SIA F

Overcurrent & Earth Fault Protection Relay

USER´S MANUAL

1. RECEPTION, HANDLING & INSTALLATION

1.1. Unpacking

Relays must only be handled by qualified personnel and special care must be taken to protect all of their parts from any damage while they are being unpacked and installed. The use of good illumination is recommended to facilitate the equipment visual inspection.

The facility must be clean and dry and relays should not be stored in places that are exposed to dust or humidity. Special care must be taken if construction work is taking place.

1.2. Reception of relays

It is necessary to inspect the equipment at the time it is delivered to ensure that the relays have not been damaged during transport.

If any defect is found, the transport company and FANOX should be informed immediately.

If the relays are not for immediate use, they should be returned to their original packaging.

1.3. Handling electronic equipment

Relays contain an electronic component that is sensitive to electrostatic discharges.

Just by moving, a person can build up an electrostatic potential of several thousand volts. Discharging this energy into electronic components can cause serious damage to electronic circuits. It is possible that this damage may not be detected straight away, but the electronic circuit reliability and life will be reduced. This electronic component in the equipment is well protected by the metal housing, which should not be removed as the equipment cannot be adjusted internally.

If it is necessary to disassemble the electronic component, this must be carried out with care and contact with electronic components, printed circuits and connections must be avoided to prevent an electrostatic discharge that could damage one of the components. If the electronic components are stored outside the metal housing, they must be placed in an antistatic conductive bag.

If it is necessary to open a module, care must be taken to preserve the equipment reliability and the duration of the life cycle as designed by the manufacturer by taking the following actions:

- Touch the housing to ensure that you have the same potential
- Avoid touching the electronic components and handle the module by its edges.
- Remember that everyone who handles the module must have the same potential.
- Use a conductive bag to transport the module.

For more information about how to handle electronic circuits, consult official documents such as the IEC 147-OF.

1.4. Installation, commissioning and service

The personnel in charge of installing, commissioning and maintaining this equipment must be qualified and must be aware of the procedures for handling it. The product documentation should be read before installing, commissioning or carrying out maintenance work on the equipment.

Personnel should take specific protection measures to avoid the risk of electronic discharge when access is unlocked on the rear part of the equipment.

In order to guarantee safety, the crimp terminal and a suitable tool must be used to meet isolation requirements on the terminal strip. Crimped terminations must be used for the voltage and current connections.

It is necessary to connect the equipment to earth through the corresponding terminal, using the shortest possible cable. As well as guaranteeing safety for the personnel, this connection allows high frequency noise to be evacuated directly to earth.

The following checks must be performed before the equipment is supplied:

- The rated voltage and polarity.
- The power rating of the CT circuit and the integrity of the connections.
- The integrity of the earth connection.

The equipment must be used within the stipulated electrical and environmental limits.

Note: Regarding the current transformer circuits: Do not open a live CT secondary circuit. The high voltage produced as a result could damage the isolation and threaten lives.

1.5. Storage

If the relays are not going to be installed immediately, they must be stored in a dust- and humidity free environment after the visual inspection has been performed.

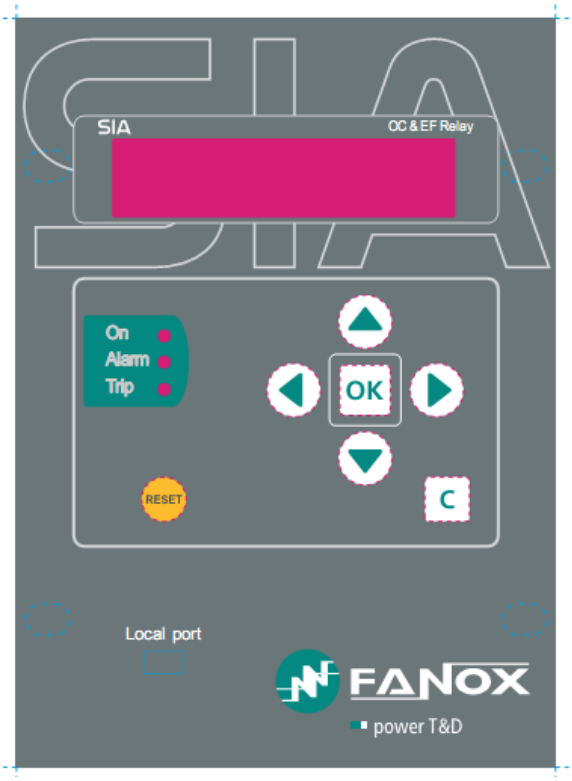
1.6. Recycling

Before recycling the equipment, the capacitors should be discharged through the external terminals. All electrical power sources should be removed before performing this operation to avoid the risk of electrical discharge.

This product must be disposed of in a safe way. It should not be incinerated or brought into contact with water sources like rivers, lakes, etc…

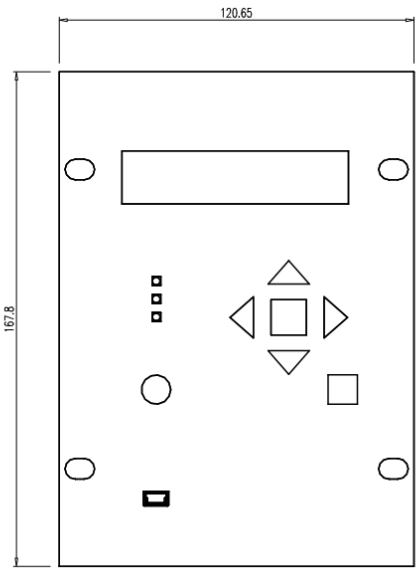
2. DIMENSIONS AND CONNECTION DIAGRAMS

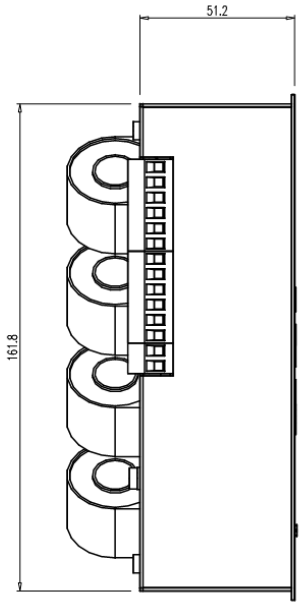
2.1. Frontal view

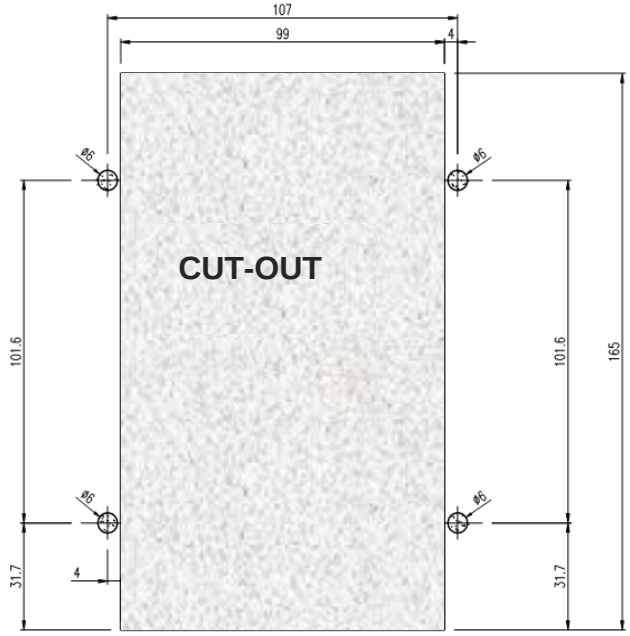


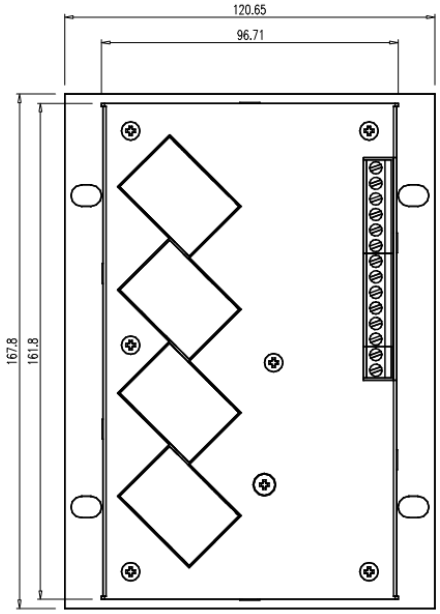
2.2. Case dimensions

The dimensions are in mm.



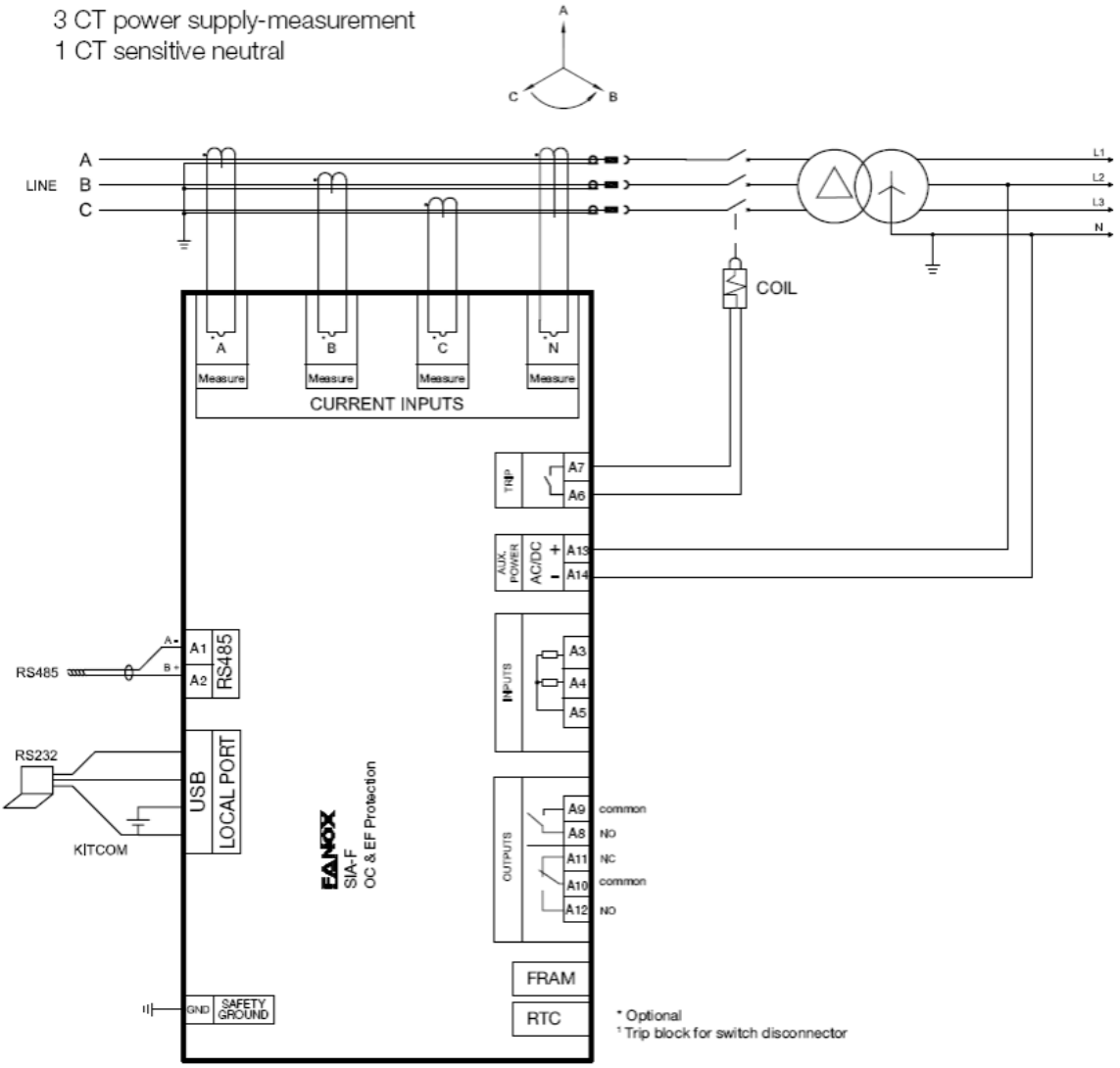






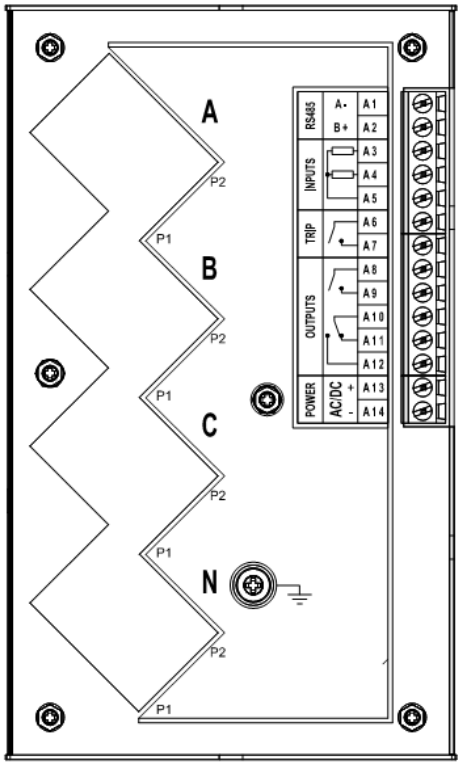
2.3. Connection diagram

3 Phase CT and neutral CT Connection



2.4. Terminals

A1	A-	RS 485
A2	B+	
A3	Input-1	INPUTS
A4	Input-2	
A5	Common inputs	
A6	NO-1	TRIP
A7	C-1	
A8	NO-2	OUTPUTS
A9	Common outputs 2	
A10	Common outputs 3	
A11	NC-3	
A12	NO-3	
A13	+	U aux
A14	-	



3. DESCRIPTION

3.1. Introduction

Worldwide, the energy sector is currently undergoing a profound change as a result of high levels of energy demand; more distribution lines and advanced supervision systems are required. Given the need for creating intelligent infrastructure, FANOX has developed the SIA family of products to carry out this function.

The family of SIA relays is designed to protect the secondary transformation and distribution centres of electricity grids. Protection features include protection against instantaneous and inverse time overcurrent (for the phases and the neutral), and it also has external trip support (temperature, pressure, etc.) depending on the characteristics of each model.

The protection functions can be enabled selectively by using both the front panel and the communications links to the SICom program, allowing for precise coordination with other equipment.

Additional benefits include that all of the models have been designed to be supplied from an external battery. This is aimed at facilitating event management and the commissioning of centres, as well as allowing it to operate properly under adverse conditions.

3.2. Equipment description

The SIA-F equipment is a protection relay designed for secondary distribution.

It is supplied with 110-230 Vac / 90-300 Vdc auxiliary voltage. It is possible to choose 24-48 Vdc auxiliary for each model. As for the rest of the SIA family, it can be supplied through its front communications port via an external battery, using the KITCOM adapter or connecting to PC directly. This facilitates the start-up of the centers and the management of events. The operation is guaranteed when the SIA-F equipment is supplied from USB.

As well as the functions to protect against instantaneous phase and neutral overcurrents and phase and neutral inverse time overcurrents, it is possible to choose thermal image, circuit braking monitoring and circuit breaker opening fault unit for each model. It is also equipped with a trip blocking to protect the switchgear in centres that combine switchgear and fuses.

Depending on model it is included a breaker management block, which monitors the switch condition, the number of breaks and the accumulated amps. It generates an indication if these are excessive, it determines whether or not an Opening fault has occurred and allows the breaker close and open commands from the HMI and via the communications port (either locally or remotely).

The SIA-F equipment has two inputs and two outputs that can be configured by the user (programmable logic) apart from trip output and 3 leds.

In order to facilitate the analysis of events, it is fitted with four fault reports. Fault report start can be configured by the user. Each register includes the events that have occurred during the incident.

The SIA-F equipment is housed in a metal box with galvanic isolation on all of its measurement or digital inputs and outputs (with the exception of ports for communications and battery power supply, as these are sporadic connections). This allows the equipment to have the best possible level of electromagnetic compatibility, both in terms of emission of, and immunity from, radiated and conducted interferences. These levels are the same as those established for primary substations.

The equipment has a LCD with two lines and twenty columns and a membrane keyboard with six buttons. These allow the display of the equipment state, the current measurements in the primary and the events or incidents associated with the equipment, and adjustments to be made to the protection criteria. Depending on the model, these events can be saved in a non-volatile memory to save them in case of power failures.

There are three LED indicators on the front of the SIA-F equipment. These indicate if the equipment is On (LED ON), if an alarm has happened (LED ALARM) or if a trip has happened (LED TRIP). The equipment has storage for up to 100 events, allowing any recorded incidents to be analyzed. All SIA-F models are equipped with a real-time clock (RTC).

Current measurements are performed using RMS values, with 2% accuracy in a band of ± 20% when compared with rated current and 4% in the rest of the range. Standard 5 A and 1 A current transformers (CTs) are used.

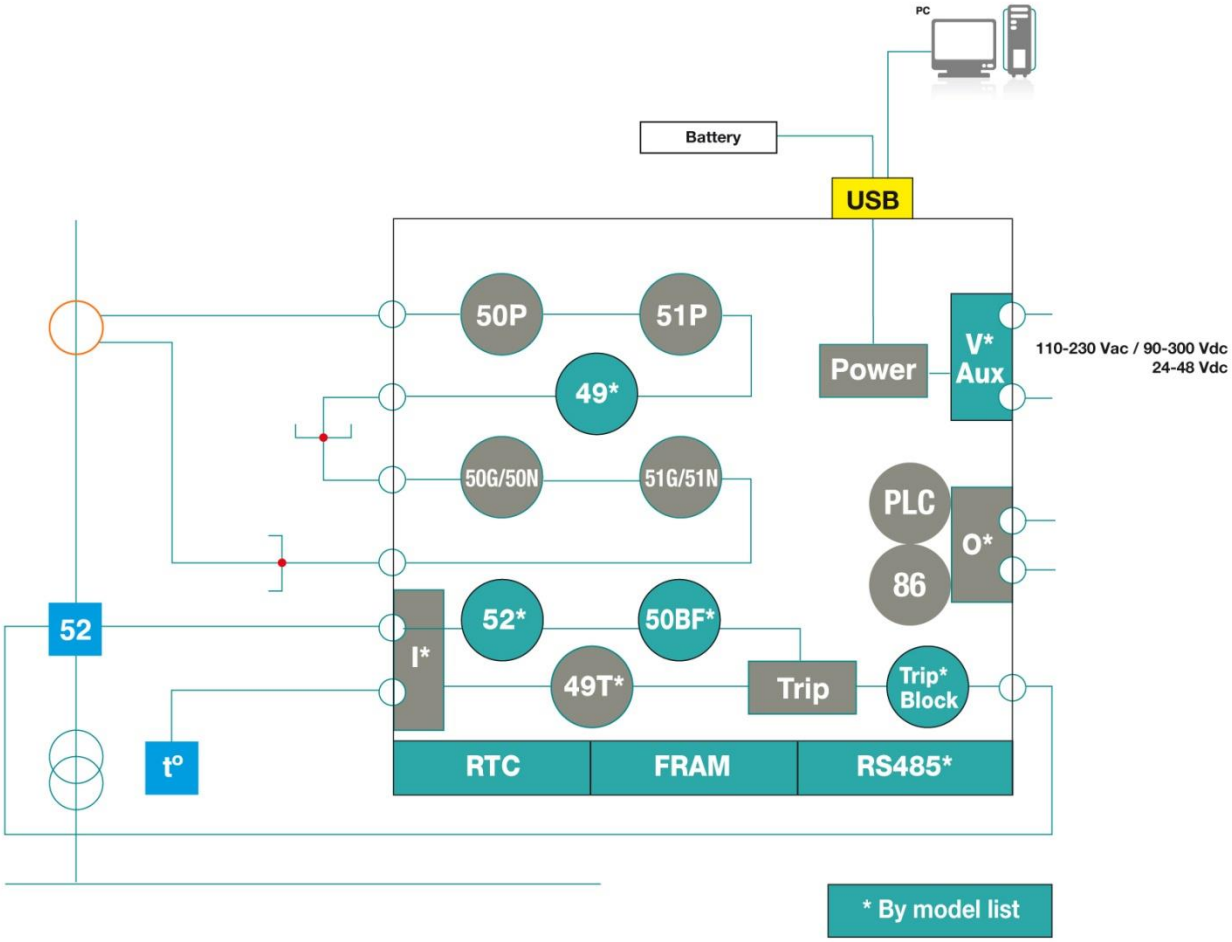
The equipment has two communication ports: a front port (USB) and a rear port (RS485). The frontal port allows a PC to be connected, which can be used to monitor the equipment using the SICom communications program (supplied by FANOX). Front port can be used to power the equipment by using an USB which can be directly connected with PC. The rear port RS485 allows the equipment to be integrated as part of a system (SCADA). The ModBus RTU protocol is used in both ports. Setting-up a session allows four levels of access to be set up with passwords that can be configured by the user.

The protective functions provided, easy-to-use interface, low amount of maintenance and simple integration make the SIA-F a precise and practical solution for protecting both industrial and public electrical grids and transformation and distribution centers. The protection offered by the SIA-F against earth faults is sensitive enough to be used in electric systems where the earth fault current is low. It can be set to 0.2 times the rated neutral current and, depending on the model, the rated neutral current can go as low as 0.1 A. The main features of the equipment are listed below, and these features will be explained in the rest of the manual:

Function	Description	SIA-F
Protection		
50P	Phase instantaneous overcurrent protection function	1
50N/50G	Neutral instantaneous overcurrent protection function	1
51P	Phase inverse time overcurrent protection function	1
51N/51G	Neutral inverse time overcurrent protection function	1
Fuse + Switchgear	Trip blocking to protect the switchgear	1 (optional)
49	Thermal image	1 (optional)
52	Circuit breaker monitoring	1 (optional)

50BF	Circuit breaker opening fault	1 (optional)
86	Trip Output Lockout using the PLC.	✓
PLC	Programmable Logic Control	V2
Measurements		
	Phase and neutral RMS measurement with 2% accuracy on a band of ±20% over the nominal current and 4% over the rest of the range.	IA, IB, IC, IN, Imax and TI
Inputs and Outputs		
	Configurable Inputs	2 (Optional)
	Configurable (PLC) outputs	2 (Optional)
	Trip output	1 Potential free
Communication and HMI		
	Front port: USB (ModBus, RTU 19200)	✓
	Rear port: RS485 (ModBus, RTU 19200)	✓
	SICom Program	✓
	HMI: LCD, 20x2 and 6 keys + 1 reset button	✓
	LED Indicators	3
Power supply		
	Auxiliary voltage 110-230 Vac / 90-300 Vdc	Optional
	Auxiliary voltage: 24-48 Vdc	Optional
	USB supply	✓
Monitoring and recording		
	Events saved in the non-volatile FRAM* memory	100
	Counters	Optional
	Commands	Optional
	Real-Time Clock (RTC)	✓
	Fault reports	4
	Test menu	✓
	Self-diagnosis	✓

3.3. Functional Diagram



3.4. Model List

TYPE	PHASES RATED CURRENT	NEUTRAL RATED CURRENT	NET FREQUENCY	POWER SUPPLY	EXTRA FEATURES	COMMUNICATION	INPUT & OUTPUT	MECHANIC	LANGUAGE	ADAPTATION	50P+51P+50G/50N+51G/51N+86+PLC
SIAF											OC & EF Relay
	1 5										1 A 5 A
		1 5 B									1 A 5 A 0,2 A
			0 5 6								Defined in general settings 50Hz 60Hz
				A B							24-48 Vcc 90-300 Vdc / 110-230 Vac
					0 1 B C						- +52+50BF+ 49 + Trip Block for switch disconnector + Trip Block for switch disconnector + 52+ 50BF +49
						0 1					Frontal USB + RS485
							0 1				3 led's + trip output + 2 inputs + 2 outputs (configurable)
								0			4U x ¼ rack
									A B C D		English, Spanish and German English, Spanish and Turkish English , Spanish and French English , Spanish and Russian
										A	-

3.5. Phase CT and neutral CT selection

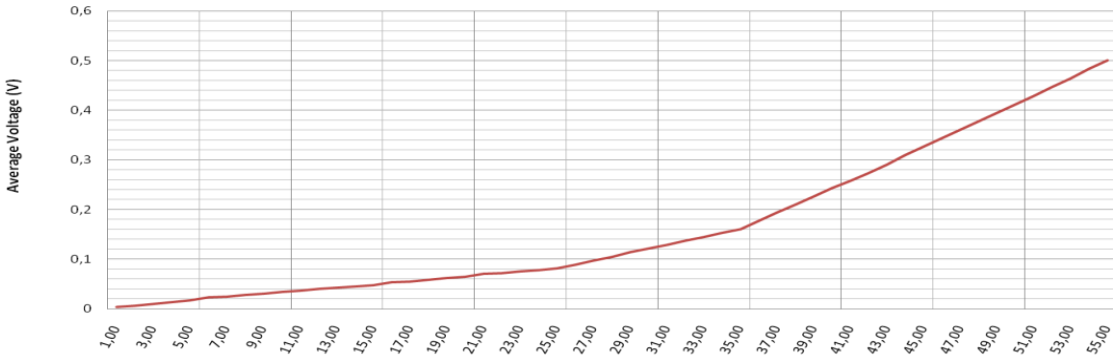
The following table shows a summary of phase and neutral CT combinations:

Model	Phase	Neutral	Phase range	Neutral range
SIAF55	CT 5 A	Residual phase connection	0,5-150 A	0,5-150 A
SIAF11	CT 1 A	Residual phase connection	0,1-30 A	0,1-30 A
SIAF51	CT 5 A	CT 1 A	0,5-150 A	0,1-30 A
SIAF5B	CT 5 A	CT 0,2 A	0,5-150 A	0,02-6 A
SIAF1B	CT 1 A	CT 0,2 A	0,1-30 A	0,02-6 A

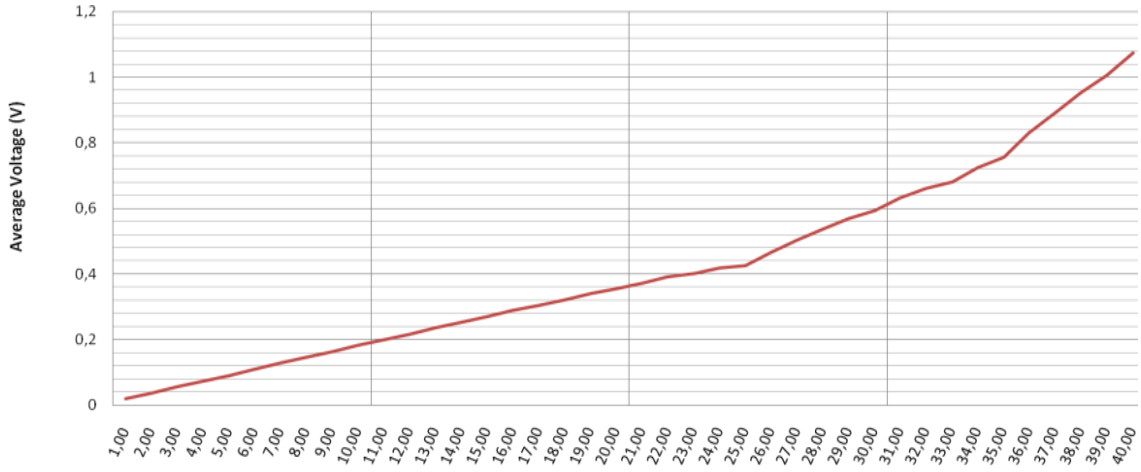
In order to assure a correct running of the relay, it is necessary to use the proper current transformer. Therefore, the load of measurement circuits of the relay and the load of connection cables between CT's and relay must be taken into account.

