White paper

Communication with SACE Emax 2 circuit-breakers

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Communication with SACE Emax 2 circuit-breakers

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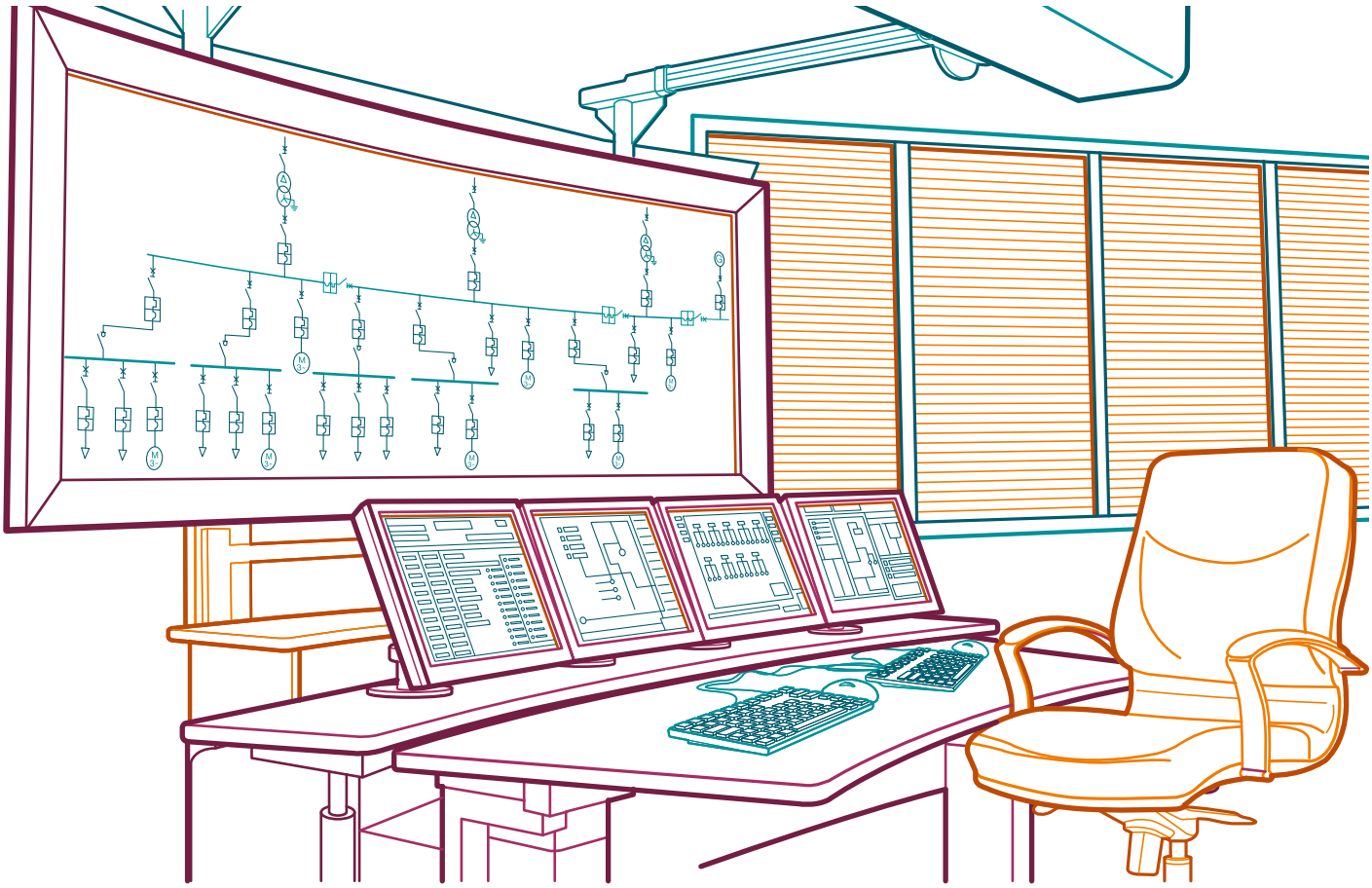
1. Introduction

Due to the growing use of automation and supervision systems for plants and industrial processes, the implementation of a communication systems for the control and supervision of electrical plants through the data available in the circuit-breakers has become more and more important. In particular, the possibility to integrate the supervision of the industrial process with the supervision of the electrical plant supplying it is more and more required. To this purpose, the automatic circuit-breaker equipped with a communication interface, besides carrying out the function of protecting the plant against overcurrents and supplying energy to the loads, is used also as a measuring and communication device for controlling and managing the electrical plant. The aim is, for instance, to limit consumption and energy costs and to guarantee service continuity in the plant.
The circuit-breaker includes the measurements, information and functions necessary for the control and the supervision of the electric plant, in particular:

- information about the circuit-breaker state (open/closed/tripped, racked-in/out position) and remote control for the management of the plant
- information about tripping and opening data (e.g.: date, time, fault currents per phase and type of protection tripped)
- alarms to reduce to the minimum the inefficiencies and downtime of the plant
- measurement of energy for cost optimization and allocation
- measurement of energy quality and of electric power supply (e.g.: power factor, total harmonic distortion, interruptions of the supply voltage)
- maintenance data of the circuit-breaker (e.g.: contact wear percentage, number of mechanical and electrical operations) to schedule preventive maintenance operations with the purpose of limiting to a minimum the plant downtime and guaranteeing service continuity.

With SACE Emax 2 circuit-breakers, all these data can be viewed in local mode, directly from the color display of the Ekip trip units, or from the switchboard front through Ekip Multimeter display.

In addition, with the above mentioned trip units, the data can be sent to supervision and control equipment such as PC, SCADA or PLC (programmable logic controllers) via a communication network.



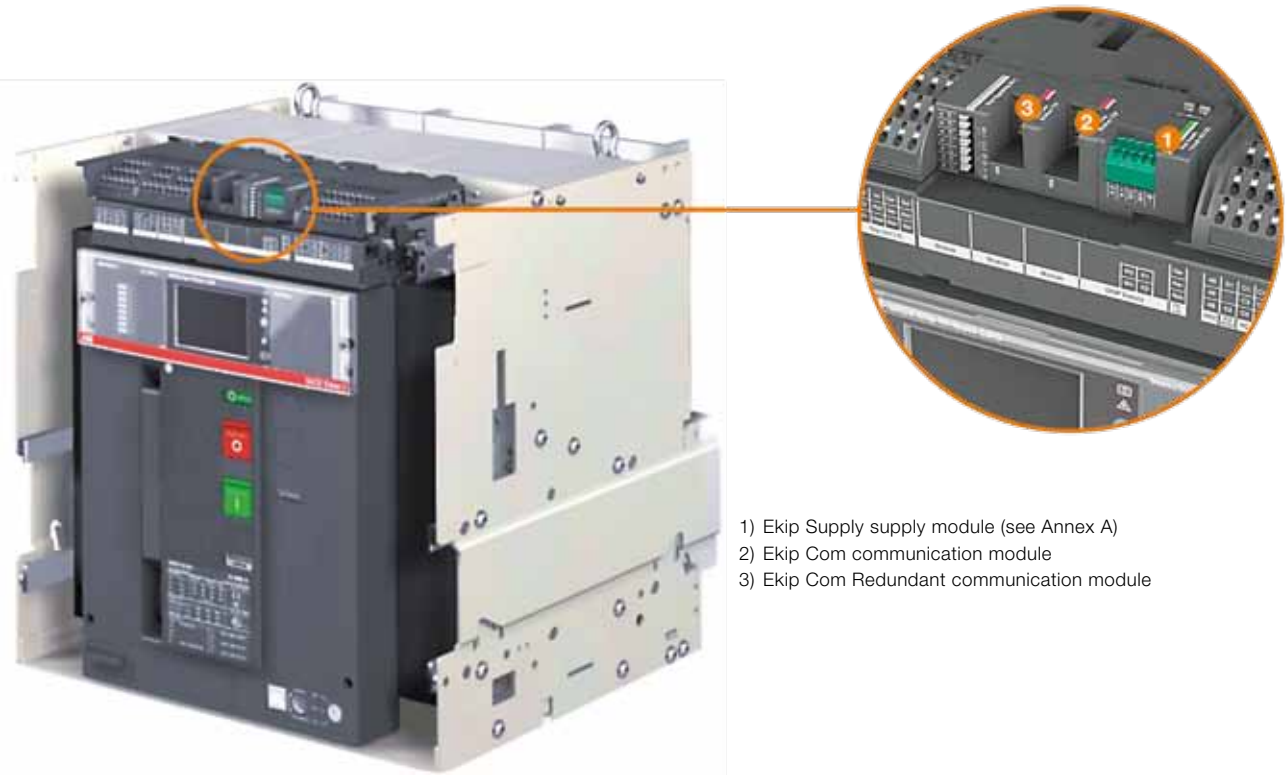
2. Communication with SACE Emax 2 circuit-breakers

With the automatic air circuit-breakers series SACE Emax 2 equipped with Ekip electronic trip units, the Ekip Com communication modules are available. They can integrate directly, without using external gateways, the circuit-breakers into the main field buses and into Ethernet communication networks with the protocols Modbus TCP and IEC 61850 (the last one for electric substations, for smart grids and for the integration between medium and low voltage plants).
In particular, communication is possible with the following protocols:
For field buses:
– Ekip Com Modbus RTU module
– Ekip Com Profibus DP module
– Ekip Com DeviceNet module.

For Ethernet networks:
– Ekip Com Modbus TCP module
– Ekip Com IEC 61850 module
– Ekip Com Profinet module
– Ekip Com EtherNet/IP module.

Ekip Com module is the communication interface that allows the trip unit to be directly connected to the field bus or to the Ethernet network. This module can be inserted anytime directly into the cartridge module area of the terminal box of the fixed part of the withdrawable circuit-breaker, thus giving the possibility to maintain communication also when the moving part of the circuit-breaker is withdrawn. With the circuit-breaker in the fixed version, this module is inserted into the upper part of the circuit-breaker.
For example, with Ekip Com module it is possible:
- to send to a remote supervision system the measurements of the electrical quantities available in the trip unit, the information about the circuit-breaker state (e.g.: open/closed/tripped, racked-in/rack-out position) and the protection alarms
- to command from remote the CB opening and closing operations
- to set from remote the parameters of the trip unit and of the protection functions.

When redundancy of the communication port is required for a better service continuity and reliability of the supervision system (e.g.: refineries, chemical installations, steelworks), there is the possibility of duplicating the communication port of the trip unit using, for each protocol, the corresponding redundant module Ekip Com Redundant.
When simultaneously used, the Ekip Com module and the corresponding Ekip Com Redundant module must be configured with different addresses. Redundancy of the communication port is made at the master/client level of the supervision and control system.



1) Ekip Supply supply module (see Annex A)
2) Ekip Com communication module
3) Ekip Com Redundant communication module

2. Communication with SACE Emax 2 circuit-breakers

2.1 The trip units, the modules and the accessories for communication

Supervision

Ekip Touch *

Ekip Hi-Touch
Ekip G Touch/Ekip G Hi-Touch

+

Ekip Supply

+

Ekip Com

+

Ekip Com
Redundant

(*) Ekip Touch can be equipped with the measuring module Ekip Measuring or with the measuring and protective module Ekip Measuring Pro (see § 2.2).

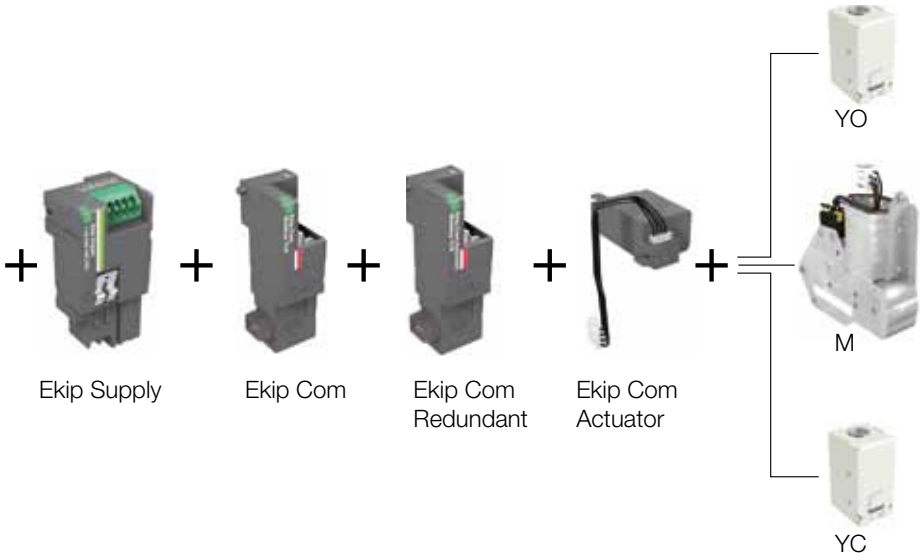
Together with the Ekip Com communication module, the following accessories are supplied by default:
- the position contact AUP (contact S75I/5) for signaling the racked-in/test/racked-out position of the CB moving part with respect to the fixed part (for circuit-breakers in withdrawable version only).
- the auxiliary contact Ekip RTC, which gives to the trip unit the signal circuit-breaker ready to close (conditions for closing: circuit-breaker open, springs charged, absence of opening command, circuit-breaker reset after tripping of Ekip trip unit).

Mounting of the contacts is customers' responsibility.

Supervision + Remote control

Ekip Touch *

Ekip Hi-Touch
Ekip G Touch/Ekip G Hi-Touch



YO: opening coil
YC: closing coil
M: motor for the automatic recharge of the CB closing springs
Ekip Com Actuator: Actuator module to command from remote, via a communication network, opening and closing of the circuit-breaker. It is an optional module to be ordered with a dedicated code number. Further information on Ekip Com Actuator are available in the kit sheet 1SDH001000R0501 in ABB Library.

(*) Ekip Touch can be equipped with the measuring module Ekip Measuring or with the measuring and protective module Ekip Measuring Pro (see § 2.2)

Together with the communication module Ekip Com, the following accessories are supplied by default:
- the position contact AUP (contact S75I/5) for signaling the racked-in/test/racked-out position of the CB moving part with respect to the fixed part (for circuit-breakers in withdrawable version only).
- the auxiliary contact Ekip RTC, which gives to the trip unit the signal circuit-breaker ready to close (conditions for closing: circuit-breaker open, springs charged, absence of opening command, circuit-breaker reset after tripping of Ekip trip unit).

Mounting of the contacts is customers' responsibility.

Note: Use of modules
It is possible to install simultaneously up to three communication modules Ekip Com or Ekip Com Redundant on the circuit-breakers Emax 2 E2.2 - E4.2 - E6.2.
It is possible to install simultaneously up to two communication modules Ekip Com or Ekip Com Redundant on the circuit-breakers Emax 2 E1.2.
A circuit-breaker cannot be equipped with more than one module Ekip Com (or Ekip Com Redundant) using the same communication protocol.
On the same circuit-breaker it is possible to install only one Ekip Com Redundant module, which must have the same communication protocol of the corresponding Ekip Com module.

2. Communication with SACE Emax 2 circuit-breakers

2.2 Available measurements

The measuring data available to monitor the electrical plant depend on the type of trip unit used and on the presence either of the measuring module Ekip Measuring or of the measuring and protection module Ekip Measuring Pro.
With the Ekip Measuring module for the Ekip Touch trip units, it is possible to use the trip unit as a multimeter to measure, in addition to the phase currents, to the currents in the neutral (1% accuracy), and to the earth fault currents (2% accuracy), also the main electrical parameters of the plant. These are for example:

- line-to-line voltage (U12, U23, U31), phase voltage (U1, U2, U3) and residual voltage (0.5% accuracy)
- active (total and phase) power (P), reactive power (Q), and apparent power (S) (2% accuracy)
- power factor (2% accuracy) and peak factor (Ip/Irms)
- total active, reactive, and apparent power (2% accuracy)
- frequency (0.1% accuracy).

The Ekip Touch trip unit, when equipped with the measuring and protection module Ekip Measuring Pro - in addition to measurements - implements the advanced protection functions based on voltage (e.g.: undervoltage UV, overvoltage OV), frequency (e.g.: underfrequency UF, overfrequency OF), and power (e.g.: reverse active power protection RP). When used with Ekip Touch trip units, Ekip Measuring Pro puts at your disposal the same electrical measurements available with Ekip Measuring.

