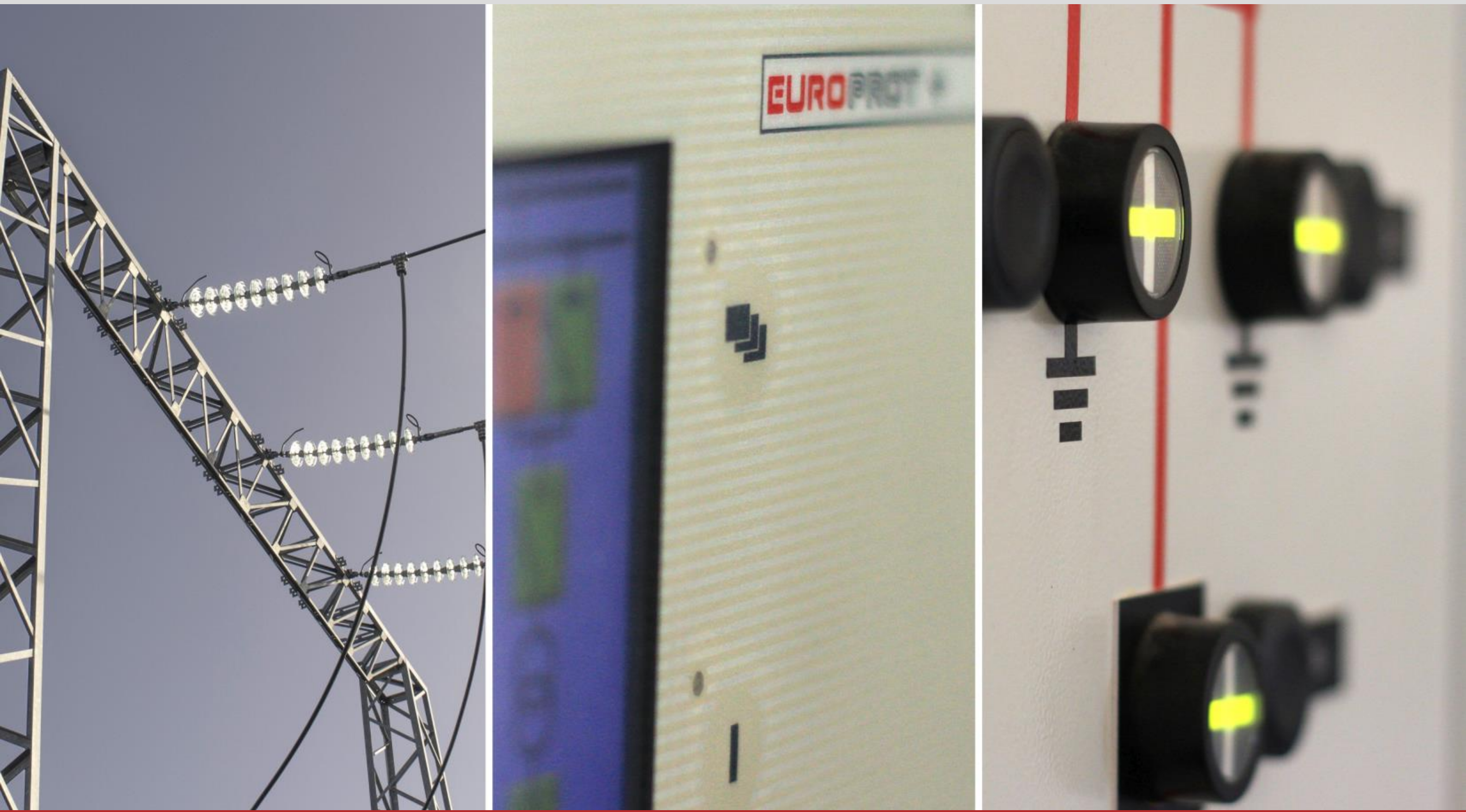


CONFIGURATION DESCRIPTION

E5-ASZKG

Automatic Generator Synchronizer
(Type: DAUT)

PROTECTA HUNGARY

DOCUMENT ID: PP-13-22089
VERSION: 1.0
2020-04-27, BUDAPEST

PROTECTION, AUTOMATION AND CONTROL FOR POWER INDUSTRY

VERSION INFORMATION

VERSION	DATE	MODIFICATION	COMPILED BY
1.0	2020-04-27	First issue	Erdős

CONTENTS

1 Introduction

The ***ASZKG*** automation device is a member of the ***EuroProt+*** product line, made by Protecta Co. Ltd. The ***EuroProt+*** type complex protection and automation devices are modular in respect of hardware and software. The modules are assembled and configured according to the requirements, and then the software determines the functions. This manual describes the specific application of the ASZKG factory configuration.

1.1 Application

The ***ASZKG*** configuration is a member the DAUT product type. The devices of this type are configured for different type of automation purposes of the electric power system. The ***ASZKG*** configuration is utilized in standard automatic generator synchronizer applications with the capability of synchronizing to two different CBs (selected by user logic).

1.1.1 Protection and automation functions

The configuration is built around one core function, see the table and figure below.

Table 1-1 The functions of the E5-ASZKG configuration

Automatic generator synchronizer					
	FAMILY				EuroProt+
	TYPE				DAUT
	CONFIGURATION				E5
HARDWARE	CT inputs				4
	VT inputs				4
	Digital inputs (max)				128
	Signaling relay outputs (max)				60
	Fast Trip outputs (max)				12
FUNCTIONALITY	Function name	IEC	ANSI	*INST.	E1
	Automatic generator synchronizer	GENSYN	25G	1	✔
	Circuit breaker control		94	1	✔
	Disconnector control				Op.
	Ethernet Links				Op.
	Voltage input				✔
	Voltage measurement				✔

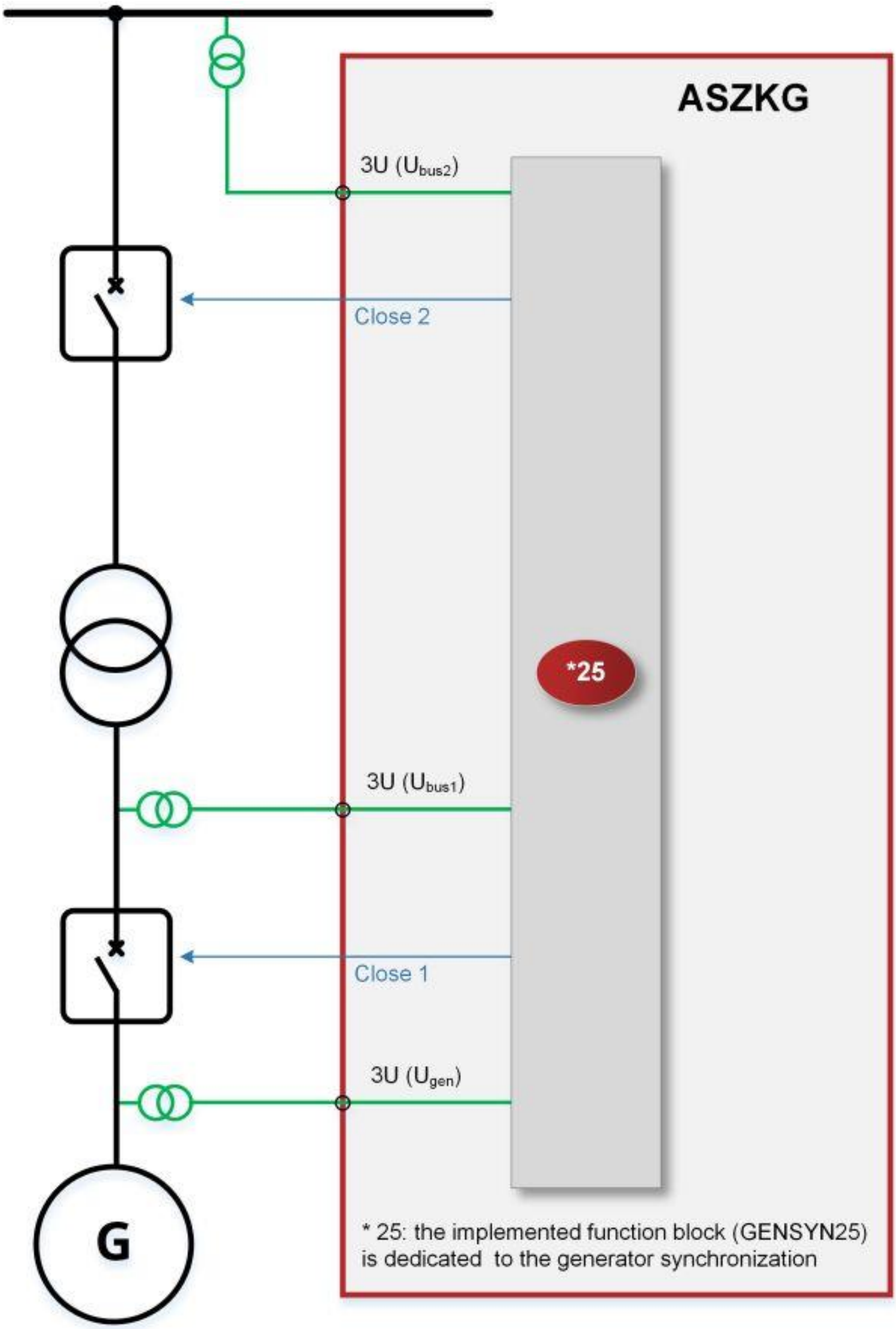


Figure 1-1 Example of the implemented automation function

1.1.2 Measurement functions

Based on the hardware inputs the measurements listed in Table below are available.

Table 1-2 The measurement functions of the E5-ASZKG configuration

MEASUREMENT FUNCTIONS	E5-ASZKG
Voltage (U12 gen, U12 bus1, U12 bus2) and frequency	X
Voltage (U1, U2, U3, U12, U23, U31, 3Uo)*	Op.

**optional 3-phase voltage measurements with calculated values for each side*

1.1.3 Hardware configuration

The minimum number of inputs and outputs are listed in the table below.

Table 1-3 The basic hardware configuration of the E5-ASZKG configuration

HARDWARE CONFIGURATION	E5-ASZKG
Mounting	Op.
Panel instrument case	X
Voltage inputs	*4
Digital inputs	12
Digital outputs	8

**if optional 3-phase voltage measuring function is chosen, then the number increases by 4 for each additional measurement*

The basic module arrangement of the E5-ASZKG configuration is shown below. (Related to 84TE rack size.)