PRECISSION	BURDEN	RELAYS
5P10	0,5 VA	SIA-F/1
5P20	0,5 VA	SIA-F/1
5P30	0,5 VA	SIA-F/1
5P10	1 VA	SIA-F/5
5P20	1 VA	SIA-F/5
5P30	1 VA	SIA-F/5

3.5.1. Load curve for relay SIA-F/1

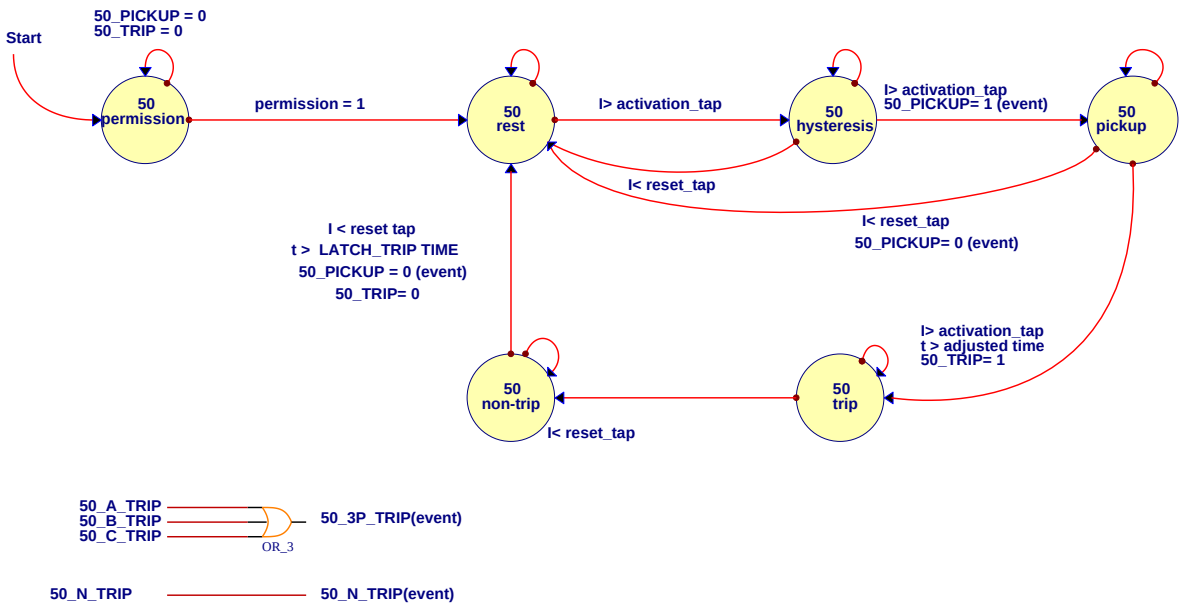


3.5.2. Load curve of relay SIA-F/5



4. PROTECTION FUNCTIONS

4.1. 50P Function. Phase instantaneous phase overcurrent



This protection function can be set by using three parameters:

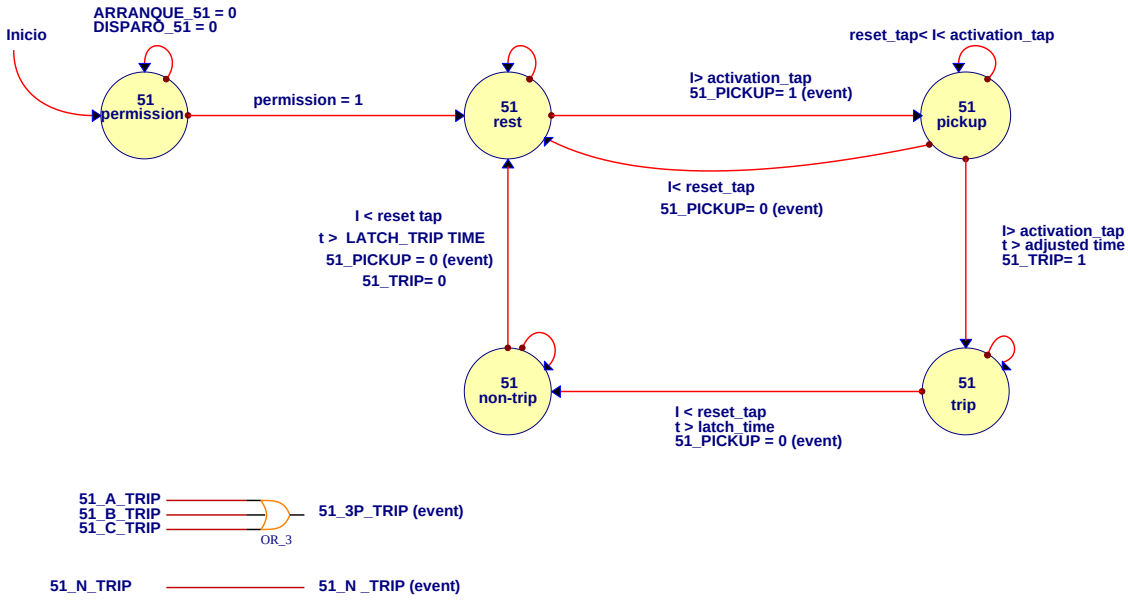
Function	Description	Minimum	Maximum	Step	Unit	Default
50P	**Phase instantaneous overcurrent**					
	Permission	-	-	Yes/No	-	No
	Tap	0,10	30,00	0,01	I nominal	5,00
	Operating time	0,02	300,0	0,01	s	0,02

The operating time is independent from the operating current flowing through the equipment, so if the phase current exceeds its predetermined value for an equal or greater amount of time than this pre-set value, the protection function activates (trips) and does not reset itself until the value of the phase drops below the point of current tap.

The function activates at 100% of the pre-set input, and deactivates at 95%. The reset is instantaneous.

The accuracy of the operating time is equal to the pre-set time plus a maximum of 30 ms.

4.2. 51P Function. Phase inverse time overcurrent



This protection function can be set by using five parameters:

Function	Description	Minimum	Maximum	Step	Unit	Default
51P	**Phase inverse time overcurrent**					
	Permission	-	-	Yes/No	-	No
	Curve	-	-	(1*)	-	Extremely Inverse
	Dial	0,05	1,25	0,01	-	1,25
	Tap	0,10	7,00	0,01	Inominal	1,00
	Operating time	0,02	300,0	0,01	s	0,02

(1*) Inverse, Very inverse, Extremely inverse, Defined time

If the option "Defined time" is selected for the curve setting, the unit behaves like an instantaneous overcurrent unit. In this case, the unit operating time is set by the parameter "Operating time".

If a curve (inverse, very inverse or extremely inverse) is selected for the curve setting, the operating time depends on the curve, dial and tap settings.

If the unit operates with defined time, the function is activated at 100% of the set tap value, and it deactivates at 95%.

If the unit operates with a curve, the function is activated at 110% of the set tap value, and it deactivates at 100%.

The reset is instantaneous in both cases.

The activation time is accurate to ±5% or ±30ms, whichever is greater, of the theoretical activation time.

The curves used are IEC 60255-151, which are described in the "Curves" section.

4.3. 50N/50G Function. Neutral instantaneous overcurrent

This protection function can be set by using three parameters:

Function	Description	Minimum	Maximum	Step	Unit	Default
50N/50G	**Neutral instantaneous overcurrent**					
	Permission	-	-	Yes/No	-	No
	Tap	0,10	30,00	0,01	I nominal	1,00
	Operating time	0,02	300,00	0,01	s	0,02

The operating time is completely independent from the operating current that flows through the equipment, so if the neutral current exceeds its predetermined value for an equal or greater amount of time than this pre-set value, the protection function activates (trips) and does not reset itself until the value of the phase drops below the point of current pick-up.

The function activates at 100% of the pre-set input, and deactivates at 95%. The reset is instantaneous.

The accuracy of the operation time is equal to the pre-set time plus a maximum of 30 ms.

4.4. 51N/51G Function. Neutral inverse time overcurrent

This protection function can be set by using the following parameters:

Function	Description	Minimum	Maximum	Step	Unit	Default
51N/51G	**Neutral inverse time overcurrent**					
	Permission	-	-	Yes/No	-	No
	Curve	-	-	(1*)	-	Extremely Inverse
	Dial	0,05	1,25	0,01	-	1,25
	Tap	0,10	7,00	0,01	Inominal	0,50
	Operating time	0,02	300,0	0,01	s	0,02

(1*) Inverse, Very inverse, Extremely inverse, Defined time

If the option "Defined time" is selected for the curve setting, the unit behaves like an instantaneous overcurrent unit. In this case, the unit operating time is adjusted by using the parameter "Operating time".

If a curve (inverse, very inverse or extremely inverse) is selected for the curve setting, the operating time depends on the curve, dial and tap settings.

If the unit operates as defined time, the function is activated at 100% of the set tap value, and it deactivates at 95%.

If the unit operates with a curve, the function is activated at 110% of the set tap value, and it deactivates at 100%. The reset is instantaneous in both cases.

The activation time is accurate to ±5% or ±30ms, whichever is higher, of the theoretical activation time.

The curves used are IEC 60255-151, which are described in the "Curves" section.

4.5. Trip blocking protection for the switchgear

Some transformation centers use a combination of switchgear and fuses for cutting out. Switchgears have a limited opening current. As a result, the fuses are responsible for cutting out the circuit for high current short circuits, as the switchgear would be destroyed if opened in this situation. In order to deal with these situations, tripping is blocked when the phase current exceeds a pre-set value.

Group	Description	Minimum	Maximum	Step	Unit	Default
	Trip blocking					
	Blocking	-	-	Yes/No	-	Yes
	Blocking limit	1,50	20,00	0,01	I nominal	7,00

4.6. 52 Function. Circuit breaker monitoring

This function allows the state of the circuit breaker to be monitored and preventive maintenance to be performed, for which the following parameters need to be configured:

Group	Description	Minimum	Maximum	Step	Unit	Default
52	**Circuit breaker monitoring**					
	Excessive number of openings	1	10000	1	-	10
	Maximum accumulated amps	1	100000	1	M(A^2)	1000
	Opening time	0,02	300,0	0,01	s	0,10
	Closing time	0,02	300,0	0,01	s	0,10
	Excessive repeated openings	1	10000	1	-	3
	Time of excessive repeated openings	1,00	300,0	0,01	min	9,00

NOTE: The “Maximum accumulated amperes” adjustment units are M (A^2) (square mega amperes) whilst the “Accumulated amperes counter” units are K (A^2) (square kilo amperes).

It is also necessary to assign the logical inputs 52a and/or 52b to a physical input.

This function provides information about the circuit breaker state and if any maintenance alarm has been activated.

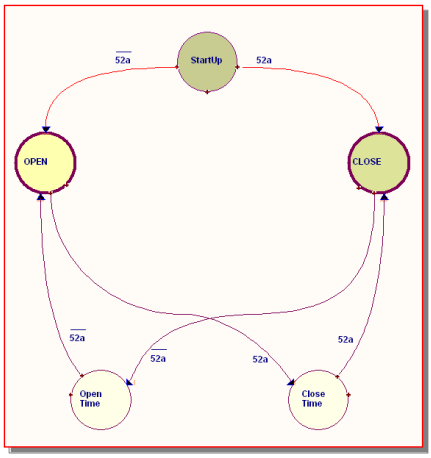
The following states are associated with this function:

Function	State	Description
52	Start	Energized/De-energized These are the different states of the circuit breaker automatic control
	Error	
	Open	
	Opening time	
	Opening fault	
	Closed	
	Closing time	
	Closing fault	
	No. of configured openings exceeded	Activated if the meter that measures the number of openings exceeds the "Excessive number of openings" setting
	No. of configured accumulated (I2t) amps exceeded	Activated if the accumulated amps meter exceeds "Maximum accumulated amps" setting
	Repeated Trips	Activated if the number of openings exceeds the setting in "Excessive repeated openings" for the time set in "Time of excessive repeated openings"
	52a	-
	52b	-

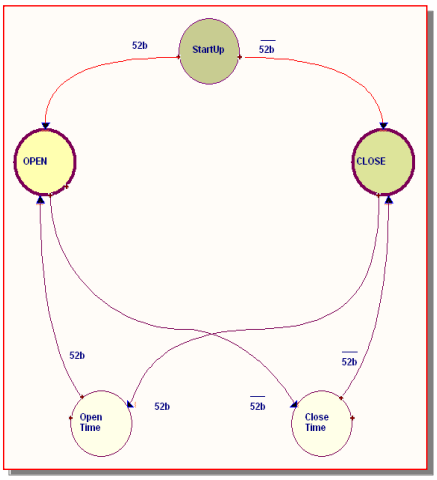
The circuit breaker performance is shown in the following finite state machine:

The way that the circuit breaker is monitored becomes more or less complex depending on whether it is fitted with one breaker contact (52a or 52b) or both (52a and 52b).

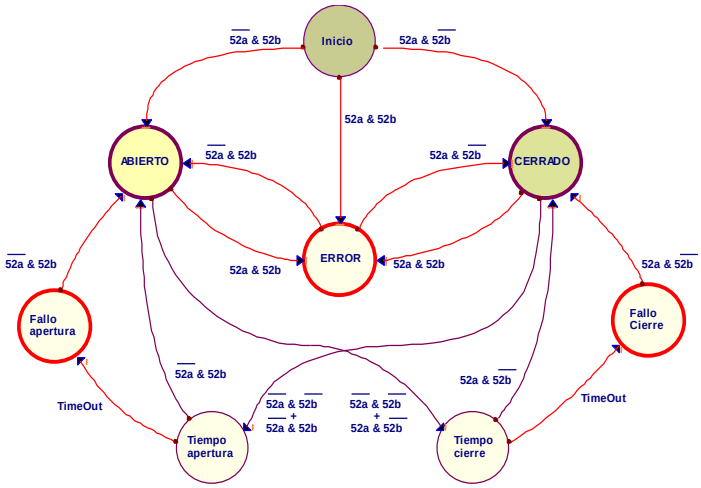
If only the circuit breaker 52a contact is available, it should be wired to the corresponding physical input. This physical input is then assigned to the "52a Input" logical input. The 52b logical input is calculated internally as the negative of 52a. The circuit breaker automaton is considered as having four states: start, open, closed and error.



If only the circuit breaker 52b contact is available, it should be wired to the corresponding physical input. This physical input is then assigned to the "52b Input" logical input. The 52a logical input is calculated internally as the negative of 52b. The circuit breaker automaton is considered as having four states: start, open, closed and error.



If both of the circuit breaker contacts 52a and 52b are available, they should be wired to the two physical inputs. These physical inputs are then assigned to the corresponding logical inputs: the circuit breaker 52a contact to the "52a Input" logical input, and the circuit breaker 52b contact to the "52b Input" logical input. The circuit breaker automaton is considered as having eight states: start, open, closed, error, opening time, opening fault, closing time and closing fault.



4.6.1. Circuit breaker opening and closing commands

The circuit breaker opening and closing commands are implemented. These commands can be executed from the HMI command menu or through communications.

For the commands to have an effect, they should be assigned to the corresponding outputs. The "Open circuit breaker" and "Close circuit breaker" bits are assigned to their corresponding outputs in the "CONTROL" state group in the state menu.

4.6.2. Counter to register the number of openings

The SIA-F equipment is fitted with a counter that registers the number of times the circuit breaker opens.

This meter is associated with the "Maximum number of openings" setting. When the number of openings exceeds this pre-set value, the "Excessive number of openings" state is activated and its corresponding event is generated.

This counter reading can be set to any value within its range from the HMI or by communications.

4.6.3. Accumulated amps counter: I2t

An accumulated amps counter is also fitted. This counter accumulates the amps that are cleared by the circuit breaker by opening.

When the circuit breaker opens, the maximum number of primary amps in any of the phases is detected. This reading is squared and divided by 1000 and then rescaled to KA and accumulated. If the current detected in the opening is less than the rated current, the rated current value is used for the accumulation.

It is used in conjunction with the metering of the number of openings, to measure the circuit breaker aging process.

Since primary amps are being accumulated, it is essential to correctly adjust the phase CT transformation ratio.

The "Maximum accumulated amps" setting is associated with this counter. When the number of accumulated amps exceeds this pre-set value, the "Excessive accumulated amps" state is activated and its corresponding event is generated.

This counter reading can be set to any value from within its range from the HMI or by communications.

4.6.4. Excessive openings in a time window

As well as counting the number of times the circuit breaker opens, the SIA-F equipment sets up a time window and the maximum number of openings allowed during this time. Both parameters can be adjusted.

When this number is exceeded, the "Repeated Trips" state is activated and its corresponding event is generated.

4.7. 49 Function. Thermal Image Protection

Thermal image is a measure of heating and cooling of an electric machine. Unlike overcurrent protection, do not start counting the time when it detects a fault, but is continuously determining the thermal state of the machine that monitors. The trip time depends on the thermal constants adjusted, the current flowing and the prior thermal state of the machine.

The thermal image is calculated based on the following equation:

$$\theta = 100 \times (I/I_t)^2 \times (1 - e^{-t/\zeta}) + \theta'_0 \times e^{-t/\zeta}$$

Where:

I, maximum R.M.S. current of three phases

I_t, adjusted tap current

ζ, thermal constant

θ'_0, initial thermal state

The trip time is given by the equation:

$$t = \zeta \times \ln \times \{[(I/I_t)^2 - (\theta'_0 / 100)] / [(I/I_t)^2 - 1]\}$$

The accuracy of the tripping time is 5% of the theoretical time.

The algorithm uses the maximum of the three phase currents. If the maximum is greater than 15% of the adjusted tap, heating thermal constant is applied. If the maximum is less than 15% of the adjusted tap cooling thermal constant is taken into account.

The overload function trips when the thermal image reaches the value of 100%. This value is reached in time when the current flowing is equal to the function adjusted in thermal function.

It provides an adjustable level of thermal imaging to generate an alarm. If the trip occurs, the function of overload is reset when the thermal image falls below the set alarm level.

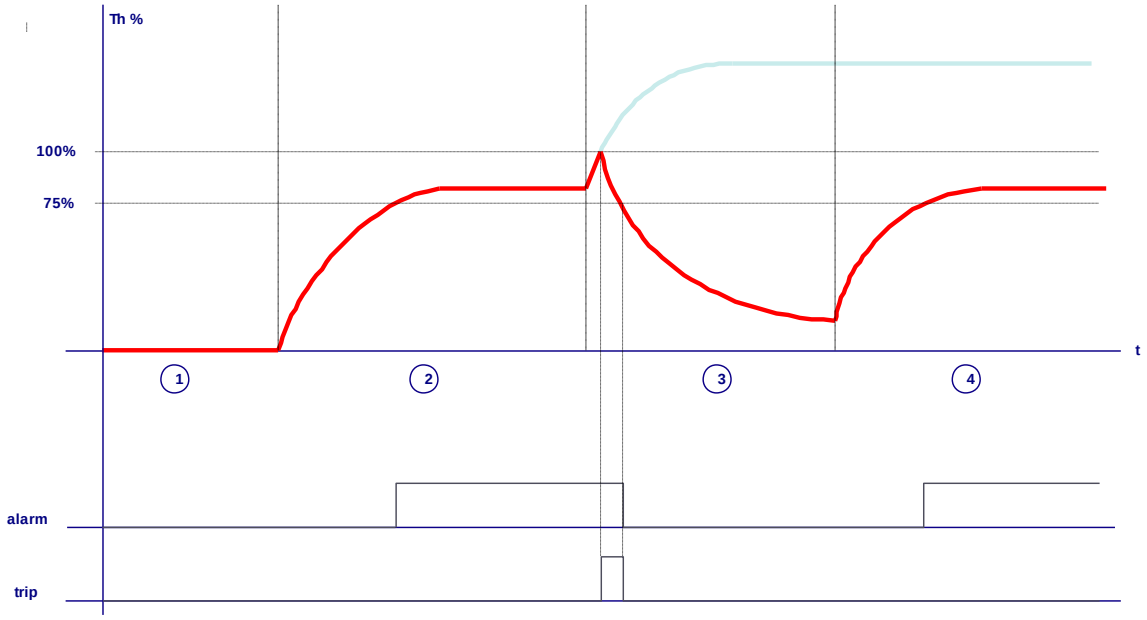
As the current measurement algorithm used is R.M.S., in the thermal model is taken into account the heat produced by the harmonics.

This protection function is adjusted by setting five different parameters:

Function	Description	Minimum	Maximum	Pitch	Unit	Default
49	**Thermal image protection function**					
	Permission	-	-	Yes/No	-	No
	Tap	0,10	2,40	0,01	I nom	1,2
	ζ heating	3	600	1	min	3
	ζ cooling	1	6	1	ζ heating	1
	Alarm	20	99	1	%	80

4.7.1. Thermal image measurement evolution graphic

On next graphic, thermal image measurement evolution can be observed depending on applied current:



We suppose that thermal image protection has and adjusted tap of 1,1 times the nominal current and an alarm level of 75%.

- Zone 1: The machine is de-energized for a long time. Thermal image is 0%.
- Zone 2: We supply the machine with the nominal current. Thermal image evolutions so as to get the value of the thermal balance corresponding to one time the nominal current Th = $(I/It)^2$ = 82%. The time that it takes in getting the thermal balance depends on the adjusted heating constant.
- Zone 3: Once reached the thermal image corresponding to the application of one time the nominal current, we apply 1,2 times the nominal current. Thermal image would evolve so as to get the thermal balance corresponding to 1,2 times the nominal current Th = $(I/It)^2$ = 119%. This would occur if we had the permission of the thermal function disabled. If the permission is disabled, 49 protection function performs when the thermal image reaches the value of 100%. Once tripped, current is cut and thermal image is getting cool based on the cooling constant.
- Zone 4: Before getting totally cool, nominal current is applied again and thermal balance is reached once passed the time determined by the heating thermal constant.

Thermal image protection alarm bit is active if the thermal image measurement is over the adjusted alarm level.

Thermal image protection trip bit is active when the measurement of the thermal image is over 100% and it is reset when the measurement of the thermal image is under the adjusted alarm level.

4.7.2. Thermal image with memory

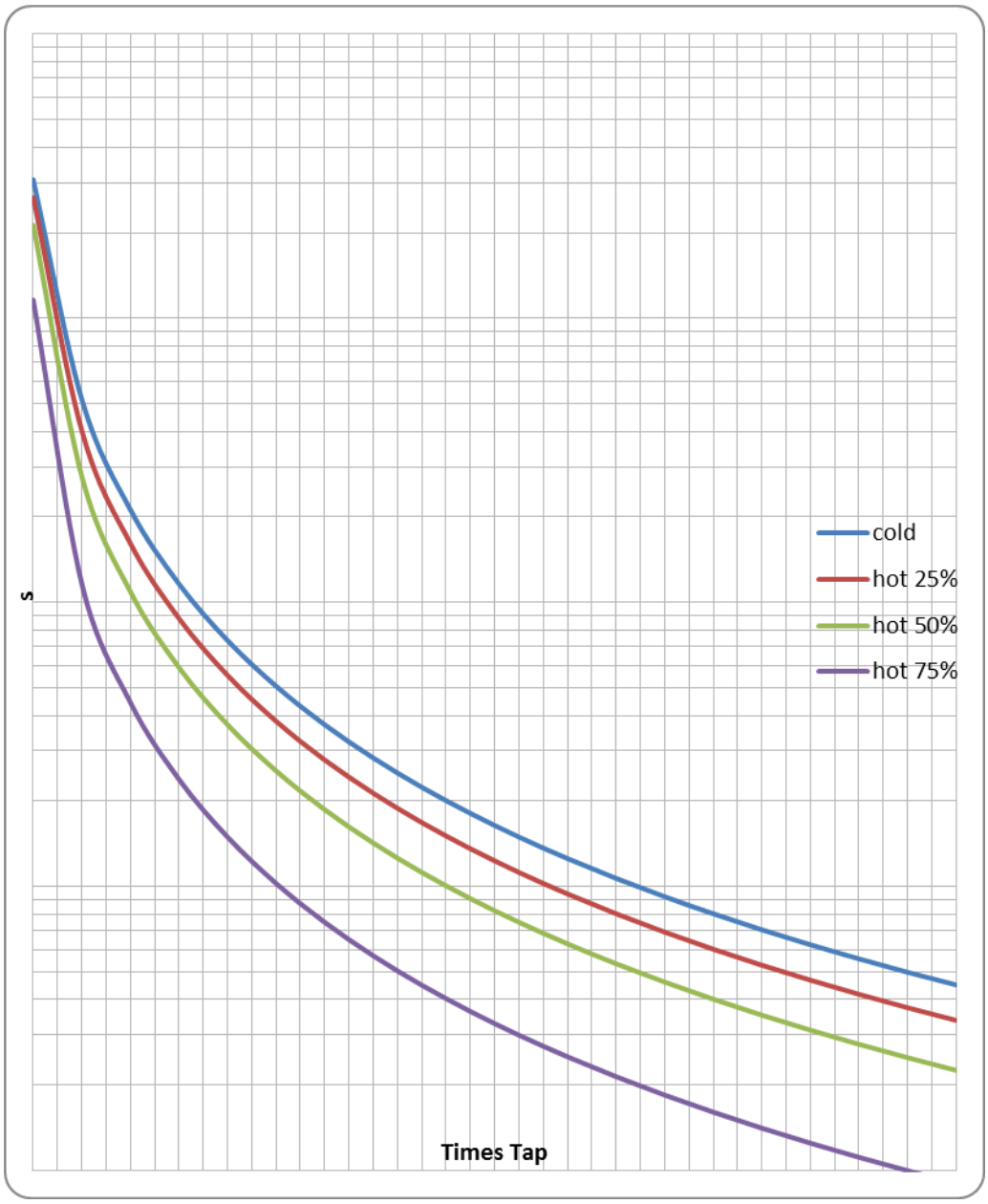
Thermal image is stored in non-volatile RAM memory periodically every second. By this way, though the relay loses the power supply, it will keep the thermal state of the machine.

4.7.3. Thermal image measurement display. Reset.

Thermal image measurement can be displayed on Measurement menu and Counters menu.

Display is possible in Measurement menu. Display and thermal image value reset is possible in Counters menu.

4.7.4. Thermal protection curves



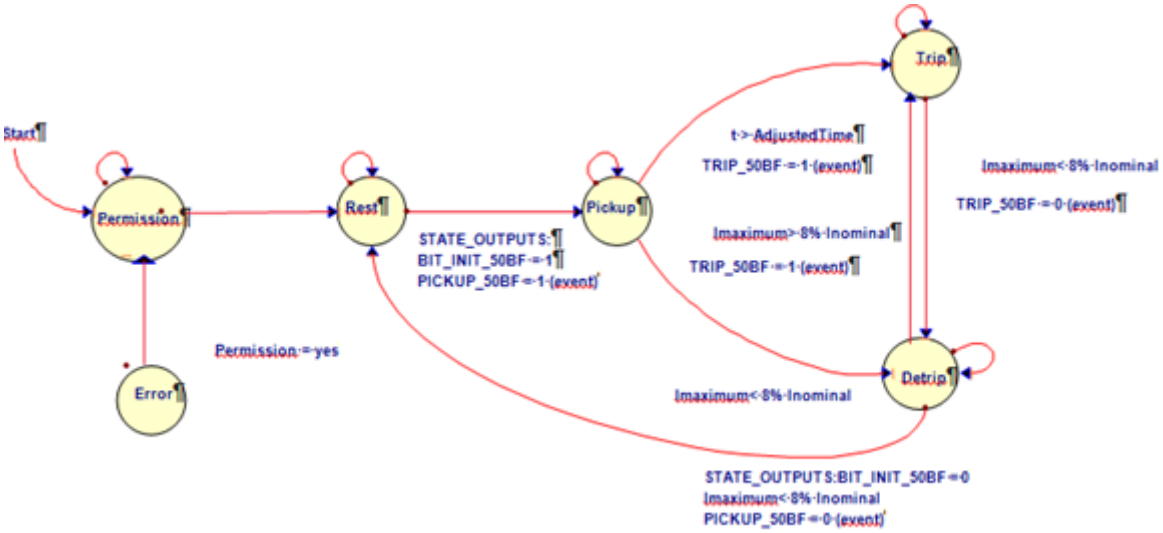
This is the thermal curve for ζ = 3 minutes.