Ekip Hi-Touch and Ekip G Hi-Touch trip units are delivered by default with the measuring and protection module Ekip Measuring Pro. These trip units, in addition to the electrical measurements available with Ekip Touch + Ekip Measuring, give also:

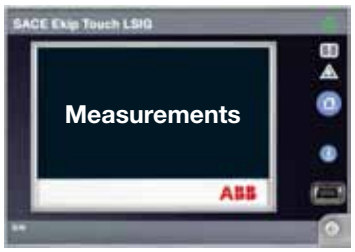
- waveforms of phase, neutral and earth fault currents
- waveforms of the line-to-line voltage (U12, U23, U31)
- the network analyzer (low-voltage supply characteristics in compliance with EN 50160 and IEC 61000-4-30)
- harmonic analysis (THDi, THDv and spectrum up to 50th harmonic at 50 Hz and 60 Hz).

See Annex B for the main measurements, information and commands available from remote.

Ekip Touch + Ekip Measuring

- Current
- Voltage
- Power
- Energy
- Frequency
- Power factor

Ekip Touch + Ekip Measuring Pro



- Current
- Voltage
- Power
- Energy
- Frequency
- Power factor

- Undervoltage protection UV-ANSI 27
- Overvoltage protection OV-ANSI
- Underfrequency protection UF-ANSI 81H
- Overfrequency protection OF-ANSI 81H
- Voltage unbalance protection VU-ANSI 47
- Rc Residual current protection ANSI 64 & 50 NTD
- Reverse active power protection RP ANSI 32R
- Phase sequence incorrect
- Power factor incorrect

3. Fieldbus communication

This Chapter presents the solution with the air circuit-breakers SACE Emax 2 for fieldbus communication, that is the serial and digital communication between supervision and control systems (e.g.: SCADA, PC or PLC) and decentralized field devices.

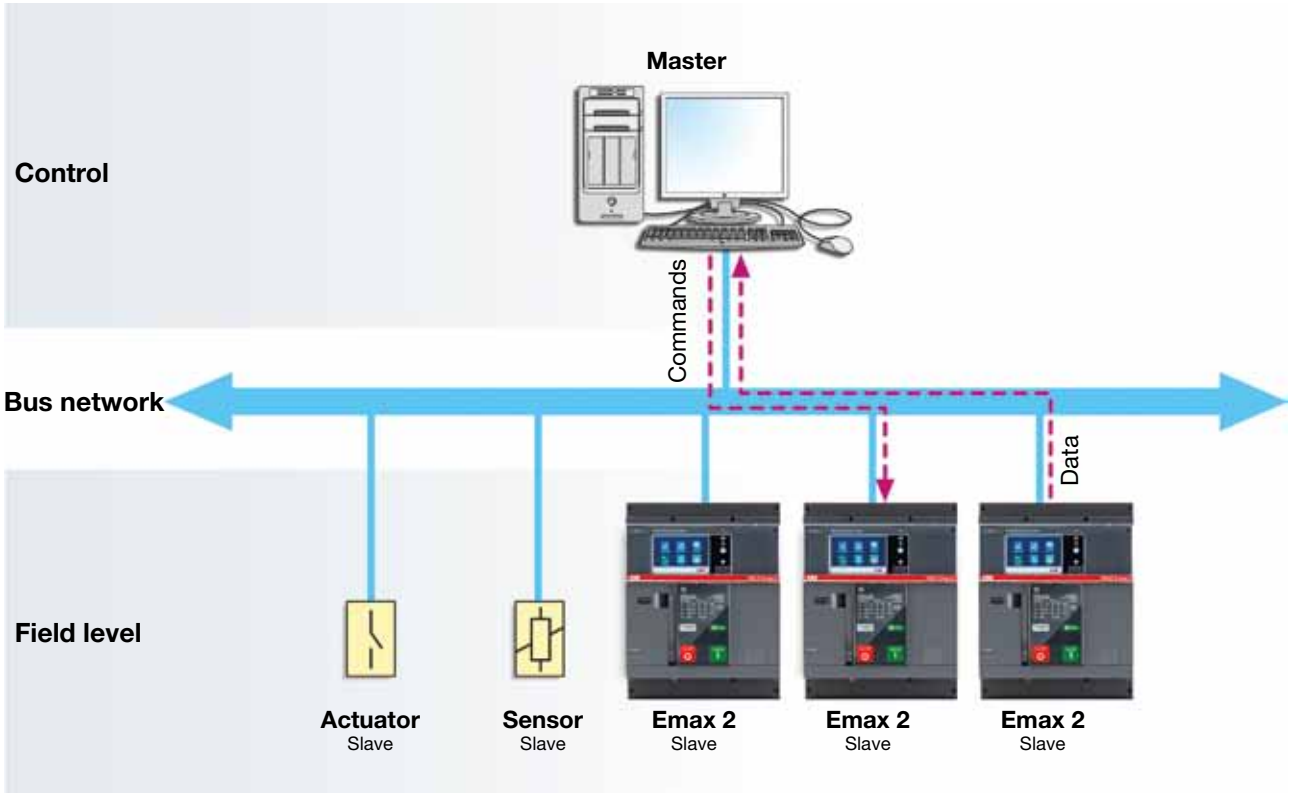
In particular, the solution for the fieldbus communication with Modbus RTU, Profibus DP and DeviceNet protocols is described.

3.1 Modbus RTU protocol

Modbus is an open communication protocol defined by a hierarchical structure (one master and various slaves). The physical access is based on a half-duplex serial transmission. The electrical interface enables point-to-point (RS232) or multipoint (e.g.: cable transmission via RS485 serial line, defined by the EIA/TIA-485 Standard) connections.
The Modbus protocol is particularly suitable for information exchange between control devices in an industrial environment based on a master-slave architecture: the various slave devices, each of them identified by its own slave address, are connected to the same serial line, with a unique master (managing and controlling the whole communication process) that periodically and cyclically polls them.
SACE Emax 2 air circuit-breakers communicate via a Modbus RTU (Remote Terminal Unit) protocol providing: 1 start bit (fixed), 8 data bits, 1 parity bit (optional, to prevent communication errors), 1 or 2 stop bits that conclude the transmission.
To implement a communication network between more slaves communicating in Modbus RTU (either measuring instruments, or protection circuit-breakers or temperature control units), it is fundamental to have the possibility of setting the same communication parameters on all the devices in the network:
- baud rate: (e.g.:19200 bps)
- data bit (no. of bits): 8
- parity bit : Even/Odd/None
- stop bit: 1 (if parity bit = even or odd) or 2 (if parity bit = none)
- address of each slave (the devices connected to the same network must have different addresses).

Once the same baud rate and the same transmission parameters have been set, and once every slave has been identified by one single, unique address, the master can proceed with the information acquisition.
For in-depth information see: www.modbus.org.

[1] Data transmission mode, which makes possible to transmit and receive messages, but not simultaneously.
[2] EIA/TIA-485 "Differential Data Transmission System Basics" is the document that describes the Standard RS485, which is the reference for all manufacturers.



3. Fieldbus communication

3.1.1 Ekip Com Modbus RTU communication module

With the communication module Ekip Com Modbus RTU you can use the LV air circuit-breakers series SACE Emax2 equipped with the trip units Ekip Touch, Ekip G Touch, Ekip Hi Touch and Ekip G-Hi Touch as slaves in a fieldbus Modbus RTU. This communication module implements the Modbus RTU protocol for RS-485 cable transmissions.
To activate communication:

- use the Ekip Supply module (see Annex A), which supplies 24V DC to the Ekip Com module and to the trip unit;
- enable the Local Bus of the trip unit directly from the display (Display -> Settings -> Modules -> Local bus -> ON).

Together with Ekip Com Modbus RTU, you can use also the module Ekip Com Modbus RTU Redundant.

Ekip Com Modbus RTU

Communication parameters

Protocol	Modbus RTU
Baud Rate	9600 ÷ 38400 bit/s
Addresses	1÷247
Parity, data, stop	E,8,1 - O,8,1 - N,8,2 - N,8,1

Default configurations

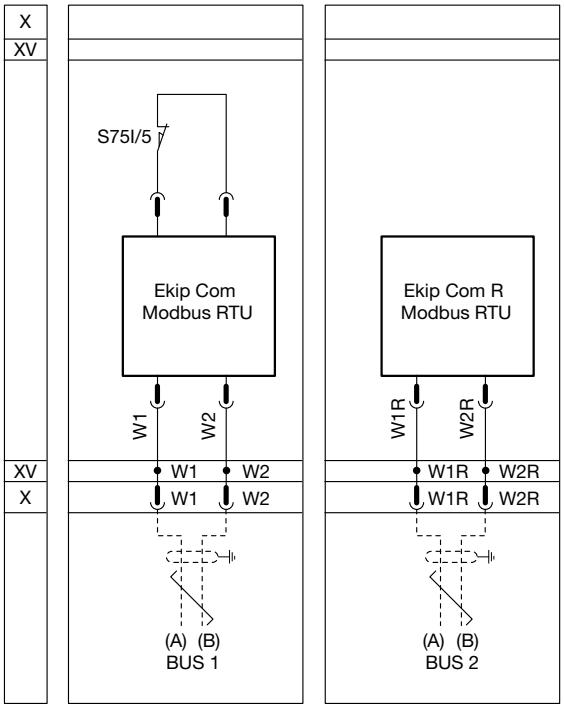
Protocol	Modbus RTU
Baud Rate	19200 bit/s
Addresses	247 for Ekip Com Modbus RTU module
Addresses	246 for Ekip Com Modbus RTU Redundant module
Parity, data, stop	E,8,1

IMPORTANT: On the same circuit-breaker, only a single Ekip Com Modbus RTU and a single Ekip Com Modbus RTU Redundant can be installed.

3.1.2 Connection to the RS-485 serial bus

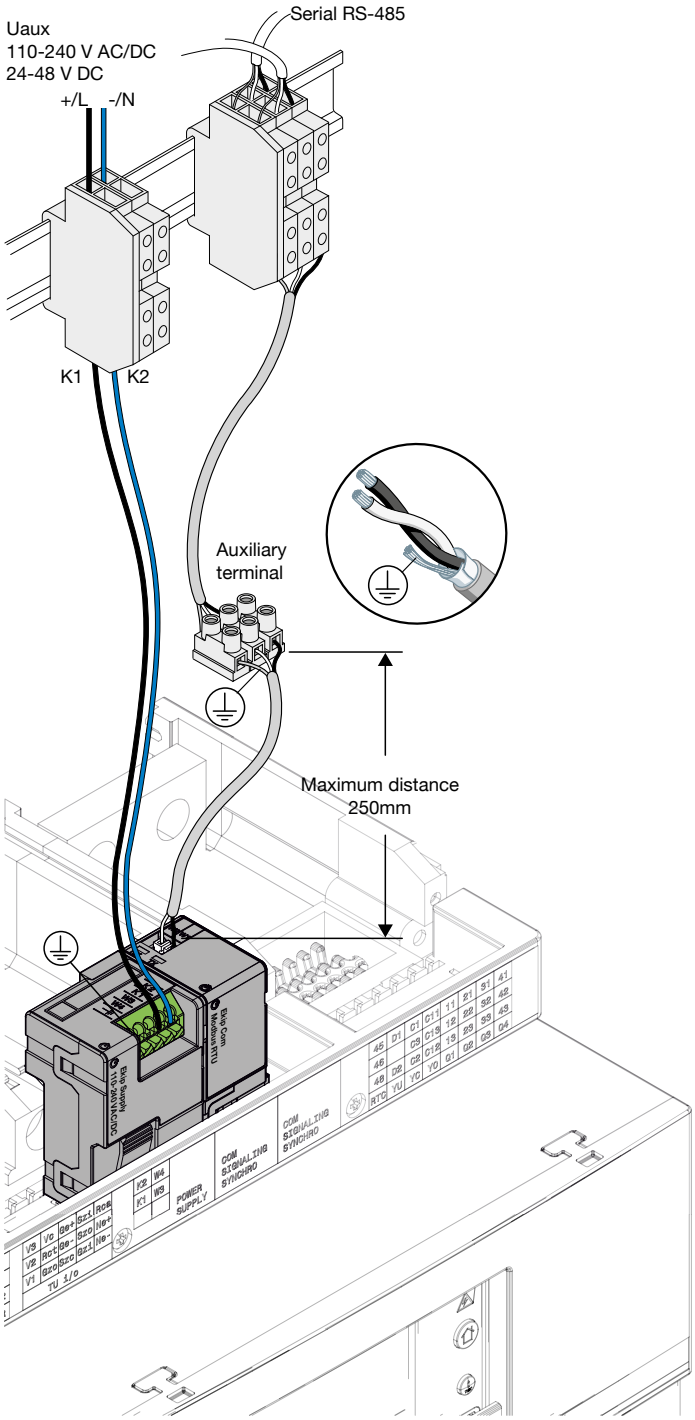
The trip unit is connected to the bus through the communication terminals W1 (A/data -) and W2 (B/data +) of the Ekip Com Modbus RTU module, according to the diagram shown in the following figure. The terminals W1 and W2, with cross-sectional area AWG 16-22, enable the direct connection of shielded twisted pair cables type A, such as, for example, Belden 3105A (AWG22).

Wiring diagram

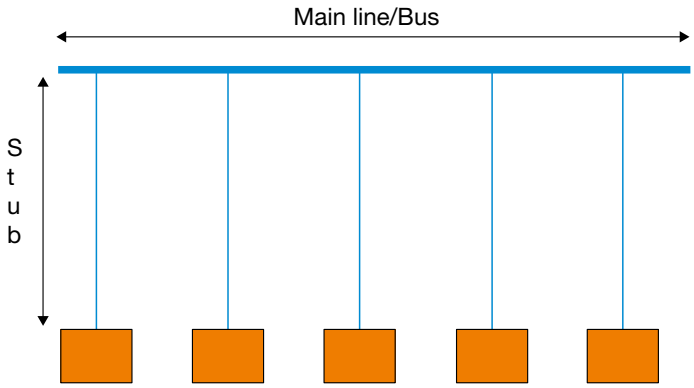


Note:
X: Connector for the auxiliary circuits of the circuit-breaker in withdrawable version.
XV: Terminal box for the auxiliary circuits of the circuit-breaker in fixed version
S75I/5 = Contact for signalling circuit-breaker in racked-in position (available only for the circuit-breakers in withdrawable version). In the presence of more Ekip Com modules, or in the presence of the module Ekip Com Modbus RTU Redundant, the contact S75I/5 must be connected to one single module only once, and never to the redundant module.
Bus 1/Bus 2: RS-485 cable for the connection to the Modbus network.

Connection example



The basic topology of a Modbus network is linear, consisting of a main line (bus) and of some (stubs) for device connection.
Up to 32 devices can be connected to the main line, including the master and without repeaters. If the bus length exceeds 50m, it must be closed at its ends with 120 Ω terminating resistance.



Characteristics of the RS-485 serial bus:
- maximum number of devices that can be connected to the main line: 32 (master included)
- maximum length of the bus: 700 m
- maximum length of the stubs: 1 m
- if the length of the main line exceeds 50 m, each end of the line must be closed with a 120 Ω terminating resistance
- check that the master initiates the polarization of the line[3]
- maximum number of repeaters that can be connected in series[4]: 3
- recommended cable: Belden 3105A (AWG22).

For further details and information: www.modbus.org.

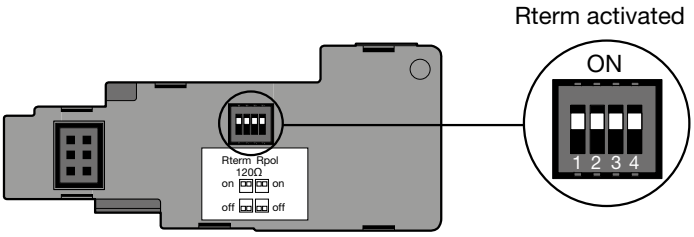
[3] Line polarization must be always implemented by the master. For depth-in information see the Standard "Application Guidelines for TIA/EIA-485-A".

[4] When using a repeater, the main cable is divided into different sections (segments); each of them can reach 700m length and connect 32 devices (the repeaters are included in this number). Three is the maximum number of repeaters that is advisable to connect in series. A greater number will introduce excessive delays in the communication system.

3. Fieldbus communication

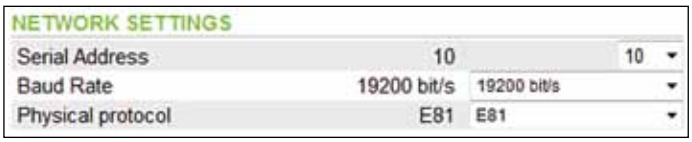
3.1.3 Terminating resistance

On the Ekip Com Modbus RTU module it is possible to activate the terminating resistance Rterm = 120 Ω. To enable the Rterm, the corresponding dip-switches 1 and 2 must be positioned to ON (see previous figure). With the Ekip Com Modbus RTU modules, the dip-switches 3 and 4 of the Rpol (polarization resistance), are not used.