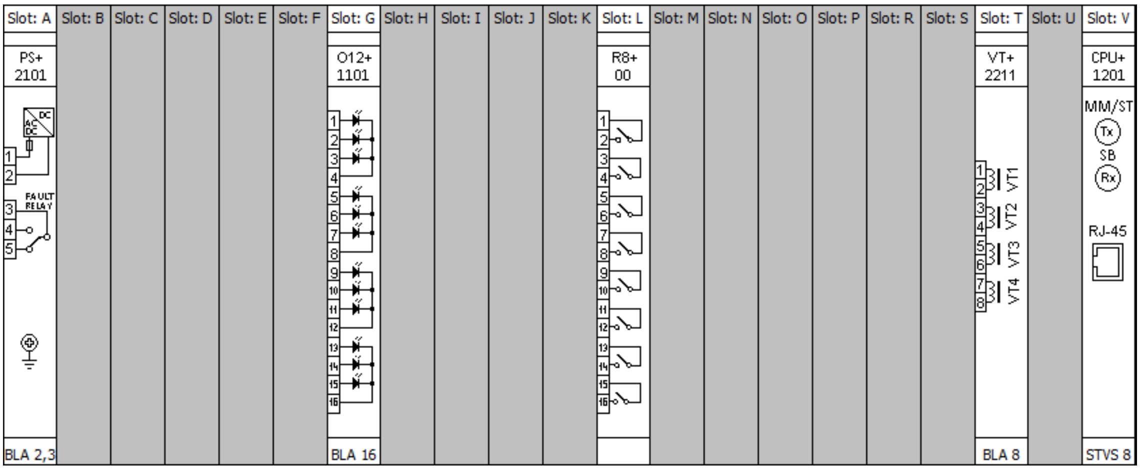


Figure 1-2 Basic module arrangement of the E5-ASZKG configuration (84TE, front and rear view)

The applied modules are listed in the table below.

The technical specification of the device and that of the modules are described in the document “***Hardware description***”.

Table 1-4 The applied modules of the E5-ASZKG configuration

MODULE IDENTIFIER	EXPLANATION
PSTP+ 2101	Power supply module with trip contacts
O12+ 1101	Binary input module
R8+ 00	Signal relay output module
VT+ 2211	Analog voltage input module
CPU+ 1201	Processing and communication module

1.2 Meeting the device

The basic information for working with the ***EuroProt+*** devices are described in the document “***Operating Manual and Troubleshooting Guide***”.

Figure 1-3 The 84TE rack of the EuroProt+ family

Figure 1-4 The 42TE rack of the EuroProt+ family

1.2.1 LED assignment

On the front panel of the device there are the user-defined LED-s with their titles on the replaceable LED description label. Some LED-s are already factory-assigned, but all are free to be defined by the user. The following tables shows the LED assignment of the E5-ASZKG configuration.

Table 1-5 The LED assignments of the E5-ASZKG configuration

LED	EXPLANATION
Ready	Synchronizer ready
InProgress	Automatic synchronizing in progress
U up	Voltage raise command
U down	Voltage lower command
Fr up	Frequency raise command
Fr down	Frequency lower command
CBClose	Synchro-switch CB Close command
	Free LED
Bus1Active	Synchronizer working to the first bus
Bus2Active	Synchronizer working to the second bus
	Free LED
	Free LED
Local	Local mode for user commands
Remote	Remote mode
Start	Manual Start command
Cancel	Manual Cancel command

2 Software configuration

2.1 On-line measurements

The measured values can be checked on the touch-screen of the device in the "On-line functions" page, or using an Internet browser of a connected computer. The displayed values are secondary currents, except the blocks "Voltage Measurement". These specific blocks display the measured values in primary units, using the VT primary value settings.

The list of measurements can be expanded with the optional 3-phase voltage measurements for each side.

The measurements are provided by several functionblocks, whose descriptions can be found in Chapter 3.

Table 2-1 The on-line measurements of the E5-ASZKG configuration

ANALOG VALUE	EXPLANATION
VT4 module (VT4)	
Voltage Ch – U1	RMS value of the Fourier fundamental harmonic voltage component in the 1st voltage channel
Angle Ch – U1	Phase angle of the Fourier fundamental harmonic voltage component in the 1st voltage channel
Voltage Ch – U2	RMS value of the Fourier fundamental harmonic voltage component in the 2nd voltage channel
Angle Ch – U2	Phase angle of the Fourier fundamental harmonic voltage component in the 2nd voltage channel
Voltage Ch – U3	RMS value of the Fourier fundamental harmonic voltage component in the 3rd voltage channel
Angle Ch – U3	Phase angle of the Fourier fundamental harmonic voltage component in the 3rd voltage channel
Voltage Ch – U4	RMS value of the Fourier fundamental harmonic voltage component in the 4th voltage channel
Angle Ch – U4	Phase angle of the Fourier fundamental harmonic voltage component in the 4th voltage channel
Synchronizer (GENSYN25)	
Voltage diff	Measured voltage difference between the generator side and the chosen bus
Frequency diff	Measured frequency difference between the generator side and the chosen bus
Angle diff	Measured angle difference between the generator side and the chosen bus
Frequency Gen measurement (MXU_F_Gen)	
Frequency Gen	Measured frequency on the generator side
Frequency Bus1 measurement (MXU_F_Bus1)	
Frequency Bus1	Measured frequency on the 1st bus side
Frequency Bus2 measurement (MXU_F_Bus2)	
Frequency Bus2	Measured frequency on the 2nd bus side
Voltage Gen measurement (MXU_V1_Gen)	

U Gen measurement	True RMS value of the L12 voltage of the generator
Voltage Bus1 measurement (MXU_V1_Bus1)	
U Bus1 measurement	True RMS value of the L12 voltage of the 1st bus
Voltage Bus2 measurement (MXU_V1_Bus2)	
U Bus2 measurement	True RMS value of the L12 voltage of the 2nd bus

2.1.1 Event recorder

The events of the device and those of the protection functions are recorded with a time stamp of 1 ms time resolution. This information with indication of the generating function can be checked on the touch-screen of the device in the “Events” page, or using an Internet browser of a connected computer.

Table 2-2 The events of the E5-ASZKG configuration

EVENT	EXPLANATION
Common	
Mode of device	Operating mode of the device
Health of device	Health state of the device
Synchronizer (GENSYN25)	
In progress	The synchronizer is in operation
CB Close	The synchronizer has issued its synchro-switch command
16Ch Event 1 (GGIO16_1)	
Start	State of the binary input of start
Cancel	State of the binary input of cancel
External Block	State of the binary input of block
Bus2 Selected	State of the binary input of indicating the usage of Bus2
Gen. VT MCB off	State of the binary input for Generator VT midget CB trip signal
Bus1 VT MCB off	State of the binary input for Bus1 VT midget CB trip signal
Bus2 VT MCB off	State of the binary input for Bus2 VT midget CB trip signal
GenSyn Ready	Synchronizer ready
Bus1_Active	Synchronizer working to the first bus
Bus2_Active	Synchronizer working to the second bus
Voltage Up	Voltage raise command
Voltage Down	Voltage lower command
Freq. Up	Frequency raise command
Freq. Down	Frequency lower command
Close Bus1	CB Close command for Bus1
Close Bus2	CB Close command for Bus2
16Ch Event 2 (GGIO16_2)	
Input01	Event channel, free programmable by the user
Input02	Event channel, free programmable by the user

Input03	Event channel, free programmable by the user
Input04	Event channel, free programmable by the user
Input05	Event channel, free programmable by the user
Input06	Event channel, free programmable by the user
Input07	Event channel, free programmable by the user
Input08	Event channel, free programmable by the user
Input09	Event channel, free programmable by the user
Input10	Event channel, free programmable by the user
Input11	Event channel, free programmable by the user
Input12	Event channel, free programmable by the user
Input13	Event channel, free programmable by the user
Input14	Event channel, free programmable by the user
Input15	Event channel, free programmable by the user
Input16	Event channel, free programmable by the user

2.1.2 Disturbance recorder

The E5-ASZKG configuration contains a disturbance recorder function. Its details are described in Chapter 3.6.

The recorded analog channels:

Table 2-3 The recorded analogue signals of the E5-ASZKG configuration

RECORDED ANALOG SIGNALS	EXPLANATION
Ugen	Measured voltage from the generator side
Ubus1	Measured voltage from bus1
Ubus2	Measured voltage from bus2

The recorded binary channels:

Table 2-4 The recorded binary signals of the E5-ASZKG configuration

RECORDED BINARY SIGNAL	EXPLANATION
Start Input	State of the binary input of start
Cancel Input	State of the binary input of cancel
Ext. Block Input	State of the binary input of block
Bus2 Sel. Input	State of the binary input of indicating the usage of Bus2
Gen. VT MCB Off	State of the binary input for Generator VT midget CB trip signal
Bus1 VT MCB Off	State of the binary input for Bus1 VT midget CB trip signal
Bus2 VT MCB Off	State of the binary input for Bus2 VT midget CB trip signal
Ready	Synchronizer ready
In Progress	Automatic synchronizing in progress
Bus1 Active	Synchronizer working to the first bus

Bus2 Active	Synchronizer working to the second bus
CB Close Signal	Synchro-switch CB Close command
U up	Voltage raise command
U down	Voltage lower command
Fr up	Frequency raise command
Fr down	Frequency lower command
Bus1 Close	CB Close command for Bus1
Bus2 Close	CB Close command for Bus2

3 Function block descriptions

3.1 Automatic Generator Synchronizer (GENSYN25)

3.1.1 Operation principle

The GENSYN25 generator synchronizer function automatically controls the procedure to connect a generator to the network. The voltage and the speed of the generator is regulated to match the voltage and the frequency of the network. During this procedure, the voltage magnitude, the frequency and the phase angle of the generator and those of the network are continuously evaluated. If the voltage and frequency difference between the network and the generator is within the defined limits, then the close command to the circuit breaker is generated in the right moment, considering the closing time of the circuit breaker, to connect the generator to the system with minimal phase angle difference.

The function is based on the SYN25 synchro-check/synchro-switch function (the description is the document "*Synchro check, synchro switch function block description*"). The applied mode is "synchro switch" mode. This function is extended with command function to increase/decrease voltage and speed of the generator. These commands are generated to meet the basic switching requirements.

The circuit breaker of the generator may be closed only if the voltages at both sides of the circuit breaker are in approximate synchronous position. This can prevent damages of the generator caused by switching at deviating voltage vectors.

The basis of the switching decision is the comparison of the voltage transformer signals at both sides of the circuit breaker.

The conditions for safe closing are as follows:

- The difference of the voltage magnitudes is below the declared limit,
- The difference of the frequencies is below the declared limit and
- The angle difference between the voltages on both sides of the circuit breaker is within the declared limit.

The voltage difference can be minimized by pulses sent to the voltage controller, the frequency (speed) difference can be minimized by pulses to the speed controller. (Both functions can be enabled by dedicated binary parameters: "U matching" and "F matching".)