4.8. 50BF Function. Circuit Breaker opening Fault

The settings of this function are as follows:

Function	Description	Minimum	Maximum	Pitch	Unit	Default
50BF	**Circuit breaker opening fault**					
	Permission	-	-	Yes/No	-	No
	Opening fault time	0,02	1,00	0,001	s	0,02

The following automaton describes the open fault function:



When the “50BF Start” state is activated, a switch is made to the "50BF" start and time is counted. If, following the adjusted open fault time, the switch is not detected to have open, the function trips. The function is reset when the circuit breaker is detected to have opened, and the “50BF Start” state has been reset.

To monitor the circuit breaker opening the current measurement via the three phases is used. When the current via the three phases is less than 8% of the rated current, the circuit breaker is considered to be open.

There is a “50BF start input” to start the open fault from an external protection.

The “50BF Start” state is an adjustable logic output. The default configuration is shown below:

- Opening fault input activation (50BF start input)
- Circuit breaker opening from an HMI/local modbus
- Circuit breaker opening from a remote modbus
- General trip

4.9. General Settings

General settings establish some parameters that are necessary for the relay to operate. These settings are defined as general because they affect the entire relay, and as a result they are not subject to a change of table.

Function	Description	Minimum	Maximum	Pitch	Unit	Default
	General settings					
	Equipment identifier	-	-	-	-	"free text"
	Frequency	-	-	*60/50*	*Hz*	*50*
	Serial Number	-	-	-	-	*0*
	Language	-	-	-	-	English
	Settings active group	1	2	1	-	1
	Transformation ratio of the phase CTs	1,0	2000,0	0,1	-	100
	Transformation ratio of the neutral CTs	1,0	2000,0	0,1	-	100
	Local communication address	1	247	1	-	1
	Password	-	-	-	-	****
	Remote communication address	1	247	1	-	2
	Remote communication baudrate	4800	38400	-	baudios	19600

(1*) "EQUIPMENT IDENTIFIER" setting it is only adjustable by communications.

(2*) "SETTINGS ACTIVE GROUP" setting can be changed also through inputs.

4.10. Setting Group

There are available two protection setting groups. The setting group, which is activated in a particular moment, can be modified in two ways:

- Changing active group. In general settings menu there is an option to establish which group is active.
- Two inputs: In this case, there are three possibilities.

Position 0 and position 3: Active group is defined by the active group which appears in general settings menu. In the rest, independently of it adjusted in general settings menu, inputs overcome settings.

In case of not using both inputs, it is possible to use one of them, but depending on which it is used, it is possible to work with group 1 or with group 2.

Input-2	Input-1	Setting group
0	0	**Active group setting**
0	1	**Group 1**
1	0	**Group 2**
1	1	**Active group setting**

4.11. Protection Settings

The SIA-F's settings are listed below with their description, maximums, minimums, units and the values for the factory settings.

Group	Description	Minimum	Maximum	Step	Unit	Default
50P	**Phases instantaneous overcurrent**					
	Permission	-	-	Yes/No	-	No
	Tap	0,10	30,00	0,01	Inominal	5,00
	Operating time	0,02	300,0	0,01	s	0,02
51P	**Phase inverse time overcurrent**					
	Permission	-	-	Yes/No	-	No
	Curve	-	-	(1*)	-	Extremely inverse
	Dial	0,05	1,25	0,01	-	1,25
	Tap	0,10	7,00	0,01	I nominal	1,00
	Operating time	0,02	300,0	0,01	s	0,02

50N/50G	**Neutral instantaneous overcurrent**					
	Permission	-	-	Yes/No	-	No
	Tap	0,20	30,00	0,01	I nominal	1,00
	Operating time	0,02	300,0	0,01	s	0,02
51N/51G	**Neutral inverse time overcurrent**					
	Permission	-	-	Yes/No	-	No
	Curve	-	-	(1*)	-	Extremely inverse
	Dial	0,05	1,25	0,01	-	1,25
	Tap	0,10	7,00	0,01	I nominal	0,50
	Operating time	0,02	300,0	0,01	s	0,02
	Breaker blocking					
	Blocking	-	-	Yes/No	-	Yes
	Blocking limit	1,50	20,00	0,01	I nominal	7,00
52	**Circuit breaker monitoring**					
	Excessive number of openings	1	10000	1	-	10
	Maximum accumulated amps	1	100000	1	$M(A^2)$	1000
	Opening time	0,02	300,0	0,01	s	0,10
	Closing time	0,02	300,0	0,01	s	0,10
	Excessive repeated openings	1	10000	1	-	3
	Time of excessive repeated openings	1,00	300,0	0,01	min	9,00

49	**Thermal Image**					
	Permission	-	-	Yes/No	-	No
	Tap	0,10	2,40	0,01	I nom	1,2
	ζ heating	3	600	1	min	3
	ζ cooling	1	6	1	ζ heating	1
	Alarm	20	99	1	%	80
50BF	**Circuit breaker opening fault**					
	Permission	-	-	Yes/No	-	No
	Opening fault time	0,02	1,00	0,01	s	0,4
	General settings					
	Equipment identifier	-	-	-	-	“free text”
	Frequency	*-*	*-*	*60/50*	*Hz*	*50*
	Serial Number	*-*	*-*	*-*	*-*	*0*
	Language	-	-	-	-	English
	Settings active group	1	2	1	-	1
	Transformation ratio of the phase CTs	1,0	2000,0	0,1	-	100
	Transformation ratio of the neutral CTs	1,0	2000,0	0,1	-	100
	Local communication address	1	247	1	-	1
	Password	-	-	-	-	****
	Remote communication address	1	247	1	-	2
	Remote communication baudrate	4800	38400	-	baudios	19600

(1*) “EQUIPMENT IDENTIFIER” setting it is only adjustable by communications.

(2*) “SETTINGS ACTIVE GROUP” setting can be changed also through inputs.

4.12. IEC 60255-151 Curves

The SIA-F relay complies with the curves shown in standard IEC 60255-151 Curves:

- Inverse Curve
- Very Inverse Curve
- Extremely Inverse Curve

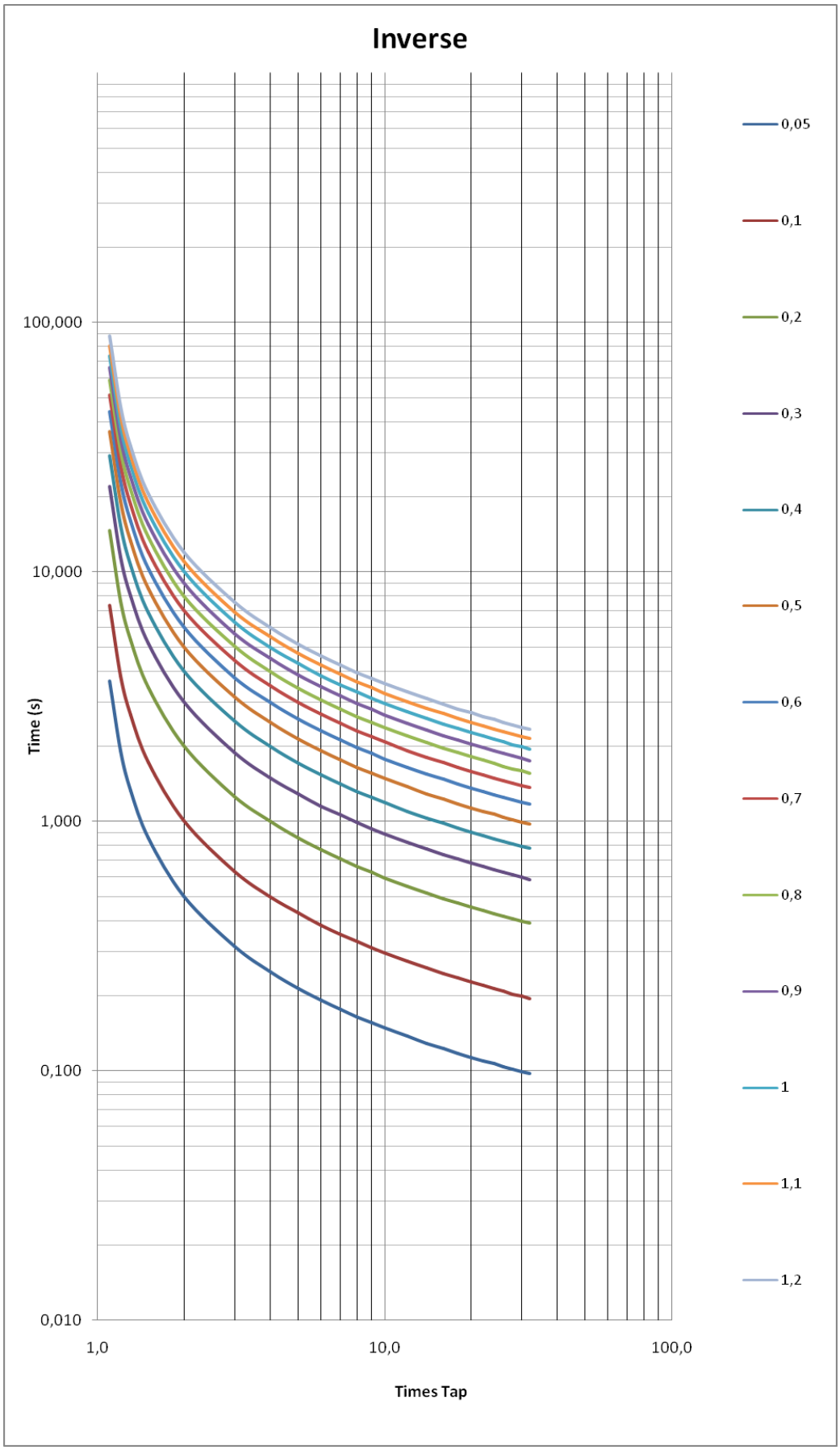
There is a general mathematical equation that defines the time in seconds as a function of the current:

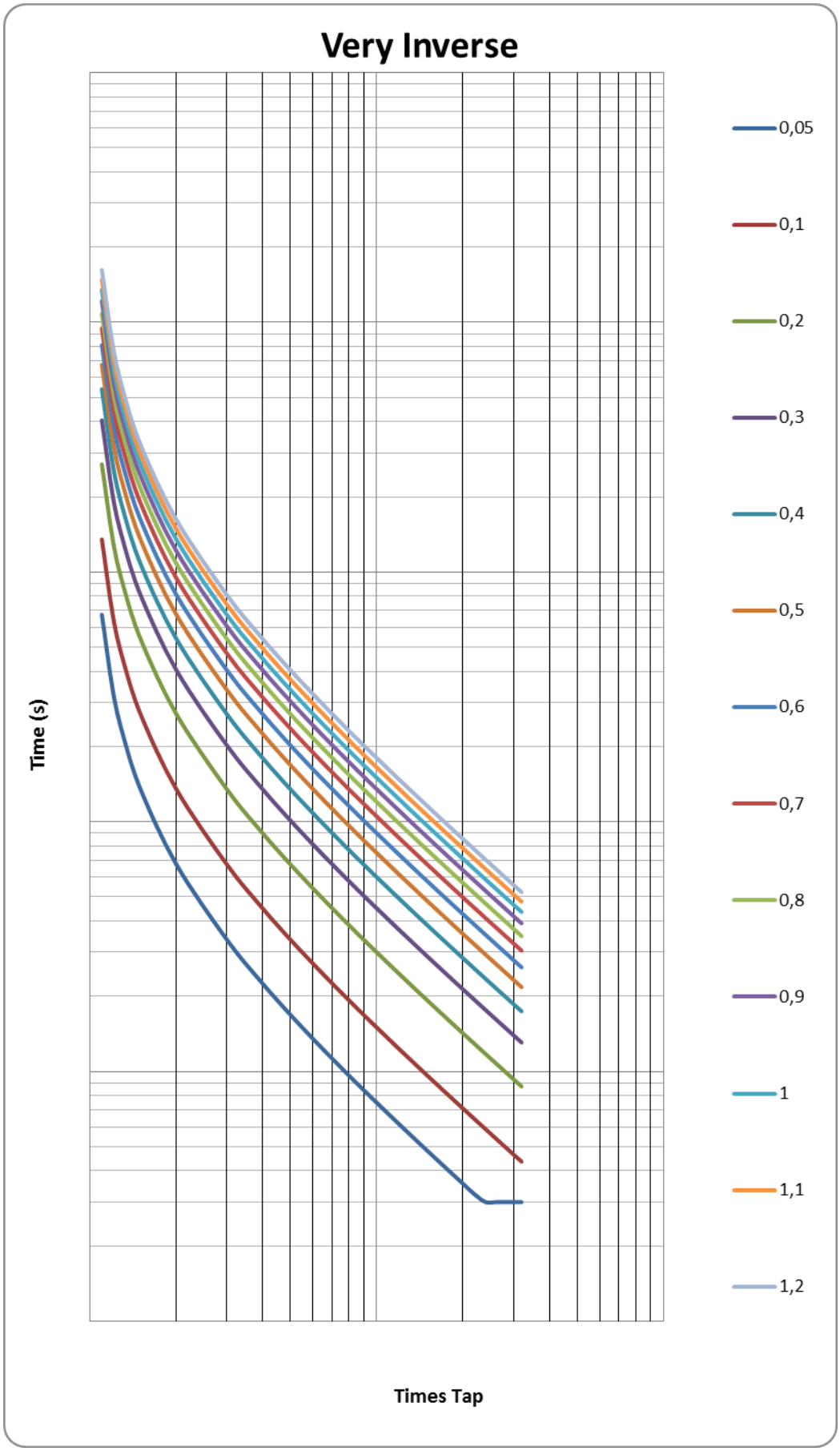
$$t = \frac{A \times D}{V^P - Q} + B \times D + K \qquad V = \frac{I}{I_{adjusted}}$$

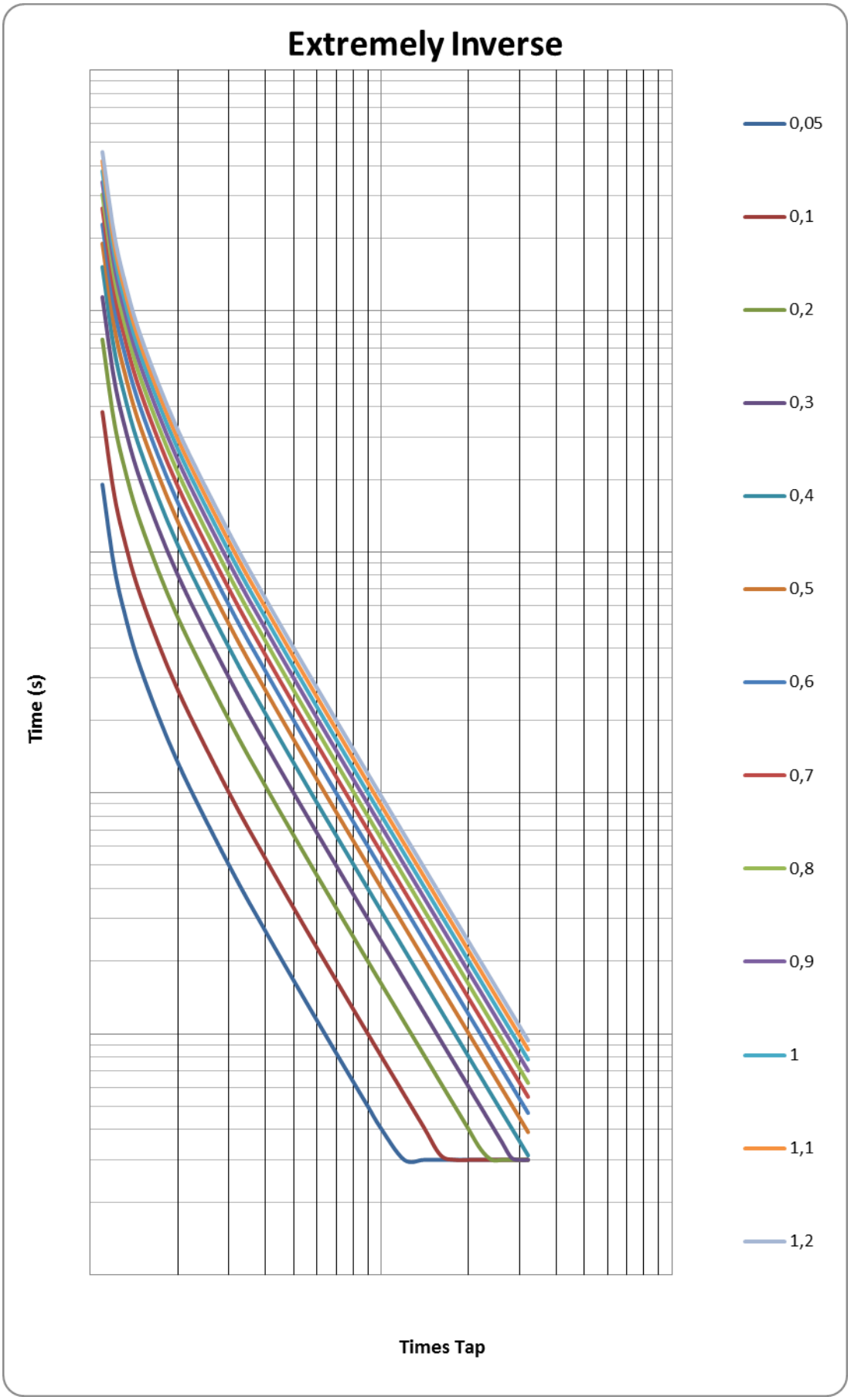
Parameters	A	P	Q	B	K
Ext. Inverse	80	2	1	0	0
Very Inverse	13,5	1	1	0	0
Inverse	0,14	0,02	1	0	0

The curve can be displaced on the axis using the time dial, **D**, which can be adjusted by the user.
V is Times Tap

$I_{adjusted}$ is the initial operating current, set by the user.


Inverse
100,000
10,000
1,000
0,100
0,010
Time (s)
1,0
10,0
100,0
Times Tap
0,05
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
0,9
1
1,1
1,2


Very Inverse
Time (s)
Times Tap
0,05
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
0,9
1
1,1
1,2


Extremely Inverse
Time (s)
Times Tap
0,05
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
0,9
1
1,1
1,2

4.13. Application examples

It is important to know that if both overcurrent protection functions (50 and 51), phase or neutral, are enable, definite time function (function 50) must be more restrictive. So, if overcurrent fault values are low, inverse time overcurrent function (function 51) must work, and if overcurrent fault reaches a certain value, definite time overcurrent function will always work. This is because, when overcurrent fault reach high values (I>>), it is necessary to be sure that trip is going to be instantaneous to get that the element we are protecting, does not be damaged.

It is shown some examples below:

APPLICATION EXAMPLE 1

Starting from the following information:

Line details:

- Transformation ratio of CT =100/1
- Primary current: I_p=100 A

51 function settings

- Curve type: IEC Inverse
- Dial: 0.05
- Tap: 1xI_n

50 function settings

- Tap: 11xI_n
- Operating time: 0.05 s

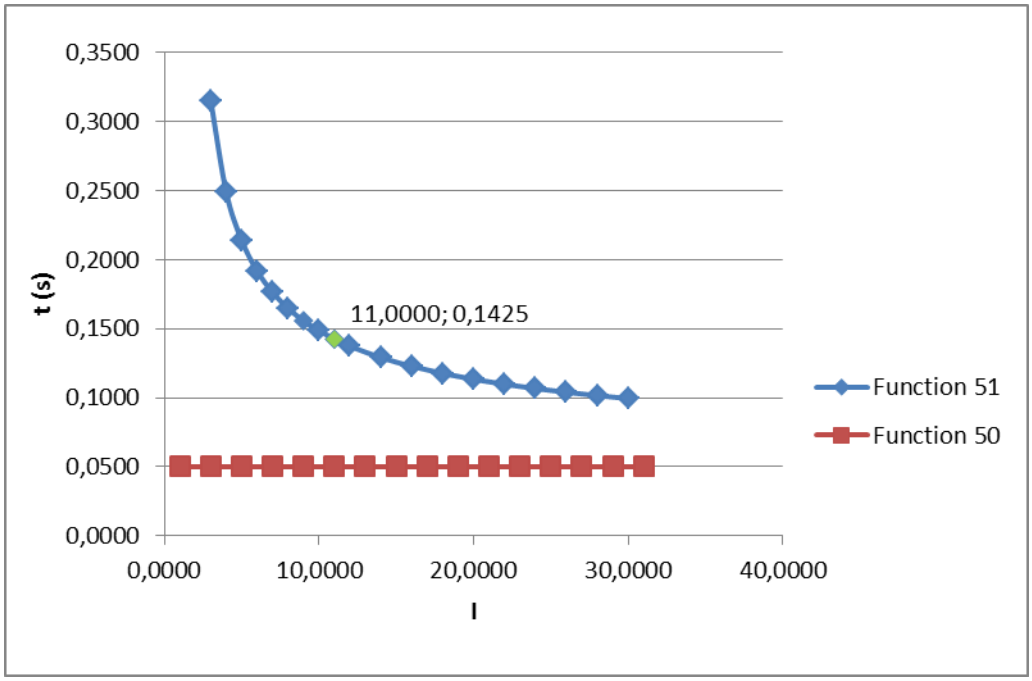


Figure 1. 50 y 51 IEC Inverse

If overcurrent fault is $11xI_n$=1100 Ap, IEC inverse curve defines a tripping value of 0.1425s (Figure1) for 51 function. It is considered that this time is too high, so when current fault reaches $11xI_n$, definite time overcurrent function will be work.

The figure below (Figure 2), shows the tripping curve of the relay:

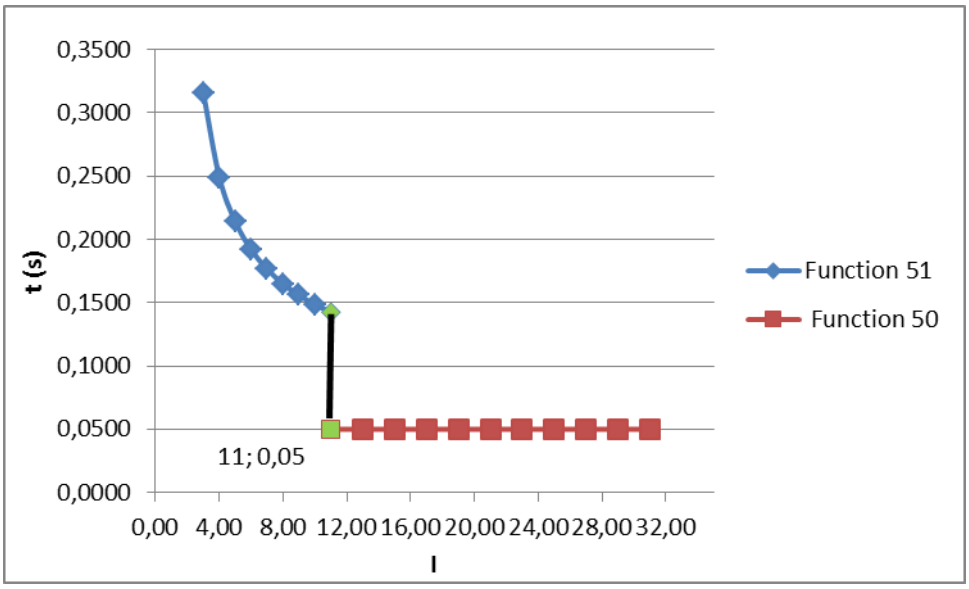


Figure 2. Relay tripping curve

APPLICATION EXAMPLE 2

Starting from the following information:

Line details:

- Transformation ratio of CT =500/1
- Primary current: I_p=500 A

51 function settings

- Curve type: ANSI Extremely Inverse
- Dial: 2.20
- Tap: $1xI_n$

50 function settings

- Tap: $14xI_n$
- Operating time: 0.1 s

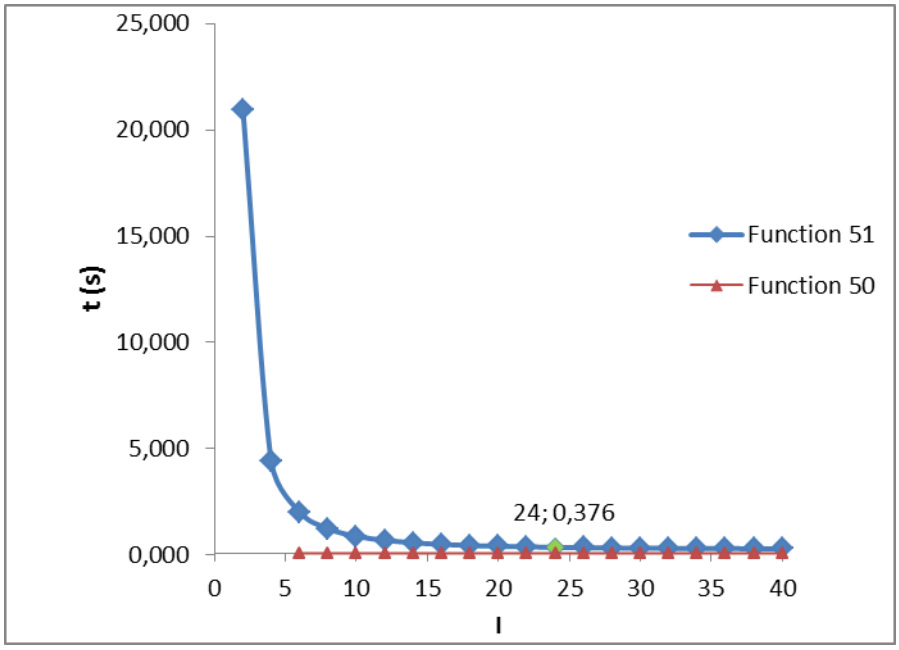


Figure 3. 50 y 51 ANSI Extremely Inverse

If overcurrent fault is $24xI_n$=12000 Ap, ANSI Extremely inverse curve defines a tripping value of 0.376 s (Figure 3) for 51 function. It is considered that this time is too high, so when current fault reaches $24xI_n$, definite time overcurrent function will be work. 50 function tap is adjusted at 14xIn so definite time overcurrent function will trip when current fault is higher than 14xIn (50 function does not wait to reach 24xIn)

The figure below (Figure 4), shows the tripping curve of the relay:

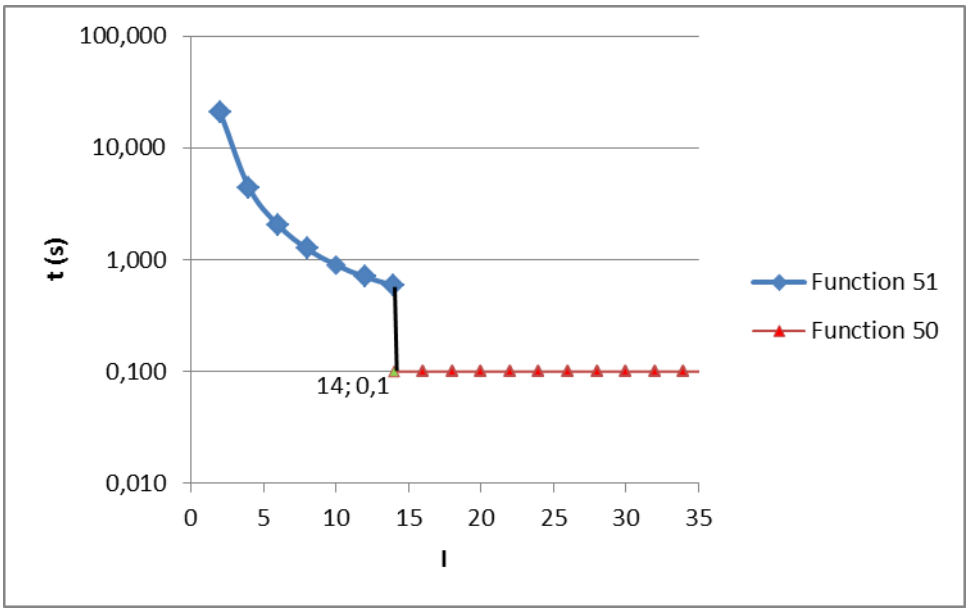


Figure 4. Relay tripping curve

APPLICATION EXAMPLE 3

In this example it is explained what occurs when it is selected in curve type parameter “DEFINITE TIME”. In this case, 51 function works as 50 function.