3.1.4 Emax 2 integration into the Modbus RTU system

The serial address (the devices connected to the same network must have different addresses), the baudrate, the parity bit and the stop bit of the communication module can be configured either directly from the display of the trip unit or via the Ekip Connect application and the Ekip Programming unit (as an alternative Ekip T&P)[5].
Example of configuration of Ekip Com Modbus RTU with Ekip Connect + Ekip Programming (or Ekip T&P).



NETWORK SETTINGS			
Serial Address	10		10
Baud Rate	19200 bit/s	19200 bit/s	
Physical protocol	E81	E81	

Setting of parameters and assigning of values is customer's responsibility.

For all the circuit-breakers SACE Emax 2 connected to the same Modbus RS-485 network, once the same baud-rate and the same communication parameters have been set, and once each slave (circuit-breaker) has been identified by its own, unique serial address, it is possible for the master (PC or PLC) to proceed to data acquisition.

For further information, see the "Installation, operation and maintenance instructions for the installer and the user", document no. *1SDH000999R0002* (for E1.2) and document no. *1SDH001000R0002* (for E2.2, E4.2, E6.2), and the "Communication System Interface", document no. 1SDH001140R0001 in ABB Library.

[5] Ekip Programming is connected on one side to one USB port of the PC and on the other to the USB port of the trip unit (for further information refer to the kit sheet *1SDH001257R0001* in ABB Library).
Ekip T&P is connected on one side to one USB port of the PC and on the other to the USB port of the trip unit (for further information see the kit sheet *1SDH001000R0517* in ABB Library).

3.2 Profibus DP protocol

Profibus is a fieldbus for serial and digital communication. It connects the controllers (e.g.: PC or PLC) or the control systems to the various decentralized field devices (e.g.: sensors, actuators, air circuit-breakers SACE Emax 2 with the Ekip Com Profibus DP communication module) via a unique cable. DP is a version of Profibus based on the Profibus DP (Decentralized Peripheral) protocol and is used, above all, where high speed data exchange is required.
The maximum baud rate can reach 12Mbps. The Profibus DP protocol uses the Master-Slave model where a device, which is the master (e.g.: PC/PLC), manages and controls one or more devices (the slaves).There are three versions of Profibus DP:

- DP-V0 for cyclical data exchange between PLC and field devices (slaves);
- DP-V1 for cyclical and acyclical data exchange between PC or PLC and field devices (slaves);
- DP-V2 that, with respect to the above mentioned versions enables also communication between the slaves, clock synchronization with all the stations and time stamp.

For the transmission via cable, Profibus DP provides RS- 485 standard (EIA/TIA-485)[6].

[6] EIA/TIA-485 "Differential Data Transmission System Basics" is the document that describes the RS485 standard, which is the main reference for all manufacturers.

3.2.1 Ekip Com Profibus DP communication module

With the Ekip com Profibus DP communication module, the low voltage air circuit-breakers series SACE Emax2 equipped with Ekip Touch, Ekip G Touch, Ekip Hi Touch and Ekip G-Hi Touch trip units can be used as slaves in a Profibus DP fieldbus.
This communication module implements the Profibus DP –V0 and DP-V1 protocols for cable transmissions over RS-485.
To activate communication:

- use the Ekip Supply module (see Annex A), which supplies 24V DC to the Ekip Com module and to the trip unit
- enable the Local Bus of the trip unit directly from the display (Display -> Settings -> Modules -> Local bus -> ON).

Together with Ekip Com Profibus DP, it is possible to use also the Ekip Com Profibus DP Redundant module.

Ekip Com Profibus DP

Communication parameters

Protocol	Profibus-DP
Baud Rate	9.6 ÷ 12000 kbit/s
Addresses	3 ÷125

Default configurations

Address	125 for Ekip Com Profibus DP module
Address	124 for Ekip Com Profibus DP Redundant module

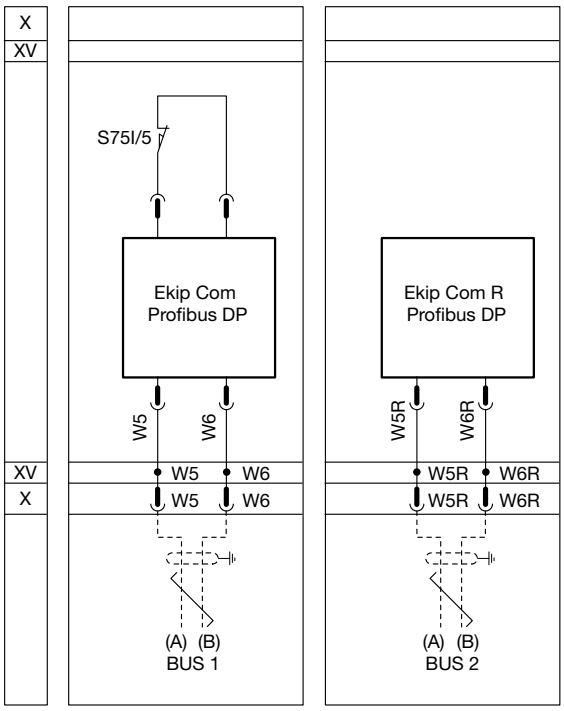
IMPORTANT: on the same circuit-breaker only a single Ekip Com Profibus DP, and a single Ekip Com Profibus Redundant can be installed.

3. Fieldbus communication

3.2.2 Connection to the RS-485 serial bus

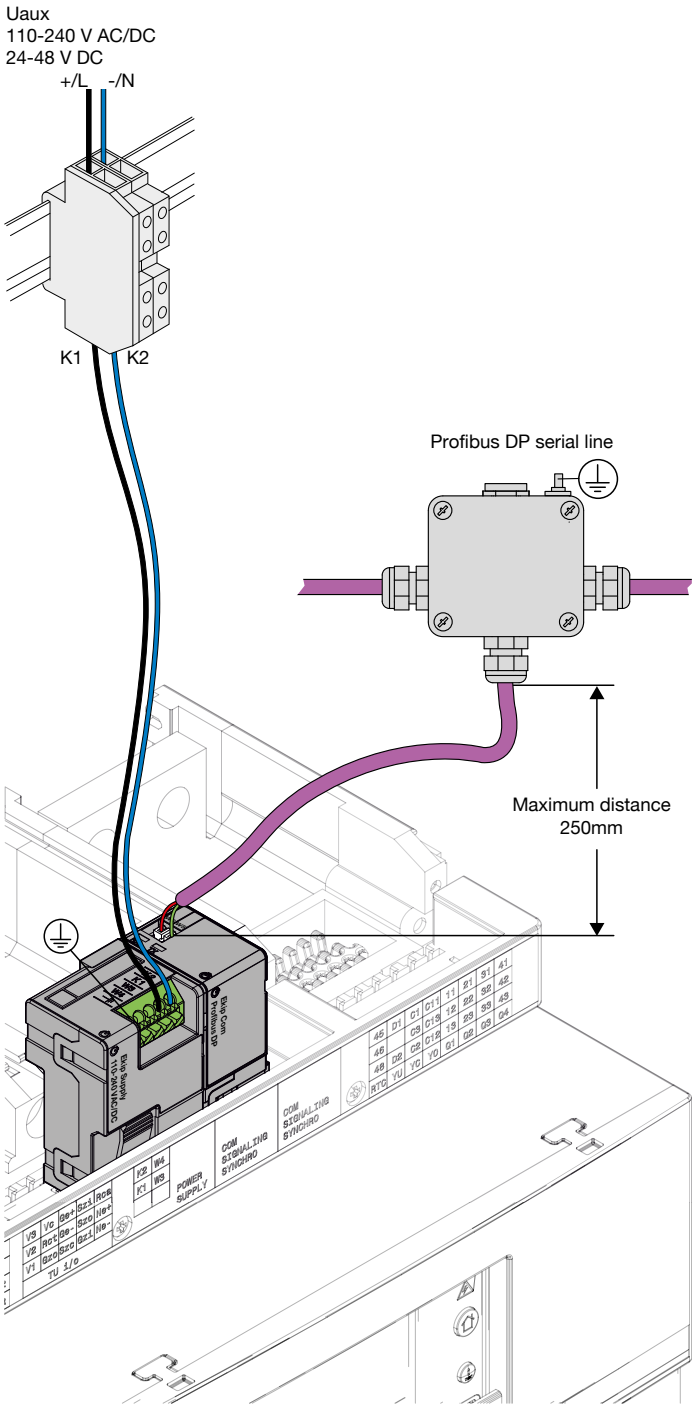
The trip unit is connected to the Profibus line via the communication terminals W5 (A/data -) and W6 (B/data +) of the Ekip Com Profibus DP module, according to the diagram shown in the following figure. The terminals W5 and W6, with cross-sectional area AWG 16-22, enable direct connection of the two-conductor shielded twisted cables of type A, such as, for example, Belden 3079A (AWG22).

Wiring diagram

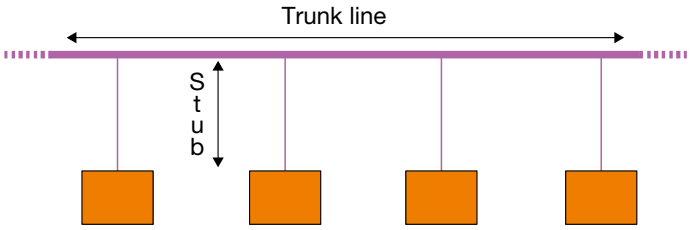


Note:
X: Connector for the auxiliary circuits of the circuit-breaker in withdrawable version
XV: Terminal box for the auxiliary circuits of the circuit-breaker in fixed version
S75I/5 = Contact for signalling circuit-breaker in racked-in position (available only for circuit-breakers in withdrawable version). When more Ekip Com modules are present, or in the presence of the module Ekip Com Profibus DP Redundant, the contact S75I/5 must be connected only once to one single module, and never to the redundant module.
Bus 1/Bus 2: RS-485 cable for the connection to the Profibus DP network.

Connection example.
With the type of connection in the figure, the maximum baud rate is 1500kbit/s.



The basic topology of a Profibus DP network is linear, consisting of a main line (trunk line) and of some derivations for the device connection. As established by the protocol, with cable transmission over RS-485, up to 32 devices (master included and without using repeaters) can be connected to the main line (to the segment). The Profibus line must be closed at its ends with 220 Ω[7] terminating resistance.



When repeaters are not used, these are the lengths for the Profibus line:

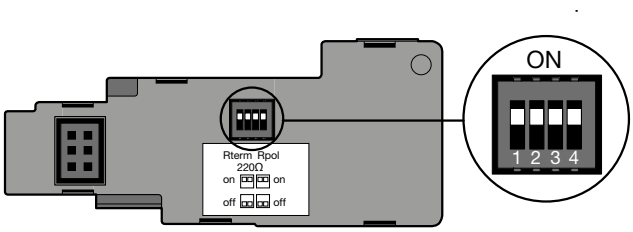
Baud rate [kbps]	Maximum length of the line [m]	Maximum length of the single stub [m]
9.6-19.2-45.45-93.75	1200	≤ 0.25
187.5	1000	≤ 0.25
500	400	≤ 0.25
1500	200	≤ 0.25

Recommended baud rate are: ≤1500 kbit/s.

For further information: http://www.profibus.com/

3.2.3 Terminating and polarization resistance

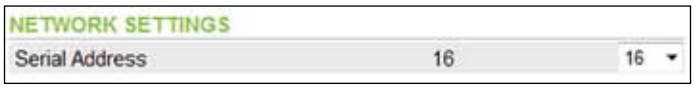
On the Ekip Com Profibus DP module it is possible to activate the terminating resistance Rterm = 220 Ω and the two polarization resistances Rpol = 390 Ω (to be enabled when enabling the Rterm). To activate the Rterm (dip-switches 1 and 2) and the Rpol (dip-switches 3 and 4), the corresponding dip-switches must be positioned to ON (see the following figure).



[7] Together with the terminating resistance, also the two 390 Ω polarization resistances are activated.

3.2.4 Integration of Emax 2 into the Profibus DP system

The serial address can be set in the communication module (the devices connected to the same network must have different addresses) either directly from the display of the trip unit or via the Ekip Connect application and the Ekip Programming unit (or, as an alternative, Ekip T&P)[8].
Example of configuration of Ekip Com Profibus DP with Ekip Connect + Ekip Programming (or Ekip T&P).



Setting of parameters and assigning of values are customer's responsibility.

The GSD[9] (Generic Station Description) file is used to configure and integrate the circuit-breaker into the Profibus DP system for communication with the master (PC or PLC). The GSD file (ABBS0E7F.gsd) for the Ekip Com Profibus DP modules is available in ABB Library.

For further information, see the "Installation, operation and maintenance instructions for the installer and the user", document no. *1SDH000999R0002* (for E1.2) and document no. *1SDH001000R0002* (for E2.2, E4.2, E6.2), and the "Communication System Interface", document no. 1SDH001140R0001 in ABB Library.

[8] Ekip Programming is connected on one side to one USB port of the PC and on the other to the USB port of the trip unit (for further information refer to the kit sheet *1SDH001257R0001* in ABB Library).
Ekip T&P is connected on one side to one USB port of the PC and on the other to the USB port of the trip unit (for further information see the kit sheet *1SDH001000R0517* in ABB Library).

[9] The GSD file is an electronic data sheet (also called device data base file) that identifies and describes a Profibus DP device and contains detailed information about it. The GSD file, when used with a Profibus DP configuration tool, allows the device to be configured and integrated into the communication system.

3. Fieldbus communication

3.3 DeviceNet protocol

DeviceNet is a protocol created to manage transmissions over CAN networks with a maximum baud rate of 500 kbps. CAN (Controller Area Network) is a serial bus based on data transmission between a master device and various slave devices and is suitable for the network control in many industrial applications. DeviceNet, mainly used for factory automation, is a centralized system that requires a master controller to manage the communication with the slave nodes. For example, it is commonly used when there are motor control centers and variable speed actuators (e.g.: inverters for the speed control of asynchronous motors).

3.3.1 Ekip Com DeviceNet communication module

With the Ekip Com DeviceNet communication module it is possible to use the low voltage air circuit-breakers type SACE Emax2 equipped with Ekip Touch, Ekip G Touch, Ekip Hi Touch or Ekip Hi-G Touch trip units as slaves in a fieldbus with DeviceNet protocol and cable transmission.
To activate communication:

- use the Ekip Supply module (see Annex A) that supplies 24V DC to the Ekip Com module and to the trip unit
- enable the Local Bus of the trip unit directly from the display (Display -> Settings -> Modules -> Local bus -> ON).

Together with Ekip Com DeviceNet, you can use also the Ekip Com DeviceNet Redundant module.

Ekip Com DeviceNet

Communication parameters

Protocol	DeviceNet
Baud Rate	125 kbit/s, 250 kbit/s, 500 kbit/s
MAC Address	1÷63

Default configurations

Baud Rate	125 kbit/s
MAC Address	63 for the Ekip Com DeviceNet module
MAC Address	62 for the Ekip Com DeviceNet Redundant module

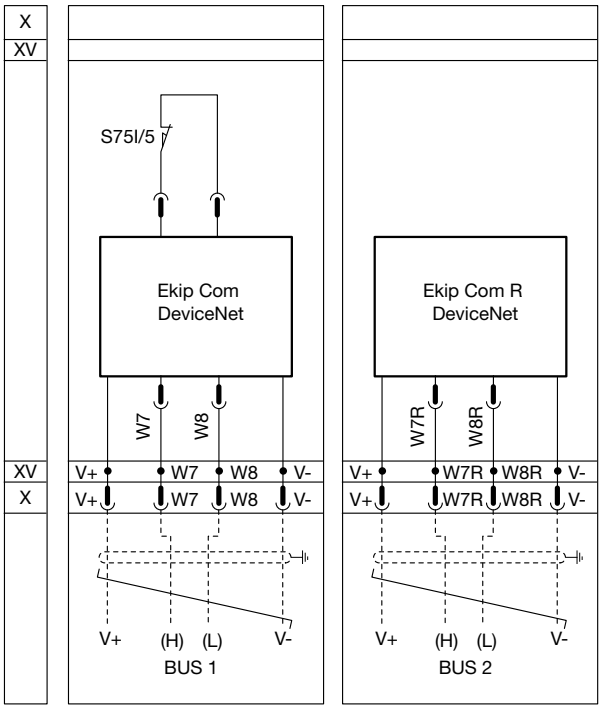
IMPORTANT: on the same circuit-breaker only a single Ekip Com DeviceNet, and a single Ekip Com DeviceNet Redundant can be installed .