The measured values are compared with the magnitude difference and frequency difference parameters: "Udiff SW Ena" and "Udiff Max" for voltage control and "FrDiff SW Ena" and "FrDiff Max" for frequency control. The function starts only if these values are within the defined broader band values. These condition can be satisfied by manual control commands, this function is not in the scope of this function. After starting, the fine tuning is performed automatically. Additionally the phase angle difference is also considered. The close command ("SW Cmd") is generated in due time, considering the operating time of the circuit breaker. To avoid the operation of the "reverse power protection" function (independent function) after closing the circuit breaker, connecting is allowed only if the speed of the generator is above the frequency of the network voltage.

3.1.1.1 Connection to the primary circuits

The function block is connected to the primary circuits as it is indicated by the figure below.

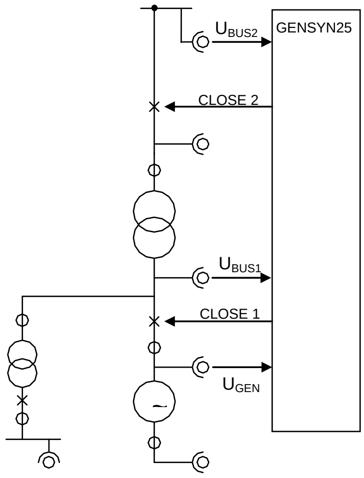


Figure 3-1 A possible connection

In this typical arrangement the synchronizing procedure can apply any of the circuit breakers: the circuit breaker at the generator voltage level or the circuit breaker at the high voltage side of the unit transformer.

If the circuit breaker at the generator voltage level is applied then the generator voltage is compared to the signal of the U_{BUS1} voltage transformer, in the second case it is compared to the signal of the U_{BUS2} voltage transformer.

The signal connected to the “BusSel” binary input of the function block indicates which option is applied. When connecting a logic TRUE signal, the U_{BUS2} measurement gets active. When this input signal is logic FALSE then U_{BUS1} measurement is active. The selected option is indicated by the output binary signals “Bus1Act” or “Bus2Act” of the function block. The function block has a single close command only: “SWCmd”. It is the task of the graphic logic editor function to direct this close command to the appropriate circuit breaker.

The turn’s ratio of the voltage transformers Bus1 and Bus2 need not be identical to that of the U_{GEN} voltage transformer. Additionally, in case of Bus2, the turn’s ratio of the unit transformer need also be considered. To cover all possibilities, for the Bus1 and Bus2 measurements the function block provides correction parameters to match the voltages to the generator side voltage. These independent parameters are “TR1 AmplCorr” and “TR2 AmplCorr” factors respectively.

The single line diagram of above shows that the Bus2 voltage can be phase shifted due to the connection group of the unit transformer. To compensate this phase shift, the parameters “TR1 phase shift” and “TR2 phase shift” should be set according to the connection group of the transformer. Positive angles mean that the generator voltage leads the bus voltage. As an example, in case of Yd11 connection group, if both voltage measurements are in the same phase then the correct parameter setting is 30 degrees.

3.1.1.2 Connecting to the VT4 voltage input

Due to the frequency measurement restrictions of the VT4 voltage input block, the generator voltage is connected to U1, Bus1 is connected to U2 and Bus2 is connected to U4 analog inputs. In the vector diagrams displayed, the reference voltage (that with fix phase angle zero degrees) is always U1. At synchronizing, the generator voltage should be always available.

3.1.1.3 Starting the sychronizing procedure

The synchronizing procedure is triggered by the binary signal connected to the “Start” input of the function block. This is to be arranged in the graphic logic editor. The conditions for starting are as follows:

- the function is not blocked (“Blk” binary input gets logic FALSE signal),
- there is no disabling signal received from the voltage transformer supervising miniature circuit breakers (“VTSGen”, “2VTSBus1” and “VTSBus2” binary inputs of the function block). (Only the active side of Bus1 or Bus2 measurements is considered.)
- both generator voltage and network voltage are above the “Umin” parameter setting limit.
- the voltage difference is below the level set by parameter “UDiff max” and
- the frequency difference is below the level set by parameter “FrDiff max”.

The possibility to start the function is indicated by the binary output „Ready” of the function block.

Closing the circuit breaker is possible only if the voltage difference is below the narrower “UDiff. eng.” limit and the frequency difference is below the narrower “FrDiff. eng.” level. Additionally, the frequency of the generator should be 40 mHz higher than that of the network.

The started state is indicated by the “InProgr” binary output of the function block. This state is terminated at Close command generation, or at timeout of the “TimeOut” timer, or at the moment when the “Cancel” binary input of the function block gets a logic TRUE signal.

3.1.1.4 Controlling the frequency and the voltage magnitude

The controlling of the voltage and frequency can be disabled individually by dedicated binary parameter setting (“UMatching” and “FMatching” respectively). If any of them is not enabled then the related “…Max” and “…SWEna” values should be set to the same value.

After starting the function block, the frequency difference and the voltage difference is controlled to get within the rage defined by parameters “FrDiff. SWEna” and “UDiff. SWEna” respectively. This state enables close command generation.

The first figure below shows the limits for frequency difference, the second shows the limits for voltage difference. The broader limits indicate when the synchronization procedure can be started, the narrower range enables close command generation for the circuit breaker.

Startings is possible if the frequency difference is between “FrDiff Max”. and “-FrDiff Max”. To reach this state, manual control is expected, this function is not in the scope of this function.

The close command can be generated if the frequency difference is below the level “FrDiff. SWEna” and additionally the frequency of the generator is at least 40 mHz higher than that of the network. The expected value of the automatic frequency control is the center of the frequency range: (FrDiff. SWEna + 40mHz)/2.

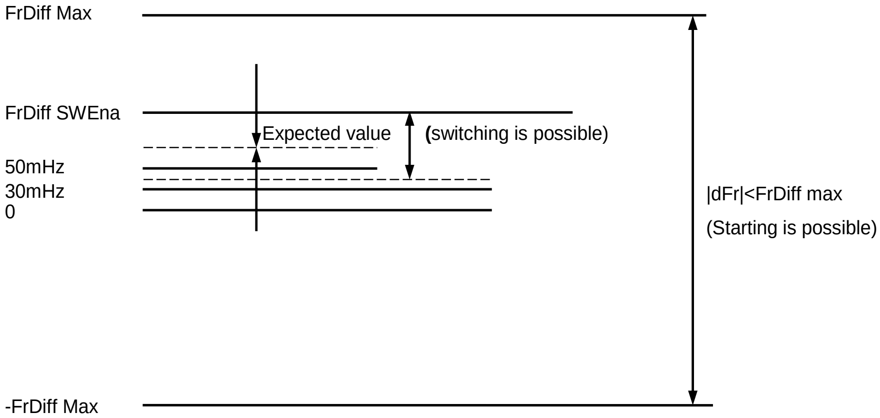


Figure 3-2 Frequency control

The next figure below shows the limits for the voltage control.

The automatic control function can be started if the voltage difference is within the range “UDiff Max” and –“UDiff Max”, and additionally both voltages are above the limit, defined by parameter “U min”. To reach this state, manual control is expected.

The close command can be generated if the voltage difference is within the range “UDiff. SWEna” and –“UDiff. SWEna” . The expected value of the automatic voltage control is the zero voltage difference.

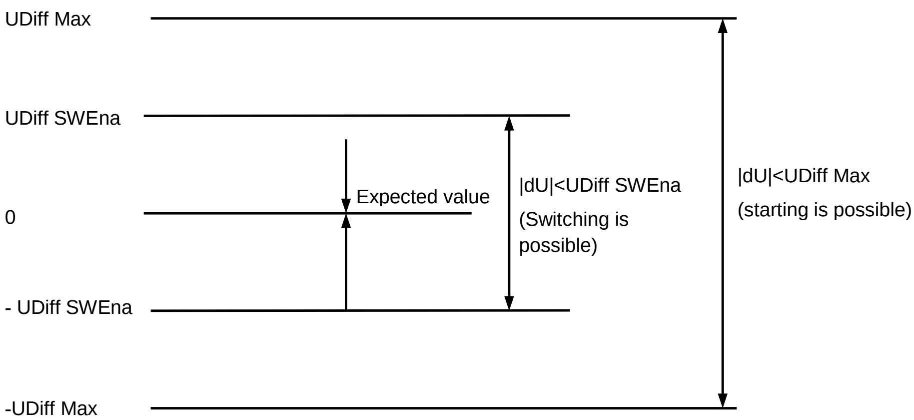


Figure 3-3 Voltage control

After starting, the control of the voltage and the frequency is performed by pulses. For voltage control, the duration of the pulse is related to the voltage difference by the setting value “dt/dU factor”. This factor is expressed in [ms/%]. This means that each percent of changing the voltage needs a pulse with duration of the numerical value in milliseconds.

In case of perfect setting, a single pulse results the expected voltage value. To avoid swings however, it is advised to approximate this value by smaller steps during the first commissioning, The duration of the generated pulses can be limited from both sides, using the parameters “UImp min” and “UImp max”. If the controlling pulse is transmitted via auxiliary relays then the minimal pulse duration should be set to allow operation of these auxiliary relays.

Controlling the frequency (speed) is also performed by pulses. The duration of the pulse is related to the frequency difference by the setting value “dt/df factor”. This factor is expressed in [ms/Hz]. This means that 1 Hz of changing the frequency needs a pulse with duration of the numerical value in milliseconds. In case of perfect setting, a single pulse results the expected frequency value. To avoid swings however it is advised to approximate this value from lower steps during the first commissioning. The duration of the generated pulses can be limited from both sides, using the parameters “FImp min” and “FImp max”. If the controlling pulse is transmitted via auxiliary relays then the minimal pulse duration should be set to allow operation of these auxiliary relays.

The effect of the pulses is not the immediate change of the voltage or frequency. To leave time to stabilize the final value, at the end of the longer pulse (frequency or voltage changing command) a timer is started with setting ”Stabilization time”. If it is needed, the subsequent control pulse is generated only after expiry of this time.

3.1.1.5 Connecting the generator parallel to the network

Based on the detected frequency difference and the circuit breaker operated time (defined as parameter “Breaker Time”), the phase angle can be calculated. If the close command is generated at that phase angle, then the circuit breaker will close at synchronous position. The algorithm generates the close command, if the angle difference is decreasing and it is at the calculated value. If at the moment of starting the angle is below the calculated value, then the command is generated at the subsequent revolution only.