Starting from the following information

***Line details**:*

- Transformation ratio of CT =100/1
- Primary current: Ip=100 A

51 function settings

- Curve type: Definite time
- Tap 1xIn
- Operating time: 5 s

50 function settings

- Tap: 15xIn
- Operating time: 1 s

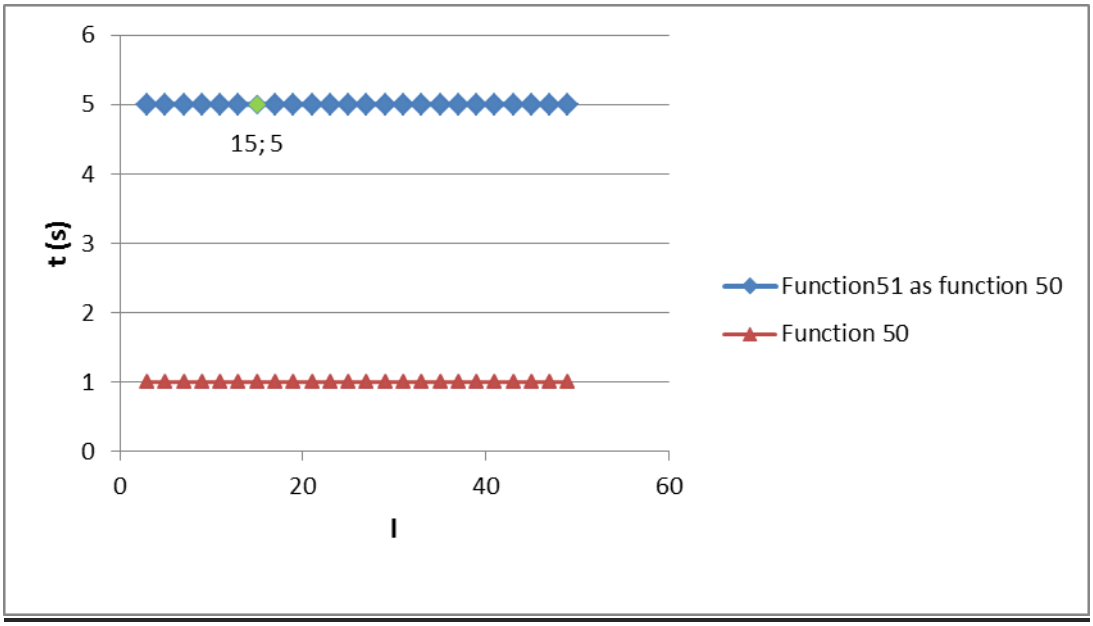


Figure 5. Function 51 (as 50) and function 50.

If overcurrent fault is $15xI_n$=1500 Ap, Definite time curve defines a tripping value of 5 s (Figure 5) for 51 function. It is considered that this time is too high, so when current fault reaches $15xI_n$, definite time overcurrent function will be work function 50).
The figure below (Figure 6), shows the tripping curve of the relay:

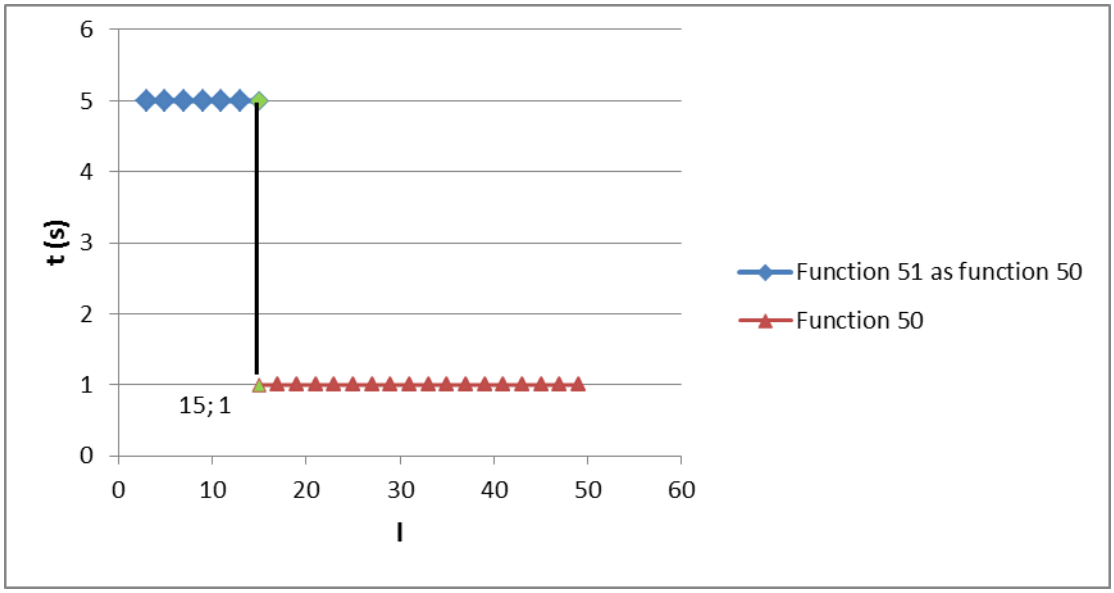


Figure 6. Relay tripping curve

5. MONITORING AND CONTROL

5.1. Measurements

Measurements of the thermal image, three-phase currents, neutral current and maximum current are given in RMS. A sampling, of 16 samples/cycle, is performed.

The accuracy of the measurement is ±2% over a band of ±20% of rated current and ±4% over the rest of the measurement range.

- Frequency 50 Hz or 60 Hz rated. ± 3 Hz
- Thermal resistance Twice the continuous rated current

5.2. Counters

The SIA-F stores in non-volatile FRAM memory:

- Breaker opening number
- Accumulated Amperes during the breaker opening

5.3. States and Events

The state is given by real-time information generated by the equipment. Some states have an event associate with them, which is a register of a change made to the state. There are states that have an activation event associated with them, and other states have two associated events: activation and reset. These events are registered in a circular memory (buffer) with a capacity for up to 100 events. The memory timestamp is accurate to 1 millisecond.

The events will be registered in non-volatile FRAM memory, and the events are conserved even if the equipment is not powered. If the Real Time Clock is used, the relay keeps and processes the correct date and time, even without electrical power, for up to 72 hours.

The events can be browsed from the HMI or by using communications. Reading the events does not mean that they get deleted; they remain stored on the equipment. To delete the events using the HMI, you have to go to the events menu and press and hold the "RESET" key until the number of events reads 1, and this event is registered as "Events deleted". To delete the events using communications, use the corresponding "delete events" command. To delete the events it is necessary to enter a password.

Events have the following structure:

Identify	Unique event identifier: e.g.: 51_1.4 = 51P START
Value	ON(Activated) /OFF(Deactivated): an event is generated for activations and deactivations
Year	
Month	
Day	
Time	
Minutes	
Seconds	
Milliseconds	

The following list shows all of the states of the equipment and their associated events:

Register description	Bit number	Bit description	Associated measurement
General states	bit-00	Trip	Maximum phase current, from trip activation until deactivation
	bit-01	External trip	-
	bit-02	Trip power error	-
	bit-03	50 Hz	-
	bit-04	Trip blocking	-
	bit-05	Measure error	-
	bit-06	Ready	-
	bit-07	Settings changed	-
	bit-08	Set data/time	-
	bit-09	Local communication	-
	bit-10	Factory settings	-
	bit-11	EEPROM error	-
	bit-12	EEPROM changed	-
	bit-13	Events error	-

Register description	Bit number	Bit description	Associated measurement
Local communication	bit-00	Local communication	-
	bit-01	HMI activity	-
	bit-16	Command select	
	bit-17	Open breaker	
	bit-18	Close breaker	
	bit-23	Reset thermal image	
51P	bit-00	51P Phase A pick-up	Phase A current
	bit-01	51P Phase B pick-up	Phase B current
	bit-02	51P Phase C pick-up	Phase C current
	bit-03	51P Pick-up	-
	bit-08	51P A Trip	Phase A current
	bit-09	51P B Trip	Phase B current
	bit-10	51P C Trip	Phase C current
	bit-11	51P Trip	-
50P	bit-00	50P Phase A pick-up	Phase A current
	bit-01	50P Phase B pick-up	Phase B current
	bit-02	50P Phase C pick-up	Phase C current
	bit-03	50P Pick-up	-
	bit-08	50P A Trip	Phase A current
	bit-09	50P B Trip	Phase B current
	bit-10	50P C Trip	Phase C current
	bit-11	50P Trip	-
51N/51G	bit-04	51N Pick-up	Neutral current
	bit-12	51N Trip	Neutral current
50N/50G	bit-04	50N Pick-up	Neutral current
	bit-12	50N Trip	Neutral current

Register description	Bit number	Bit description	Associated measurement
Inputs	bit-00	Input 1	-
	bit-01	Input 2	-
Outputs	bit-00	LED On	-
	bit-01	LED Alarm	-
	bit-02	LED Trip	-
	bit-03	Trip Output	-
	bit-04	Output 2	-
	bit-05	Output 3	-
	bit-06	Input 52a logical output	-
	bit-07	Input 52b logical output	-
	bit-08	External trip logical output	-
	bit-09	50BF start logical output	-
	bit-10	Fault start logical output	-
	bit-11	50P block logical output	-
	bit-12	50N block logical output	-
	bit-13	Reset logical output	
	bit-14	Active group 1 logical output	
	bit-15	Active group 2 logical output	
Trip blocking	bit-00	Phase A blocking	-
	bit-01	Phase B blocking	-
	bit-02	Phase C blocking	-
	bit-03	Phase blocking	-
49	bit-04	49 Alarm	-
	bit-12	49 Trip	-
50BF	bit-00	50BF Pick-up	-
	bit-01	50BF Trip	-

Register description	Bit number	Bit description	Associated measurement
52	bit-00	52 Start	-
	bit-01	52 Error	-
	bit-02	52 Open	-
	bit-03	52 Opening time	-
	bit-04	52 Opening error	-
	bit-05	52 Closed	-
	bit-06	52 Closing time	-
	bit-07	52 Closing error	-
	bit-08	Number of openings alarm	-
	bit-09	I2t alarm	-
	bit-10	Openings excess/ min	
	bit-11	Contact 52a	-
	bit-12	Contact 52b	-
Remote communication	bit-00	Remote communication	-
	bit-01	HMI activity	
	bit-16	Command select	-
	bit-17	Open breaker	-
	bit-18	Close breaker	-
	bit-23	Reset thermal image	-

A brief description of the general states is given below:

- **Trip**: The equipment has tripped.
- **Temperature trip**: A trip has been caused by the activation of the excess temperature input (external trip).
- **Measurement error**: The self-diagnosis algorithms have detected a problem in the measurement block.
- **Setting change**: This activates when the settings are changed.
- **Date-time set**: This activates when the date-time are synchronized.
- **Communication in local**: this is the sum of the "HMI activity" and "Local communication" bits from the "Local communication" state group
- **Eeprom by default**: the equipment is set to default settings and does not execute the trip.

- **Eeprom Error**: The self-diagnosis algorithms have detected a problem in the eeprom memory, which contains the settings.
- **Eeprom change**: this activates when the settings or configuration (user passwords) are changed.
- **Events error**: due to the fact that the events buffer is circular, new events overwrite the older events once the buffer is full, and the older events are lost. To show this situation, the "Events error" bit is activated. This bit is reset by deleting the events (from the HMI or by using communications).
- **HMI activity**: this state is active if any key has been pressed in the last 15 minutes.
- **Local communication**: this state becomes active if communications are detected in the front USB port.

5.4. Fault Reports

Four fault reports are generated and they are registered in no-volatile FRAM memory. From the HMI, by pressing key "◄", you will gain access to fault reports. The information displayed is as follows:

- Date-time at which the fault started.
- List of all events occurred in the equipment during the fault.

Each new fault report is overwritten on the previous one, and therefore the information contained in the previous report will be lost.

5.5. Date and Time by Real Time Clock (RTC)

The Protection devices require a clock, enabling them to have a date and time stamped for events and registers. This clock has a capacitor that allows operation while maintaining the date and time even without power, up to 72 hours (It is understood that the capacitor was previously loaded).

If an event queue occurs, and if synchronized with a date-time previous to the last stored event, the relay will not rearrange the queue but will store the new events immediately after the stored events.

This clock can be synchronized by any of the two following procedures:

- From the HMI. In this case the date and time can be entered via the keyboard. The relay will store the new event indicating that it has been synchronized.
- Protocol. The behavior is identical to the HMI. The relay will synchronize the date and time, and a new synchronization event is carried out.

5.6. Digital Inputs

The SIA-F has two digital inputs that can be configured by the user.

The configuration of the inputs is described in point *5.7 Programmable Logic Control & Digital Outputs.*

5.7. Programmable Logic Control & Digital Outputs

Firstly, it is defined the concept of physical input, physical output and logical signal.

Physical inputs are the real inputs of the device. SIA-F device has two physical inputs (Input 1 and Input 2). These inputs are translated to two internal binary states which later, can be assigned to logical signal to get a specific operation.

Physical outputs are the real outputs of the Device. SIA-F has a trip output and other two digital outputs (*Trip output, Output 2* y *Output 3).* SIA-F device has 3 LEDS (*ON, Alarm and Trip*), which receive the same treatment some working on output relays and others working on led diodes.

Logical signal are internal binary states result of the Programmable Logic Control. The logical signal has a specific and defined meaning to be used by the rest functions of the Device.

LEDs	LED On
	LED Alarm
	LED Trip
PHYSICAL OUTPUTS	Trip Output
	Output 2
	Output 3
LOGICAL SIGNAL	52a contact
	52b contact
	External Trip
	50BF start
	Fault start
	50P block
	50N block
	Reset logical signals
	Active group 1
	Active group 2

All the outputs (Leds, physical outputs and logical signal) are the result of a PROGRAMMABLE LOGIC CONTROL which can be configured from HMI or from SICom software).

For each output there is a LOGICAL GATE. It can perform a logical operation up to 4 binary states to obtain other binary result.

In V2 of the PLC the LOGICAL GATES that are supported by SIAF are:

LOGICAL GATE	HMI SYMBOL
OR4	+
NOR4	τ
OR4_LACTH	Ю
NOR4_LACTH	Φ
OR4_PULSES	⌠
AND4	&
NAND4	§
AND4_PULSES	$

By default, outputs configuration is:

	OUTPUT	*LOGICAL GATE*	BINARY STATES
LEDs	LED On	*OR4_PULSES*	• Ready
	LED Alarm	*NOR4*	• Ready
	LED Trip	*OR4_LACTH*	• General trip
PHYSICAL OUTPUTS	Trip output	*OR4*	• Local opening • General trip
	Output 2	*OR4*	• Local closing
	Output 3	*No configured*	
LOGICAL SIGNAL	52a contact	*No configured*	
	52b contact	*OR4*	• Input-2
	External Trip	*OR4*	• Input-1
	50BF start	*OR4*	• Local opening • Remote opening • General trip
	Fault start	*OR4_LACTH*	• General trip
	50P block	*No configured*	

	50N block	*No configured*	
	Reset logical signals	*No configured*	
	Active group 1	*No configured*	
	Active group 2	*No configured*	

We are going to use configuration by default as an example:

OUTPUT	LOGICAL GATE	BINARY STATES	DESCRIPTIONS
LED On	*OR4_PULSES*	• Ready	Led On blinks when internal signal "READY" of general state of the device is activated, this indicates that the device is working correctly without any failures.
LED Alarm	*NOR4*	• Ready	Led alarm will activate when internal signal "READY" of general state of the device is deactivated, this indicates some failure has occurred.
LED Trip	*OR4_LACTH*	• General Trip	Led trip will activate when internal signal "GENERAL TRIP" of general state of the device is activated, this indicates that some protection function has tripped. This led will continue activated until the reset of the leds is made.
Trip output	*OR4*	• Local opening • General trip	Trip output will activate when there is a general trip or when 52 opening command is carried out, from local communications or from HMI.
Output 2	*OR4*	• Local closing	Output 2 will be activated when 52 closing command is carried out from local communications or from HMI.
52b logical signal	*OR4*	• Input-2	When physical input 2 is activated, 52a logical output will be activated, and it will used to determine the breaker state.
External trip logical signal	*OR4*	• Input-1	When physical input 1 is activated external trip logical output will be activated, and it will be used to generate a general trip by general protection function.

Start 50BF logical signal	*OR4*	• Local opening • Remote opening • General trip	When a general trip has occurred or when 52a opening command is carried out from local communications start 50BF logical output will be activated and it will be used to initiate the detection of breaker failure by 50BF function.
Fault Start logical signal	*OR4_LACTH*	• General trip	When general trip is activated, fault start logical output will be activated and it will generate a new fault register.

5.8. 86 Function. Trip Output Lockout

When the TRIP OUTPUT is configured like OR4_LACTH

5.9. Self-diagnosis

Diagnostic algorithms are run while the equipment is being started up and continuously when the relay is operating. This diagnostic is a preventative process to guarantee that the equipment is in good operational condition.

As general considerations, we should point the following:

- Communications between different CPUs are confirmed by the corresponding integrity checking. If continuous anomalies are detected, the equipment will be reset.
- Data related to set values are confirmed by the corresponding checking. Likewise, all setting tables are doubled, and the relay has the capability for working with a damage table, but not with two damaged tables.
- There is a Watchdog device both between and in main CPUs. If any CPU goes out of operation the equipment will be reset and this condition will be identified as an event.

The following state bits are associated with this process:

Measurement error	Problem in the measurement block
Protection error	Problem in the protection block
Eeprom error	Problem in the eeprom memory, some group is corrupt
Events error	Error in the register of events

On the other hand, “Default settings” means that the equipment is operating under factory settings, being all protection functions disabled.

5.10. Commands

By HMI o by communications is possible to:

- Open Breaker
- Close Breaker
- Reset Thermal Image

5.11. Test Menu

The SIA-F equipment has a test menu that can be used to check the operation of the signalling components (LED indicators) and the outputs. It is important to point out that the operation of the outputs is not guaranteed if the test is performed with the battery.

The following table shows the components that can be tested, along with their state depending on whether they are activated or deactivated:

LED ON	Deactivated	On LED off
	Activated	On LED green blinking
LED ALARM	Deactivated	Alarm LED off
	Activated	Alarm LED red fixed
LED TRIP	Deactivated	Trip LED off
	Activated	Trip LED red fixed
Trip Output	Deactivated	Trip Output deactivated
	Activated	Trip Output activated
Output 2	Deactivated	Output 2 deactivated
	Activated	Output 2 activated
Output 3	Deactivated	Output 3 deactivated
	Activated	Output 3 activated

The following key sequence is used to gain access to the test menu: from the main menu, press the keys “◄”, “▼”, and “►” in sequence and then press and hold the "OK" key until the "Test menu" appears on the display. The test menu is accessed by pressing the "OK" key again, and the “▲” and “▼” keys can be used to navigate through the different menu items. Each item can be activated or deactivated by pressing "OK" on it (if the item is deactivated, it is activated by pressing OK; if the item is activated, it is deactivated by pressing “OK”). Press the “C” key to exit the test menu.

To obtain more detailed information, the method for navigating the menus is explained graphically in the keypad and display section.

5.12. Power supply

The SIA-F equipment is designed to be supplied from an auxiliary voltage of 110-230 Vac / 90-300 Vdc or 24-48 Vdc (can be selected for each model).

It can also be supplied from a USB cable which goes directly till PC. The USB is plugged into the front communications port. It is useful for cases like commissioning operations, discharges and repairs to the transformation centre as these are situations when there is no auxiliary voltage or current in the line, and normally cause more events, ground connections, forgotten tools, poor terminations, etc.

Using battery power supply does not inhibit the USB communications port, as it can be used simultaneously.

6. TECHNICAL SPECIFICATIONS AND STANDARDS

6.1. Technical Specifications

Function **50P**	Permission: yes/no
	Operating range: 0.10 to 30 x In (step 0.01)
	Operating time: 0.02 to 300 s (step 0.01s)
	Activation level 100%
	Deactivation level 95%
	Instantaneous deactivation
	Timing accuracy: 30 ms
Function **50N/50G**	Permission: yes/no
	Operating range: 0.10 to 30 x In (step 0.01)
	Operating time: 0.02 to 300 s (step 0.01s)
	Activation level 100%
	Deactivation level 95%
	Instantaneous deactivation
	Timing accuracy: 30 ms
Function **51P**	Permission: yes/no
	Operating range: 0.10 to 7 x In (step 0.01)
	Curves: IEC 60255-151
	Operating time: inverse curve, very inverse curve, extremely inverse curve. Defined time: 0.02 to 300 s (step 0.01 s)
	Dial: 0.05 to 1.25 (step 0.01)
	Curve, activation level 110%
	Curve, deactivation level 100%
	Defined time, activation level 100%
	Defined time, deactivation level 95%
	Instantaneous deactivation
	Timing accuracy: 5% or 30 ms (greater of both)
Function **51N/51G**	Permission: yes/no

	Operating range: 0.10 to 7 x In (step 0.01)
	Curves: IEC 60255-151
	Operating time: inverse curve, very inverse curve, extremely inverse curve. Defined time: 0.02 to 300 s (step 0.01 s)
	Dial: 0.05 to 1.25 (step 0.01)
	Curve, activation level 110%
	Curve, deactivation level 100%
	Defined time, activation level 100%
	Defined time, deactivation level 95%
	Instantaneous deactivation
	Timing accuracy: 5% or 30 ms (greater of both)
Trip blocking	Blocking level: 1.5 to 20 x In (step 0.01)
Circuit breaker monitoring	Circuit Breaker state: start, open, closed, error, opening time, opening error, closing time, closing error
	Input 52a and/or input 52b
	Opening and closing command
	Alarm, maximum number of openings: 1 a 10000
	Alarm, accumulated amps: 0 a 100000 M(A^2)
	Excessive repeated openings: 1 a 10000
	Time of excessive repeated openings: 1 a 300 min
Function 50BF	Function permission : yes/no
	Opening failure time: 0.02 to 1.00 s (step 0.01 s)
	Open breaker activation threshold: 8% In
	Open breaker reset threshold: 10% In
	Function start: Device trip, opening failure input activation, breaker opening command activation
Function 49	Function permission : yes/no
	Tap: 0.10 a 2.40 Inominal (step 0.01)
	ζ heating: 3 a 600 minutes (step 1 min)
	ζ cooling: 1 a 6 x ζ heating (step 1)
	Alarm level: 20 a 99% (step 1 %)
	Trip level: 100%

	Trip reset: 95% of alarm level
	Timing accuracy:± 5% regarding theoretical value
Programmable logic control (PLC)	OR4, OR4_LATCH, OR4_PULSES, NOR4, NOR4_LATCH, AND4, AND4_PULSES, NAND4
Function 86	Allows to latch (lock out) the contact trip due to programmable logic (PLC).
2 inputs configurable	The same voltage as auxiliary power supply
Frequency	50/60Hz
Current measure	True RMS
	Sampling: 16 samples/cycle
	Accuracy of ±2% in a band of 20% over the rated current and ±4% for the rest of measurement range
Fault reports	4 fault reports
Communications	USB port: Modbus RTU
	RS485 port: Modbus RTU
Auxiliary power supply	110-230 Vac / 90-300 Vdc ±20%
	24-48 Vdc ±20%
Battery supply	With KITCOM adapter to USB
Environment	Operating temperature: -10 to 70ºC
	Storage temperature: -20 to 80 ºC
	Humidity: 95%
Transformers	3 or 4 CT /5, /1 or /0.2
Mechanical features	Metallic box
	Panel Mounting
	1/4 Rack – 4 U
	IP-54 on panel

6.2. Standards

IEC 61000-4-2	Electrostatic discharge immunity tests	Level 4 Contact ±8kV Air ±15kV
IEC 61000-4-3	Testing for immunity to RF electromagnetic field interference	Level 4: 30 V/m at MHz 80-1000 800-960 1400-6000
IEC61000-4-4	Immunity to fast transients	Level 4: ±4kV – 5kHz and 0.75 ms ±20% 100kHz
IEC 61000-4-5	Surge immunity	Level 4, Class 5 ±2kV Line-Line ±4kV Line-Ground
IEC 61000-4-6	Immunity to conducted disturbances induced by radio frequency fields	Level 3 0.15 – 80 MHz 140 dB (µV) 10V
IEC 61000-4-8	Power frequency magnetic field immunity test	Level 5 Continuous: 100 A/m 3s: 1000 A/m
IEC 61000-4-9	Pulse magnetic field immunity	Level 5: 1000 A/m
IEC 61000-4-10	Immunity to damped oscillatory magnetic fields	Level 5: 100 A/m
IEC 61000-4-11	Voltage dip, short interruption and voltage variation immunity	Class 3 Voltage: 0.5 period 0% 1 period 0% 10/12 periods 40% 25/30 periods 70% 250/300 periods 80% Interruptions: 250/300 periods 0%
IEC 61000-4-12	Interruptions: Damped RF oscillatory wave immunity	Level 4: ±2kV Line-Line ±4kV Line-Ground
IEC 61000-4-14	Voltage fluctuation immunity	Class 3: 12%
IEC 61000-4-17	Ripple on DC input power port immunity	Level 4: 15% V DC
IEC 61000-4-18	Damped oscillatory wave immunity test (100kHz – 30MHz)	Slow waves: Level 3 25kV common mode 1kV differential mode

		Fast waves: Level 4 4kV common mode 4kV differential mode
IEC 61000-4-27	Imbalance	Class 3
IEC 61000-4-29	Voltage dip, short interruption and voltage variation on DC input power port immunity	Dips: 40% and 70% 1s Interruption: 1s
IEC 60255-5	Dielectric strength	Level 4
IEC 60255-5	Insulation strength	500 V DC Line-Ground
IEC 60255-5	Impulse voltage	±1kV Line-Line ±1kV Line-Ground
EN 60068-2-1	Cold	Essay Ab, -10ºC, 72h
EN 60068-2-2	Dry heat	Essay Bb +85ºC, 72h
EN 60068-2-14	Temperature change	Essay -25ºC y + 79ºC 3h (5 cycles)
IEC 60255-21-1	Sinusoidal vibrations	Class 2: 1g 10Hz – 150Hz
IEC 60255-21-2	Shock and bump tests	Class 2: 10g/11ms
IEC 60255-21-3	Seismic tests	Class 2: 2g horizontal axis 1g vertical axis
EN 50263	Generic standard for measuring relays and protective equipment	
EN 61000-6-4	Emission standard for industrial environments	
EN 61000-6-2	General standard for immunity in industrial environments	
EN 55011 **EN 55022**	RF energy emissions	Limitations for group 1, class A
IEC 60255-22-1	Interruptions: Damped RF oscillatory wave immunity	Level 3
	ISO 9001:2000 Quality Management System	

6.3. Output relays

Outputs relays				
Voltage		48Vdc	110Vdc	230Vac
Rated current	Resistive load	1A	0,3A	8A
	cosϕ=0.4 L/R=7ms	600mA	80mA	6A
Max. switching power	Resistive load	2000VA, 150W		
	cosϕ=0.4 L/R=7ms	1250VA, 90W		
Max. switching voltage	400Vac, 200Vdc			
Rated load	Resistive load	8A a 250Vac, 5A a 30Vdc		
	cosϕ=0.4 L/R=7ms	5A a 250Vac, 3A a 30Vdc		
Operating time		15ms max.		
Release time		5ms max.		