3.3.2 Connection to the DeviceNet network

To implement a DeviceNet network, use a cable that simultaneously provides the power supply (24V DC) and the signal, such as the cable Belden 3084A. This is a four-conductor shielded twisted pair cable where: a pair, consisting of V+(red)/V-(black), serves to provide power supply, and a second pair, formed by CAN_H (white)/CAN_L (blue), serves to support the signal. The trip unit is connected to the DeviceNet network via the communication terminals W7 (CAN_H) and W8 (CAN_L) and the supply terminals V+ e V- of the Ekip Com DeviceNet module, in accordance to the diagram shown in the following figure.
Note: Since the Ekip Com DeviceNet module is supplied at 24V DC by the Ekip Supply module, the connection to the terminals V+ and V- serves only to the communication module to verify the presence of the supply to the DeviceNet network.

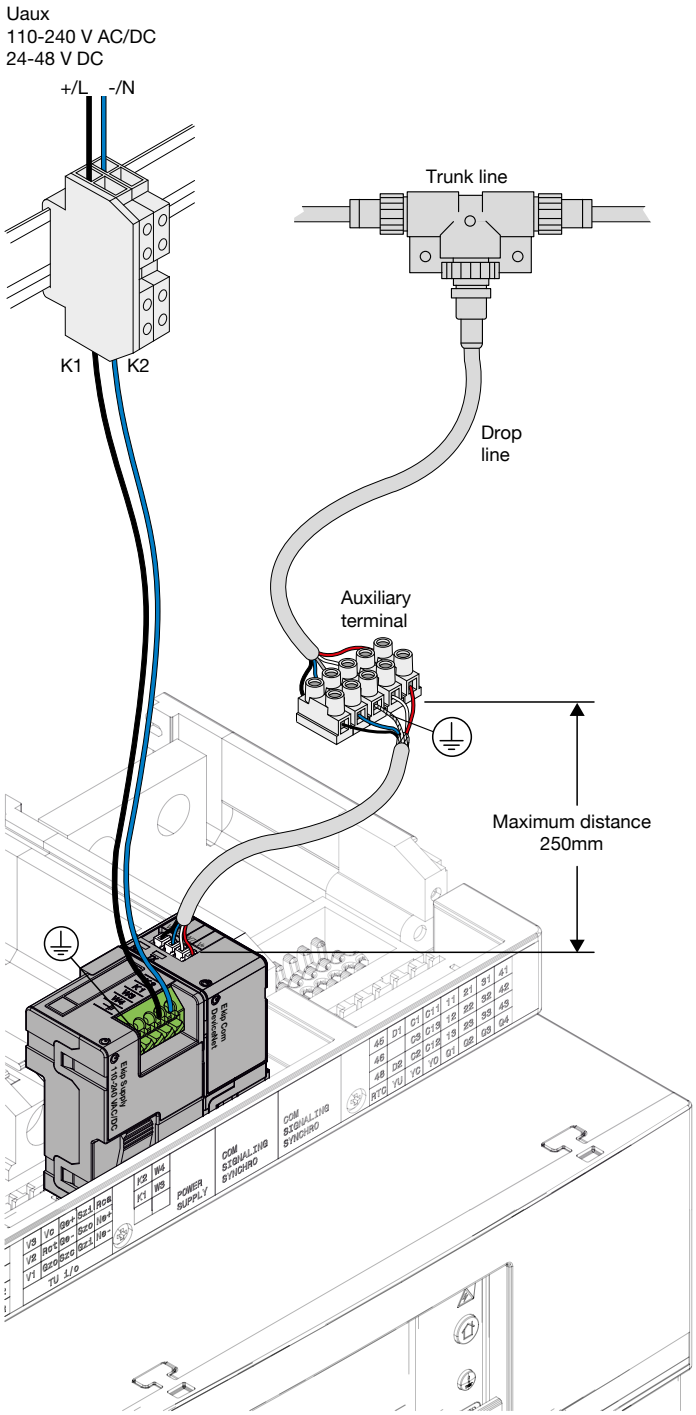
Note: Since the Ekip Com DeviceNet module is supplied at 24V DC by the Ekip Supply module, the connection to the terminals V+ and V- serves only to the communication module to verify that the DeviceNet network is supplied.

Wiring diagram



Note:
X: Connector for the auxiliary circuits of the circuit-breaker in withdrawable version
XV: Terminal box for the auxiliary circuits of the circuit-breaker in fixed version
S75I/5 = Contact for signalling circuit-breaker in racked-in position (available only for circuit-breakers in withdrawable version). When there are more Ekip Com modules, or in the presence of the module Ekip Com DeviceNet Redundant, the contact S75I/5 must be connected to one single module, and never to the redundant module.
Bus 1/Bus 2: RS-485 cable for the connection to the DeviceNet network.

Connection example



The DeviceNet network has linear topology consisting of a main line (trunk line) and of the derivations (drop lines) for device connection. Up to 64 devices (slaves), including the master and without using repeaters, can be connected to the main line; the trunk line must be closed at its ends with 120 Ω terminating resistance. The terminating resistances must never be integrated into the nodes/slaves. The terminating resistances must not be installed at the end of a drop line, but they can be installed only at the two terminations of the trunk line.

According to the baud rate and with thin[10] type cable, these are the lengths:

Baud rate [kbps]	Length of the main line or trunk line (with thin cable) [m]	Maximum length of the single stub [m]	Maximum length of the derivations (∑ of all derivations) [m]
125	100	6	156
250	100	6	78
500	100	6	39

For further information: www.odva.org – www.can-cia.org

[10] An example of thin cable is Belden 3084A, having the following characteristics: a pair of twisted cables, red and black (AWG 22), for 24V DC power supply, and a pair of twisted cables, white and blue (AWG 24), for signaling.

3. Fieldbus communication

3.3.3 Integration of Emax 2 into the DeviceNet system

The MAC Address (the devices connected to the same network must have different addresses) and the baud rate can be set in the communication module, either directly from the display of the trip unit or via the Ekip Connect application and the Ekip Programming unit (or, as an alternative, Ekip T&P)[11].

Example of configuration of Ekip Com DeviceNet with Ekip Connect + Ekip Programming (or Ekip T&P)

NETWORK SETTINGS			
MAC Address	30		30
Baud Rate	250 kbit/s	250 kbit/s	

Setting of parameters and assigning of values are customer's responsibility

[11] Ekip Programming is connected on one side to one USB port of the PC and on the other to the USB port of the trip unit (for further information refer to the kit sheet ***1SDH001257R0001*** in ABB Library).
The Ekip T&P unit is connected on one side to one USB port of the PC and on the other to the USB port of the trip unit (for further information see the kit sheet ***1SDH001000R0517*** In ABB Library).

The EDS* (Electronic Data Sheet) file is used to configure and integrate the circuit-breaker into the DeviceNet system for the communication with the master (PC or PLC). The EDS file (Ekip_COM_DeviceNet_02v01.eds) for the Ekip Com DeviceNet modules is available in ABB Library.

For further information, see the "Installation, operation and maintenance instructions for the installer and the user", document no. ***1SDH000999R0002*** (for E1.2) and document no. ***1SDH001000R0002*** (for E2.2, E4.2, E6.2), and the "Communication System Interface", document no. 1SDH001140R0001 in ABB Library.

*The EDS file is an electronic data sheet that identifies and describes a DeviceNet device and contains detailed information about it. The EDS file, when used with a DeviceNet configuration software, allows the device to be configured and integrated into the communication system.

4. Communication in Ethernet TCP/IP networks

This Chapter illustrates the solution with SACE Emax 2 air circuit-breakers for the communication in the networks type "industrial Ethernet".
In particular, it presents the solution for the communication in the Ethernet TCP/IP networks with the Modbus TCP and IEC 61850 protocols[12].

4.1 Modbus/TCP protocol

Developed in 1999, Modbus/TCP has been one of the first industrial protocols using Ethernet and TCP/IP. As indicated by the name, this protocol is an adaptation of traditional Modbus (on serial port) to the Ethernet networks that use the TCP/IP[13] protocols for data transmission.
The main advantages are:

- ease, which makes it simply implementable both on new devices and for adaptations of existing devices
- the similarity with the traditional Modbus protocol, already known by many programmers and developers of control and supervision systems.

From a conceptual point of view, the master-slave architecture of Modbus RTU (see § 3.1) is replaced by a client-server architecture. The sensor, or actuator, acts as a server: a device making available for other devices (the clients) data for reading, or space for writing. This representation is the same as the traditional Modbus protocol, in which the data are registers that can be read or written. The client is the device wishing to read or write the data; to do it, it sends a request telegram, to which the server responds with a response telegram.

The structure of the telegram is the same as traditional Modbus, as regards both length and coding:

- the reading request consists of a command (indicated in the Function Code) that tells the type of action to be performed (e.g.: reading of data), followed by the address of the register (or registers) to be read (these information are contained in the field Data of the telegram);
- the request of writing includes: command (indicated in the Function Code), address and data to be written (included in the field Data);
- the response telegrams, to indicate that the command has been successfully completed, repeat the command (in case followed by the required data); on the contrary, if the command cannot be performed, the response telegrams include an error code (exception response).

The data format is the same as traditional Modbus, and also the codes (Function Code) used to indicate the reading and/or writing functions and the exception response codes are the same. This allows system developers to re-use a large amount of the code already written to implement the traditional Modbus. Besides, this enables the single telegrams to be converted with no need of storing additional data and without losing information.

NOTE: For in-depth information, refer to the following documents: "MODBUS Protocol Specification", available on http://www.modbus.org/specs.php, and "MODBUS Messaging Implementation Guide V1.0b", available on http://www.modbus.org/specs.php.

[12]For the Ekip Com Profinet and Ekip Com Ethernet/IP modules please refer to the following documents: "Installation, operation and maintenance instructions for the installer and the user", document no. 1SDH000999R0002 (for E1.2) and document no. 1SDH001000R0002 (for E2.2, E4.2, E6.2), and the "Communication System Interface", document no. 1SDH001140R0001.

[13]TCP/IP (Transmission Control Protocol/Internet Protocol): transmission protocol developed to implement geographic connections, it is the basic element for internet connection and data transfer via Ethernet. TCP/IP defines a suite of protocols that transfer data from a device to another one, over one or more interconnected network. TCP/IP is also used to transfer files (ftp protocol), Web pages (http protocol), e-mails (SMTP protocol), and videos to be watched in real time (streaming). In short, the TCP protocol organizes the fragmentation into packets of the data to be transmitted and controls transmission, whereas the IP protocol controls the addressing and routing of the data packets.

4. Communication in Ethernet TCP/IP networks

4.1.1 Ekip Com Modbus TCP communication module

With the Ekip Com Modbus TCP communication module, which complies with the Standard IEEE 802.3, the low voltage air circuit-breakers SACE Emax 2 equipped with the Ekip Touch, Ekip G Touch, Ekip Hi Touch and Ekip G- Hi Touch trip units can be used in the Ethernet TCP/IP networks. This module implements the Modbus TCP protocol on the communication port 502.

To activate communication:

- use the Ekip Supply module (see Annex A), which supplies 24V DC to the Ekip Com Modbus TCP module and to the trip unit;
- enable the Local Bus of the trip unit directly from the display (Display -> Settings -> Modules -> Local bus -> ON).

It is possible to use, together with Ekip Com Modbus TCP, also the corresponding Ekip Com Modbus TCP Redundant module.

Ekip Com Modbus TCP

Characteristics of the module

Protocol	Modbus TCP on the communication port 502
Baud Rate	10-100 Mbps
Porta Ethernet	RJ45 female connector (W9)

Default parameters of the module

Parameter	Default
Function	Modbus TCP
Force Static IP Address	OFF (*)
Static IP Address Modbus TCP	0.0.0.0
Static IP Address Modbus TCP Redundant	0.0.0.0
Static Network Mask	0.0.0.0
Static Gateway Address	0.0.0.0
TCP clients	These are the IP Addresses of the clients connected to the module. Up to 3 clients can be connected to one module.
MAC Address (**)	It is the address assigned by ABB; it has the following OUI ac:d3:64.

(*) With the Force Static IP Address in OFF, the module waits to receive the IP Address from a DHCP (Dynamic Host Configuration Protocol) server. Without a DHCP server, the modules adopts an Autoconfiguration IP Address in the range 169.254.xxx.xxx, calculated through an algorithm, such as to be the same at each switching on.

(**) The MAC address is a unique address that identifies the Ethernet interface of each module; it is formed by 6 bytes, the first 3 of which are used for OUI. OUI (Organizationally Unique Identifier): it consists of the first 3 bytes of a MAC Address and is unique to the manufacturer of an Ethernet device, identifying it unequivocally.

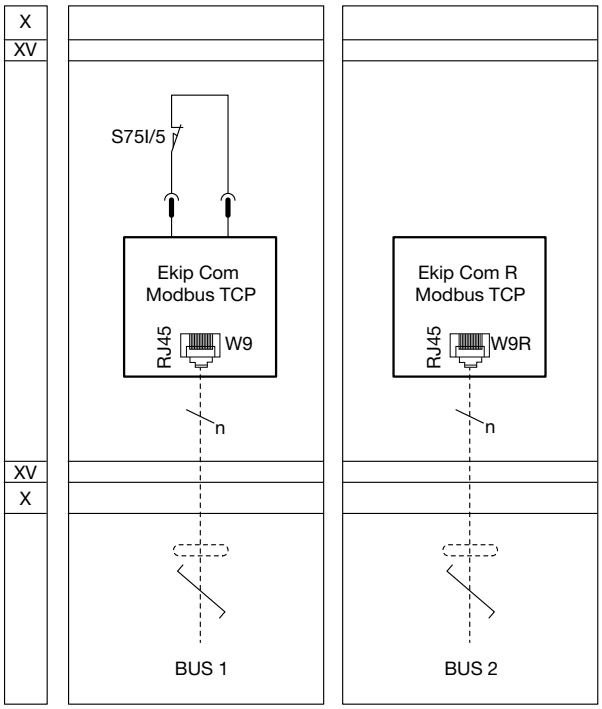
On the same circuit-breaker, only a single Ekip Com Modbus TCP, and a single Ekip Com Modbus TCP Redundant can be installed.

These modules enable the control of the circuit-breaker and the access to the data contained in the trip unit, therefore they must be connected only to the networks provided with all necessary requirements of security and access prevention from unauthorized addresses (e.g. the network of the control system of a plant). It is the responsibility of the panel builder to guarantee that all the necessary security measures (for instance, firewalls) have been adopted. The modules must not be directly connected to Internet. Connection is recommended to dedicated Ethernet networks only, via the Modbus TCP communication protocol.

4.1.2 Connection to the Ethernet network

The circuit-breaker is connected to the Ethernet network via the RJ45 female connector (W9) of the Ekip Com Modbus TCP module, according to the following diagram. Use of Ethernet Cat6 S/FTP cables is recommended.

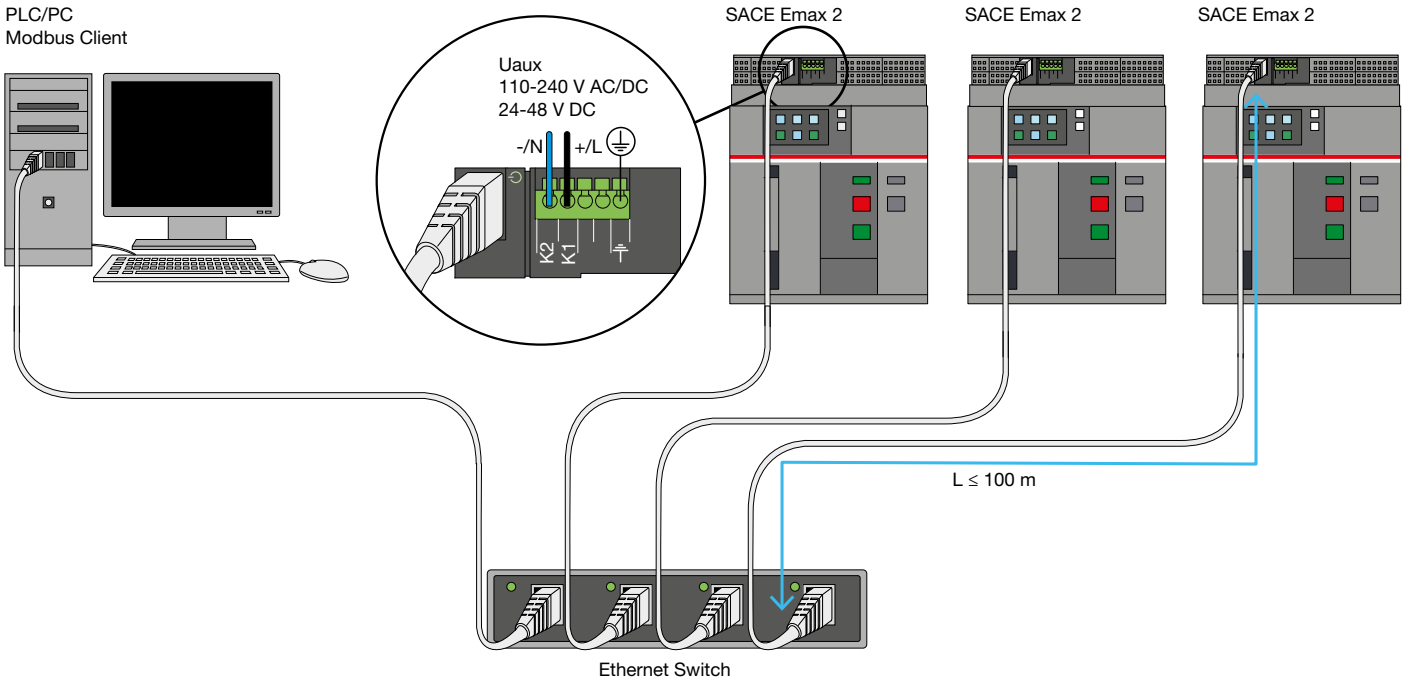
Wiring diagram



As regards the implementation of the communication networks, for which customers are responsible, the usual installation procedures of the Ethernet industrial networks must be complied with, for instance, in terms of maximum length and types of cable.