3.1.2 Automatic Generator Synchronizer function overview

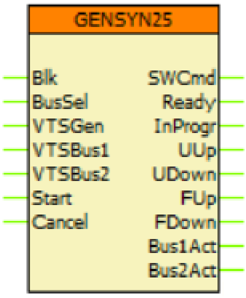


Figure 3-4 Graphic appearance of the function block of the automatic generator synchronizer function

3.1.2.1 Settings

3.1.2.1.1 Parameters

Table 3-1 Parameters of the automatic generator synchronizer function

TITLE	DIM	RANGE	STEP	DEFAULT	EXPLANATION
Operation	-	Off, On	-	Off	Mode of operation
U min	%	60 – 110	1	70	Voltage minimum, needed for synchronizing
TR1 phase shift	deg	-180 – 180	1	0	Phase shift at Bus1
TR2 phase shift	deg	-180 – 180	1	0	Phase shift at Bus2
TR1 AmplCorr	-	0.500 – 2.000	0.001	1.000	Voltage correction factor for Bus1 measurement
TR2 AmplCorr	-	0.500 – 2.000	0.001	1.000	Voltage correction factor for Bus2 measurement
TimeOut	sec	10 – 600	1	30	Timeout for switching
Stabilization time	sec	1 – 300	1	5	Stabilization time after control command generation
Breaker Time	msec	30 – 500	1	80	Circuit breaker operating time for closing
Close Pulse	msec	10 – 60000	1	1000	Pulse command duration
U matching	-	FALSE, TRUE	-	TRUE	Voltage control selection. “0” means that no voltage control is applied.
dt/dU factor	ms/%	100 –10000	1	200	Slope of voltage control
Udiff SWEna	%	2 – 20	1	10	Maximum voltage difference for switching
Udiff Max	%	5 – 30	1	10	Maximum voltage difference for starting
Uimp min	msec	100 – 30000	1	500	Minimum duration of voltage control command
Uimp max	msec	100 – 30000	1	10000	Maximum duration of voltage control command
F matching	-	FALSE, TRUE	-	TRUE	Frequency control selection. “0” means that no frequency control is applied
dt/df factor	ms/Hz	100 – 60000	1	200	Slope of frequency control
FrDiff SWEna	Hz	0.10 – 1.00	0.01	0.20	Maximum frequency difference for switching
FDiff Max	Hz	0.10 – 5.00	0.01	2.00	Maximum frequency difference for starting
Fimp min	msec	100 – 30000	1	500	Minimum duration of frequency control command
Fimp max	msec	100 – 30000	1	10000	Maximum duration of frequency control command

3.1.2.2 Function I/O

3.1.2.2.1 Parameters

This section describes briefly the analogue and digital inputs and outputs of the function block.

3.1.2.2.2 Analog input signals

The analogue inputs of the measurement functions are

- the Fourier components of the three measured voltages

3.1.2.2.3 Analog output signals (measurements)

The analogue measurements of the measurement functions are

- The difference of the voltage magnitudes
- The difference of the frequencies
- The angle difference between the voltages

All differences are measured between the Generator side and one of the Bus sides.

3.1.2.2.4 Binary input signals (graphed output statuses)

The conditions of the inputs are defined by the user, applying the graphic equation editor (logic editor). The part written in **bold** is seen on the function block in the logic editor.

BINARY INPUT SIGNAL	EXPLANATION
SYN25_**Blk**_GrO_	Blocking signal of the function
SYN25_**BusSel**_GrO_	If this signal is logic TRUE, then the voltage of Bus2 is selected for evaluation
SYN25_**VTSGen**_GrO_	Blocking signal of the voltage transformer supervision function evaluating the generator voltage
SYN25_**VTSBus1**_GrO_	Blocking signal of the voltage transformer supervision function evaluating the Bus1 voltage
SYN25_**VTSBus2**_GrO_	Blocking signal of the voltage transformer supervision function evaluating the Bus2 voltage
SYN25_**Start**_GrO_	Start signal initiating the synchronization procedure
SYN25_**Cancel**_GrO_	Signal to interrupt (cancel) the synchronization procedure

Table 3-2 The binary input signals of the automatic generator synchronizer function

3.1.2.2.5 Binary output signals (graphed input statuses)

The binary output status signals of the differential protection function. Parts written in **bold** are seen on the function block in the logic editor.

BINARY OUTPUT SIGNAL	SIGNAL TITLE	EXPLANATION
SYN25_**SWCmd**_Grl_	Syn Cmd	Close command for the circuit breaker, generated in due time before synchron position of the voltage vectors
SYN25_**Ready**_Grl_	Ready	The function can be started
SYN25_**InProgr**_Grl_	InProgr	Synchronization in progress
SYN25_**UUp**_Grl_	U Up	Pulse for increasing the voltage
SYN25_**UDown**_Grl_	U Down	Pulse for decreasing the voltage
SYN25_**FUp**_Grl_	F Up	Pulse for increasing the frequency
SYN25_**FDown**_Grl_	F Down	Pulse for decreasing the frequency
SYN25_**Bus1Act**_Grl_	Bus1 Active	Active measurements at Bus1
SYN25_**Bus2Act**_Grl_	Bus2 Active	Active measurements at Bus2

Table 3-3 The binary output signals of the automatic generator synchronizer function

3.1.2.2.6 On-line data

Visible values on the on-line data page:

SIGNAL TITLE	DIMENSION	EXPLANATION
Voltage Diff	%	Difference of the voltage magnitudes
Frequency Diff	Hz	Difference of the frequencies
Angle Diff	deg	Angle difference between the voltages
Syn Cmd	-	Close command for the circuit breaker, generated in due time before synchron position of the voltage vectors
Ready	-	The function can be started
InProgr	-	Synchronization in progress
U Up	-	Pulse for increasing the voltage
U Down	-	Pulse for decreasing the voltage
F Up	-	Pulse for increasing the frequency
F Down	-	Pulse for decreasing the frequency
Bus1 Active	-	Active measurements at Bus1
Bus2 Active	-	Active measurements at Bus2

Table 3-4 On-line data of the automatic generator synchronizer function

3.1.2.2.7 Events

The following events are generated in the event list, as well as sent to SCADA according to the configuration.

EVENT	VALUE	EXPLANATION
In progress	Off, On	The synchronizer is in operation
CB Close	Off, On	The synchronizer has issued its synchro-switch command

Table 3-5 Events of the automatic generator synchronizer function

3.1.2.3 Technical data

Table 3-6 Technical data of the generator synchronizer function

FUNCTION	VALUE	ACCURACY
Rated Voltage Un	100/200V, parameter setting	
Voltage effective range	10-110 % of Un	±1% of Un
Frequency	47.5 – 52.5 Hz	±10 mHz
Phase angle		±3 °
Operate time	Setting value	±3 ms

3.2 Circuit breaker control function block (CB1Pol)

3.2.1 Operation principle

The circuit breaker control block can be used to integrate the circuit breaker control of the EuroProt+ device into the station control system and to apply active scheme screens of the local LCD of the device.

3.2.1.1 Mode of operation

The circuit breaker control block receives remote commands from the SCADA system and local commands from the local LCD of the device, performs the prescribed checking and transmits the commands to the circuit breaker. It processes the status signals received from the circuit breaker and offers them to the status display of the local LCD and to the SCADA system.

Main features:

- Local (LCD of the device) and Remote (SCADA) operation modes can be enabled or disabled individually.
- The signals and commands of the synchro-check / synchro-switch function block can be integrated into the operation of the function block.
- Interlocking functions can be programmed by the user applying the inputs “EnaOff” and “EnaOn”, using the graphic equation editor.
- Programmed conditions can be used to temporarily disable the operation of the function block using the graphic equation editor.
- The function block supports the control models prescribed by the IEC 61850 standard.
- All necessary timing tasks are performed within the function block:
    - Time limitation to execute a command
    - Command pulse duration
    - Filtering the intermediate state of the circuit breaker
    - Checking the synchro-check and synchro-switch times
    - Controlling the individual steps of the manual commands
- Sending trip and close commands to the circuit breaker (to be combined with the trip commands of the protection functions and with the close command of the automatic reclosing function; the protection functions and the automatic reclosing function directly gives commands to the CB). The combination is made graphically using the graphic equation editor
- Operation counter
- Event reporting

3.2.2 Circuit Breaker control function overview

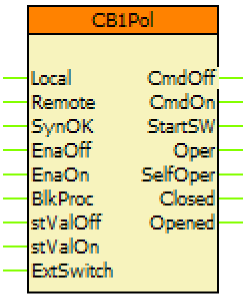


Figure 3-5 Graphic appearance of the function block of the circuit breaker control function

3.2.2.1 Settings

3.2.2.1.1 Parameters

Table 3-7 Parameters of the circuit breaker control function

TITLE	DIM	RANGE	STEP	DEFAULT	EXPLANATION
ControlModel	-	Direct normal, Direct enhanced, SBO enhanced	-	Direct normal	The control model of the circuit breaker node according to the IEC 61850 standard
Forced Check	-	FALSE, TRUE	-	TRUE	If true, then the check function cannot be neglected by the check attribute defined by the IEC 61850 standard
Max Operating Time	ms	10 – 1000	1	200	When either enhanced control model is selected, the status of the CB must change within this time after the issued command. At timeout an invalid-position error will be generated for the client.
Pulse Duration	ms	50 – 1000	1	300	Duration of the generated On and Off impulse*
Max Intermediate Time	ms	20 – 500	1	100	Waiting time for status signals, at expiry the CB is reported to be in intermediate state
Max SynCheck Time	ms	10 – 5000	1	1000	Length of the time period to wait for the conditions of the synchronous state. After expiry of this time, the synchro-switch procedure is initiated (see synchro-check/ synchro-switch function block description)
Max SynSW Time**	ms	0 – 60000	1	0	Length of the time period to wait for the synchro-switch impulse (see synchro-check/ synchro-switch function block description). After this time the function resets, no switching is performed
SBO Timeout	ms	1000 – 20000	1	5000	Duration of the waiting time between object selection and command selection. At timeout no command is performed

** If the input status signals (stValOff, stValOn) indicate the successful switching then the pulse is withdrawn, but the minimum duration is 100 ms (factory setting).*
*** If this parameter is set to 0, then the “StartSW” output is not activated*

3.2.2.2 Function I/O

This section describes briefly the analogue and digital inputs and outputs of the function block.

3.2.2.2.1 Binary input signals (graphed output statuses)

The conditions of the inputs are defined by the user, applying the graphic equation editor (logic editor). The part written in **bold** is seen on the function block in the logic editor.

Table 3-8 The binary input signals of the circuit breaker control function

BINARY INPUT SIGNAL	EXPLANATION
CB1Pol_**Local**_GrO_	If this input is active, the circuit breaker can be controlled using the local LCD of the device.
CB1Pol_**Remote**_GrO_	If this input is active, the circuit breaker can be controlled via remote communication channels of the SCADA system or the device web page ('commands' menu)
CB1Pol_**SynOK**_GrO_	This input indicates if the synchronous state of the voltage vectors at both sides of the circuit breaker enables the closing command. This signal is usually generated by the synchro check/ synchro switch function. If this function is not available, set the input to logic true.
CB1Pol_**EnaOff**_GrO_	The active state of this input enables the opening of the circuit breaker. The state is usually generated by the *interlocking conditions defined graphically by the user*.
CB1Pol_**EnaOn**_GrO_	The active state of this input enables the closing of the circuit breaker. The state is usually generated by the *interlocking conditions defined graphically by the user*.
CB1Pol_**BlkProc**_GrO_	The active state of this input blocks the operation of the circuit breaker. The conditions are defined graphically by the user.
CB1Pol_**stValOff**_GrO_	Off (Opened) state of the circuit breaker.
CB1Pol_**stValOn**_GrO_	On (Closed) state of the circuit breaker.
CB1Pol_**ExtSwitch**_GrO_	This signal is considered only when evaluating unintended operation (see "SelfOper" output in Chapter 3.2.2.2.2). It indicates that an external command has been issued to the circuit breaker (e.g. trip request from other protection device or external on/off command is given).