7. COMMUNICATION AND HMI

7.1. Front Communication: USB

One communications port is installed on the front of the equipment. The connector that is used is a mini USB. The protocol that is used is Modbus RTU (19200 -8bit – no parity – 1 stop bit). The protocol map and documentation that are used are attached in an appendix to this manual.

The adapter (KITCOM) can be connected to this communications port to supply the equipment with an external battery. It should be pointed out that this port can be used simultaneously for communication, even when the equipment is being powered by an external battery.

The PC earth should be connected to the same earth as the relay to avoid communication problems.

For writing commands it is necessary to set up a communication session (identification command) which it will be closed after a period of time without communication. To set up a communication session it will be necessary a password. For writing commands the password will be adjustable. Slave address is fixed and equal to 1

7.2. Rear Communication: RS485

An option exists to fit the SIA-F with a rear communications port RS485, to communicate with SCADA or RTU system.

The RS485 port output has two terminals B+, A-), located on the rear of the equipment. The protocol that is used is ModBus RTU (8bit – no parity – 1 stop bit).

The protocol map and documentation that are used are attached in *8.ModBus RTU protocol*.

This port can be used to continuously monitor the equipment from a remote PC or SCADA system. Up to 32 pieces of equipment can be connected to one bus; each piece with a different ModBus address. The equipment ModBus address and baudrate can be configured using the communications or from HMI.

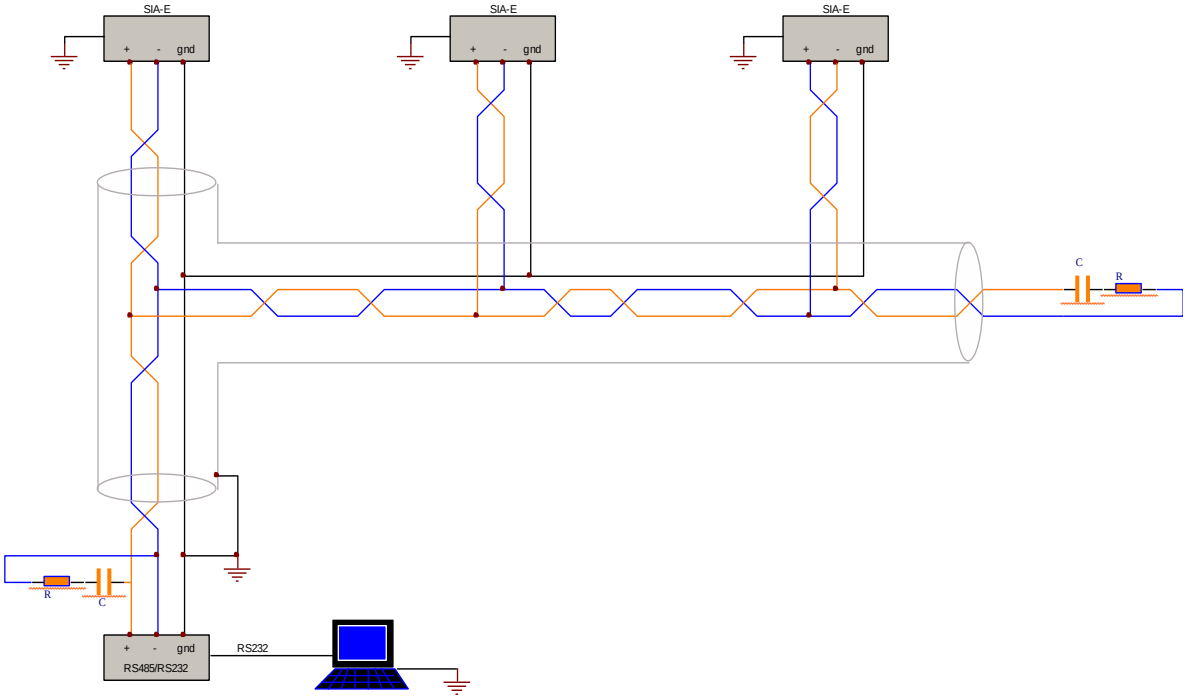
For writing commands it is necessary to open a communication session (identification command) which it will be closed after a period of time without communication. To open a communication session it will be necessary a password

To minimize communication errors as a result of noise, the use of a stranded and shielded cable is recommended for the physical connection. All of the + terminals on one side, and all of the - terminals on the other must be connected together in order to make the connection.

If a 2 strand cable is used for communication, the GND terminals must be connected to the shielding. The shielding must be connected to the GND at only one point to avoid circular currents.

Resistors should be used at each end if very long cables are used. The best solution for avoiding reflection is to install resistors at both ends of the cable. The ohm value of these resistors must be equal to the cable impedance value. Fiber optics can be used in very aggressive environments, and they are connected by using the corresponding converters.

Connection diagram of an RS485 bus:



7.3. LED Indicators

The SIA-F front panel has three LED pilot lights to show if the equipment is ON (LED ON), if there has been an alarm (LED ALARM) or a trip has occurred (LED TRIP). The LEDs are switched off when the equipment is not On, when there is not an alarm or when there is not a trip, and they are switched on when some of those situations occur. Available leds are:

Led ON	It is activated (Green led blinking), if the equipment is switch on
Led Alarm	It is activated (red led fixed) if an alarm occurs
Led Trip	It is activated (red led fixed) if a trip occurs. This led will continue activated until the reset of the leds is made.

Few situations can occur that involve the activation of different LEDs, this is, it can be more than one led activated at the same moment. It is possible to verify the correct running of the LEDs via test menu.

7.4. LCD and keypad

The front of the SIA-F relay is fitted with an alphanumeric LCD screen, measuring 20x2. This screen provides the user with access to read information about the settings parameters, measurements, state and events. All of this information is arranged in a system of menus.

A keypad is fitted to the relay front panel, which can be used to access the information shown on the LCD screen and to navigate through the menu system.

This membrane keyboard has 6 keys that can be used to navigate through the different menus and to change the setting parameters. The ▲ ▼ and ◄ ► keys can be used to navigate through the different menus, the different options in each menu and the different values for the settings parameters.

The "**OK**" key is used to access the menus and the different options, as well as to approve changes to values. The "**C**" key is used to delete and to go back through the menu levels.

As well as the 6 keys, there is also a "**Reset**" key. When "**Reset**" is pressed, the alarm led and the trip led return to their initial position. The "**Reset**" key can also be used to delete all of the events in the "Events" menu.

7.5. SICom Communications program

The SICom program, which works with the Windows® 2000/XP and Windows 7 operating system is provided, and can be used to gain access to all of the equipment information, to modify the settings and to save events using a graphic user interface.

The following operations can be carried out using the SICom program:

- State reading
- Measurement reading
- Reading and changing settings
- Reading and deleting events
- Changing the user passwords
- Loading settings files
- Date-time synchronization
- Checking the versions of the equipment
- Configuring the Modbus address
- Reading and changing counters
- Processes for opening and closing the circuit breaker
- Configuration of the inputs
- Configuration of the outputs
- Configuration of the causes that start a Fault Report

7.6. Setting-up the session: Password and access levels

Users must identify themselves with a password in order to execute commands and to change the equipment settings or configuration using the HMI. Depending on the access level, it may or may not be possible to perform the operations shown on the table below.

ACCESS LEVEL	Read-only permission: Status and measurements Settings Events	Permission to: Change settings Download and delete the events buffer	Permission to: Execute commands	Permission to: Change configuration
1	YES	YES	NO	NO
2	YES	YES	NO	NO
3	YES	NO	YES	NO
4	YES	YES	YES	NO
5	YES	YES	YES	YES

Four passwords and their associated levels of access are set up when the equipment is configured using the SIcom program. By default, the equipment is programmed with the following passwords and their associated levels:

PASSWORD	ACCESS LEVEL
2222	2
3333	3
4444	4
5555	5

7.7. MENUS

7.7.1. Standby mode screen

The standby mode screen displays the equipment model. The first line of menus can be accessed by pressing "OK": measurements, state, adjustments and events. If the HMI is left in any position, it returns automatically to its standby mode screen after five minutes if no key is pressed.

```
    SIAF115AC110AA
0.00  0.00  0.00  0.00
```

If any error is detected by the self-diagnosis, an error message appears in the second line (instead the current measurements) on the main screen, which can show any of the following information: (see inside self-diagnosis section).

- PROTECTION ERROR
- MEASUREMENT ERROR
- EEPROM ERROR

7.7.2. Accessing the menus

The keys ▲, ▼, ◄ and ► are used to navigate through the different options and menus. The "**OK**" key is used to accept and to enter and menu or an option. The "**C**" key is used to move up through the menu levels.

It is not necessary to enter any password to read or view the parameters, measurements or settings…

A 4-character password must be entered in order to modify any parameter.

After returning to the main screen, the password must be entered again to make any further modifications.

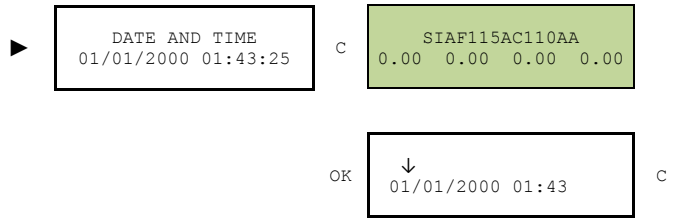
The keys ◄ and ► are used to navigate from one item to another within a parameter. The keys ▲ and ▼ are used to increase or decrease the value. If an invalid value is entered during the process, the "**C**" key can be used to delete it.

The navigation through the menus is described as graphically as possible below.

7.7.3. Date-time menu

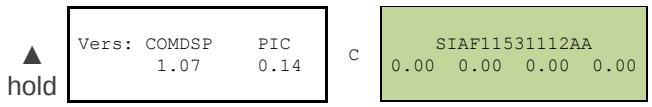
The date-time menu can be accessed by pressing the "►" key from the standby mode screen. From here, press the "OK" key to access the date-time modification screen. Use the "►" and "◄" keys to position the cursor over the digit that you want to change, and assign a value to this digit using the "▲" and "▼" keys. Once the date-time has been entered, press "OK" to change the equipment date. Press the "C" key to return to the standby mode screen.

The date-time information can be viewed by pressing the "►" key from the main screen.



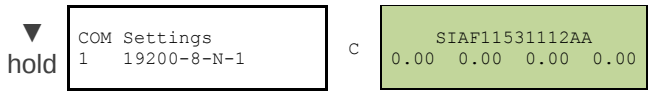
7.7.4. Versions

The equipment versions menu can be accessed from the standby mode screen by pressing the keys "▲". This displays the software versions of the relay processors. Press the "C" key to return to the standby mode screen.



7.7.5. Communication parameters

The communications parameters can be viewed holding down the "▼" key from the standby mode screen.

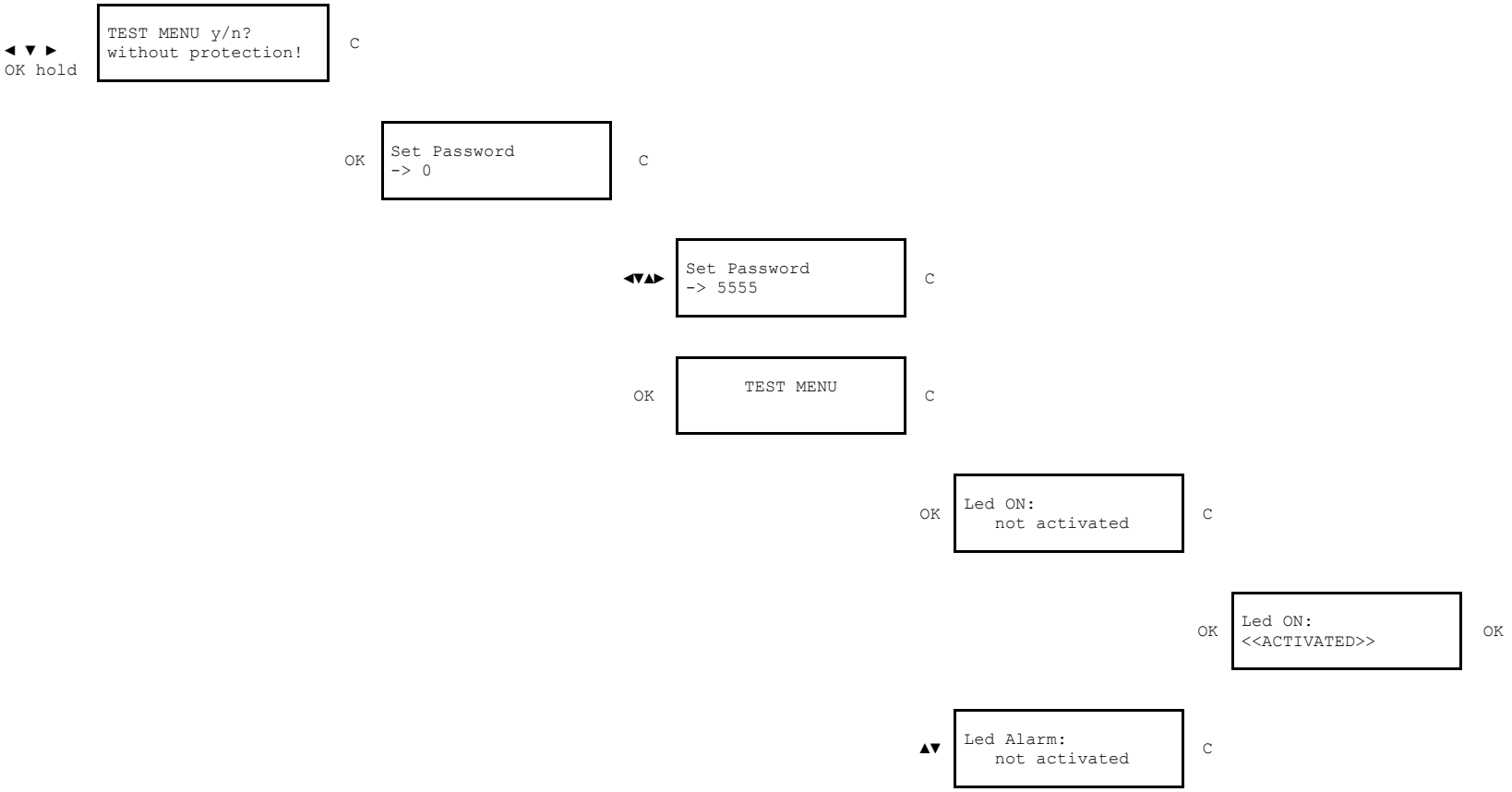


7.7.6. Fault report

From the "sleep" mode screen, press the "◄" key to access the fault report. Using the "▲" and "▼" keys we find the fault report that we are looking for and pressing "OK" we can read the data of this fault report.

7.7.7. Test Menu

The “Test menu” is accessed from the standby mode screen by sequentially pressing the “◄”, “▼” and “►” keys, and then holding down the “OK” key. From here, press “OK” to access the components that can be tested.

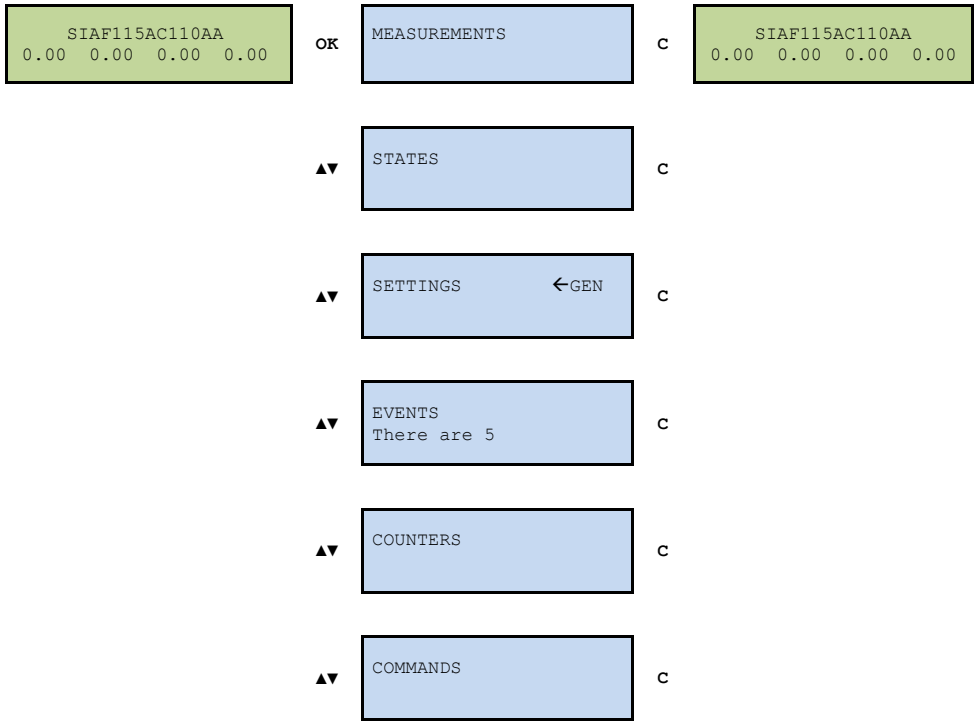


```
                                   OK  Led Alarm:          OK
                                       <<ACTIVATED>>

▲▼  Led Trip:                      C
       not activated

                                   OK  Led Trip:           OK
                                       <<ACTIVATED>>

▲▼  Trip Output:                   C
       not activated

                                   OK  Trip Output:        OK
                                       <<ACTIVATED>>

▲▼  Output 2:                      C
       not activated

                                   OK  Output 2:           OK
                                       <<ACTIVATED>>

▲▼  Output 3:                      C
       not activated

                                   OK  Output 3:           OK
                                       <<ACTIVATED>>
```

7.7.8. Functions Menu

The SIA-F relay menu is split up into 6 main parts:

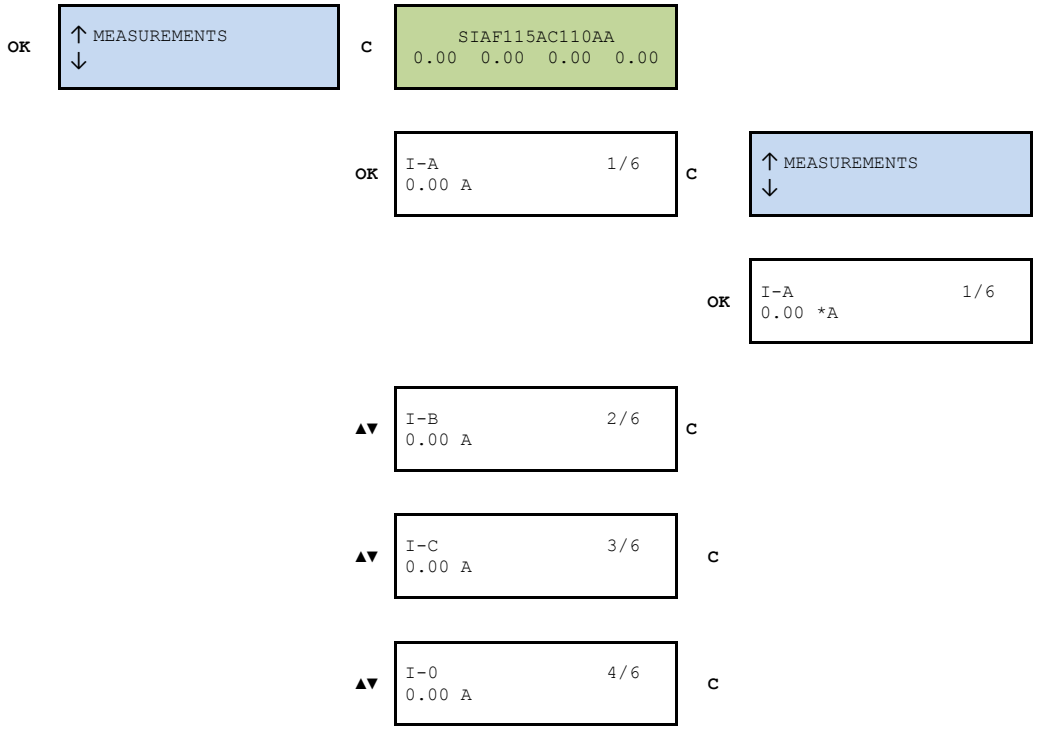
- Measurements.
- State.
- Settings.
- Events.
- Counters
- Commands

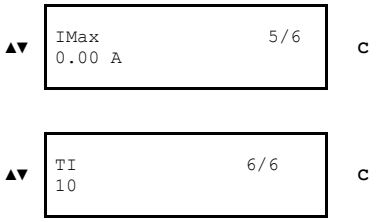


Press the “**OK**” key to access the second level from the main screen. Use the ▲ and ▼ keys to move from one menu section to another in the second level. Use the “**C**” key to return to a higher level.

7.7.9. Measurements Menu

From the standby mode screen, press the “OK” key to access the first line of menus. Use the “▲” and “▼” keys to position the cursor over the “MEASUREMENTS” screen and press “OK”. Use the “▲” and “▼” keys to position the cursor over the measurement and to see its value.

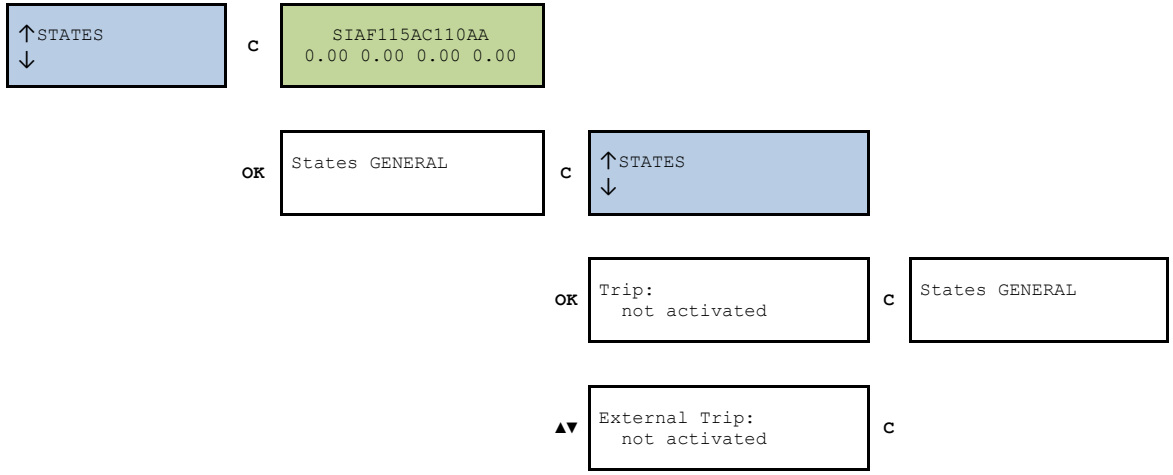




7.7.10. States Menu

From the standby mode screen, press the “OK” key to access the first line of menus. Use the “▲” and “▼” keys to position the cursor over the “STATE” screen and press “OK”. This takes you to the state group line. Use the “▲” and “▼” keys to position the cursor over a group of states, and press the “OK” key to access the states that belong to this group. Use the “▲” and “▼” keys to browse through the different states. The information shows whether or not each state is active. The message “>Activations present” appears under the name of the group in the state group menus if any of the states in that group are active.

The method for navigating through the state menu is shown graphically below.