Choice and installation of the Ethernet switches are customer's responsibility. The maximum length of the cable for the connection of the Ekip Com Modbus TCP module to the switch is 100 m (Ethernet Cat6 S/FTP cable).

Note:
X: Connector for the auxiliary circuits of the circuit-breaker in withdrawable version
XV: Terminal box for the auxiliary circuits of the circuit-breaker in fixed version
S75I/5 = Contact for signalling circuit-breaker in racked-in position (available only for circuit-breakers in withdrawable version). When more Ekip Com modules are present, or in the presence of the module Ekip Com Modbus TCP Redundant, the contact S75I/5 must be connected to one single module only once, and never to the redundant module.
Bus 1/Bus 2: Ethernet cable.



4.1.3 Configuration of the Ekip Com Modbus TCP module

This module is configured with Force Static IP Address OFF by default.
The Ekip Com Modbus TCP module can be addressed either directly from the display of the trip unit, or through the Ekip Connect application and the Ekip Programming unit (or, as an alternative, Ekip T&P)[14], by modifying the following parameters:

- Force Static IP Address ON
- Static IP Address (the address must be valid and unique in the Ethernet network)
- Static Network Mask
- Static Gateway Address.

Configuration example of the static IP Address with Ekip Connect + Ekip Programming (or Ekip T&P).

STATIC IP ADDRESS		
Force Static IP Address	ON	ON
Static IP address	10.0.0.100	10.0.0.100
Static Network Mask	255.255.255.0	255.255.255.0
Static Gateway address	10.0.0.100	10.0.0.100

Setting of parameters and assigning of values are customer's responsibility.

[14] Ekip Programming is connected on one side to one of the USB ports of the PC and on the other to the USB port of the trip unit (for further information refer to the kit sheet *1SDH001257R0001* in ABB Library).
The Ekip T&P unit is connected on one side to one of the USB port of the PC and on the other to the USB port of the trip unit (for further information see the kit sheet *1SDH001000R0517* in ABB Library).

To configure the other parameters, the Ekip Connect software must be used:

- together with the Ekip Programming unit (or, as an alternative, with Ekip T&P) connected to the trip unit, and ABB Key scan

or

- with SACE Emax 2 circuit-breakers, equipped with the Ekip Com Modbus TCP module, connected to the Ethernet network, and Ethernet scan.

The parameters of the module configurable only through Ekip Connect are:

- Enable IEEE 1588 (to enable the IEEE 1588 protocol for clock signal distribution and synchronization)
- IEEE 1588 master (to set the modules as master in the related network segment)
- IEEE 1588 time zone and IEEE 1588 Daylight Saving (to calculate the time starting from the clock signal received)
- Disable Gratuituos ARP (to enable/disable the periodic generation of a message Gratuituos ARP, which is used by Ekip Connect to find quickly the modules through Ethernet scan without knowing in advance their IP Address).

For further information, see the "Installation, operation and maintenance instructions for the installer and the user", document no. *1SDH000999R0002* (for E1.2) and document no. *1SDH001000R0002* (for E2.2, E4.2, E6.2), and the "Communication System Interface", document no. 1SDH001140R0001 in ABB Library.

4.1.4 Web Server Function

The Web Server function of the Ekip Com Modbus TCP module enables reading access to the information of the circuit-breaker from a web browser by writing the IP Address of the module in the address bar (http://). To gain access to the information, it is possible to use the following browsers:

- Microsoft Internet Explorer (version 10.0 or higher)
- Google Chrome (version 30.0 or higher)
- Mozilla Firefox (version 24.0 or higher)
- Opera (version 17 or higher)
- Apple Safari (version 5.1.7 or higher)

When it is used as HTTP server, the module sends the data and the information of the circuit-breaker to the browser through the communication port 80/TCP with HTTP[16] protocol. When the function HTTP Server is enabled, it is not possible to send commands to the circuit-breaker, to configure the parameters of the trip unit or to modify the parameters of the protection functions. Access to the same circuit-breaker is possible from no more than three browsers at the same time.

To activate communication:

- use the Ekip Supply module (see Annex A), which supplies 24V DC to the Ekip Com module and to the trip unit
- enable the Local Bus of the trip unit directly from the display (Display -> Settings -> Modules -> Local bus -> ON).

With the function HTTP Server enabled, the module Ekip Com Modbus TCP Redundant can be used.

HTTP Server

[16] HTTP Hypertext Transfer Protocol: it is the whole of the rules that allows a web page to be transferred from the server where it is hosted (e.g.: Ekip Com Modbus TCP module) to the device that displays it (e.g.: a PC with an internet browser installed).

Characteristics of the HTTP Server

Protocol	HTTP on the communication port 80/TCP
Baud Rate	10-100 Mbps
Ethernet Interface	RJ45 female connector (W9)

Default parameters of the module

Parameter	Default
Function	Modbus TCP. To enable the function Server HTTP see § 4.1.4.1
Force Static IP Address	OFF (*)
Static IP Address Modbus TCP	0.0.0.0
Static IP Address Modbus TCP Redundant	0.0.0.0
Static Network Mask	0.0.0.0
Static Gateway Address	0.0.0.0
MAC Address (**)	It is the address assigned by ABB; it has the following OUI ac:d3:64

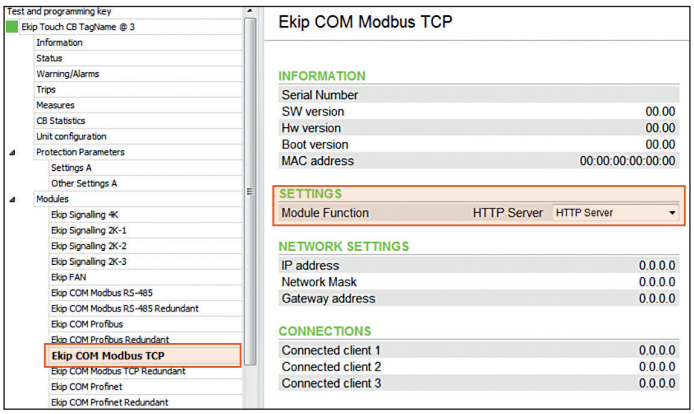
(*) With the Force Static IP Address in OFF, the module waits to receive the IP Address from a DHCP (Dynamic Host Configuration Protocol) server. Without a DHCP server, the modules adopts an Autoconfiguration IP Address in the range 169.254.xxx.xxx, calculated through an algorithm, such as to be the same at each switching on.

(**) The MAC address is a unique address that identifies the Ethernet interface of each module. It is formed by 6 bytes, the first 3 of which are used for OUI. OUI (Organizationally Unique Identifier): consists of the first 3 bytes of a MAC Address and is unique to the manufacturer of an Ethernet device, identifying it unequivocally.

On the same circuit-breaker, only one Ekip Com Modbus TCP and one Ekip Com Modbus TCP Redundant can be installed.

4.1.4.1 Configuration of the module as HTTP Server

Since the module is configured by default for the communication with the Modbus TCP protocol, to use it as a webserver the HTTP Server function must be enabled.
Activation can be made either directly from the display of the trip unit (Display -> Settings -> Modules -> Ekip Com Modbus TCP -> Function of the module -> HTTP Server) or through the Ekip Connect application and the Ekip Programming unit (or, as an alternative, Ekip T&P)[18], as the following figure shows:

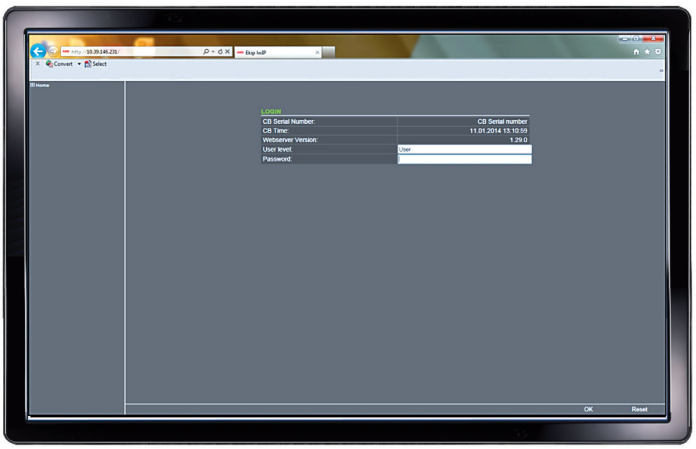


[18] Ekip Programming is connected on one side to one of the USB ports of the PC and, on the other side, to the USB port of the trip unit (for further information refer to the kit sheet *1SDH001257R0001* in ABB Library).
The Ekip T&P unit is connected on one side to one of the USB ports of the PC and, on the other side, to the USB port of the trip unit (for further information see the kit sheet *1SDH001000R0517* in ABB Library).

The address is assigned to the HTTP Server from the display of the trip unit or through the Ekip Connect application and the Ekip Programming unit (or, as an alternative, Ekip T&P), by modifying the following parameters:

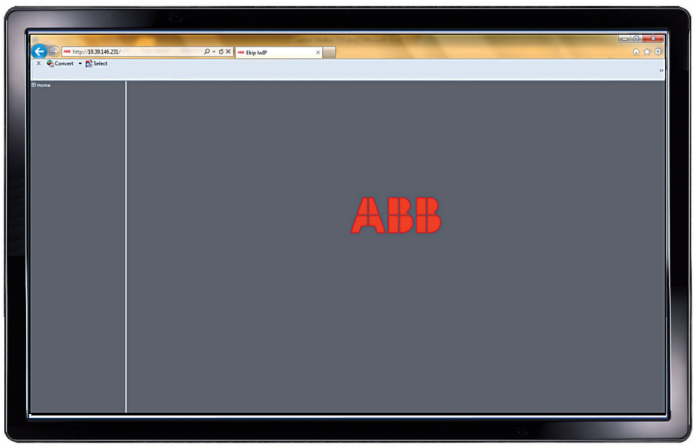
- Force Static IP Address ON
- Static IP Address (the address must be valid and unique in the LAN network)
- Static Network Mask (indicate the network mask used by one's own LAN network)
- Static Gateway Address (in the presence of a router or of another device putting the LAN network into communication with other networks or with internet, its address shall be specified in this field).

The network parameters of the webserver and the assignment of values are customer's responsibility. They must be set according to the configuration of the LAN network to which the webserver must be linked.
Once these operations have been completed, if the network configuration is correct, when opening an internet browser and entering the IP Address of the module in the address bar (http://), the following page shows:



By entering the password, the following main page appears:

Home

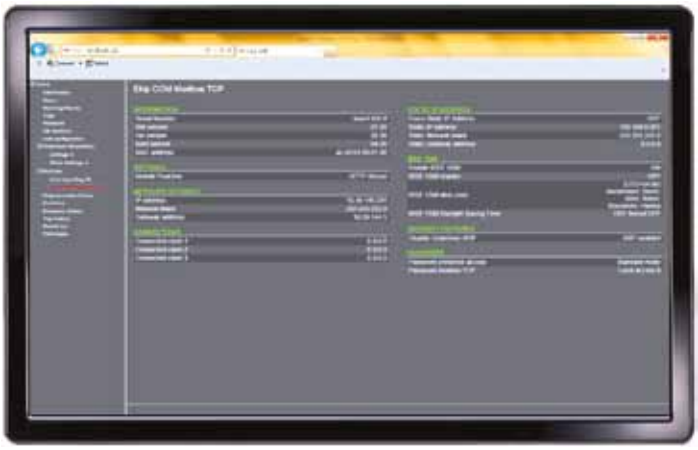


From the navigation menu, on the left side of the window screen, it is possible to select the submenus with the data and information available and display them in the main window. Below you find some examples of the available pages.

Information

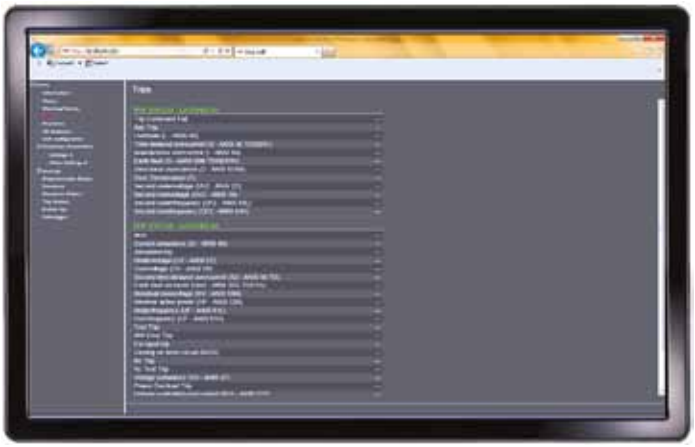
Measures

Ekip Com Modbus TCP

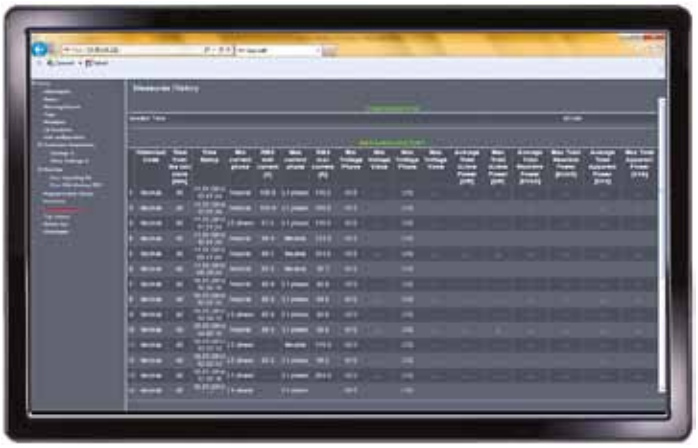


Unit configuration

Trips

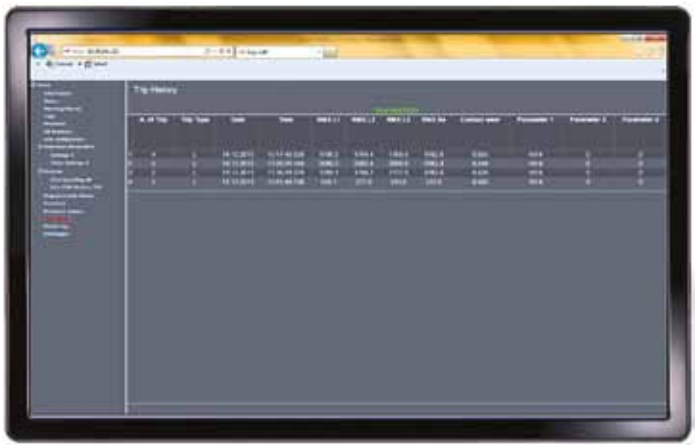


Measurement history



4. Communication in Ethernet TCP/IP networks

Trip history



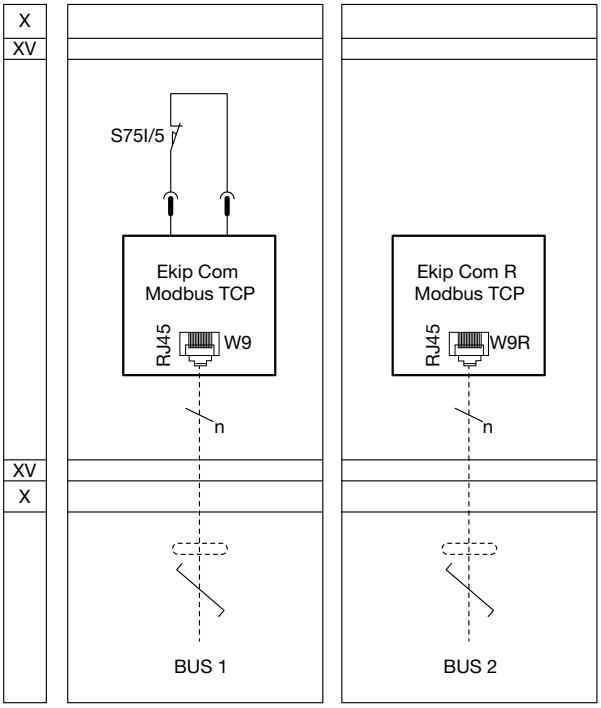
Warnings and alarms

For further information, see the “Installation, operation and maintenance instructions for the installer and the user”, document no. *1SDH000999R0002* (for E1.2) and document no. *1SDH001000R0002* (for E2.2, E4.2, E6.2), and the “Communication System Interface”, document no. 1SDH001140R0001 in ABB Library.