3.2.2.2.2 Binary output signals (graphed input statuses)

The binary output status signals of the differential protection function. Parts written in **bold** are seen on the function block in the logic editor.

Table 3-9 The binary output signals of the circuit breaker control function

BINARY OUTPUT SIGNAL	SIGNAL TITLE	EXPLANATION
CB1Pol_**CmdOff**_Grl_	Off Command	Off command impulse, the duration of which is defined by the parameter “Pulse duration”
CB1Pol_**CmdOn**_Grl_	On Command	On command impulse, the duration of which is defined by the parameter “Pulse duration”
CB1Pol_**StartSW**_Grl_	Start Synchro-switch	If the synchro check/synchro switch function is applied and the synchronous state conditions are not valid for the time defined by the parameter “Max.SynChk time”, then this output triggers the synchro switch function (see synchro-check/ synchro-switch function block description).
CB1Pol_**Oper**_Grl_	Operation	An impulse with a duration of 150 ms at any operation of the circuit breaker
CB1Pol_**SelfOper**_Grl_	Unintended Operation	This output is logic true if the status of the circuit breaker has changed without detected command from the SCADA system or on the input “ExtSwitch”
CB1Pol_**Closed**_Grl_	Closed	The filtered status signal for closed state of the circuit breaker
CB1Pol_**Opened**_Grl_	Opened	The filtered status signal for opened state of the circuit breaker

3.2.2.2.3 On-line data

Visible values on the on-line data page:

Table 3-10 On-line data of the circuit breaker control function

SIGNAL TITLE	DIMENSION	EXPLANATION
Status	-	State of the CB (see Chapter 3.2.2.2.6)
Off Command	-	Off command impulse, the duration of which is defined by the parameter “Pulse duration”
On Command	-	On command impulse, the duration of which is defined by the parameter “Pulse duration”
Operation	-	An impulse with a duration of 150 ms at any operation of the circuit breaker
Unintended Operation	-	This output is logic TRUE if the status of the circuit breaker has changed without detected command from the SCADA system or on the input “ExtSwitch”
Opened	-	The filtered status signal for opened state of the circuit breaker
Closed	-	The filtered status signal for closed state of the circuit breaker
Operation counter	-	Resettable* counter that increments every time the Operation (see above) output gets active

**The operation counter can be reset on the device web page on-line menu.*

3.2.2.2.4 Events

The following events are generated in the event list, as well as sent to SCADA according to the configuration.

Table 3-11 Event of the circuit breaker control function

EVENT	VALUE	EXPLANATION
Status	Intermediate,Off,On,Bad	CB state indication based on the received signals

3.2.2.2.5 Commands

The following table contains the issuable commands of the function block. The name of the command channel is used while working in the EuroCAP configuration tool, whereas the title is seen by the user on the device web page.

Table 3-12 The command of the circuit breaker control function

COMMAND CHANNEL	TITLE	RANGE	EXPLANATION
CB1Pol_Oper_Con_	Operation	Off,On	Issue open (off) or close (on) command on the corresponding outputs of the function block

3.2.2.2.6 Indication of the four states (Intermediate, On, Off, Bad)

To generate an active scheme on the local LCD, there is an internal status variable indicating the state of the circuit breaker. Different graphic symbols can be assigned to the values, the function block's events are generated also according to this status variable.

This integer status has four values based on the states of the **stValOn** and **stValOff** inputs of the function block.

Table 3-13 State signals from the circuit breaker control function

INTEGER STATUS	TITLE	STVALON STATE	STVALOFF STATE	VALUE	EXPLANATION
CB1Pol_stVal_ISt_	Status	**FALSE**	**FALSE**	0: Intermediate	Integer status signal for indicating the state of the CB according to the corresponding inputs of the function block
CB1Pol_stVal_ISt_	Status	**FALSE**	**TRUE**	1: Off	Integer status signal for indicating the state of the CB according to the corresponding inputs of the function block
CB1Pol_stVal_ISt_	Status	**TRUE**	**FALSE**	2: On	Integer status signal for indicating the state of the CB according to the corresponding inputs of the function block
CB1Pol_stVal_ISt_	Status	**TRUE**	**TRUE**	3: Bad	Integer status signal for indicating the state of the CB according to the corresponding inputs of the function block

3.2.2.3 Technical data

Table 3-14 The technical data of the circuit breaker control function

FUNCTION	VALUE	ACCURACY
Pulse time		< 3 ms

3.2.2.3.1 Notes for testing

If the commands get blocked from time to time during commissioning, it is advised to check how the conditions are fulfilled to issue commands on the function block. The following **three** conditions must be fulfilled at the same time:

- Local or Remote input is active appropriately
- The enabling input (EnaOff or EnaOn) of the issued command (off or on) is active
- (close/on command only) Synchro-check is OK (SynOK input is active)

If there are no conditions to be defined for any of these three (e.g. there is no synchro-check function present, so no valid signal can be provided to that input), the corresponding input can be connected to constant logical TRUE signal provided by the fixture output of the Common function block.

3.2.2.3.2 IEC 61850 commands

In several configurations the Interlocking and Control logical nodes may have the same prefix for CB and DC function blocks (**INT**CILO# and **SBw**CSWI# respectively where the '#' marks the instance number). This means that their instance number not necessarily corresponds to the actual function block:

- Example: if there are **2** DC and **1** CB function blocks in the same configuration where the former ones were added first, the instance number **#1** and **#2** will belong to the DC function blocks whereas number **#3** will belong to the CB function block even if it is the only CB control function in the device.
- Make sure to check which logical nodes belong to which function by checking the DOI description using the EuroCAP tool (right click the function block in the Logic editor)

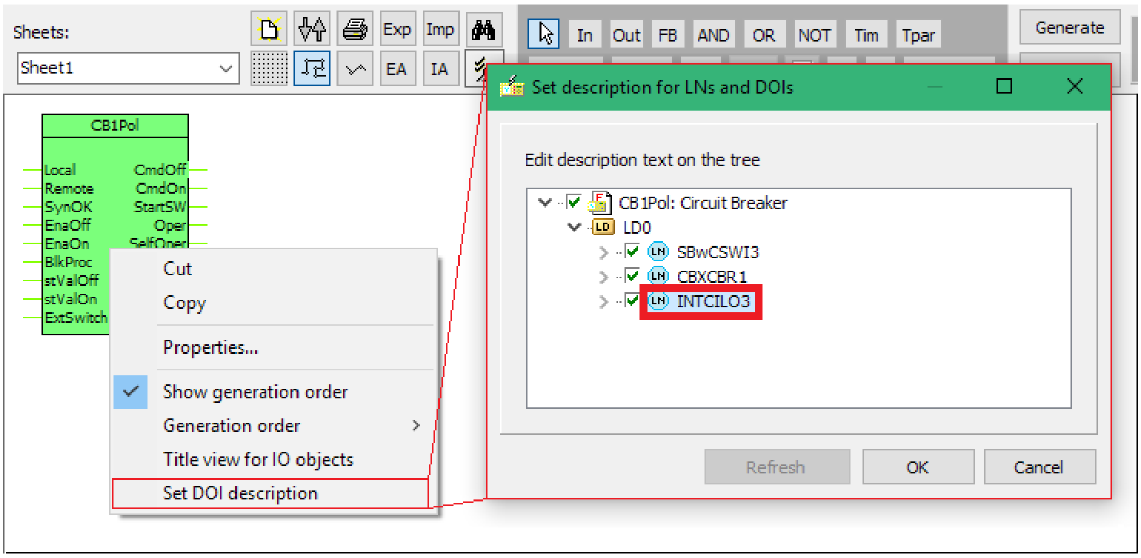


Figure 3-6 Checking the description of the Interlocking LN of the function block

In other cases, the two prefixes are given according to the type of the function block, so they are individual for each (i.e. **CBCILO#** and **CBCSW#** for circuit breaker and **DCCILO#** and **DCCSW#** for disconnector).

3.3 Four-Channel control function block (Con4Ch)

3.3.1 Operation principle

In many applications there is a need to generate commands (binary signals),

- which can influence either the behavior of the protection functions already configured in the device,
- or these commands can be transmitted to the primary system.

The four channel control block provides four channels,

- the signals of which can be generated by the user,
- the effect of these commands can be assigned to “any“ functionality, provided by the device configuration.

3.3.1.1 Mode of operation

If a “four channel control block” (Con4Ch) is involved in the configuration then the device can receive commands

- From the local front-panel touch-screen of the device, (in Local mode of operation).
- From the computer screen connected to the same Ethernet network, (in Remote mode of operation).
- Via SCADA system, if it is configured (in Remote mode of operation).

NOTE1: Depending on the factory configuration, some of these possibilities can be missing.

NOTE2: The Remote/Local toggling is described in the Manual of the “Common” function block.

If the four channel control block is applied then the “Commands” menu of the device (on the computer screen connected to the Ethernet network) includes the “Off” and “On” buttons. This is shown on the figure below.

Figure 3-7 Default command labels of the four-channel control function

Using this command possibility means that clicking either button generates a command pulse of duration according to parameter setting is available in the logic functionality of the device. It means that the user can assign these pulses to any functionality available in the device. The command assignment is performed using the EuroCAP configuration tool. This means that the outputs of this function block can be connected graphically to several signals as a source.

At the same time the four-channel control block provides inputs the changes of which are recorded in the event log with a time stamp of 1 ms time resolution.

3.3.2 Four-Channel Control function overview

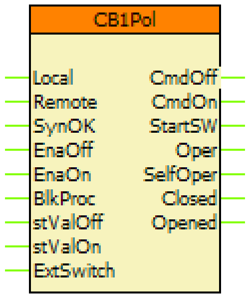


Figure 3-8 Graphic appearance of the function block of the four-channel control function

3.3.2.1 Settings

3.3.2.1.1 Parameters

Table 3-15 Parameters of the four-channel control function

TITLE	DIM	RANGE	STEP	DEFAULT	EXPLANATION
Pulse Duration	ms	50 – 2000	1	100	Duration of the generated On and Off impulse*

** If the input status signals (stValOff, stValOn) indicate the successful switching then the pulse is withdrawn, but the minimum duration is 100 ms (factory setting).*

3.3.2.2 Function I/O

This section describes briefly the analogue and digital inputs and outputs of the function block.