▲▼ Supply Trip error:
not activated C

▲▼ 50 Hz:
<<ACTIVATED>> C

▲▼ Trip Blocking:
not activated C

▲▼ Measurement Error:
not activated C

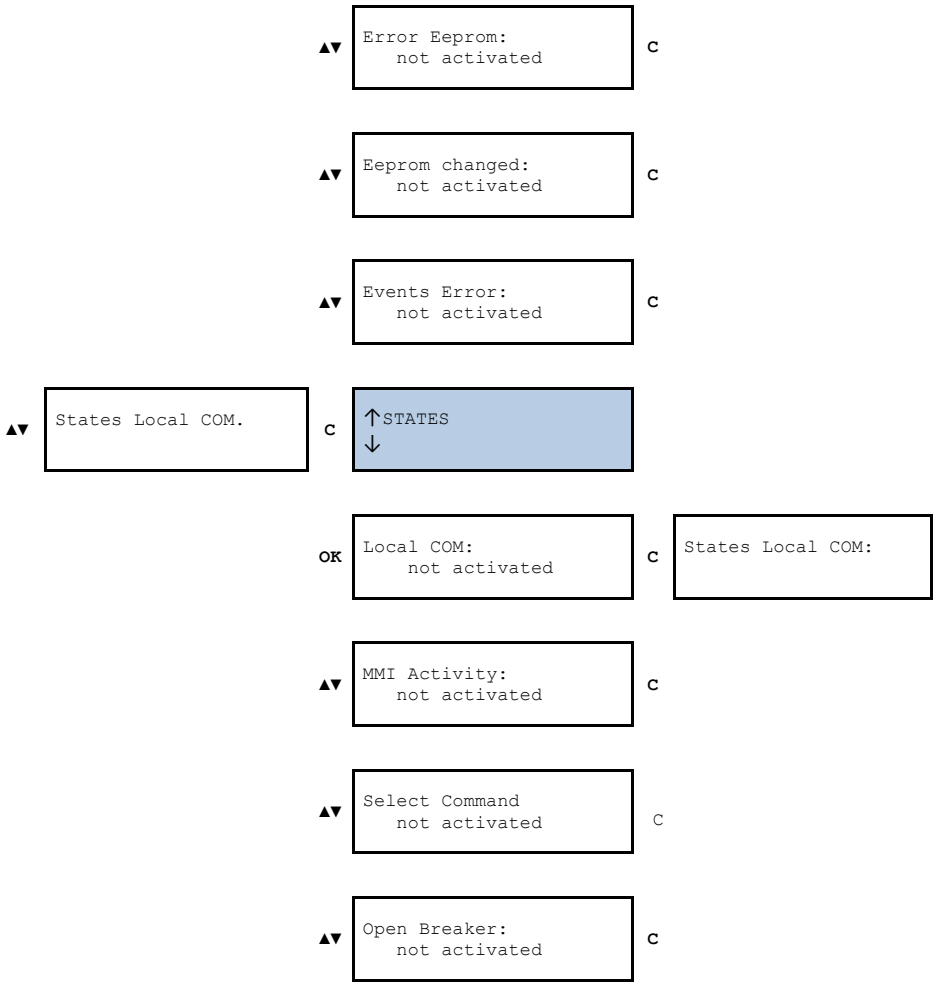
▲▼ Ready:
<<ACTIVATED>> C

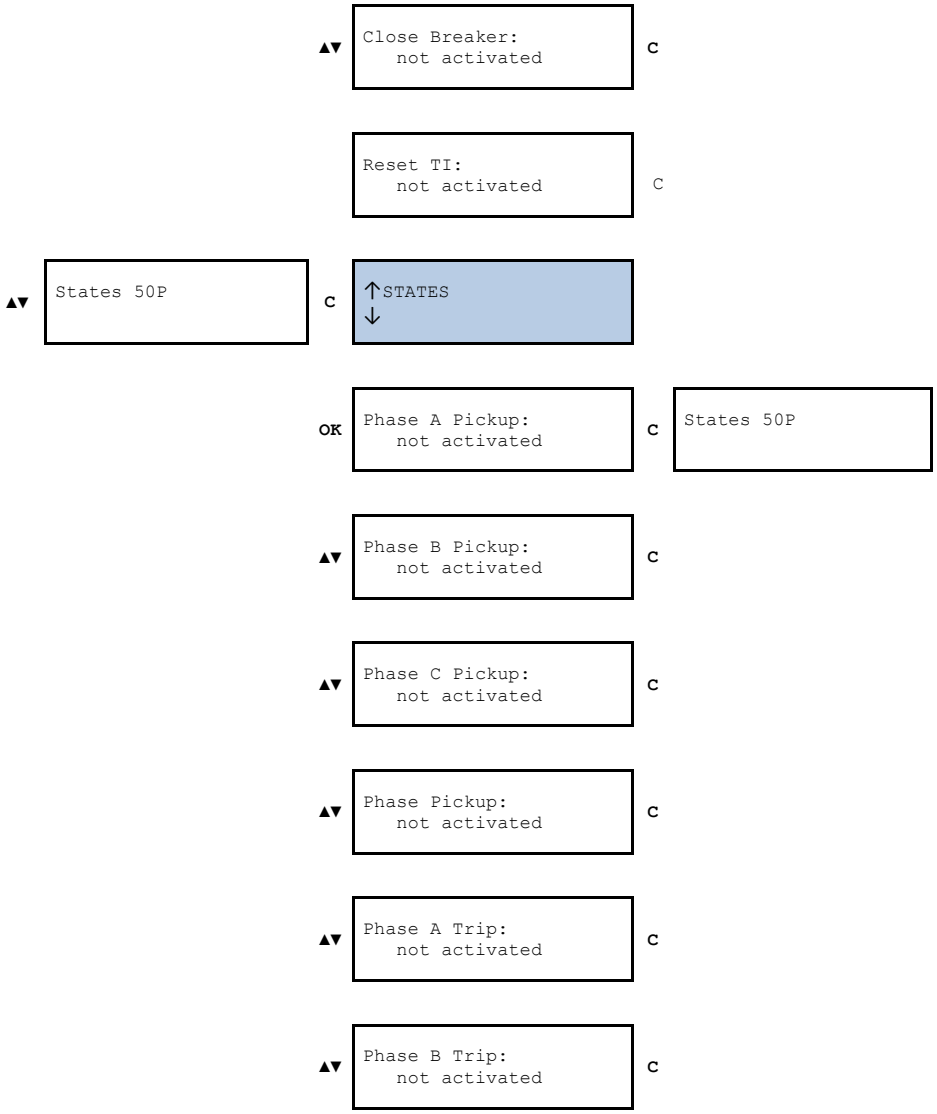
▲▼ Set Data/Time:
not activated C

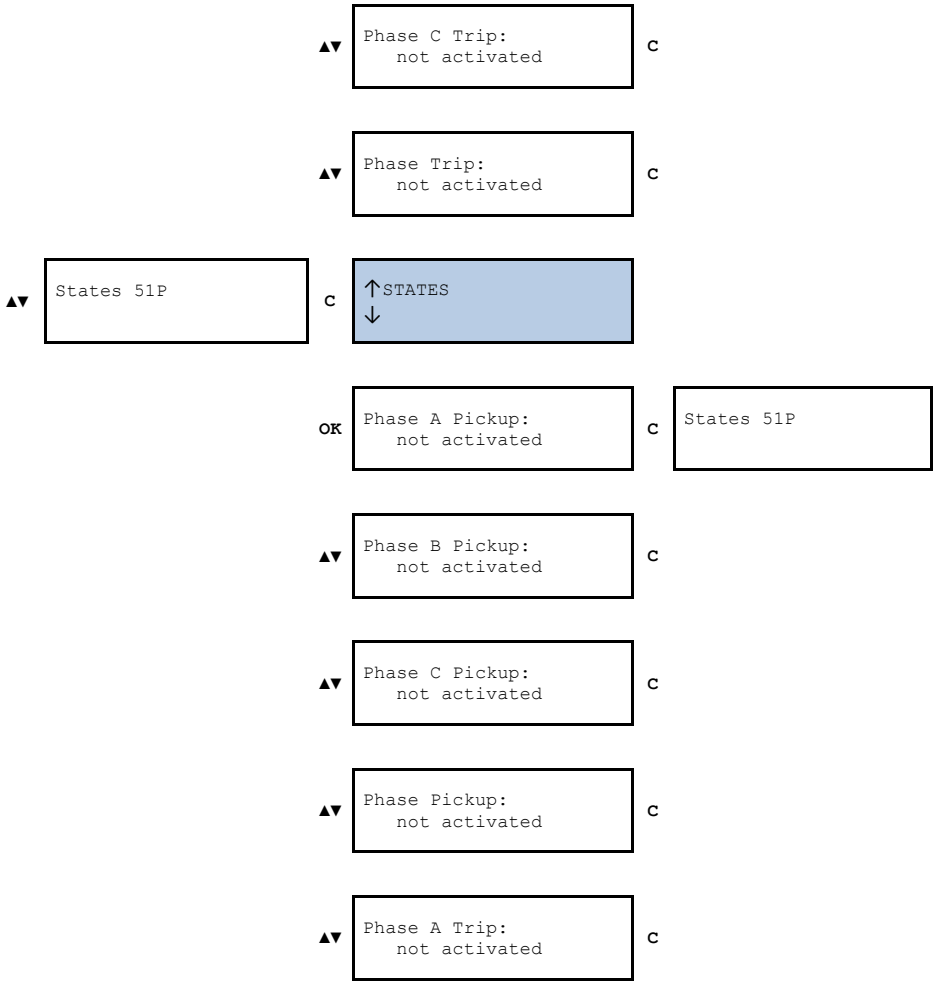
▲▼ Settings changed
Not activated C

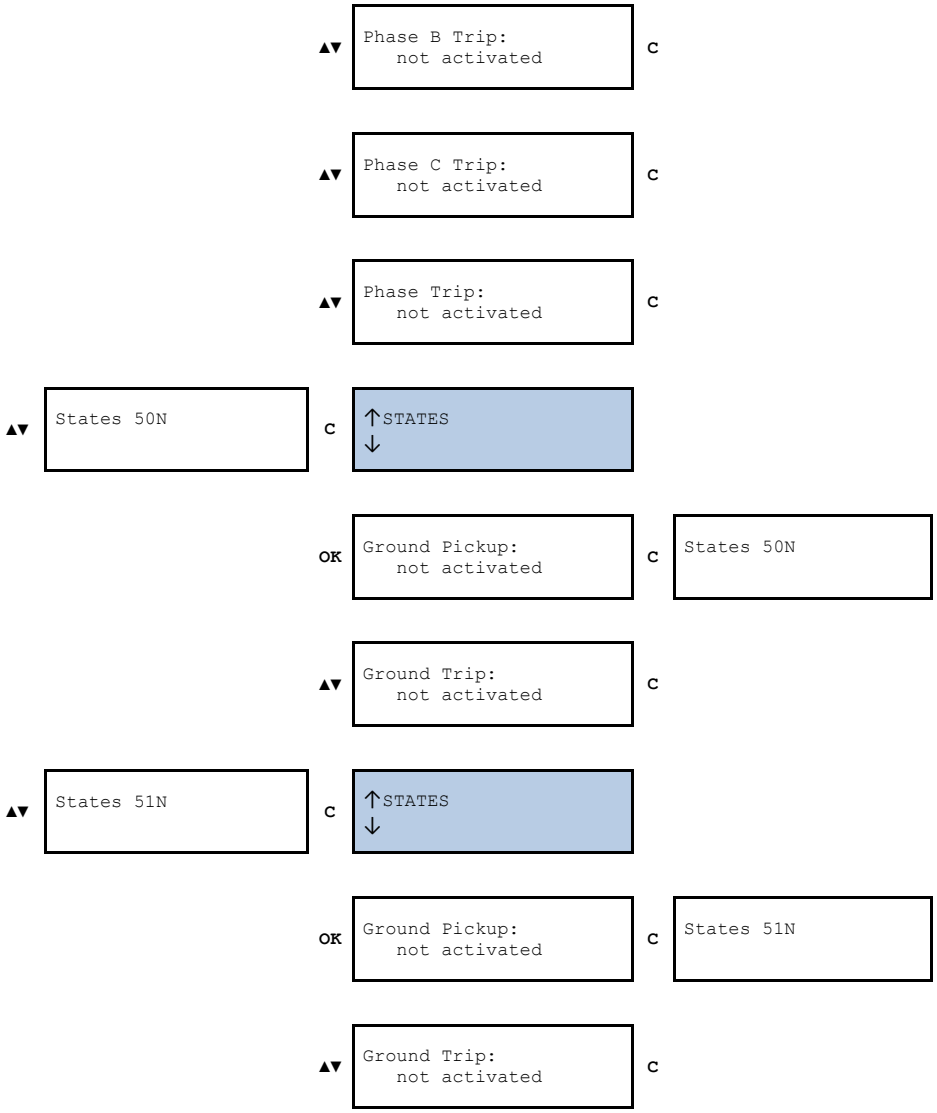
▲▼ Local communication:
not activated C

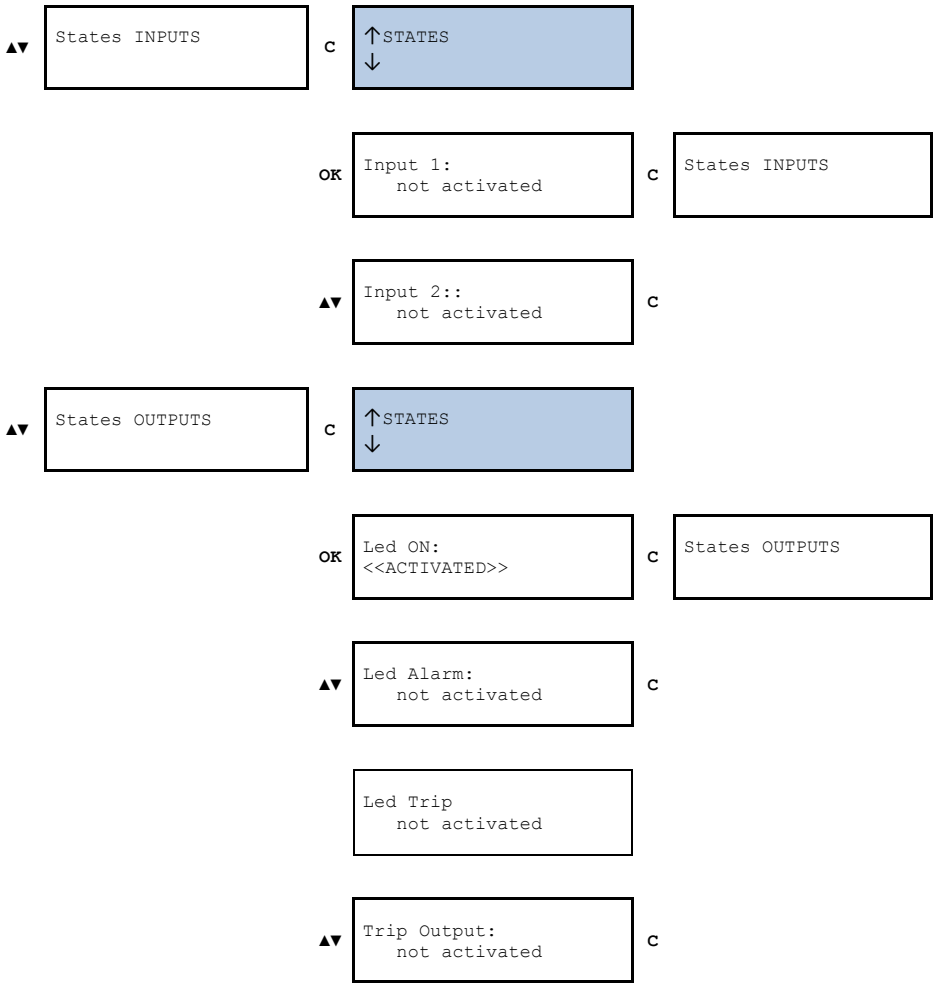
▲▼ Factory Settings:
not activated C


▲▼
Error Eeprom:
not activated
C
▲▼
Eeprom changed:
not activated
C
▲▼
Events Error:
not activated
C
▲▼
States Local COM.
C
↑STATES
↓
OK
Local COM:
not activated
C
States Local COM:
▲▼
MMI Activity:
not activated
C
▲▼
Select Command
not activated
C
▲▼
Open Breaker:
not activated
C


States 50P
Close Breaker:
not activated
Reset TI:
not activated
STATES
Phase A Pickup:
not activated
States 50P
Phase B Pickup:
not activated
Phase C Pickup:
not activated
Phase Pickup:
not activated
Phase A Trip:
not activated
Phase B Trip:
not activated


States 51P
Phase C Trip:
not activated
Phase Trip:
not activated
STATES
Phase A Pickup:
not activated
States 51P
Phase B Pickup:
not activated
Phase C Pickup:
not activated
Phase Pickup:
not activated
Phase A Trip:
not activated


▲▼
Phase B Trip:
not activated
C
▲▼
Phase C Trip:
not activated
C
▲▼
Phase Trip:
not activated
C
▲▼
States 50N
C
↑STATES
↓
OK
Ground Pickup:
not activated
C
States 50N
▲▼
Ground Trip:
not activated
C
▲▼
States 51N
C
↑STATES
↓
OK
Ground Pickup:
not activated
C
States 51N
▲▼
Ground Trip:
not activated
C


States INPUTS
C
↑STATES
↓
OK
Input 1:
not activated
C
States INPUTS
Input 2::
not activated
C
States OUTPUTS
C
↑STATES
↓
OK
Led ON:
<<ACTIVATED>>
C
States OUTPUTS
Led Alarm:
not activated
C
Led Trip
not activated
Trip Output:
not activated
C

▲▼ Output 2:
not activated C

▲▼ Output 3:
not activated C

▲▼ 52a:
not activated C

▲▼ 52b:
not activated C

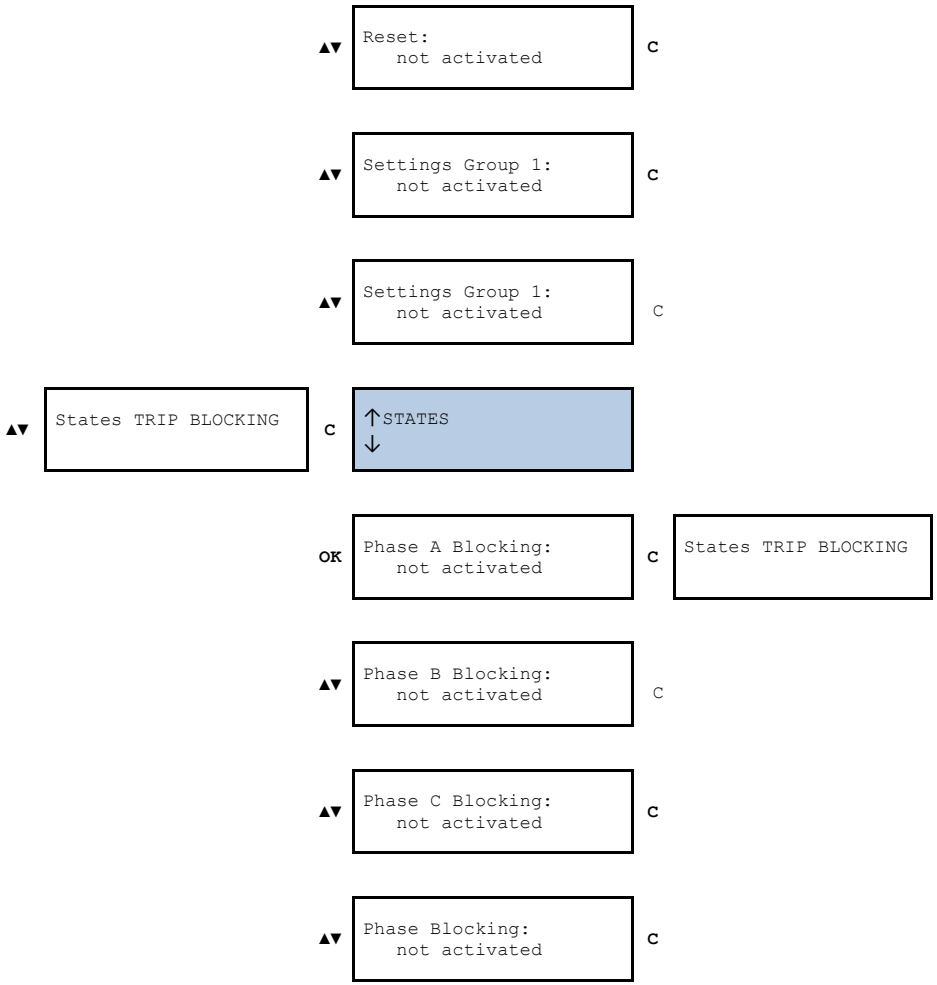
▲▼ External Trip:
not activated C

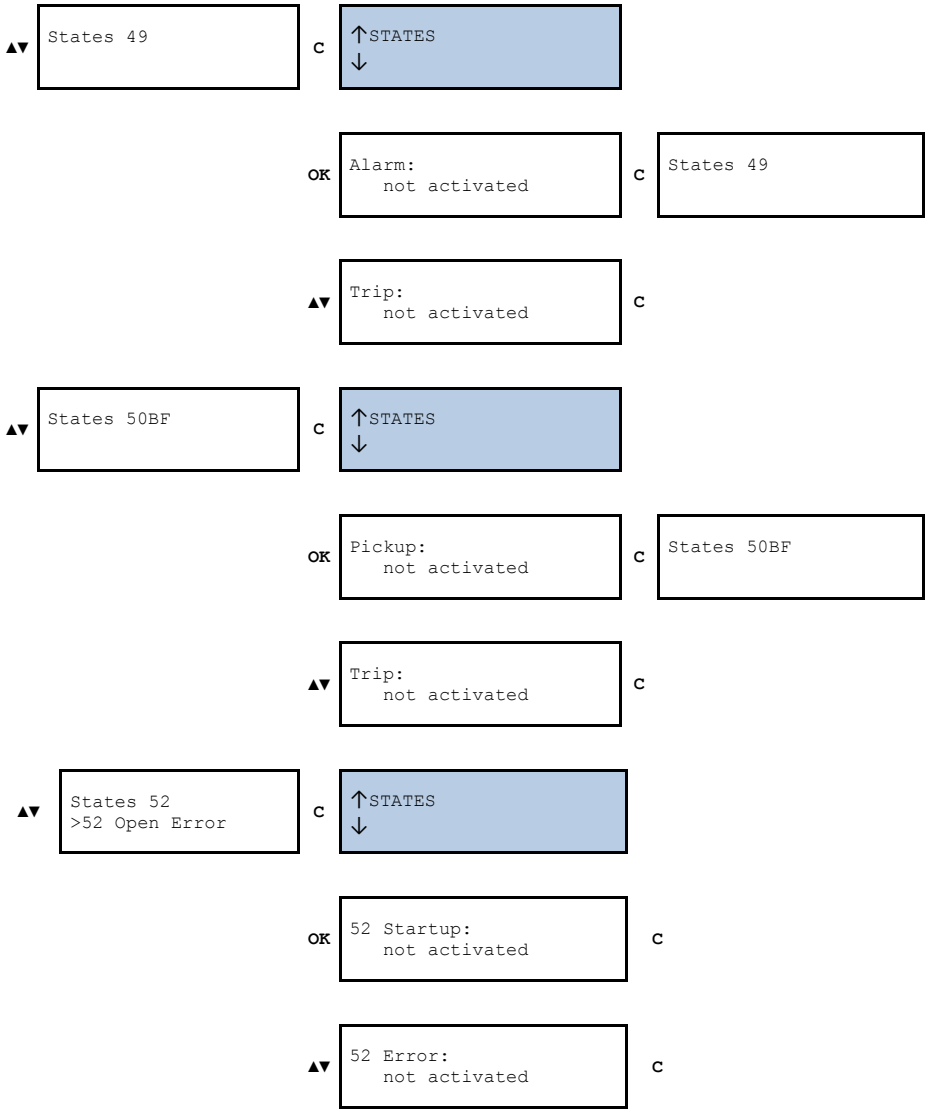
▲▼ 50BF Start:
not activated

▲▼ Fault Start:
not activated C

▲▼ Block 50P:
not activated C

▲▼ Block 50N:
not activated C


▲▼
Reset:
not activated
C
▲▼
Settings Group 1:
not activated
C
▲▼
Settings Group 1:
not activated
C
▲▼
States TRIP BLOCKING
C
↑STATES
↓
OK
Phase A Blocking:
not activated
C
States TRIP BLOCKING
▲▼
Phase B Blocking:
not activated
C
▲▼
Phase C Blocking:
not activated
C
▲▼
Phase Blocking:
not activated
C


States 49
C
↑STATES
↓
OK
Alarm:
not activated
C
States 49
▲▼
Trip:
not activated
C
States 50BF
C
↑STATES
↓
OK
Pickup:
not activated
C
States 50BF
▲▼
Trip:
not activated
C
States 52
>52 Open Error
C
↑STATES
↓
OK
52 Startup:
not activated
C
▲▼
52 Error:
not activated
C

▲▼ 52 Open:
not activated C

▲▼ 52 Open Time:
not activated C

▲▼ 52 Open Error:
<<ACTIVATED>> C

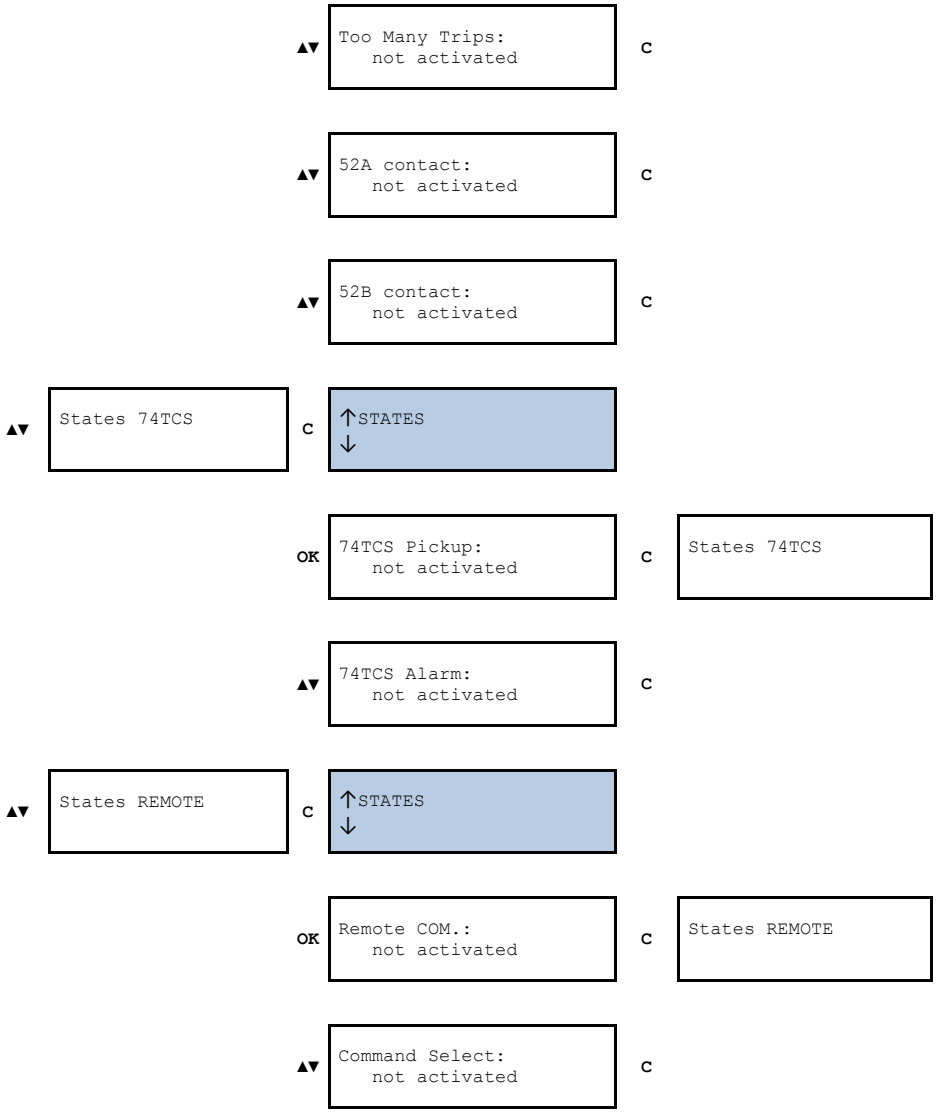
▲▼ 52 Close:
not activated C

▲▼ 52 Close Time:
not activated C

▲▼ 52 Close Error:
not activated C

▲▼ Open Num. Alarm:
<<ACTIVATED>> C

▲▼ I2t Alarm:
<<ACTIVATED>> C


▲▼
Too Many Trips:
not activated
C
▲▼
52A contact:
not activated
C
▲▼
52B contact:
not activated
C
▲▼
States 74TCS
C
↑STATES
↓
OK
74TCS Pickup:
not activated
C
States 74TCS
▲▼
74TCS Alarm:
not activated
C
▲▼
States REMOTE
C
↑STATES
↓
OK
Remote COM.:
not activated
C
States REMOTE
▲▼
Command Select:
not activated
C

```
▲▼ Open Breaker:
      not activated        C

▲▼ Close Breaker:
      not activated        C

▲▼ Reset TI:
      not activated        C
```

7.7.11. Settings Menu

From the standby mode screen, press the “OK” key to access the first line of menus. Use the “▲” and “▼” keys to position the cursor over the “SETTINGS” screen and press “OK”. This takes you to the setting groups’ line. Use the “▲” and “▼” keys to position the cursor over a settings group, and press the “OK” key to access the settings that belong to this group. Use the “▲” and “▼” keys to move through the different settings. The information that appears underneath the setting name is its value.

Press the “◄” key to access the general settings from the "SETTINGS" screen.

The general setting "Equipment name" can be viewed from the HMI, but it can only be modified by using the SICom program.

The value of the "TI Phase ratio” and “TI Neutral ratio” in general settings, is the result given by dividing the number of turns on the primary winding by the number on the secondary winding. For example: With TI 500/5, the setting would be 100.