4.1.4.2 Connection to the Ethernet network

The circuit-breaker is connected to the Ethernet network through the RJ45 female connector (W9) of the Ekip Com Modbus TCP module, according to the following scheme. The use of the Ethernet Cat6 S/FTP cable is recommended.

Wiring diagram



Note:
X: Connector for the auxiliary circuits of the circuit-breaker in withdrawable version
XV: Terminal box for the auxiliary circuits of the circuit-breaker in fixed version
S75I/5 = Contact for signalling circuit-breaker in racked-in position (available only for circuit-breakers in withdrawable version).
When more Ekip Com modules are present, or in the presence of the module Ekip Com Modbus TCP Redundant, the contact S75I/5 must be connected to one single module only once, and never to the redundant module.
Bus 1/Bus 2: Ethernet cable.

4.2 IEC61850 protocol

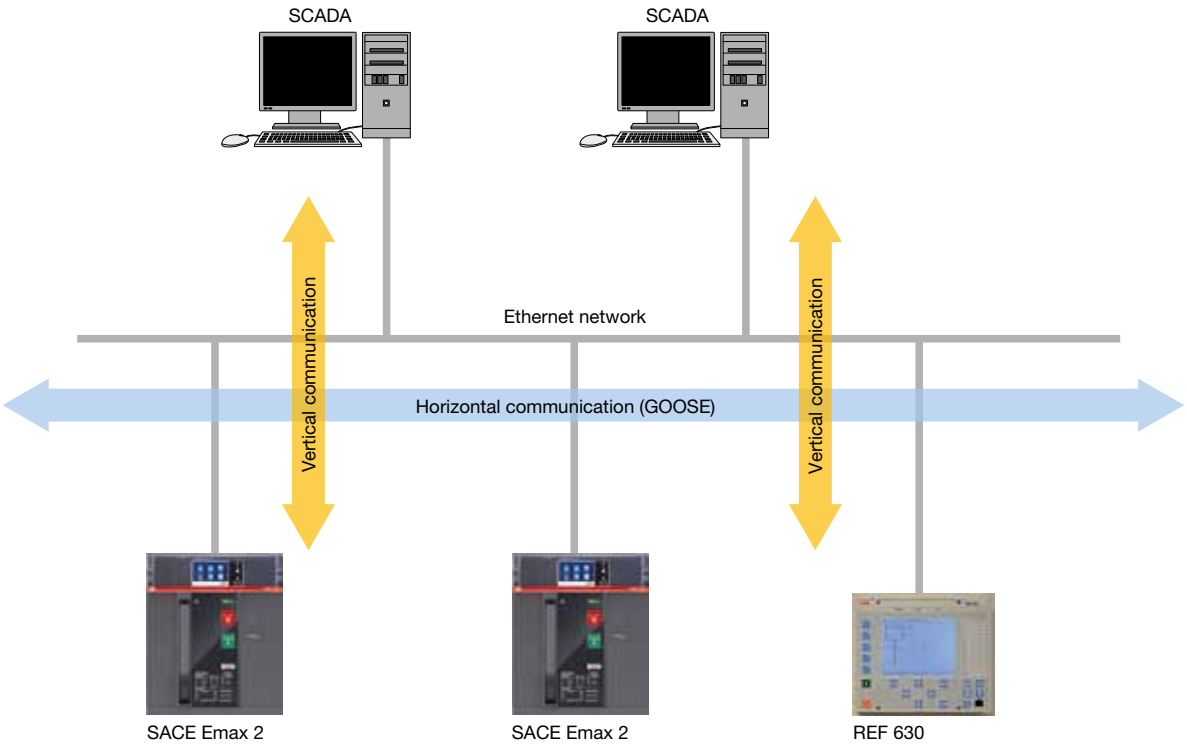
The standard IEC61850 is becoming more and more widespread as communication protocol for the protection and control systems of the electrical plants. Unlikely other protocols, chiefly designed for process control, IEC61850 has been designed with specific characteristics, suitable for the applications related to electrical power (e.g. electrical substations and distribution plants).

From a functional point of view, data communication in the applications for electrical plant protection and control must satisfy two different requirements:

- under normal operating conditions, the supervision system collects the data on the electric values (voltages, currents, power, energies) without pressing speed requirements. Usually, in this case, the communication is cyclic (i.e. at regular interval) and "vertical" (i.e. between each of the measuring devices and a central supervision and control system)
- in case of fault, the information on the state of the protections must be transmitted very quickly to permit the implementation of common behaviors (e.g.: fault signaling for selectivity). In this case, data transmission must occur with the shortest possible delay since the moment of the fault and this without a cyclic scheduling of the access to the communication medium, in fact, by taking priority over the cyclic data. Thus, we talk of "event-driven" communication. Furthermore, the information about the fault must be transferred from a protection device to another one, without involving the supervision system. In this case, we talk of "horizontal" communication via GOOSE[19] messages.

The IEC 61850 protocol allows both communication modes to function simultaneously in an effective way.

[19] GOOSE (Generic Object Oriented Substation Event) is a communication service offered by the protocol IEC 61850, through which the information about the events can be transmitted rapidly between different devices. The quick exchange mode of GOOSE messages permits a horizontal type communication which can be possible also between devices which are normally used as IEC 61850 servers. For further details see the following Standards: IEC 61850-7-2 and IEC 61850-8-1.



4. Communication in Ethernet TCP/IP networks

Besides these functional characteristics, the IEC61850 protocol has some other features:

- the types of data, the parameters measured and the available protection functions are univocally defined, as the format and the names used to access the data. It is a real language that describes the informative content of the devices in a significant way from the point of view of the application; thus, it becomes possible to simplify system engineering and design, to reduce the likelihood of errors and to allow interoperability of devices by different manufacturers
- the physical level and the wiring system are the same for all electronic devices. Ethernet is used both for data exchange between the measuring devices and protection trip units, as well as between the last ones and the supervision and control systems
- each transmitted data is completed with additional information describing the quality of measurements (e.g.: accuracy, unit of measurement, etc.), possible diagnostic alarms of the device from which the data is transmitted (e.g.: disconnected current sensors), etc.; this offers users all the necessary elements to asses how to use the received data.

4.2.1 Ekip Com IEC61850 communication module

Thanks to the Ekip Com IEC61850 communication module, the following LV air circuit-breakers SACE Emax2 equipped with the Ekip Touch, Ekip G Touch, Ekip Hi Touch and Ekip G- Hi Touch trip units can be used in the Ethernet TCP/IP communication networks with IEC61850 protocol.
To activate communication:

- use the Ekip Supply module (see Annex A), which supplies 24V DC to the Ekip Com module and to the trip unit
- enable the Local Bus of the trip unit directly from the display (Display -> Settings -> Modules -> Local bus -> ON).

The Ekip Com IEC61850 module cannot be supplied through the PoE[20] system.
Together with Ekip Com IEC61850, also the corresponding module Ekip Com IEC61850 Redundant can be used.

[20] PoE: Power over Ethernet is a technology that permits power supply through the infrastructure of the LAN network. In other words, this system permits to supply the devices using the same cable that connect them to the Ethernet data network.

Ekip Com IEC61850

Characteristics of the module

Protocol	IEC61850
Baud Rate	10-100 Mbps
Ethernet Port	RJ45 female connector (W12)

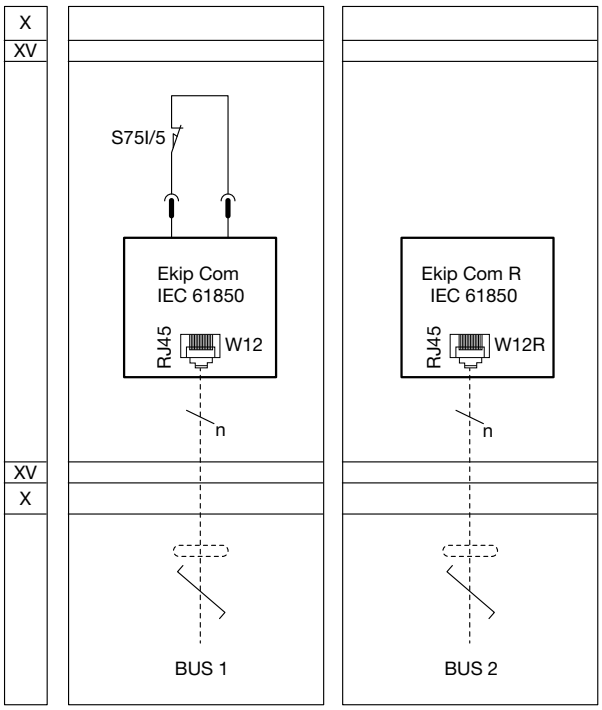
IMPORTANT:
On the same circuit-breaker, only a single Ekip Com IEC61850, and a single Ekip Com IEC61850 Redundant can be installed. Since these modules permit the circuit-breaker control and the access to the data inside the trip unit, they can be connected only to the networks that are equipped with the necessary requirements of security and prevention against unauthorized access (e.g. the network of the control system of a plant). It is the installer's responsibility to verify that all the necessary security measures (e.g. firewalls) are used. The modules must not be directly connected to Internet. Connection is recommended to dedicated Ethernet networks only, via the IEC61850 communication protocol.

For further information, see the "Installation, operation and maintenance instructions for the installer and the user", document no. ***1SDH000999R0002*** (for E1.2) and document no. ***1SDH001000R0002*** (for E2.2, E4.2, E6.2), and the "Communication System Interface", document no. 1SDH001140R0001 in ABB Library.

4.2.2 Connection to the Ethernet network

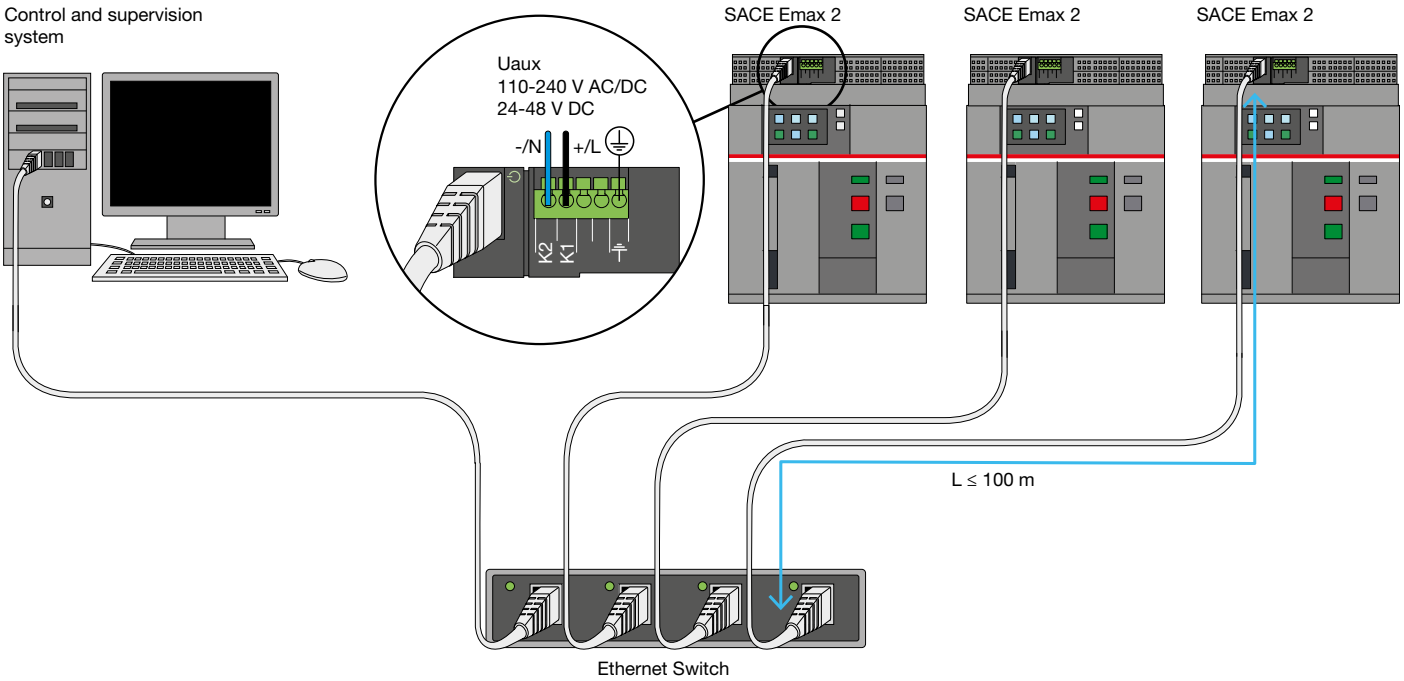
The circuit-breaker is connected to the Ethernet network through the RJ45 female connector (W12) of the Ekip Com Modbus IEC61850 module, according to the diagram shown in the following figure. The connector is usually linked to an Ethernet cable that, in turn, connects the circuit-breaker to one of the port of an Ethernet switch. The use of the cable Ethernet Cat6 S/FTP is recommended.

Wiring diagram



For the implementation of the communication network, which is the customer's responsibility, it is fundamental to comply with the standard installation procedures of the industrial Ethernet networks in terms, for instance, of maximum length and type of cables. Choice and installation of the Ethernet switches are customer's responsibility. It is also his responsibility to make sure that the switches can be used in the Ethernet networks with the IEC61850 communication protocol. The maximum length of the cable for the connection from the Ekip Com IEC61850 module to the switch is about 100 m (Ethernet Cat6 S/FTP cable).

Note:
X: Connector for the auxiliary circuits of the circuit-breaker in withdrawable version
XV: Terminal box for the auxiliary circuits of the circuit-breaker in fixed version
S75I/5 = Contact for signalling circuit-breaker in racked-in position (available only for circuit-breakers in withdrawable version).
When more Ekip Com modules are present, or in the presence of the module Ekip Com Modbus TCP Redundant, the contact S75I/5 must be connected to one single module only once, and never to the redundant module.
Bus 1/Bus 2: Ethernet cable.



4.2.3 Logic interface

Emax 2 circuit-breakers with the Ekip Com IEC61850 module provide both types of interface foreseen by the protocol: MMS for vertical communication, and GOOSE for horizontal communication.
The information made available by the circuit-breaker through MMS objects/messages are listed in the table below.
MMS (Manufacturing Message Specification) is the service on which all client-server messaging systems of IEC 61850 is based. It defines the communication messages between the control centers or clients (e.g.: SCADA) and the server stations (called IED), for instance, for the reading or writing of the process variables. In particular, the MMS service is used to send demands from the client stations (e.g.: SCADA) to which the server station (called IED) answers with the data required.
GOOSE (Generic Object Oriented Substation Event) is a communication service offered by the IEC 61850 protocol, through which the information about the events can be quickly transmitted between different devices.

The quick exchange mode of GOOSE messages of the IEC 61850 protocol permits a horizontal type communication which can be possible also between devices which are normally used as IEC 61850 servers. For further details see the following standards: IEC 61850, Part 7 (7-1; 7-2; 7-3; 7-4) – Modelling of the data and of the communication services and IEC 61850, Part 8-1 – Mapping of the communication services onto Ethernet.
Through the Ekip Com IEC 61850 module, it is possible to command from remote the circuit-breaker closing.

*IED (Intelliget Electronic Device): In this context, a SACE Emax 2 circuit-breaker equipped with trip unit Ekip Touch/Ekip Hi Touch + module Ekip Com IEC61850 is an IED.