3.3.2.2.1 Binary input signals (graphed output statuses)

The conditions of the inputs are defined by the user, applying the graphic equation editor (logic editor). The part written in **bold** is seen on the function block in the logic editor.

Table 3-16 The binary input signals of the four-channel control function

BINARY INPUT SIGNAL	EXPLANATION
Con4Ch_**Local**_GrO_	Input for indication the local control mode. In this mode the local LCD is active to receive commands
Con4Ch_**Remote**_GrO_	Input for indication the remote control mode. In this mode commands can be generated from a computer Connected to the Ethernet network or via SCADA system
Con4Ch_**stValOn1**_GrO_	Input signal No.1; the changes can be recorded as an event*
Con4Ch_**stValOn2**_GrO_	Input signal No.2; the changes can be recorded as an event*
Con4Ch_**stValOn3**_GrO_	Input signal No.3; the changes can be recorded as an event*
Con4Ch_**stValOn4**_GrO_	Input signal No.4; the changes can be recorded as an event*

**by default, changing the state of these inputs do not result in an event. If this is required, contact Protecta Support first*

3.3.2.2.2 Binary output signals (graphed input statuses)

The binary output status signals of the differential protection function. Parts written in **bold** are seen on the function block in the logic editor.

Table 3-17 The binary output signals of the four-channel control function

BINARY OUTPUT SIGNAL	SIGNAL TITLE	EXPLANATION
CB1Pol_**CmdOff1**_Grl_	Off Command Ch1	Off command pulse of channel 1
CB1Pol_**CmdOn1**_Grl_	On Command Ch1	On command pulse of channel 1
CB1Pol_**CmdOff2**_Grl_	Off Command Ch2	Off command pulse of channel 2
CB1Pol_**CmdOn2**_Grl_	On Command Ch2	On command pulse of channel 2
CB1Pol_**CmdOff3**_Grl_	Off Command Ch3	Off command pulse of channel 3
CB1Pol_**CmdOn3**_Grl_	On Command Ch3	On command pulse of channel 3
CB1Pol_**CmdOff4**_Grl_	Off Command Ch4	Off command pulse of channel 4
CB1Pol_**CmdOn4**_Grl_	On Command Ch4	On command pulse of channel 4

3.3.2.2.3 On-line data

Visible values on the on-line data page:

Table 3-18 On-line data of the four-channel control function

SIGNAL TITLE	DIMENSION	EXPLANATION
Off Command Ch1	-	Off command pulse of channel 1
On Command Ch1	-	On command pulse of channel 1
Off Command Ch2	-	Off command pulse of channel 2
On Command Ch2	-	On command pulse of channel 2
Off Command Ch3	-	Off command pulse of channel 3
On Command Ch3	-	On command pulse of channel 3
Off Command Ch4	-	Off command pulse of channel 4
On Command Ch4	-	On command pulse of channel 4

3.3.2.2.4 Events

The following events are generated in the event list, as well as sent to SCADA according to the configuration, if they are switched to be generated. Note: this can be made by Protecta personnel only.

Table 3-19 Event of the four-channel control function

EVENT	VALUE	EXPLANATION
Status Ch1	Off,On	Indication of an issued command in Ch1
Status Ch2	Off,On	Indication of an issued command in Ch2
Status Ch3	Off,On	Indication of an issued command in Ch3
Status Ch4	Off,On	Indication of an issued command in Ch4

3.3.2.2.5 Commands

The following table contains the issuable commands of the function block. The name of the command channel is used while working in the EuroCAP configuration tool, whereas the title is seen by the user on the device web page.

Table 3-20 The commands of the four-channel control function

COMMAND CHANNEL	TITLE	RANGE	EXPLANATION
Con4Ch_Oper1_Con_	Operation	Off,On	Issue off or on command on the corresponding outputs of the function block
Con4Ch_Oper2_Con_	Operation	Off,On	Issue off or on command on the corresponding outputs of the function block
Con4Ch_Oper3_Con_	Operation	Off,On	Issue off or on command on the corresponding outputs of the function block
Con4Ch_Oper4_Con_	Operation	Off,On	Issue off or on command on the corresponding outputs of the function block

3.4 Voltage input function (VT4)

3.4.1 Operation principle

If the factory configuration includes a voltage transformer hardware module, the voltage input function block is automatically configured among the software function blocks. Separate voltage input function blocks are assigned to each voltage transformer hardware module.

A voltage transformer hardware module is equipped with four special intermediate voltage transformers. (See Chapter 6 of the EuroProt+ hardware description document.) As usual, the first three voltage inputs receive the three phase voltages (UL1, UL2, UL3), the fourth input is reserved for zero sequence voltage or for a voltage from the other side of the circuit breaker for synchron switching. All inputs have a common parameter for type selection: 100V or 200V.

Additionally, there is a correction factor available if the rated secondary voltage of the main voltage transformer (e.g. 110V) does not match the rated input of the device.

The role of the voltage input function block is to

- set the required parameters associated to the voltage inputs,
- deliver the sampled voltage values for disturbance recording,
- perform the basic calculations
    - Fourier basic harmonic magnitude and angle,
    - True RMS value;
- provide the pre-calculated voltage values to the subsequent software modules,
- deliver the calculated basic Fourier component values for on-line displaying.

3.4.1.1 Mode of operation

The voltage input function block receives the sampled voltage values from the internal operating system. The scaling (even hardware scaling) depends on parameter setting. See the parameter “Range”. The options to choose from are 100V or 200V, no hardware modification is needed. This parameter influences the internal number format and, naturally, accuracy. (A small voltage is processed with finer resolution if 100V is selected.)

The connection of the first three VT secondary windings must be set to reflect actual physical connection of the main VTs. The associated parameter is “Connection U1-3”. The selection can be: Ph-N, Ph-Ph or Ph-N-Isolated.

The Ph-N option is applied in solidly grounded networks, where the measured phase voltage is never above 1.5-Un. In this case the primary rated voltage of the VT must be the value of the rated PHASE-TO-NEUTRAL voltage.

The Ph-N-Isolated option is applied in compensated or isolated networks, where the measured phase voltage can be above 1.5-Un even in normal operation. In this case the primary rated voltage of the VT must be the value of the rated PHASE-TO-PHASE voltage.

If phase-to-phase voltage is connected to the VT input of the device, then the Ph-Ph option is to be selected. Here, the primary rated voltage of the VT must be the value of the rated PHASE-TO-PHASE voltage. This option must not be selected if the distance protection function is supplied from the VT input.

The fourth input is reserved for zero sequence voltage or for a voltage from the other side of the circuit breaker for synchro-switching. Accordingly, the connected voltage must be identified with parameter setting “Connection U4”. Here, phase-to-neutral or phase-to-phase voltage can be selected: Ph-N,Ph-Ph

If needed, the phase voltages can be inverted by setting the parameter ”Direction U1-3”. This selection applies to each of the channels UL1, UL2 and UL3. The fourth voltage channel can be inverted by setting the parameter “Direction U4”. This inversion may be needed in protection functions such as distance protection or for any functions with directional decision, or for checking the voltage vector positions.

Additionally, there is a correction factor available if the rated secondary voltage of the main voltage transformer (e.g. 110V) does not match the rated input of the device. The related parameter is “VT correction”. As an example: if the rated secondary voltage of the main voltage transformer is 110V, then select Type 100 for the parameter “Range” and the required value to set here is 110%.

These modified sampled values are available for further processing and for disturbance recording.

The performed basic calculation results the Fourier basic harmonic magnitude and angle and the true RMS value of the voltages. These results are processed by subsequent protection function blocks and they are available for on-line displaying as well.

The function block also provides parameters for setting the primary rated voltages of the main voltage transformer. This function block does not need that parameter setting. These values are passed on to function blocks such as displaying primary measured values, primary power calculation, etc. Concerning the rated voltage, see the instructions related to the parameter for the connection of the first three VT secondary winding.

3.4.2 Voltage input function overview

3.4.2.1 Settings

3.4.2.1.1 Parameters

Table 3-21 Parameters of the voltage input function

TITLE	DIM	RANGE	STEP	DEFAULT	EXPLANATION
Range	-	Type 100, Type 200	-	Type 100	Rated secondary voltage of the input channels.
Connection U1-3	-	Ph-N, Ph-Ph, Ph-N-Isolated	-	Ph-N	Connection of the first three voltage inputs (main VT secondary)
Connection U4	-	Ph-N, Ph-Ph	-	Ph-Ph	Selection of the fourth channel input: phase-to-neutral or phase-to-phase voltage
Direction U1-3	-	Normal, Inverted	-	Normal	Definition of the positive direction of the first three input channels, given as normal or inverted
Direction U4	-	Normal, Inverted	-	Normal	Definition of the positive direction of the fourth voltage, given as normal or inverted
VT correction	-	100 – 115	1	100	VT correction factor for primary VTs with different secondary than 100V or 200V. (e.g. for 110V secondary, the setting is 110%)
Rated Primary U1-3*	kV	1.00 – 1000.00	0.01	100.00	Rated primary voltage of the first three voltage channels
Rated Primary U4*	kV	1.00 – 1000.00	0.01	100.00	Rated primary voltage of the fourth voltage channel

**the rated primary voltage of the channels is not needed for the voltage input function block itself. These values are passed on to the subsequent function blocks (e.g. Line measurement)*

3.4.2.2 Function I/O

This section describes briefly the inputs and outputs of the function block.

3.4.2.2.1 Analogue inputs

The analogue inputs of the function are

- the Fourier components and true RMS values of the measured and calculated secondary voltages

3.4.2.2.2 Analogue outputs (measurements)

The outputs are: the Fourier components and true RMS values of the measured voltages.

- the Fourier components of the measured secondary voltages
- the true RMS values of the measured secondary voltages
- angles of each input voltage related to the configured reference (usually the first voltage channel V1)

3.4.2.2.3 On-line data

The on-line visible values of the following:

Table 3-22 Measurements of voltage input function

MEASURED VALUE	DIMENSION	EXPLANATION
Voltage Ch – U1	V	Fourier basic component of the voltage in channel U1 (secondary)
Voltage Ch – U2	V	Fourier basic component of the voltage in channel U2 (secondary)
Voltage Ch – U3	V	Fourier basic component of the voltage in channel U3 (secondary)
Voltage Ch – U4	V	Fourier basic component of the voltage in channel U4 (secondary)
Angle Ch – U1	deg	Vector position of the voltage in channel U1
Angle Ch – U2	deg	Vector position of the voltage in channel U2
Angle Ch – U3	deg	Vector position of the voltage in channel U3
Angle Ch – U4	deg	Vector position of the voltage in channel U4

The **scaling of the Fourier basic component** is such that if pure sinusoid 57V RMS of the rated frequency is injected, the displayed value is 57V. (The displayed value does not depend on the parameter setting values “Rated Secondary”.)

