in the *Site manager*, in the *Event* log and, if possible, in the remote control end. See Figure 18.

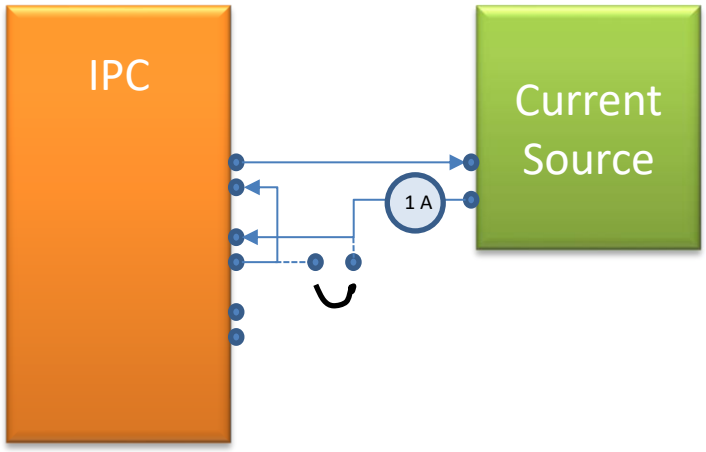


Figure 18. Current injection in two opposing phases.

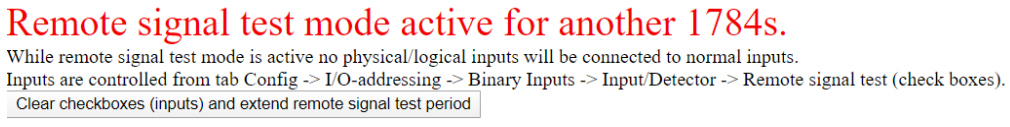
   b. With a current connected in counter phase to two inputs, both overcurrents and earth faults can be verified. For testing of earth faults, typically apply 0.5 A and then short-circuit one of the phases swiftly on a terminal or directly on the plug-in contact of the device.

   c. If no current injection instrument is available and if the station is in operation with measurable currents, a simple test of the earth fault detector can be performed by short-circuiting a phase briefly on the terminal.

   d. If it is not possible to apply voltage/current on the inputs and there is no load current available, one can use simulated signals to verify the logical connection to the remote control center.

      On the tab ***System*** it is possible to activate the function for testing signals to the remote control center by pressing the button *Activate remote signal test*.

      The following text is shown:



      A new column, **Remote signal test,** is then added to the object settings for binary inputs on the tabs ***Binary Inputs/Input 1-16*** and ***Binary Inputs/Detector m***.

      Clicking on a checkbox creates an object that is sent to the remote control center.

13 References

[1] *IPC4020-datablad-xxyy-en.pdf*

[2] *IPC4022-datablad-xxyy-en.pdf*

[3] *IPC4010-12_manual_xxyy_en.pdf*

Ensto Protrol AB, Alfagatan 3, SE-431 49 Mölndal, SWEDEN

Phone: +46 31 45 82 00. E-mail: info@protrol.se

www.protrol.se