Logical Node	MMS Information
XCBR (circuit-breaker state)	Circuit-breaker state: open/closed
	Warning, if state information is not available
RBRF (breaker failure)	TRIP command failed (the trip unit has opened the circuit-breaker through the back-up protection)
PTRC (trip and timing of protections)	Trip indication of all protections (e.g.: L,S,I,G, UV/OV, UF/OF, RP) and timing of delayed protection functions (e.g.: L,S, G, UV/OV, UF/OF) (*)
MMXU (measures)	Phase currents (IL1-IL2-IL3), neutral current (**), earth fault current [A]
	Frequency [Hz]
	Line-to-line voltages (U12, U23, U31), phase-to-neutral votages (U1, U2, U3) (***) and residual voltage [V]
	Total power factor
	Total active power (Ptot) and phase power (P1, P2, P3) [kW]
	Total reactive power (Qtot) and phase power (Q1, Q2, Q3) [kVAR]
	Total apparent power (Stot) and phase power (S1, S2, S3) [kVA]
LPHD (warnings/alarms)	Indication any warning (OR of all notices) (****)
	Indication any alarm (OR of all alarms) (****)

(*) For further information about the protection functions available with Ekip trip units see the following documents: 1SDH001000R0002, 1SDH000999R0002, 1SDC200023D0202
(**) Available with 4-pole or 3-pole circuit-breaker + CT for external neutral
(***) Available with 4-pole circuit-breaker
(****) For further information on the warnings and alarms available see the documents 1SDH001000R0002 and 1SDH000999R0002.
For further information on the data available from remote, see the document *Communication system interface* - document 1SDH001140R0001.

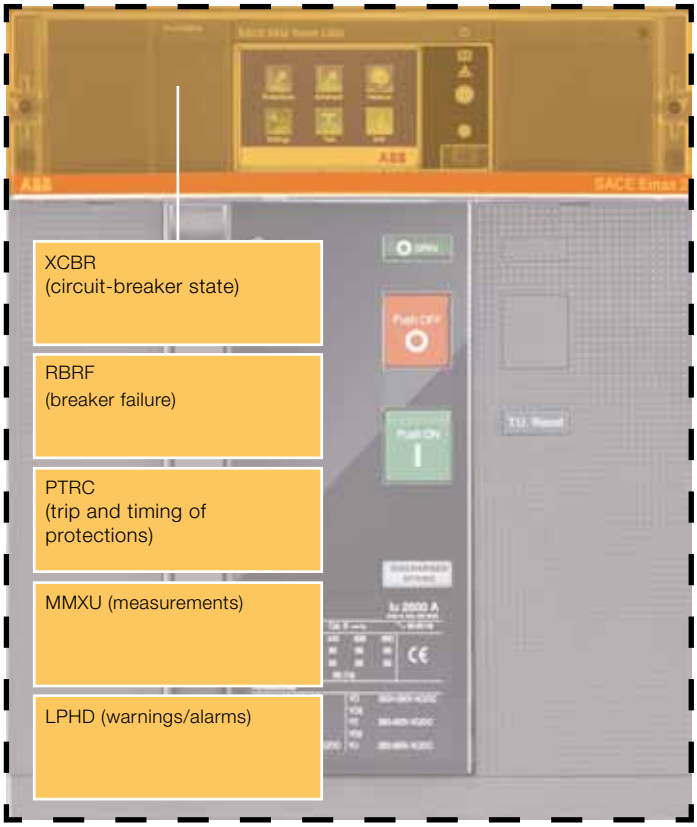
The information released through GOOSE are listed in the table below.
GOOSE messages comply with class P1: in fact, the GOOSE referred to an event in the circuit-breaker takes place in a time t<10ms after the event itself.

The Ekip Com IEC61850 module handles GOOSE output messages.
For further information about the available measurements and data, see the document “Communication System Interface” (1SDH001140R0001) in ABB Library.

Logical Node	GOOSE information
RBRF (breaker failure)	TRIP command failed (the trip unit has opened the circuit-breaker through the back-up protection)
XCBR (circuit-breaker state)	Circuit-breaker state: open/closed
	Warning, if state information is not available
PTRC (trip and timing of protections)	Trip indication of all protections (e.g.: L,S,I,G, UV/OV, UF/OF, RP) (*)
	Timing of the time-delayed protections (e.g.: L,S, G, UV/OV, UF/OF) (*)

(*) For further information about the protection functions available with Ekip trip units see the following documents: 1SDH001000R0002 - 1SDH000999R0002 and 1SDC200023D0202

Logical Device

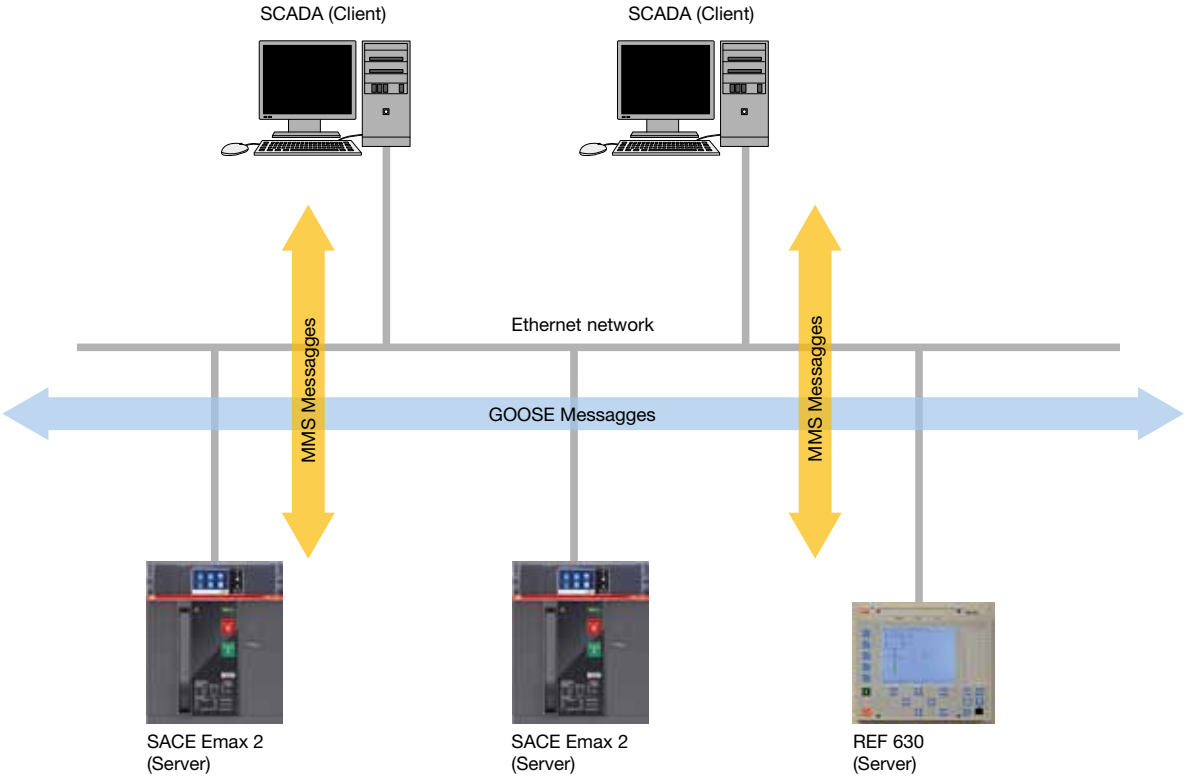


Circuit-breaker

Logical Node

4. Communication in Ethernet TCP/IP networks

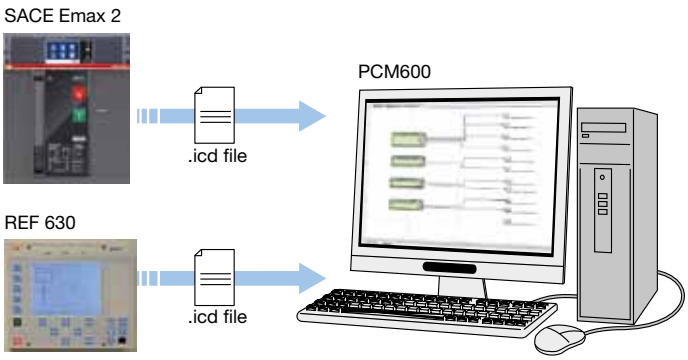
MMS and GOOSE messages



4.2.4 Configuration and putting into service of the circuit-breaker

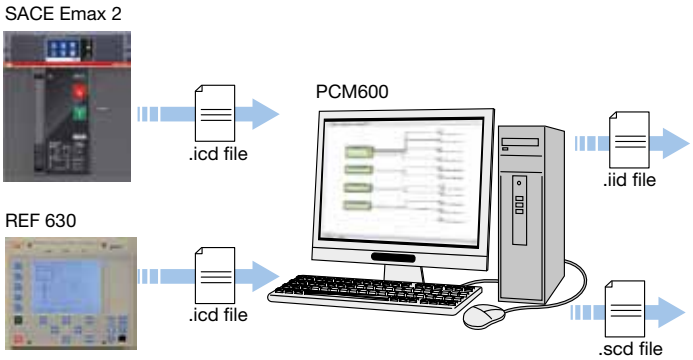
The configuration of the IEC61850 module must be performed by using the Ekip Connect software. Besides, it is necessary that the whole communication system is configured through a dedicated configuration software such as, for example, IET600 or PCM600. The configuration procedure with the PCM600 software comprises the following steps:

1. Creation of the project with all the servers involved: the .icd file of every server station involved in the IEC 61850 communication system must be input. The .icd file for the IEC 61850 communication with the air circuit-breakers series SACE Emax 2 is available in ABB Library.

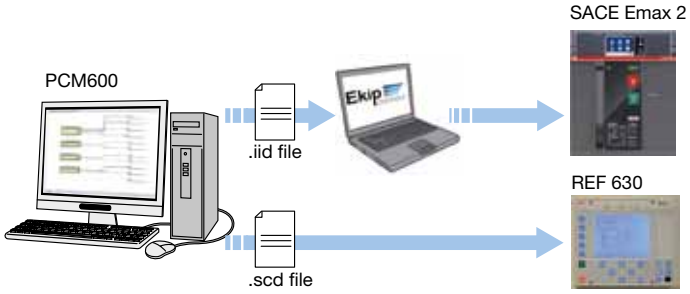


2. Communication configuration: specifies which devices must send or receive the information and which information are exchanged between the devices (either in GOOSE or in MMS format).

3. Generation of the plant configuration files .scd and .iid that contain all the relations between the single devices (servers) configured.



4. Transfer of the files to every device (server). For SACE Emax 2 circuit-breakers, the transfer is performed through the software ABB Ekip Connect.



For further information on the configuration, see the document “Communication System Interface” (1SDH001140R0001) in ABB Library.

5. Ekip Connect software

5 Ekip Connect software

Ekip Connect is a software application for PCs (with operating system Microsoft Windows 7 and Windows 8). It allows data to be exchanged with one or more ABB low voltage devices. This document takes into consideration the use of the Ekip Connect software for the communication between a PC and one or more ABB circuit-breakers simultaneously connected to a RS-485 serial line with the Modbus RTU protocol, or to an Ethernet network with the Modbus TCP protocol.
Ekip Connect can be used also for:

- putting into service, testing and monitoring the devices connected to the RS-485 serial networks with the Modbus RTU protocol or connected to the Ethernet networks with the Modbus TCP protocol;
- interacting and exchanging data with ABB electronic trip units with Modbus RTU or Modbus TCP communication interfaces.

Ekip Connect is useful during the phases of putting into service, configuration, monitoring, maintenance and testing of the circuit-breakers equipped with Modbus RTU or Modbus TCP communication interfaces.
The software permits the user to:

1) carry out the control and complete scan of the communication network to identify all the devices connected
2) interact, in real time, with the following devices:

Circuit-breaker	Trip unit
SACE Emax 2 E1.2÷E6.2	Ekip Touch/G-Touch + Ekip Com Modbus RTU/TCP module Ekip Hi-Touch/G Hi-Touch + Ekip Com Modbus RTU/TCP module
New Emax E1÷E6	PR122/P + PR120/D-M module PR123/P + PR120/D-M module
SACE Tmax XT2-XT4	Ekip LSI + Ekip Com module Ekip LSIG + Ekip Com module Ekip M-LRIU + Ekip Com module
Tmax T4÷T6	PR222DS-PD PR223DS PR223EF
Tmax T7 - Emax X1	PR332/P + PR330/D-M module PR333/P + PR330/D-M module
Emax DC	PR122/DC + PR120/D-M communication module PR123/DC + PR120/D-M communication module
Emax E2/VF-E3/VF	PR122/VF + PR120/D-M communication module
Circuit-breaker with thermal-magnetic or microprocessor-based trip unit Switch-disconnector	Flex interface SD030DX (Modbus RTU protocol)

5.1 Ekip Connect and Modbus RTU

To make the PC (on which Ekip Connect is installed) communicate with the trip units equipped with Ekip Com Modbus RTU and connected to a RS-485 serial line, a serial converter can be necessary for the conversion from the RS-485 physical layer to the physical layer available on the PC (e.g.: RS-232, USB, Ethernet).
The communication protocol used is Modbus RTU.

5.1.1 Scanning of the RS-485 serial bus

When testing an electrical switchboard equipped with devices that communicate via Modbus RTU and designed to be installed in a plant with a supervision system, scan of the system bus is particularly useful. In fact, this control operation permits detection of any possible anomaly in the cabling of the devices connected to the serial network, or of configuration errors (e.g.: speed, parity, stop bit, serial address, etc.), with the consequent possibility of correct them when the switchboard is still to be put into service. Before scanning, attention shall be paid that all the trip units connected to the network have different serial addresses.
Setting of the serial address and assigning of values is the customer's responsibility.
The serial address of the trip units already connected to the network can be modified:

1) from the display of the trip unit (trip unit in local mode and local bus enabled)

or

2) from the PC (connected to the network of the switchboard) on which the Ekip Connect software is installed and supplying one trip unit at a time

or

3) from the USB port of the trip unit by using Ekip Connect and the Ekip Programming unit (or, as an alternative, the Ekip T&P unit).

When pushing the button "Serial", Ekip Connect performs an automatic scan of the RS-485 network and identifies all the devices connected to the bus. At the end of the scan, the found devices are displayed:

- in the Navigation Tree, which lists the trip units found by scanning and the pages available for each of them;
- in the Working Area in the page Device List that shows the trip units found while scanning, with their main communication parameters, and gives indications about any possible configuration error detected while scanning (e.g.: two devices with different transmission speed or two devices with the same serial address). Ekip Connect signals also the presence of non-ABB devices able to communicate through the Modbus RTU protocol.

Navigation Tree Working Area (Device List)

After scanning has been completed, for each trip unit connected to the network it is possible to find in the Working Area some pages with all the information and the data contained in the trip unit. From these pages, it is also possible to modify the communication and protection parameters of the trip unit or to send the commands to the circuit-breaker (see § 5.3).

5.2 Ekip Connect and Modbus TCP

5.2.1 Scanning of the Ethernet network

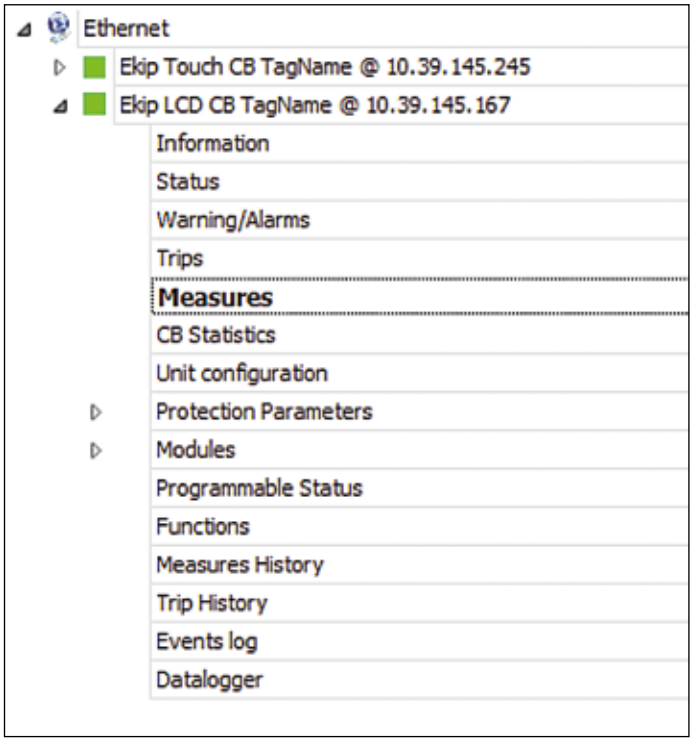
After the installation of Ekip Connect on a PC connected to an Ethernet network, it is possible to scan the network and identify the ABB circuit-breakers that are connected and communicate via the Modbus TCP protocol.
The ABB circuit-breakers that are connected and communicate via the Modbus TCP protocol. After scanning has been completed, the devices that have been found are displayed both in the Navigation Tree and in the Working Area through the page Device List, where the trip units connected to the network can be viewed with their IP Addresses.