The **reference of the angle measurement** is defined in the configuration, indicated among the functionblock’s inputs “ExtRef Fourier ch.”. If the reference signal is absent, all angles show zero degrees, but note that the reference is only required for the displaying of the voltage vectors, and not for the actual protection functions. Its absence does not affect the voltage-using functions (e.g. distance protection). If the assigned object is “Const_MinusOne”, then the reference is the first voltage channel of the corresponding VT input module.

3.4.2.3 Technical data

Table 3-23 The technical data of the voltage input function

FUNCTION	RANGE	ACCURACY
Voltage accuracy	30% … 130%	< 0.5 %

3.4.2.3.1 Notes for testing

When testing directional functions (directional OC, impedance-based functions etc.) during commissioning, keep in mind that the polarity of the measured voltages can be swapped by parameter.

3.5 Measurement function blocks (MXU)

3.5.1 Operation principle

The measurement

The input values of the EuroProt+ devices are the secondary signals of the voltage transformers and those of the current transformers.

These signals are pre-processed by the “Voltage transformer input” function block and by the “Current transformer input” function block. These function blocks are described in separate documents. The pre-processed values include the Fourier basic harmonic phasors of the voltages and currents and the true RMS values. Additionally, it is in these function blocks that parameters are set concerning the voltage ratio of the primary voltage transformers and current ratio of the current transformers.

Based on the pre-processed values and the measured transformer parameters, the measurement function blocks calculate - depending on the hardware and software configuration - the primary RMS values of the voltages and/or currents and some additional values such as active and reactive power, symmetrical components of voltages and currents. These values are available as primary quantities and they can be displayed on the on-line screen of the device or on the remote user interface of the computers connected to the communication network and they are available for the SCADA system using the configured communication system.

Reporting the measured values and the changes

It is usual for the SCADA systems that they sample the measured and calculated values in regular time periods and additionally they receive the changed values as reports at the moment when any significant change is detected in the primary system. The measurement function blocks can perform such reporting for the SCADA system.

3.5.1.1 Mode of operation

The **inputs** of the measurement functions are

- the Fourier components and true RMS values of the measured voltages and/or currents (depends on the type of the function, see the next chapter)
- parameters.

The **outputs** of the line measurement function are

- displayed measured values,
- reports to the SCADA system.

NOTE: the scaling values are entered as parameter setting for the “Voltage transformer input” function block and for the “Current transformer input” function block.

3.5.1.2 The measurement

3.5.1.2.1 The measured values; variants of the function

There are six variants of the MXU function, based on their **measured values**. Parameters and measurements are alike for each. The **type of the variant** is shown in the *function block name*:

- Line Measurement (*MXU_**LM***)
- Frequency Measurement (*MXU_**F***)
- Voltage measurement (*MXU_**V***)
- Voltage measurement (*MXU_**V1***) (single voltage)
- Current measurement (*MXU_**C***)
- Current measurement (*MXU_**C1***) (single current)

Table 3-24 Measured values for each variant

ON-LINE MEASURED VALUE	EXPLANATION	MXU FUNCTION BLOCK VARIANT					
		LM	F	V	V1	C	C1
MXU_P_OLM_	Active Power – P (Fourier base harmonic value)	X					
MXU_Q_OLM_	Reactive Power – Q (Fourier base harmonic value)	X					
MXU_S_OLM_	Apparent Power – S (Fourier base harmonic value)	X					
MXU_Fi_OLM_	Power factor	X					
MXU_I1_OLM_	Current L1	X				X	X
MXU_I2_OLM_	Current L2	X				X	
MXU_I3_OLM_	Current L3	X				X	
MXU_3Io_OLM_	Calculated 3Io	X				X	
MXU_U1_OLM_	Voltage L1	X		X	X		
MXU_U2_OLM_	Voltage L2	X		X			
MXU_U3_OLM_	Voltage L3	X		X			
MXU_U12_OLM_	Voltage L12	X		X			
MXU_U23_OLM_	Voltage L23	X		X			
MXU_U31_OLM_	Voltage L31	X		X			
MXU_3Uo_OLM_	Calculated 3Uo	X		X			
MXU_f_OLM_	Frequency		X	X			

3.5.1.2.2 The measurement modes

Regarding the power measurements there are two possibilities for the measurement modes. The first one is the "ThreePhase"-method, where all three measured voltages and currents are considered in the power calculation. The second one is the "Aron"-method, where two phase-to-phase voltages and two phase currents are taken into the calculation. This method has correct results only in case when the voltages and currents are symmetrical. The user can choose the mode with the "Measurement mode" parameter. For the "Aron"-method there are three options:

Table 3-25 Explanation for the Aron measurement modes

Measurement mode	Used phase-currents	Used phase-to-phase voltages
Aron-4-8	L2, L3	L1-L2, L3-L1
Aron-8-12	L1, L3	L1-L2, L2-L3
Aron-12-4	L1, L2	L2-L3, L3-L1

3.5.1.3 Reporting the measurement and the changes

For reporting, additional information is needed, which is defined in the parameter setting. Three parameters define this reporting:

- *Report Deadband* for choosing the type of reporting, or disabling the reporting
- *Deadband Value* for defining the deadband width
- *Range (value)* for evaluating the "out-of-range" condition

The usage of these parameters are explained in the following chapters.

3.5.1.3.1 "Amplitude" mode of reporting

If the "Amplitude" mode is selected for reporting, a report is generated if the measured value leaves the deadband around the previously reported value. As an example, the figure below shows that the current becomes higher than the value reported in "report1" PLUS the Deadband value, this results "report2", etc.

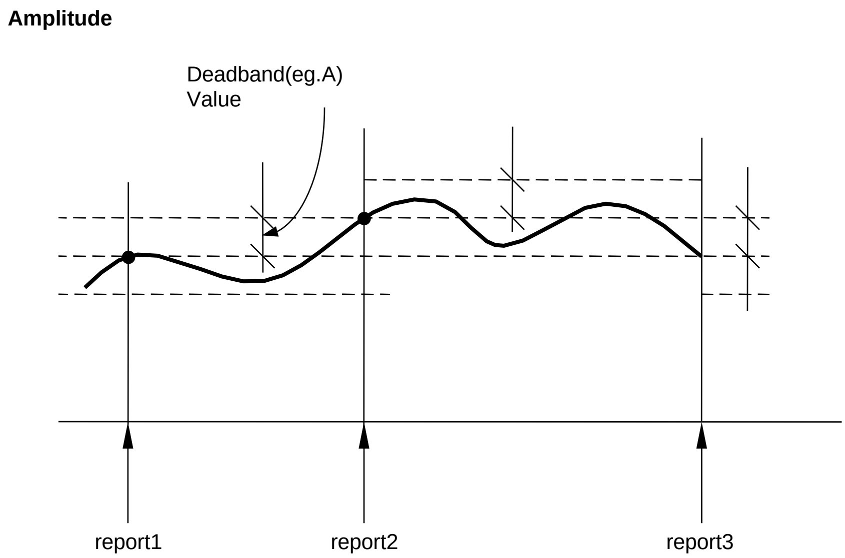


Figure 3-9 Reporting in "Amplitude" mode

3.5.1.3.2 “Integrated” mode of reporting

If the “Integrated” mode is selected for reporting, a report is generated if the time integral of the measured value since the last report gets becomes larger, in the positive or negative direction, then the (deadband*1sec) area. As an example, the following figure shows that the integral of the current in time becomes higher than the Deadband value multiplied by 1sec, this results “report2”, etc.

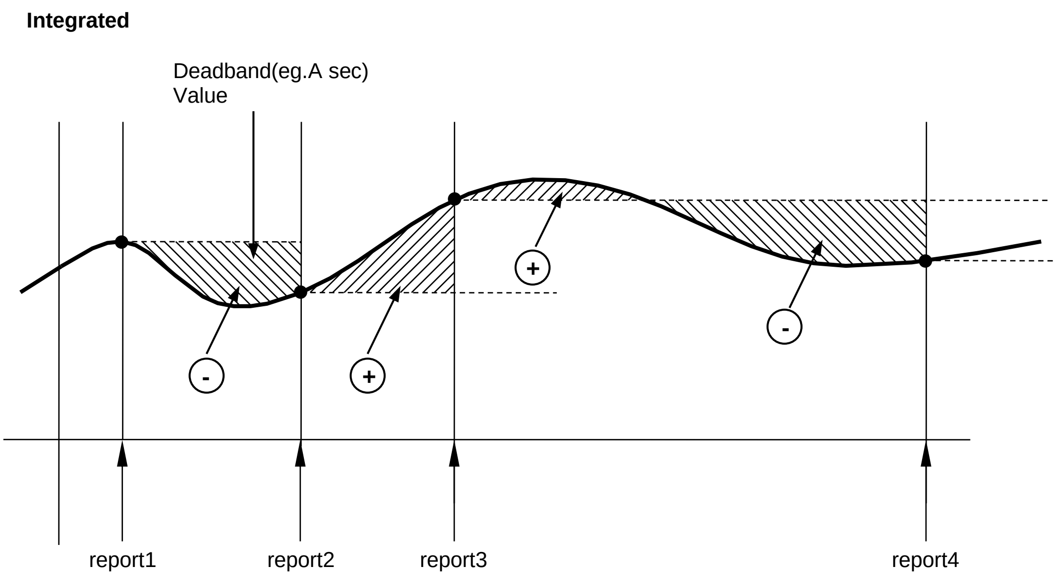


Figure 3-10 Reporting in “Integrated” mode

3.5.1.3.3 Periodic reporting

Periodic reporting is generated independently of the changes of the measured values when the defined time period elapses. If the reporting time period is set to 0, then no periodic reporting is performed for this quantity.

*Applying periodic reporting and setting up its interval is done by using the **Communication configurator**, a part of the **EuroCAP** software (see its description for detailed information).*

Once the “**Trigger period**” property is set to “True”, the “**Integrity period**” setting becomes available to set (in milliseconds). As an example, see the picture below.