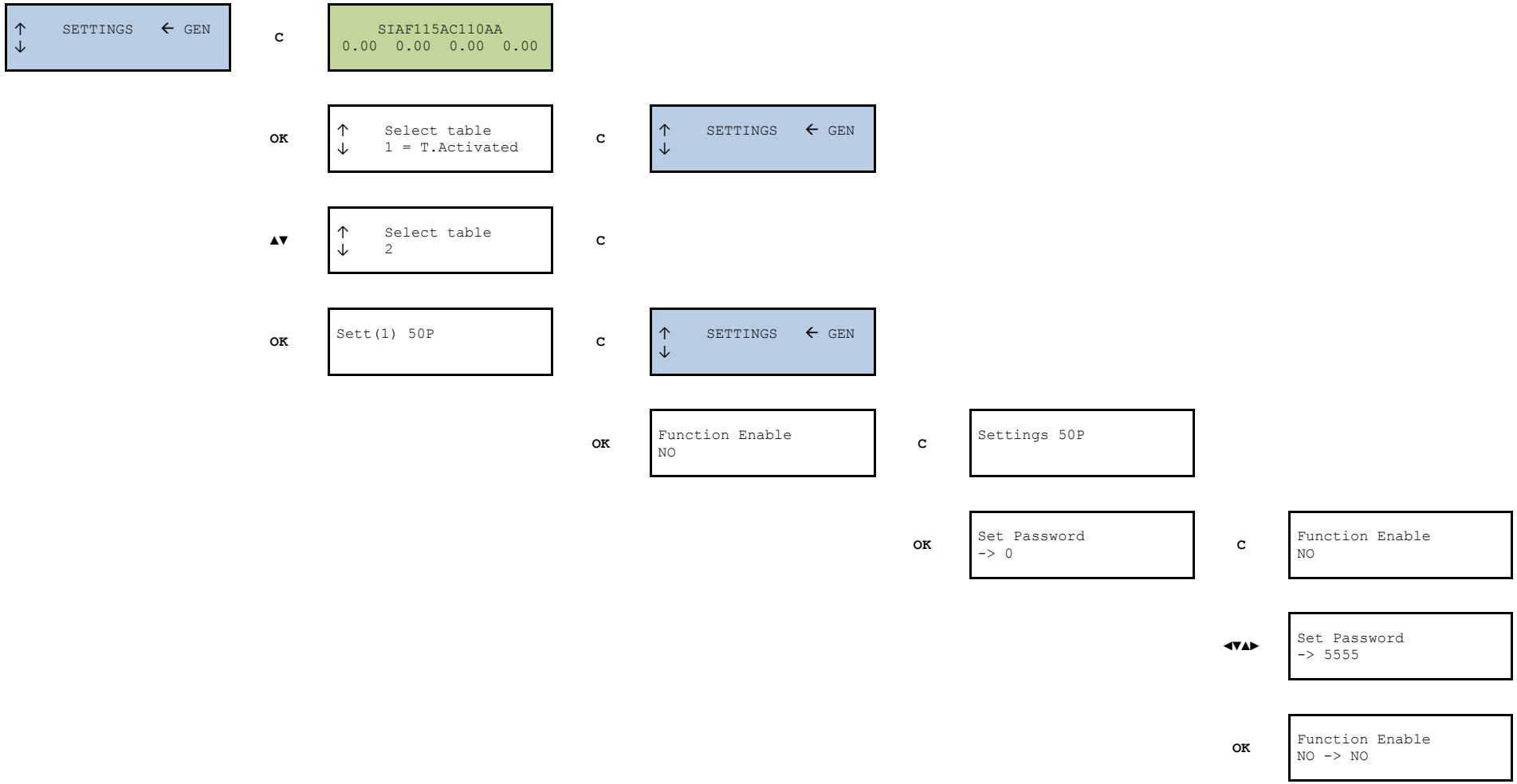
The frequency is selected for each model. The value is read only.

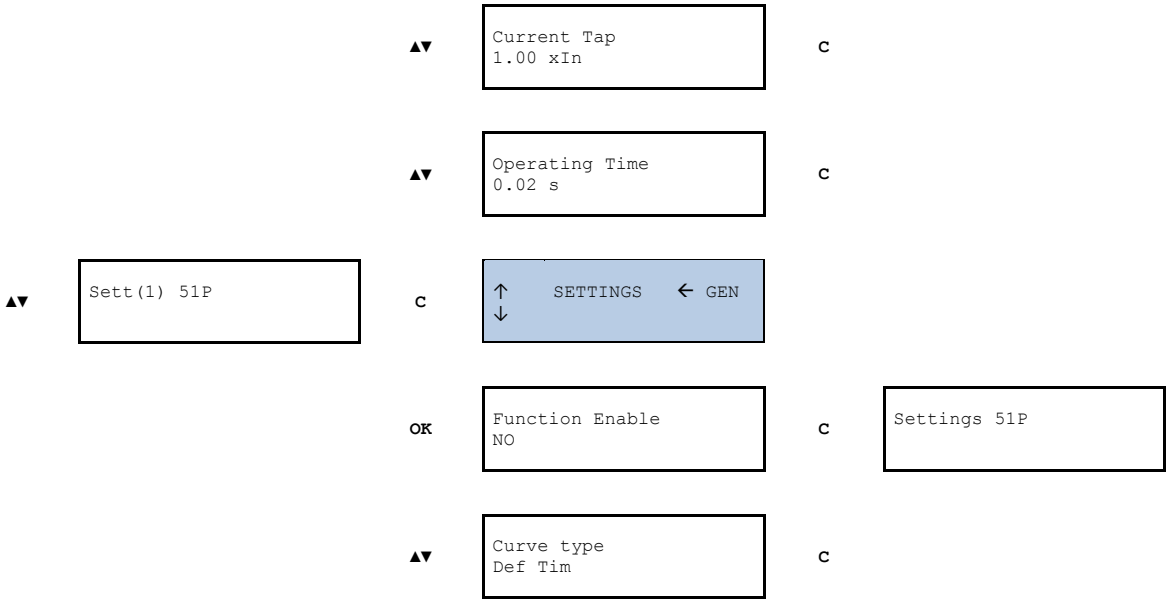
It is necessary to enter a password to change a setting for the first time. The settings can be changed after entering the password, until returning either manually or automatically to the standby mode screen. The system returns automatically to the standby mode screen if no key is pressed for five minutes.

The factory setting password for the equipment is 5555. This password can be changed using the SICom program.

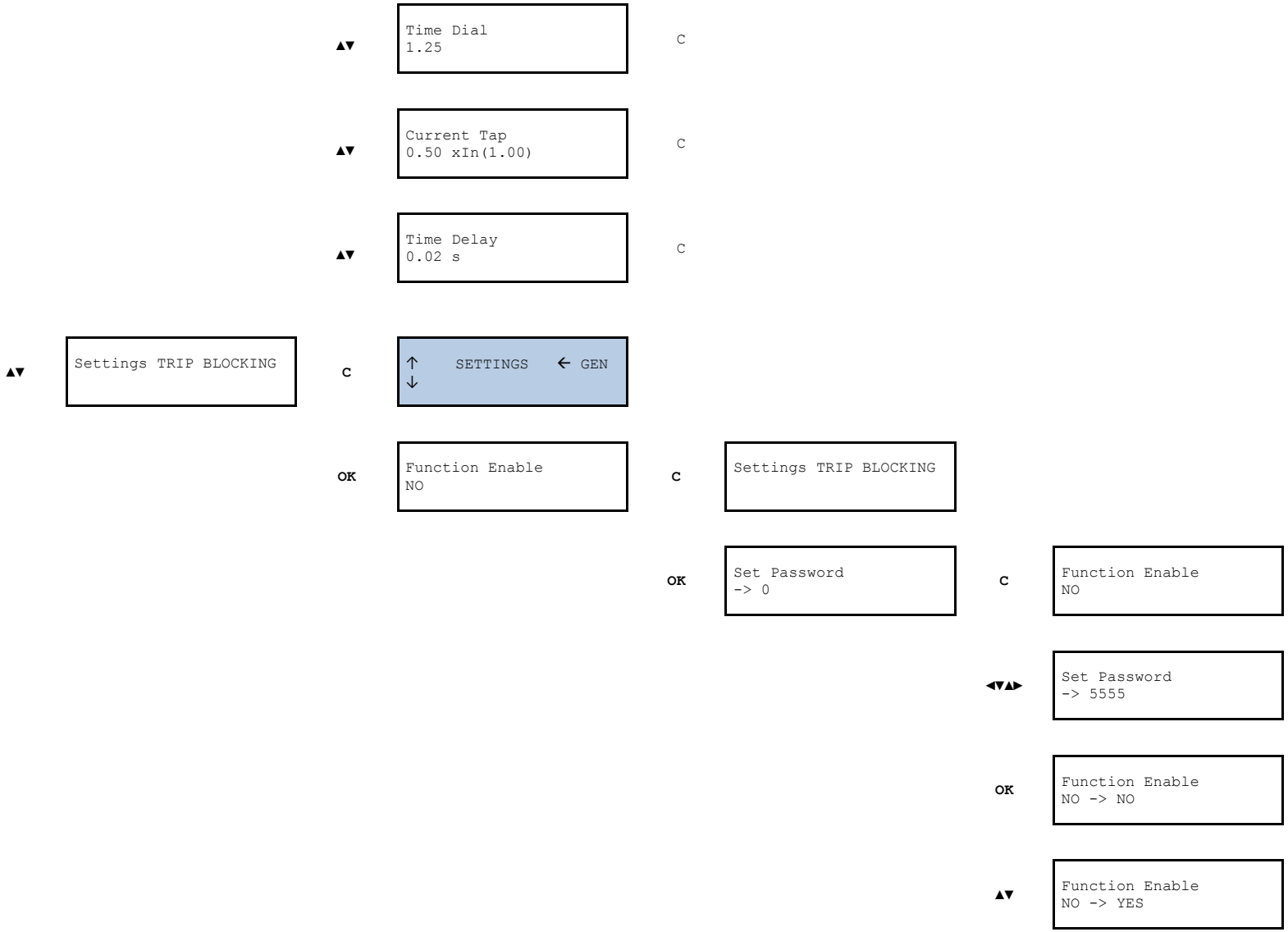
The keys ▲, ▼, ◄ and ► are used to enter the password. ▲ and ▼ are used to introduce a value or a character, and the ◄ and ► keys are used to move from one character to another. If it is necessary to change one of the password characters or numbers due to an error, press "**C**" to delete it. Press "**OK**” to validate the password.

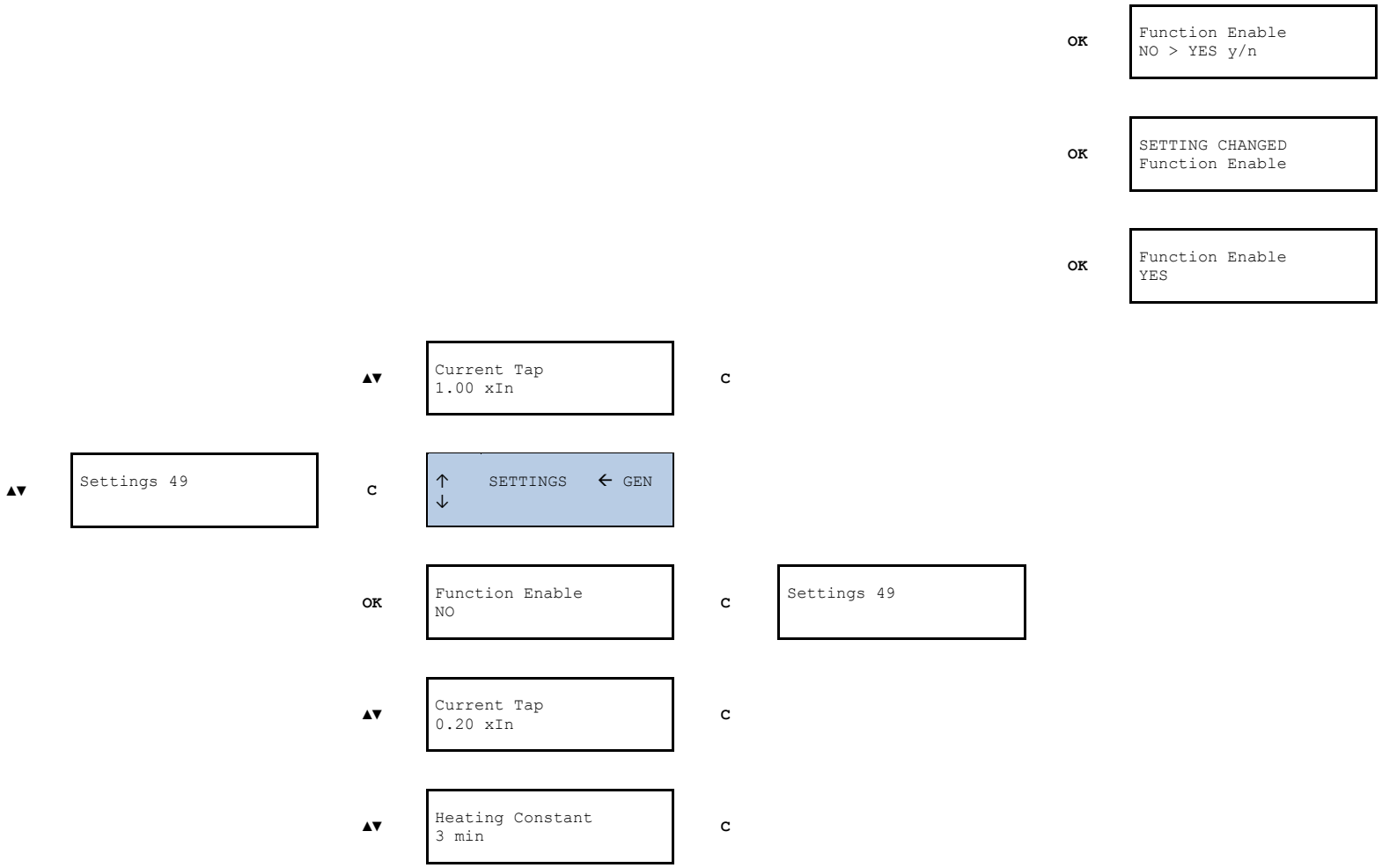
The method for navigating through the settings menu and the sequence to follow to change a setting are shown graphically below:




▲▼
Sett(1) 51P
C
↑ SETTINGS ← GEN
↓
OK
Function Enable
NO
C
Settings 51P
▲▼
Curve type
Def Tim
C
▲▼
Current Tap
1.00 xIn
C
▲▼
Operating Time
0.02 s
C
▲▼
Function Enable
NO -> YES
OK
Function Enable
NO > YES y/n
OK
SETTING CHANGED
Function Enable
OK
Function Enable
YES

		▲▼	Time Dial 0.05	C
		▲▼	Current Tap 0.20 xIn	C
▲▼	Sett(1) 50N	C		
		OK	Function Enable NO	C
		▲▼	Current Tap 1.00 xIn(1.00)	C
		▲▼	Time Delay 0.02 s	C
▲▼	Sett(1) 51N	C		
		OK	Function Enable NO	C
		▲▼	Curve type E.I.	C


Time Dial
1.25
C
Current Tap
0.50 xIn(1.00)
C
Time Delay
0.02 s
C
Settings TRIP BLOCKING
C
↑ SETTINGS ← GEN
↓
OK
Function Enable
NO
C
Settings TRIP BLOCKING
OK
Set Password
-> 0
C
Function Enable
NO
Set Password
-> 5555
OK
Function Enable
NO -> NO
Function Enable
NO -> YES


OK
Function Enable
NO > YES y/n
OK
SETTING CHANGED
Function Enable
OK
Function Enable
YES
▲▼
Current Tap
1.00 xIn
C
▲▼
Settings 49
C
↑ SETTINGS ← GEN
↓
OK
Function Enable
NO
C
Settings 49
▲▼
Current Tap
0.20 xIn
C
▲▼
Heating Constant
3 min
C

		▲▼	Cooling constant 3x heating constant	C		
		▲▼	Alarm 80	C		
▲▼	Settings 50BF	C	↑ SETTINGS ← GEN ↓			
		OK	Function Enable NO	C	Settings 50BF	
		▲▼	Time Delay 0,02 s	C		
▲▼	Settings 52	C	↑ SETTINGS ← GEN ↓			
		OK	Opening Max num 10	C	Settings 52	
		▲▼	Max Accum. Amp 1000 MA2	C		
		▲▼	Max. Opening Time 0.10 s	C		

▲▼	Max. Closing Time 0.10 s	C
▲▼	Max Repetitive Open. 3	C
▲▼	Max. openings/Time 9 min	C

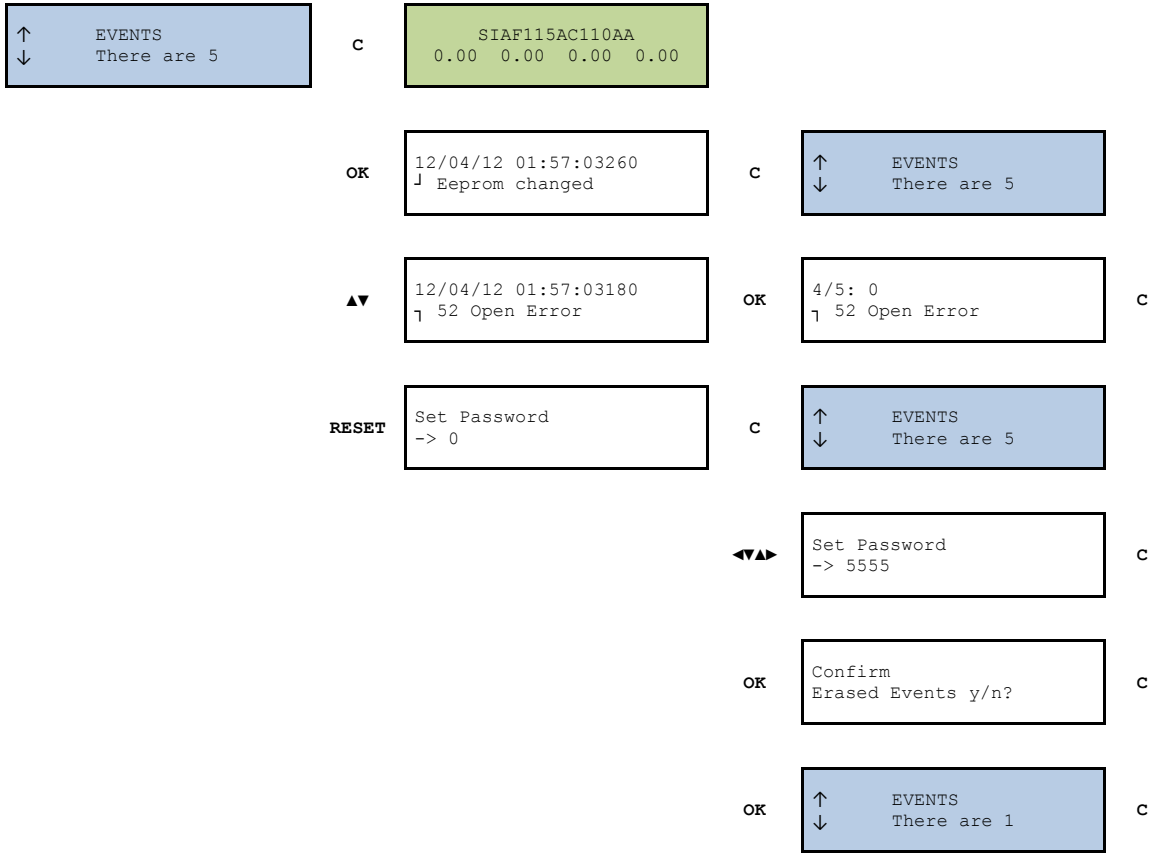
To access the general settings from the “SETTINGS” menus, press “◀”

◀	Identification free text	C	↑ SETTINGS ← GEN ↓	
		▲▼	Frequency 50Hz	C
		▲▼	Serial Number 0	C
		▲▼	Language ENG.	C
		▲▼	Active Settings Group 1	C

▲▼	CT Phase Ratio 10	C
▲▼	CT Neutral ratio. 10	C
▲▼	Local COM Address 1	
▲▼	Password ****	C
▲▼	Remote COM Address 2	

7.7.12. Events Menu

From the standby mode screen, press the “OK” key to access the first line of menus. Use the “▲” and “▼” keys to position the cursor over the “EVENTS” screen and the number of events in the buffer will be displayed. Press "OK" and use the “▲” and “▼” keys to position the cursor over the events.

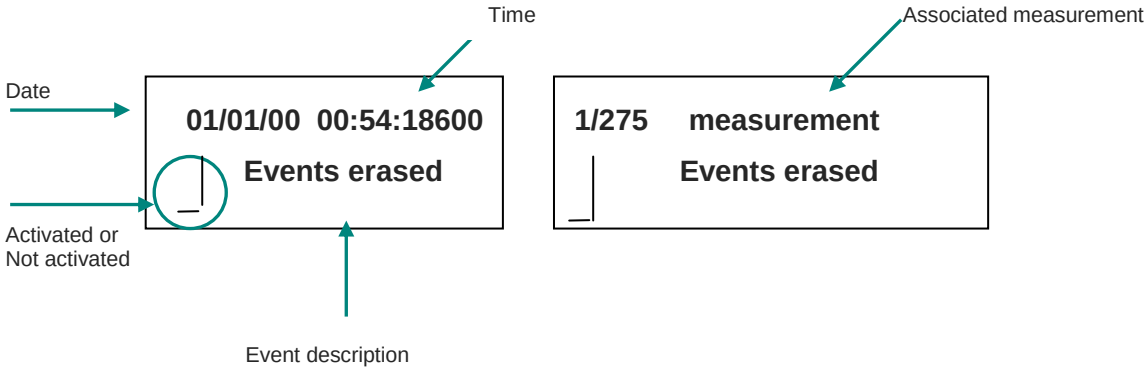


The "┘" and "┐" shows the event has been caused by the activation or reset of the associated state.

To delete the events buffer, position the cursor over the events menu and press and hold the "RESET" key, until there is only one event shown. This one event is "Deleted events".

Each event contains the following information:

- Date-time
- Description of the event
- Size of the events buffer
- Position of the event within the list of events
- Events generated by a state activation or reset
- Associated measurement (if it has one)



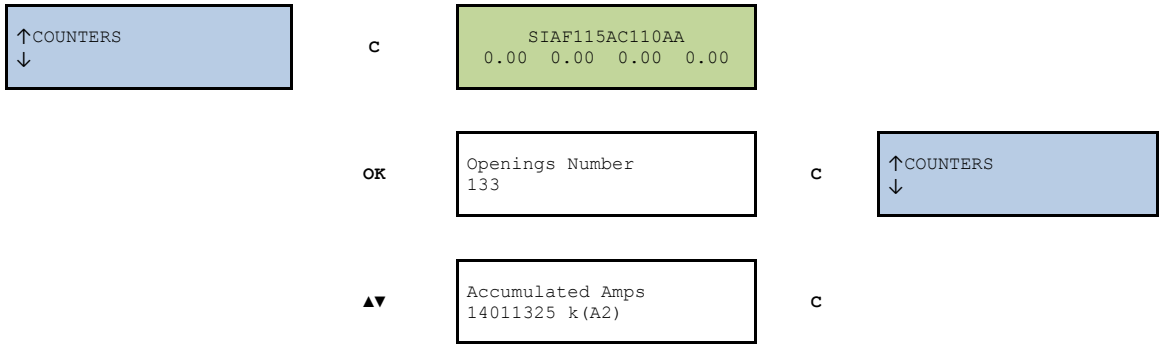
7.7.13. Counters Menu

The first line of menus can be accessed from the standby mode screen by pressing the “OK” key. Use the “▲” and “▼” keys to move the cursor through the different screens until it is positioned over the "COUNTERS" screen. Press "OK" and use the “▲” and “▼” keys to view the different counters. The information displayed below the meter name is its value.

The password must be entered before attempting to change a counter for the first time. Meter changes are allowed once the password has been entered, until the standby mode screen is returned to automatically or manually. The system returns automatically to the standby mode screen if no key is pressed for five minutes.

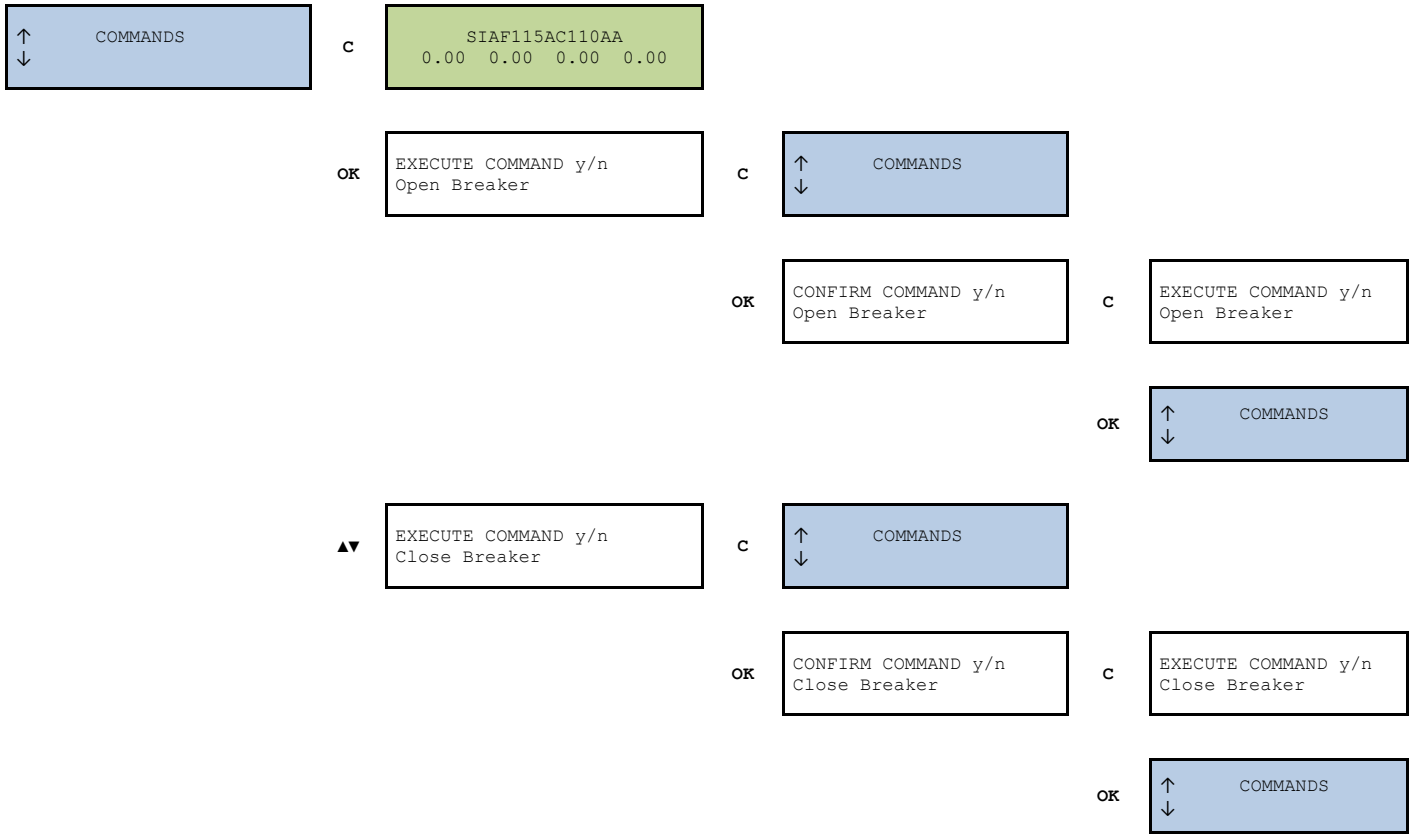
The factory setting password for the equipment is 5555. The password can be changed using the SICom program.

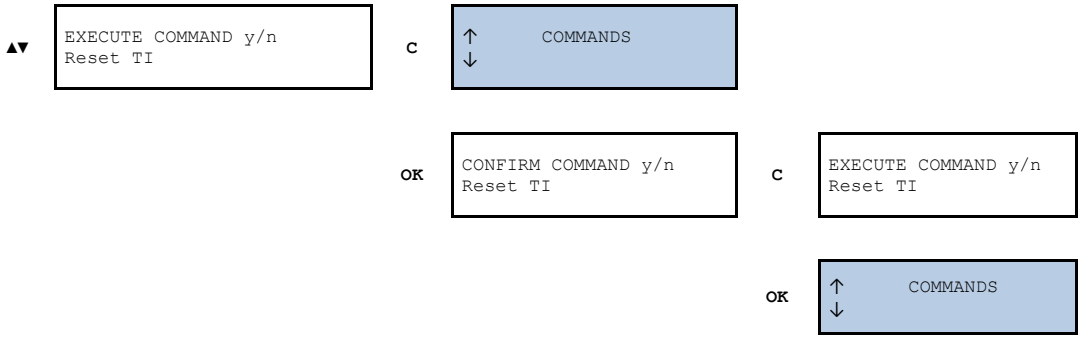
The keys ▲, ▼, ◄ and ► are used to enter the password. ▲ and ▼ are used to introduce a value or a character, and the ◄ and ► keys are used to move from one character to another. If it is necessary to change one of the password characters or numbers due to an error, press "C" to delete it. Press "OK” to validate the password.