The following figure shows an example of the window of Ekip Connect, the Navigation Tree and the Device List generated after scanning of the Ethernet network.

Navigation Tree Working Area (Device List)

5. Ekip Connect software

The following figure shows an example of the Navigation Tree generated after scanning of the Ethernet network.

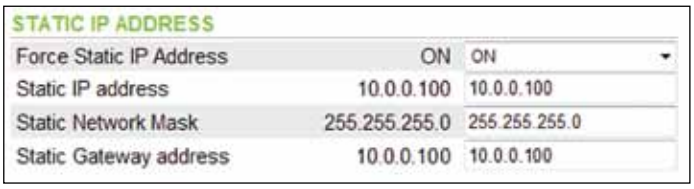


The first level shows the Ethernet network at which the trip units are connected. By clicking on the first level, the page Device List opens in the Working Area; there, a list of all detected devices is available, including their communication parameters.
The second level shows the ABB trip units connected to the Ethernet network. By clicking on the name of the trip unit, a page opens at the second level in the Working Area, with general information about the circuit-breaker (e.g.: E1.2 B 800, serial number of the circuit-breaker, serial number of the trip unit) and the main communication parameters (e.g.: IP address, MAC address).
At the third level there are the pages made available by the selected trip unit; by clicking on the different pages, it is possible to view, in the Working Area, all the information and the data contained in the trip unit. It is possible to modify the communication parameters or the settings of the protections or to issue the commands to the circuit-breaker (see § 5.3).

5.2.2 Scanning of the electrical switchboard

When testing an electrical switchboard housing air circuit-brakers Emax 2 equipped with the Ekip Com Modbus module and designed to be installed in a plant with a supervision system with the Modbus TCP protocol, scanning of the Ethernet network is useful. In fact, it permits the user to control all the connected Emax 2 circuit-breakers when the switchboard is still to be put into service. Besides, thanks to Ekip Connect, all the protection functions can be set (curves, times and thresholds of the protections), or all the trip units of the circuit-breakers connected to the network can be configured from a unique station (e.g. as regards rated voltage, network frequency, neutral).
NOTE: before using the Ekip Connect software to scan the Ethernet network of the switchboard, be sure that the connected trip units are configured with Force Static IP Address OFF or have different IP addresses.
The IP address of the trip units connected to the switchboard network can be set:
1) from the display of the trip unit
or
2) from the PC (connected to the network of the switchboard) on which the Ekip Connect software is installed and supplying one trip unit at a time
or
3) from the USB port of the trip unit by using Ekip Connect and the Ekip Programming unit (or, as an alternative, the Ekip T&P unit)
by modifying the following parameters:
- Force Static IP Address ON
- Static IP Address (the address must be valid and unique in the Ethernet network)
- Static Network Mask
- Static Gateway Address

Example of configuration of the static IP Address with Ekip Connect + Ekip Programming (or Ekip T&P)



STATIC IP ADDRESS		
Force Static IP Address	ON	ON
Static IP address	10.0.0.100	10.0.0.100
Static Network Mask	255.255.255.0	255.255.255.0
Static Gateway address	10.0.0.100	10.0.0.100

Setting of parameters and assigning of values is customer's responsibility.

5.3 Communication with the single device

Ekip Connect provides some graphic screens through which it is possible to interact with the electronic trip units with Modbus RTU or Modbus TCP communication interface.
These graphic pages are displayed in the Working Area when an item from the Navigation Tree (3rd level) is selected. Each trip unit is associated to some pages through which, for instance, it is possible:

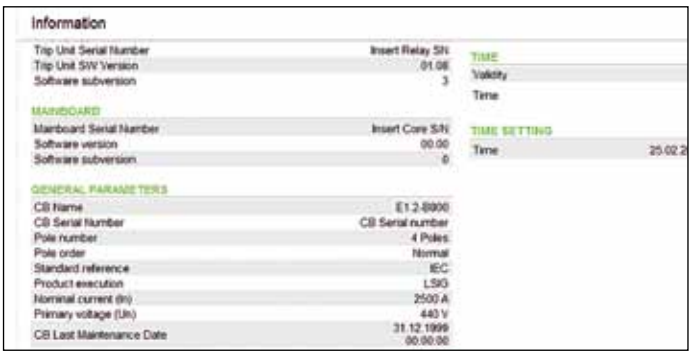
- to read the information about the circuit-breaker and the protection trip unit;
- to know the circuit-breaker state (e.g.; open/closed/tripped, racked-in/out position);
- to view the alarms of the protections;
- to read the values measured in real time (e.g.: current, voltage, power, energy);
- to view the settings of the protection functions associated to the trip unit;
- to view the history data relevant to the last trips of the unit;
- to view the history of the events and the measurements stored in the trip unit.

Besides, through these graphic screens it is possible:

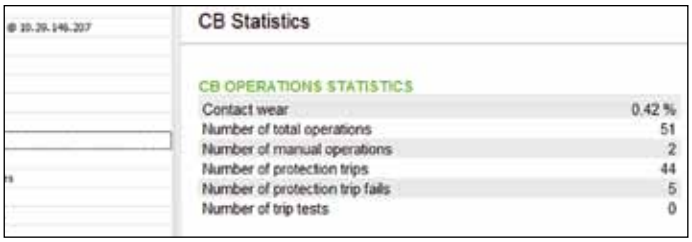
- to send opening and closing commands to the circuit-breaker;
- to set the protection functions (curves, times, and thresholds);
- to configure the trip unit (e.g.: rated voltage, network frequency, neutral conductor);
- to view the time-current curves of the protections;
- to send wink commands through which the blinking of a LED of the trip unit is activated to make easier to locate the circuit-breaker when it is installed in the plant.

The amount and type of information that can be viewed through the graphic pages vary according to the type of trip unit you are interacting with.
Hereunder you find some examples of these graphic screens.

Information
This page shows general information on the device (e.g: reference Standard, rated current of the circuit-breaker, software version, trip unit type and circuit-breaker type).



Statistics of the circuit-breaker
This page displays the following data: percentage of contact wear, total number of operations, number of manual operations, number of protection trips, number of trip failures and number of trip tests carried out by the circuit-breaker.



State
This page shows some information about the circuit-breaker state (e.g.: open/closed, racked-in/out position), about the presence of the Ekip Signaling modules and about the power supply of the trip unit. From this page, the following commands can be sent: opening/closing of the circuit-breaker, trip unit reset, wink. To send these commands, a password must be typed in. When the device is in local mode, these commands are not available.

Measurements
This page displays, in real time, the measurements acquired by the trip unit. The information and the electrical parameters displayed vary according to the type of trip unit involved.

5. Ekip Connect software

Measurement history

With the Ekip Touch + Ekip Measuring/Measuring Pro or Ekip Hi-touch trip units, the following parameters can be recorded:

- phase current (phase with minimum current + RMS value of the minimum current, phase with maximum current + RMS value of the maximum current)
- line-to-line voltage (minimum line-to-line voltage + minimum voltage value, maximum line-to-line voltage + maximum voltage value)
- total active power: average and maximum value
- total reactive power: average and maximum value
- total apparent power: average and maximum value

measured in the last 25 time periods that can be set with intervals from 5 to 240 minutes.

Warnings/Alarms

This page displays the alarms of the protection functions associated to the trip unit and the diagnostic alarms (e.g.: trip coil disconnected or damaged, current sensors disconnected). The number and the type of alarms displayed vary according to the type of trip unit involved.

Trip history

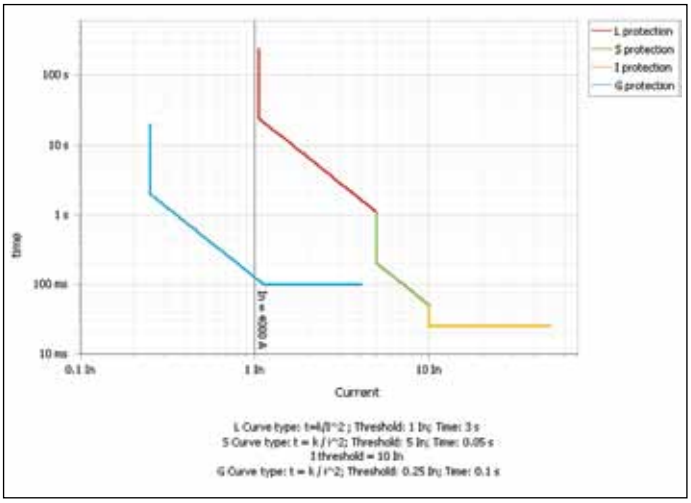
Through this page, you can get further information (e.g.: type of protection tripped, tripped current value, time and date of trip, percentage of contact wear) on the last 30 trips of the trip unit. The information displayed vary according to the type of trip unit involved.

Parameters of the protections

Through this page, you can view and set the parameters (thresholds and trip times) of the protection functions of the trip unit. The protection functions displayed vary according to the trip unit involved.

Time-current curve

Thanks to this function it is possible to display the time-current curves of the main protection functions (L, S, I and G).



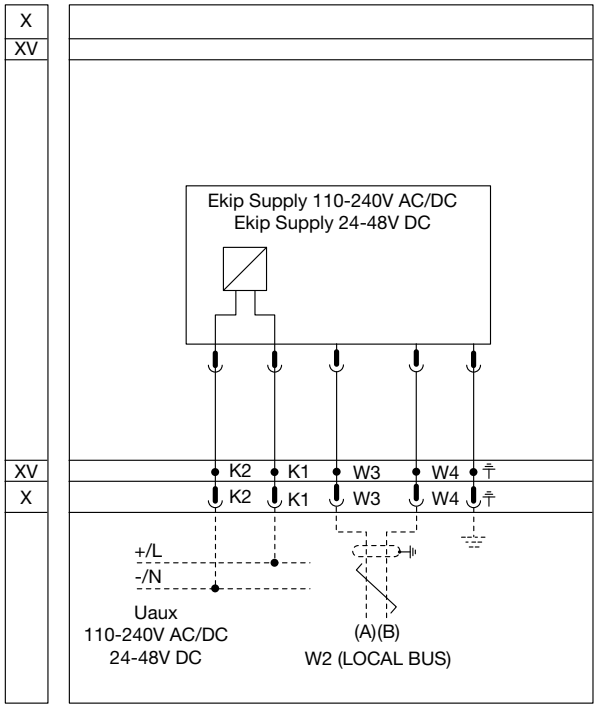
NOTE: For further information on Ekip Connect, please refer to the document 1SDH000891R0001 in ABB Library.

Ekip Programming is connected on one side to one of the USB ports of the PC, and on the other to the USB port of the trip unit (for further information see the kit sheet *1SDH001257R0001* in ABB Library).

Ekip T&P is connected on one side to one of the USB ports of the PC, and on the other to the USB port of the trip unit (for further information see the kit sheet *1SDH001000R0517* in ABB Library).

Annex A: Ekip Supply power supply module

The Ekip Supply module must be used to activate communication and to supply, with 24V DC voltage, the Ekip Com modules and the trip units Ekip Touch, Hi-Touch, G Touch and G Hi-Touch.
Two versions of Ekip Supply are available according to the input primary voltage used to feed it:
– Ekip Supply 110-240V AC/DC
– Ekip Supply 24-48V DC
The auxiliary voltage available in the electrical switchboard can be used to supply this module. The voltage is carried to the input terminals marked with K1 (+/L) and K2 (-/N) as shown in the following diagram:



Connections outside the circuit-breaker

X: Connector for the auxiliary circuits of the circuit-breaker
XV: Terminal box for the auxiliary circuits of the circuit-breaker in fixed version
K1-K2: Supply terminals of Ekip Supply.
W2: Local bus of Ekip Supply (terminals W3 and W4) to communicate with ABB SACE devices.

Electrical features of Ekip Supply:

Supply	Ekip Supply DC	Ekip Supply AC/DC
Primary voltage	24÷48 V DC	110÷240 V AC/DC
Voltage interval	21.5÷53 V DC	105-265 V AC/DC
Frequency interval	-	45÷66 Hz
Rated power (modules included)	10 W max	10 VA/W max

Annex B: Measurements-Information-Commands

	Ekip Touch	Ekip Touch + Ekip Measuring / Measuring Pro Ekip G Touch	Ekip Hi-Touch Ekip G Hi-Touch
Measurements			
Phase currents (IL1-IL2-IL3), neutral current (*), earth fault current (**)	■	■	■
Peak factor (Ip/Irms) in the three phases and in the neutral	■	■	■
Measurement history: currents (Imax, Imin, Imean)	■	■	■
Line-to-line voltages (U12, U23, U31), phase-to-neutral voltages (U1, U2, U3) (***) and residual voltage		■	■
Measurement history: voltages (Uline-to-line max, Uline-to-line min)		■	■
Frequency		■	■
Total active power (Ptot) and phase power (P1, P2, P3)		■	■
Measurement history: Ptot (Ptot mean, Ptot max)		■	■
Total reactive power (Qtot) and phase power (Q1, Q2, Q3)		■	■
Measurement history: (Qtot mean, Qtot max)		■	■
Total apparent power (Stot) and phase power (S1, S2, S3)		■	■
Measurement history: Stot (Stot mean, Stot max)		■	■
Total power and line power factor		■	■
Total active energy meter [kWh]		■	■
Total reactive energy meter [kVARh]		■	■
Total apparent energy meter [kVAh]		■	■
Waveforms of phase, neutral (*) and ground (**) currents			■
Waveform of line-to-line voltages			■
Harmonic analysis (THDi, THDv and spectrum up to the 50th harmonic at 50 Hz and 60 Hz)			■
Network Analyzer (supply voltage characteristics in compliance with EN 50160)			■
State information			
Circuit-breaker state (open/closed/tripped, racked-in/out-test position)	■	■	■
Circuit-breaker ready to close	■	■	■
Mode (local, remote)	■	■	■
Protection parameters set (curves, times and protetion thresholds)	■	■	■
Maintenace data			
Number of total operations (from closed to open)	■	■	■
Total number of trips due to protection intervention	■	■	■
Number of trip tests	■	■	■
Number of operations (from closed to open) with opening command	■	■	■
Number of trips failed	■	■	■
Contact wear (estimated percentage)	■	■	■
Data of the last 30 openings (type of protections tripped, fault values, date and time of trip)	■	■	■
Date of installation of the circuit-breaker	■	■	■
Date of last maintenance operation	■	■	■

	Ekip Touch	Ekip Touch + Ekip Measuring / Measuring Pro Ekip G Touch	Ekip Hi-Touch Ekip G Hi-Touch
Alarms and protection trips			
Trip indication of basic protections (e.g.: L,S,I,G, MCR, IU) and advanced protections (e.g. UV/OV, UF/OF, RP) (****)	■	■	■
Timing and trip/Timing and alarm of the time-delayed protections, basic (e.g. L,S,G) and advanced (e.g. UV/OV, UF/OF) (****)	■	■	■
Pre-alarm of L and G protections	■	■	■
Diagnostics alarms			
Current sensors disconnected	■	■	■
Trip coil disconnected or in fault condition	■	■	■
Rating Plug disconnected or not installed	■	■	
Maintenance signal necessary	■	■	■
Fault on the opening mechanism (TRIP command failed)	■	■	■
Battery not working or absent	■	■	■
Harmonic distortion > 2.1	■	■	■
Pre-alarm (contact wear ≥ 80%)	■	■	■
Contact wear = 100%	■	■	■
Commands/Configurations			
Opening/Closing of the circuit-breaker	■	■	■
Alarm reset (Trip reset)	■	■	■
Trip test	■	■	■
Setting of the protection functions (curves, times and protection thresholds)	■	■	■
Configurations of the trip unit (e.g.: rated voltage, network frequency, neutral)	■	■	■
Dual setting			■
Event Logs (the last 200)			
Change of state of the circuit-breaker, of the protections, of all alarms and modification of parameters	■	■	■

For the information and the commands from remote with the IEC 61850 protocol, see § 4.2.

(*) Available with 4-pole or 3-pole circuit-breakers + CT for external neutral conductor
(**) Available with LSIG version of the trip unit
(***) Available with 4-pole circuit-breaker
(****) Advanced protections are available with: Ekip Touch + Ekip Measuring Pro, Ekip G Touch, Ekip Hi-Touch and Ekip G Hi-Touch. With Ekip G Touch and Ekip G Hi-Touch trip units, the protections for low voltage generators are available. For further information see the White Paper Generators protection: Ekip G trip unit for SACE Emax 2 - *1SDC007409G0202.*

For further information about the basic and advanced protection functions and about the data available with Ekip trip units see the documents: *1SDH001000R0002* and *1SDH000999R0002*.
For further information on the data available from remote, see the document Communication system interface - document 1SDH001140R0001 in ABB Library.

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