7.7.14. Commands Menu

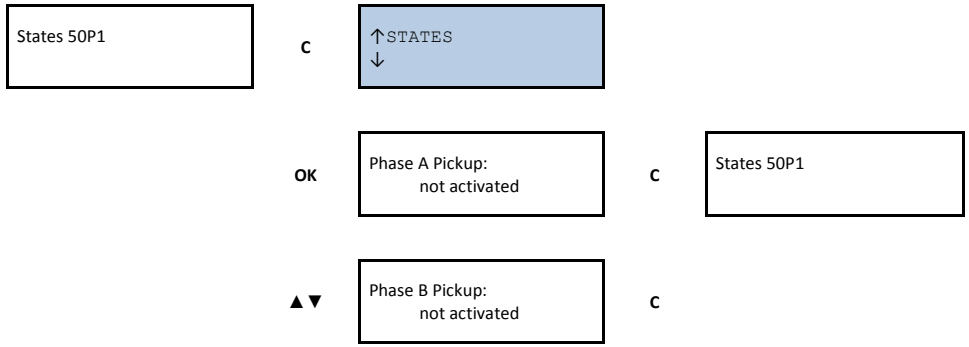
The first line of menus can be accessed from the standby mode screen by pressing the “OK” key. Use the “▲” and “▼” keys to move the cursor through the different screens until it is positioned over the "COMMANDS" screen. Press "OK" and use the “▲” and “▼” keys to view the different possible commands. Press the "OK" key to perform a command, and press the "OK" key again to confirm the command.

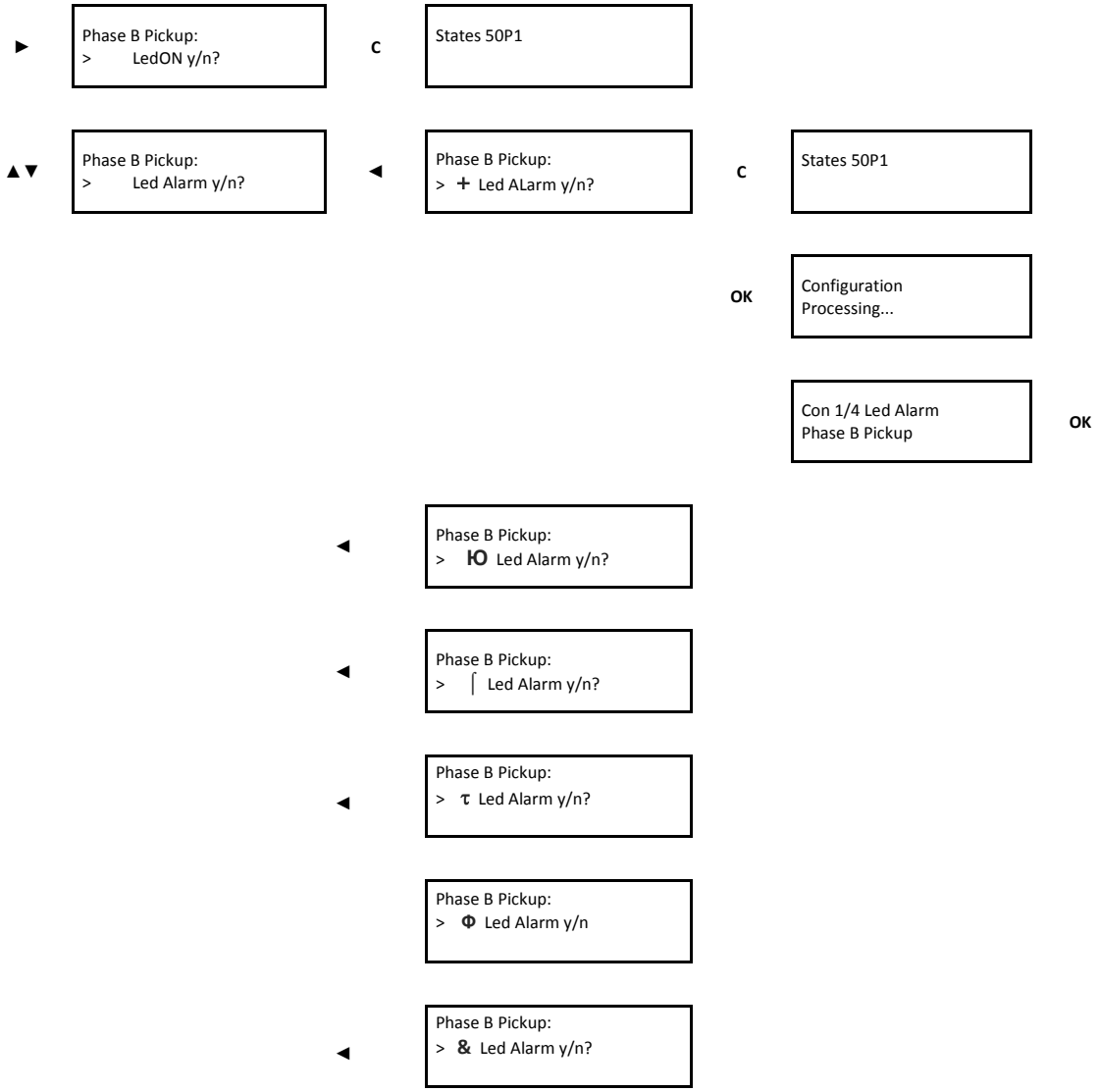


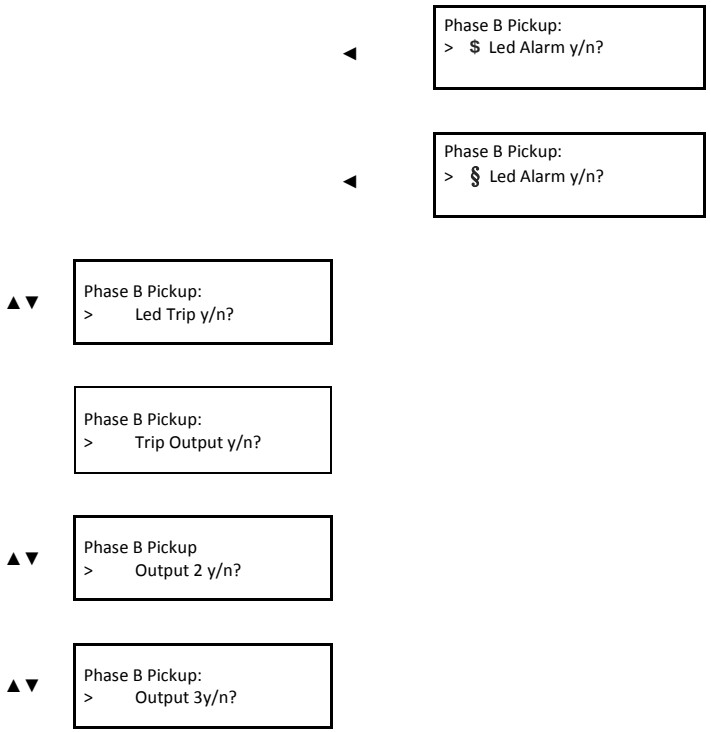


7.7.15. PLC and Output Configuration Menu

To assign an instantaneous state to a physical output, browse through the STATE menu to find the desired instantaneous state. When the state appears, press ► to enter the output configuration menu. Use the "▲" and "▼" keys in this menu to find the desired physical output. Then it is necessary to assign the logical gate. To do it, it is necessary to press ◄. Finally it is necessary to confirm the choice by pressing "OK". After, the confirmation is displayed on the screen; the index of 1 to 4 associated to the instantaneous state within the physical output configuration is displayed. Go up through the menu levels by pressing the "C" key.




►
Phase B Pickup:
> LedON y/n?
C
States 50P1
▲▼
Phase B Pickup:
> Led Alarm y/n?
◄
Phase B Pickup:
> + Led ALarm y/n?
C
States 50P1
OK
Configuration
Processing...
Con 1/4 Led Alarm
Phase B Pickup
OK
◄
Phase B Pickup:
> Ю Led Alarm y/n?
◄
Phase B Pickup:
> ⎧ Led Alarm y/n?
◄
Phase B Pickup:
> τ Led Alarm y/n?
Phase B Pickup:
> Φ Led Alarm y/n
◄
Phase B Pickup:
> & Led Alarm y/n?



To view or remove the instantaneous states assigned to a physical output, go to the “OUTPUT STATE" menu. When the output current state (activated or deactivated) is displayed, press the "OK” key to replace this current state reading with the first instantaneous state that is associated with the output, along with its index number from 1 to 4. The “▲” and “▼” keys can be used in this menu to browse all of the states (up to 4) that are associated with a physical output.

Press and hold the “RESET” key while viewing any of the instantaneous states associated with the output and its index number from 1 to 4 to remove the association with the physical output.

8. MODBUS RTU PROTOCOL

This document describes the steps to follow to read and write data on the SIA-F relay, as per the ModBus/RTU protocol. This memory map is only valid for one piece of equipment and one version of the memory. The positions of existing objects in the memory remain fixed from one version to the next, but new objects will naturally have new addresses which will, in turn, remain fixed in future versions. The memory map is described further on.

The standard ModBus/RTU protocol is used, so any program or PC can communicate easily with the equipment.

The SIA-F always acts as a slave, which means that it never initiates communications. The master is always responsible for initiating communications.

Only a subset of the ModBus/RTU functions is implemented:

- Reading function 3.
- Writing function 16.

The ModBus/RTU protocol is independent from the hardware. Therefore, the physical layer can exist in different hardware configurations: RS232, RS485, fiber optic or Ethernet.

Specifically, the relay has a front RS232 port and, as an option, a rear RS485 port. The data stream in any of the configurations is “half-duplex”.

Each byte of data is transmitted asynchronously and is made up of: 1 start bit, 8 data bits, 1 stop bit and 1 parity bit, if this is how it is programmed. Therefore, the data has 10 or 11 bits, depending on whether or not it includes parity.

When the equipment has a single front port, the address can be configured but the rest of the parameters are fixed: the speed is 19200, without parity and with 1 stop bit.

If the equipment is fitted with two switched ports, one front and one rear, the following features can be configured: speed (1200, 2400, 4800, 9600 or 19200), parity (even, odd or no parity), the stop bits (1 or 2) and the address (1 to 247).

The master must know the address of the slave that it is going to communicate with. No unit will act on requests from the master if the message is not addressed to them. The exception is when the 0 address, or “broadcast” address, is used, in which case the relay will act but will not send an answer of any type.

Communications are made in packages or frames, which are groups of data that are sent asynchronously. The master transmits a frame to the slave, and the slave then replies with another frame (except in the case of “broadcast” messages).

The end of the frame is marked by a dead time or silence time in the communication medium. The length of this time of silence varies depending on the transmission speed, as it is equivalent to 3 characters.

The following table shows the generic package format that is valid for transmission and reception. However, each function has its own peculiarities, as will be described further on.

8.1. ModBus packaged format

CUSTOMER ADDRESS	1 byte	Each device on a communication bus must have a unique address, otherwise two different units could reply simultaneously to the same request. All ports of the relay will use this address which can be set a value between 1 and 247. When the master transmits a frame with the slave address to 0 indicates a Broadcast. All the slaves in the communications bus will carry out the requested action, but no one will reply to the master. The Broadcast will only be accepted to write, as it makes no sense to make a read request in the Broadcast, as no one will reply this request.
FUNCTION CODE	1 byte	This is one of the function codes supported by the equipment. In this case, the only function codes supported are 3 to read and 16 to write. When the slave has to reply with an exception one of these frames, it is indicated by putting 1 in the most important bit of the correspondent function. Thus, an exception for the function 3 will be indicated with a 83 as a function code; and an exception for the function code 16 or 0x10 in hexadecimal, will be indicated with an 0x90.
DATA	N bytes	This part consists of a variable number of bytes, depending on the function code. It may include: addresses, data lengths, settings, commands or exception codes sent by the user.
CRC	2 bytes	Control code of two bytes. The ModBus/RTU includes a 16 bit CRC in each frame, to detect errors. If the slave detects an erroneous frame, based on a CRC that is not correct, it won't take any action, nor will reply anything to the master. The management of the CRC is LSB-MSB.
DEAD TIME	Necessary time to transmit 3,5 Bytes	A frame is terminated when nothing is received for a period of 3,5 bytes. It means: 15 ms at 2400 bps 2 ms at 19200 bps ...etc.

8.2. Function codes

HEX DEC CODE	MODBUS NAME	DEFINITION	COMMENT
0x03 3	Read Holding Registers	Reading of Any Value	This function allows the master to read 1 or more consecutive addresses of a relay. The registers always are of 16 bits, with the most important byte at first. The maximum number of registers to be read in a package is 60.
0x10 16	Preset Multiple Registers	Script	This function allows to write one or more registers that represent one or more settings. The registers are values of 2 bytes of length, transmitted with the most important byte at first. The maximum number of register to be written in a package is 60.

8.3. Exemptions and error answers

The error codes defined by the ModBus protocol are as follows:

01	**ILLEGAL FUNCTION**	The slave does not support any function with the function code received in this message.
02	**ILLEGAL DATA ADDRESS**	The master is trying to do an operation in a wrong address.
03	**ILLEGAL DATA VALUE**	The slave has detected that the value sent by the master is not valid.
04	**SLAVE DEVICE FAILURE**	Indicates an error occurred in the slave while trying to execute the request of the master.
05	**ACKNOWLEDGE**	Generic recognition.
06	**SLAVE DEVICE BUSY**	The slave is busy and unable to perform the required operation.
07	**NEGATIVE ACKNOWLEDGE**	Generic non-recognition.

8.4. Data type

TYPE	LENGTH	DESCRIPTION
UCHAR	1/2	Integer without sign of 1 byte
BYTE	1/2	Integer with sign of 1 byte
BIT16	1	Gathered bits type, groups of 16. E. g.: 0x1A41 = 0001101001000001b
BIT32	2	Gathered bits type, groups of 32.
ENUM	1	Integer without sign of 16 bits. Each of the values that the integer can be will have a correspondence in the auxiliary list of the database. I this list is the correspondence chain which must be shown for each of the values. Memory will only receive an integer value. E. g.: 0, 1 Correspondence to “CLOSED”, “OPEN”
DENUM	2	Integer without sign of 32 bits
UINT	1	Integer without sign of 2 bytes
INT	1	Integer with sign of 2 bytes
LONG	2	Integer without sign of 4 bytes
FLOAT	2	Number in floating decimal point “Float” of 4 bytes
ASCIIxx	xx/2	String: Length variable character chain. Final of String marked with ‘\0’. E. g.: “ABC” 0x41x42x43x00....
FH	5	Year(UINT).month(UCHAR).day(UCHAR).hour(UCHAR).minutes(UCHAR).seconds(UCHAR).hundredth(UCHAR).thousandth(UINT)
EVENT2	10	Criteria Directory(UINT).Event Identifier(UINT).Value(UINT).Associated Measure(float).Date and Time(FH)
EVENTO2	11	Antiquity(UINT).Event(EVENT2)

When a data format takes up more than 1 byte, it is always sent, firstly the most significant BYTE and lastly the lowest significant BYTE by communications.

DENUMCURVE	0	IEC 60255-151 inverse
	1	IEC 60255-151 very inverse
	2	IEC 60255-151 extremely inverse
	3	Definite time
DENUM 5060Hz	0	60Hz
	1	50Hz
DENUM NOYES	0	NO
	1	YES
DENUMBAUD	0	4800 bauds
	1	9600 bauds
	2	19200 bauds
	3	38400 bauds
DENUM LANGUAGE	0	English
	1	Spanish
	2	Depending on model

8.5. Memory map of SIA-F

Function	Description	Start address	Number of registries	Format	
16	Write the Directory of Event	1	1	UINT	
16	Write the number of the Setting List	6	1	UNIT	
03	Read of Model and Version	100	44	ASCII88	
16	Write access code	168	2	UCHAR4	See Passwords and Access Levels
03 y 16	Date and Time	170	5	FH	
16	Selection of Command	200	1	UINT	See commands map
16	Confirmation of Command	201	1	UINT	See commands map
03 y 16	Counters	202	2	CONT	See counters map

03 y 16	Counters	204	2	CONT	See counters map
16	Test state	250	2	BIT32	See test state map
03	Serial number	252	2	LONG	
03	Equipment identifier	254	44	ASCII88	
03	Primary measurement	300	2	FLOAT	MEASUREMENT_IA
03	Primary measurement	302	2	FLOAT	MEASUREMENT _IB
03	Primary measurement	304	2	FLOAT	MEASUREMENT _IC
03	Primary measurement	306	2	FLOAT	MEASUREMENT _IN
03	Primary measurement	308	2	FLOAT	MEASUREMENT _TI
03	Primary measurement	310	2	FLOAT	MEASUREMENT _IMAX
03	Read and Delete the oldest Event	400	11	EVENTO2	See events list
03	One event reading	410	11	EVENTO2	See events list
16	Delete All Events	420	1	dummy	
03	State reading	500	2	BIT32	General states map
03	State reading	502	2	BIT32	Local communication states map
03	State reading	504	2	BIT32	50P function map
03	State reading	506	2	BIT32	51P function map
03	State reading	508	2	BIT32	50N function map
03	State reading	510	2	BIT32	51N function map
03	State reading	512	2	BIT32	Inputs map
03	State reading	514	2	BIT32	Outputs map
03	State reading	516	2	BIT32	Trip blocking function map
03	State reading	518	2	BIT32	50BF function map
03	State reading	520	2	BIT32	52 function map
03	State reading	522	2	BIT32	49 function map
03	State reading	524	2	BIT32	Remote communication states map
03 y 16	Setting	600	10	ASCII20	Equipment identifier
03	Setting	610	2	DENUM 5060Hz	Frequency
03	Setting	612	2	LONG	Serial number

03 y 16	Setting	614	2	DENUM LANGUAGE	Language
03 y 16	Setting	616	2	LONG	Active group
03 y 16	Setting	618	2	FLOAT	CT phase ratio
03 y 16	Setting	620	2	FLOAT	CT neutral ratio
03 y 16	Setting	622	2	LONG	Local address
03 y 16	Setting	624	2	ASCII4	Password[4]
03 y 16	Setting	626	2	LONG	Remote address
03 y 16	Setting	628	2	DENUMBAUD	Remote baudrate
03 y 16	Setting	630	2	DENUM NOSI	F50P Permission
03 y 16	Setting	632	2	FLOAT	F50P Tap
03 y 16	Setting	634	2	FLOAT	F50P Operating time
03 y 16	Setting	636	2	DENUM NOSI	F51P Permission
03 y 16	Setting	638	2	DENUMCURVA	F51P Curve
03 y 16	Setting	640	2	FLOAT	F51P Dial
03 y 16	Setting	642	2	FLOAT	F51P Tap
03 y 16	Setting	644	2	FLOAT	F51P Definite time
03 y 16	Setting	646	2	DENUM NOSI	F50N Permission
03 y 16	Setting	648	2	FLOAT	F50NTap
03 y 16	Setting	650	2	FLOAT	F50N Operating time
03 y 16	Setting	652	2	DENUM NOSI	F51N Permission
03 y 16	Setting	654	2	LONG	F51N Curve
03 y 16	Setting	656	2	FLOAT	F51N Dial
03 y 16	Setting	658	2	FLOAT	F51N Tap
03 y 16	Setting	660	2	FLOAT	F51N Definite time
03 y 16	Setting	662	2	DENUM NOSI	F49 Permission
03 y 16	Setting	664	2	FLOAT	F49 Tap
03 y 16	Setting	666	2	LONG	F49 Heating constant
03 y 16	Setting	668	2	LONG	F49 cooling constant
03 y 16	Setting	670	2	LONG	F49 Alarm
03 y 16	Setting	672	2	DENUM NOSI	Blocking trip permission

03 y 16	Setting	674	2	FLOAT	Blocking trip tap
03 y 16	Setting	676	2	DENUM NOSI	F50BF Permission
03 y 16	Setting	678	2	FLOAT	F50BF Operating time
03 y 16	Setting	680	2	LONG	F52 Max openings number
03 y 16	Setting	682	2	LONG	F52 Max amperes number
03 y 16	Setting	684	2	FLOAT	F52 Max opening time
03 y 16	Setting	686	2	FLOAT	F52 Max closing time
03 y 16	Setting	688	2	LONG	F52 Excess openings number
03 y 16	Setting	690	2	FLOAT	F52 Excess openings time
16	Confirm setting	800	10		Equipment identifier
16	Confirm setting	810	2		Frequency
16	Confirm setting	812	2		Serial number
16	Confirm setting	814	2		Language
16	Confirm setting	816	2		Active group
16	Confirm setting	818	2		CT phase ratio
16	Confirm setting	820	2		CT neutral ratio
16	Confirm setting	822	2		Local address
16	Confirm setting	824	2		Password[4]
16	Confirm setting	826	2		Remote address
16	Confirm setting	828	2		Remote Baudrate
16	Confirm setting	830	2		F50P Permission
16	Confirm setting	832	2		F50P Tap
16	Confirm setting	834	2		F50P Operating time
16	Confirm setting	836	2		F51P Permission
16	Confirm setting	838	2		F51P Curve
16	Confirm setting	840	2		F51P Dial
16	Confirm setting	842	2		F51P Tap
16	Confirm setting	844	2		F51P Definite time
16	Confirm setting	846	2		F50N Permission
16	Confirm setting	848	2		F50NTap
16	Confirm setting	850	2		F50N Operating time

16	Confirm setting	852	2		F51N Permission
16	Confirm setting	854	2		F51N Curve
16	Confirm setting	856	2		F51N Dial
16	Confirm setting	858	2		F51N Tap
16	Confirm setting	860	2		F51N Definite time
16	Confirm setting	862	2		F49 Permission
16	Confirm setting	864	2		F49 Tap
16	Confirm setting	866	2		F49 Heating constant
16	Confirm setting	868	2		F49 cooling constant
16	Confirm setting	870	2		F49 Alarm
16	Confirm setting	872	2		Blocking trip permission
16	Confirm setting	874	2		Blocking trip tap
16	Confirm setting	876	2		F50BF Permiso
16	Confirm setting	878	2		F50BF Tiempo de Operacion
16	Confirm setting	880	2		F50BF Permission
16	Confirm setting	882	2		F50BF Operating time
16	Confirm setting	884	2		F52 Max openings number
16	Confirm setting	886	2		F52 Max amperes number
16	Confirm setting	888	2		F52 Max opening time
16	Confirm setting	890	2		F52 Max closing time

8.6. Commands Map

1	Open Circuit breaker
2	Close circuit breaker
7	Reset thermal image

8.7. Examples of ModBus frames

8.7.1. Writing the access password “5555” to equipment nº 1

Address	01
Function	10
H start address	00
L start address	A8
Number of H registers	00
Number of L registers	02
Number of bytes	04
Password	35,35,35,35
Checksum H	4A
Checksum L	50

And SIA respond OK:

Address	01
Function	10
H start address	00
L start address	A8
Number of H registers	00
Number of L registers	02
Number of bytes	04
Checksum H	29
Checksum L	93

9. COMMISSIONING

9.1. Checklist for Commissioning

The commissioning sheets that are needed to register the commissioning process and the specific settings for each installed piece of equipment are found in the Appendix.

9.2. Electrostatic discharge

Before handling any of the equipment electronic components, make sure that you have read the section of the user manual related to electrostatic discharges.

9.3. Visual Inspection

Make sure that the cabling has been installed as per the external connection diagrams.

9.4. Earthing

It is very important for the equipment to be earthed correctly. To check this, make sure that the equipment earth connection, located on the reverse side of the relay, is correctly connected to the facility local earth connection.

9.5. Current transformers

The high voltage that is generated in the secondary circuits of current transformers can cause death and could damage the facility. Therefore, the secondary circuits of current transformers should never be opened.

9.6. Auxiliary power

If an SIA-F relay with auxiliary power is required, this must be specified on the order reference. The amount of auxiliary power required for the SIA-F relay should be checked: 110-230 Vac 50/60 Hz or 90-300 Vdc or 24-48 Vdc.

9.7. Front communications port

To perform this test, connect a PC with the SICom software program to the SIA-F relay, and check that there are no communication errors. It is important to check communications port (COM) which is assign to USB.

9.8. Commissioning

It is recommended that the following safety measures are taken before starting up the facility for the first time, or after a trip event:

- FANOX recommends the use of the KITCOM accessory with a battery in the front port. This additional energy source allows the relay to be monitored and the trip to function without the need for self-power in any breakdown situation.
- Once all of the connections have been made, we recommend a check to make sure that they are correct, safe and well attached.
- The "complete test" menu procedure should be applied. ✋ **NOTE! See 5.10.**
- It is important to check that the measurements are correct once the facility has been powered up.

Maintenance: FANOX recommends a minimum of one facility inspection per year, to at least go through the test menu and check the values of the measurements.

10. APPENDIX

10.1. Identification

Date : .....

Manager : .....

Substation : .....

Circuit : .....

Model : .....

Serial n^{o}. : .....

Software Versions : .....

Model: .....

S	I	A	F											**MODEL SELECTION TABLE** Example: SIAF555B0000AA
				1 5										1 A phase measurement 5 A phase measurement
					1 5 B									1 A neutral measurement 5 A neutral measurement 0,2 A neutral measurement
						5 6								50 Hz 60 Hz
							A B							24- 48 Vdc 90 Vdc – 300 Vdc / 110 Vac – 230 Vac
								0 1 B C						- +52+50BF+49 + Trip block for switch disconnector + Trip block for switch disconnector+52+50BF+49
									0 1					Frontal USB +rear RS485
										0 1				3 led´s + trip output + 2 inputs + 2 outputs (configurable)
											0			-
												A B C D		English, Spanish and German English, Spanish and Turkish English, Spanish and French English, Spanish and Russian
													A	-

10.2. Checks

Cabling check: ❒

Box earth: ❒

Vaux value: ❒

10.3. Test menu

On LED:	❒	Trip Output	❒
Alarm LED:	❒	Output 2:	❒
Trip LED:	❒	Output 3:	❒

10.4. Register of commissioning settings

Password: ……

Identification: ……

CT Ratio

Phase CT Ratio: …….....……

Neutral CT Ratio: …….....……

50P

Permission ❒ Enabled ❒ Disabled

Tap.....…… x In

Operating Time: .....…….... s

50N/50G

Permission ❒ Enabled ❒ Disabled

Tap.....…… x In

Operating Time: .....…….... s

51P

Permission ❒ Enabled ❒ Disabled

Tap.....…… x In

IEC curve ❒ Inverse ❒ Very Inverse ❒ Extrem. Inverse ❒ Definite time

Dial .....……

Operating Time …… s

51N/51G

Permission ❒ Enabled ❒ Disabled

Tap.....…… x In

IEC curve ❒ Inverse ❒ Very Inverse ❒ Extrem. Inverse ❒ Definite time

Dial…….....……

Operating Time…..…..…… s

49

Permission ❒ Enabled ❒ Disabled

Tap……..…….. x In

ζ heating: …….. min

ζ cooling: …….. ζ heating

Alarm: …….. %

50BF

Permission ❒ Enabled ❒ Disabled

Operating time ……..… s

Trip blocking

Permission ❒ Enabled ❒ Disabled

Blocking level.....…… x In

Circuit breaker

Excessive number of openings ….....……

Excessive accumulated amps….....……

Opening time….....……

Closing time….....……...

Excessive repeated openings …….....……..

Time of repeated openings ….....……

10.5. Output configuration

	OUTPUT	LOGICAL GATE	BINARY STATES
LEDs	LED On		
	LED Alarm		
	LED Trip		
PHYSICAL OUTPUTS	Trip output		
	Output 2		
	Output 3		
LOGICAL SIGNAL	52a logical output		
	52b logical output		
	External trip logical output		
	50BF start logical output		
	Fault start logical output		
	50P Block logical output		
	50N Block logical output		
	Reset logical output		
	Active group 1 logical output		
	Active group 2 logical output		

10.6. Comments

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Person in charge of commissioning…….....…….....……..Date…….....…

Maintenance performed on the…….. by ……..……..

NOTES:

FANOX

power T&D

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