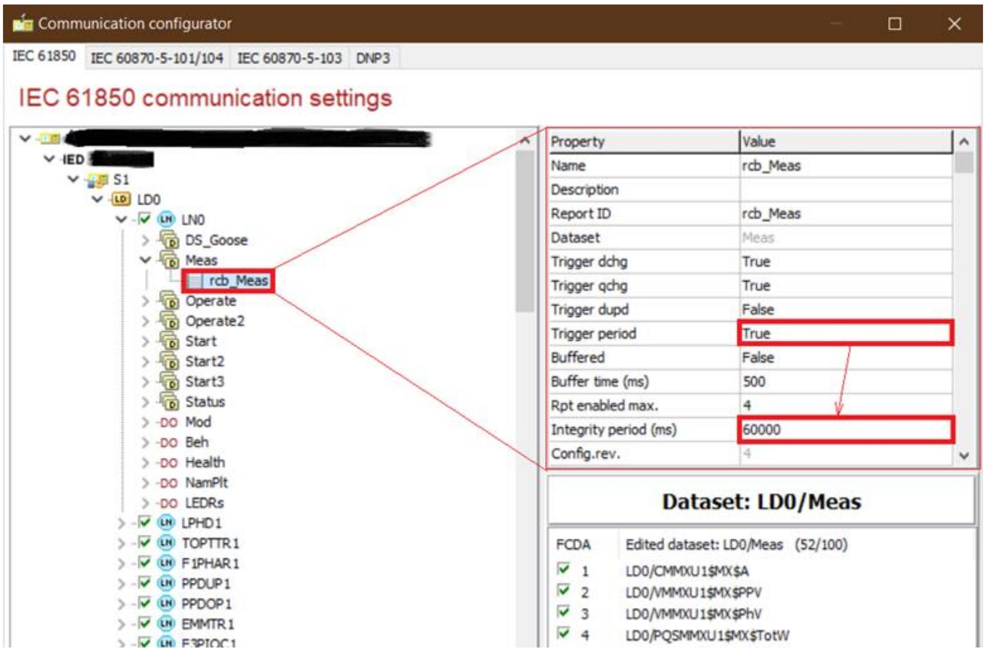


Figure 3-11 Setting up periodic reporting in EuroCAP

3.5.2 Measurement functions' overview

3.5.2.1 Settings

3.5.2.1.1 Parameters

The following parameters are the parameters of the Line Measurement and Frequency measurement functionblocks (LM and F variants). The other functions' parameters follow the pattern of the corresponding measured values.

Table 3-26 Parameters of the line measurement and frequency measurement functions

TITLE	DIM*	RANGE**	STEP	DEFAULT	EXPLANATION
Measurement mode	-	Aron-4-8, Aron-8-12, Aron-12-4, ThreePhase	-	ThreePhase	Selection of the measurement mode
Report Deadband – U	-	Off, Amplitude, Integrated	-	Off	Selection of the reporting mode for voltage measurement
Deadband Value – Uph-N	kV	0.10 – 100.00	0.01	5.00	Deadband value for the phase-to-neutral voltage
Range – Uph-N	kV	1.0 – 1000.0	0.1	231.0	Range value for the phase-to-phase voltage
Deadband Value – Uph-ph	kV	0.10 – 100.00	0.01	5.00	Deadband value for the phase-to-phase voltage
Range – Uph-ph	kV	1.0 – 1000.0	0.1	400.0	Range value for the phase-to-phase voltage
Deadband Value – U Res	kV	0.10 – 100.00	0.01	5.00	Deadband value for the calculated residual voltage
Range – U Res	kV	1.0 – 1000.0	0.1	20.0	Range value for the calculated residual voltage
Report Deadband – I	-	Off, Amplitude, Integrated	-	Off	Selection of the reporting mode for current measurement
Deadband Value – I	A	1 – 2000	1	10	Deadband value for the current
Range – I	A	1 – 5000	1	500	Range value for the current
Deadband Value – I Res	A	1 – 500	1	10	Deadband value for the calculated residual current
Range – I Res	A	10 – 1000	1	100	Range value for the calculated residual current
Report Deadband – P		Off, Amplitude, Integrated	-	Off	Selection of the reporting mode for active power measurement
Deadband Value – P	MW	0.10 – 10000.00	0.01	10.00	Deadband value for the active power
Range Value – P	MW	1.0 – 100000.00	0.01	500.00	Range value for the active power
Report Deadband – Q	-	Off, Amplitude, Integrated	-	Off	Selection of the reporting mode for reactive power measurement

Deadband Value – Q	MVAr	0.10 – 10000.00	0.01	10.00	Deadband value for the reactive power
Range Value – Q	MVAr	1.0 – 100000.00	0.01	500.00	Range value for the reactive power
Report Deadband – S	-	Off, Amplitude, Integrated	-	Off	Selection of the reporting mode for apparent power measurement
Deadband Value – S	MVA	0.10 – 10000.00	0.01	10.00	Deadband value for the apparent power
Range Value – S	MVA	1.0 – 100000.00	0.01	500.00	Range value for the apparent power
Frequency measurement					
Report Deadband	-	Off, Amplitude, Integrated	-	Off	Selection of the reporting mode for frequency measurement
Deadband Value	Hz	0.01 – 1.00	0.01	0.03	Deadband value for the frequency
Range Value	Hz	0.04 – 10.00	0.01	5.00	Range value for the frequency

**units of power measurements can be kW/kVAr/kVA or W/VAr/VA depending on the configuration; changing between these can be done by Protecta personnel*
***if the setting range needs to be extended, contact Protecta personnel*

3.5.2.2 Function I/O

This section describes briefly the analogue and digital inputs and outputs of the function block.

3.5.2.2.1 Analogue inputs

The analogue inputs of the measurement functions are

- the Fourier components and true RMS values of the measured and calculated secondary voltages
- the Fourier components and true RMS values of the measured secondary currents,

3.5.2.2.2 Analogue outputs (measurements)

Table 3-27 Measurements of the line measurement and frequency measurement functions

MEASURED VALUE	DIMENSION*	EXPLANATION
Active Power – P	MW	Calculated three-phase active power
Reactive Power – Q	MVAr	Calculated three-phase reactive power
Apparent Power – S	MVA	Calculated three-phase apparent power
Power factor		Calculated power factor
Current L1	A	Measured primary current L1 based on the nominal values of the CT4 current input function
Current L2	A	Measured primary current L2 based on the nominal values of the CT4 current input function
Current L3	A	Measured primary current L3 based on the nominal values of the CT4 current input function
Calculated 3Io	A	Calculated 3Io from the three phase currents
Voltage L1	kV	Measured primary L1 phase voltage L1 based on the nominal values of the VT4 voltage input function
Voltage L2	kV	Measured primary L2 phase voltage L2 based on the nominal values of the VT4 voltage input function
Voltage L3	kV	Measured primary L3 phase voltage L3 based on the nominal values of the VT4 voltage input function
Voltage L12	kV	Calculated L12 phase-to-phase voltage
Voltage L23	kV	Calculated L23 phase-to-phase voltage
Voltage L31	kV	Calculated L31 phase-to-phase voltage
Calculated 3Uo	kV	Calculated 3Uo from the three phase voltages

**units of power measurements can be kW/kVAr/kVA or W/VAr/VA depending on the configuration; changing between these can be done by Protecta personnel*

3.5.2.2.3 On-line data

The on-line visible values of the function are its measurements, see Chapter 3.4.2.2.2

3.5.2.3 Technical data

Table 3-28 The technical data of the line measurement and frequency measurement functions

FUNCTION	RANGE	ACCURACY
Current accuracy		
with CT/5151 or CT/5102 modules	0,2 In – 0,5 In	±2%, ±1 digit
	0,5 In – 20 In	±1%, ±1 digit
with CT/1500 module	0,03 In – 2 In	±0,5%, ±1 digit
Voltage accuracy	5 – 150% of Un	±1% of Un, ±1 digit
Power accuracy	I>15% In	±3%, ±1 digit
Frequency accuracy	U>3.5%Un 40Hz – 60Hz	2mHz (displayed digits: 10mHz)

3.5.2.3.1 Notes for testing

If there are no measurements provided to the SCADA, check the Report Deadband parameter and/or the settings of the periodic reporting in the Communication Configurator. The former's default value is 'Off', and the latter's is 'False', meaning that by default the reporting is disabled.

Note again that the **periodic reporting** is defined in the device configuration file (.epc) using EuroCAP. This also means that changing the properties of this will require downloading the configuration to the device (thus a full device restart).

3.6 Disturbance recorder function

3.6.1 Operation principle

The disturbance recorder function can record analog signals and binary status signals. These signals are configured using the EuroCAP software tool.

The disturbance recorder function has a binary input signal, which serves the purpose of starting the function**. The conditions of starting are defined by the user, applying the graphic equation editor.** The disturbance recorder function keeps on recording during the active state of this signal but the total recording time is limited by the timer parameter setting.

The pre-fault time, max recording time and post-fault time can be defined by parameters.

3.6.1.1 The mode of recording

If the triggering conditions defined by the user – using the graphic equation editor – are satisfied and the function is enabled by parameter setting, then the disturbance recorder starts recording the sampled values of configured analog signals and binary signals.

The analog signals can be sampled values (voltages and currents) received via input modules or they can be calculated analog values (such as negative sequence components, etc.)

The number of the configured binary signals for recording is limited to 64, and up to 32 analog channels can be recorded.

The available memory for disturbance records is 12 MB.

There are two function blocks available. The first function (**DRE**) applies 20 sampling in a network period. Accordingly for 50 Hz, the sampling frequency is 1 kHz. (For 60 Hz the sampling frequency is 1.2 kHz). This is used in all configurations by default.

The second function (**DRE2**) is capable to be set by parameter to apply 20 or 40 sampling in a network period. This way accordingly for 50 Hz, the sampling frequency is 1 kHz or 2 kHz (and for 60 Hz the sampling frequency is 1.2 kHz or 2.4 kHz). *Except for this, the two function blocks are the same*.

As an example, for 50 Hz, if the duration of the record is 1000 ms then one analog channel needs about 7 kB and a binary channel needs 2 kB, Using the following formula the memory size can be estimated:

Memory size of a record = (n*7 kB+ m*2 kB)*record duration(s)

Here n,m: are the number of analog and binary channels respectively.

During the operation of the function, the pre-fault signals are preserved for the time duration as defined by the parameter “PreFault”.

The recording duration is limited by the parameter “Max Recording Time” but if the triggering signal resets earlier, this section is shorter.

The post-fault signals are preserved for the time duration as defined by the parameter “PostFault”.

During or after the running of the recording, the triggering condition must be reset for a new recording procedure to start.

3.6.1.2 Format of recording

The records are stored in standard COMTRADE format.

- The configuration is defined by the file .cfg,
- The data are stored in the file .dat,
- Plain text comments can be written in the file .inf.

3.6.1.3 Downloading and evaluating disturbance records

The procedure for downloading the records is described in detail in the EuroProt+ manual “Remote user interface description”, Chapter 4.7. The three files are zipped in a file .zip. This procedure assures that the three component files (.cfg, .dat and .inf) are stored in the same location.

The evaluation can be performed using any COMTRADE evaluator software. Protecta offers the **“srEval”** software for this purpose. The application of this software is described in detail in the “srEval manual”. This manual can be downloaded from the following Internet address: http://www.softreal.hu/product/sreval_en.shtml.

3.6.1.4 The recorded signals

The analog and binary signals to be recorded are configured using the EuroCAP software tool in the menu item “Software configuration/Disturbance recorder”. (The access level of the user must be at least “Master”.) The application of this software is described in detail in the EuroCAP manual.

3.6.2 Disturbance recorder function overview

The graphic appearance of the function blocks of the disturbance recorder are shown on the figure below.

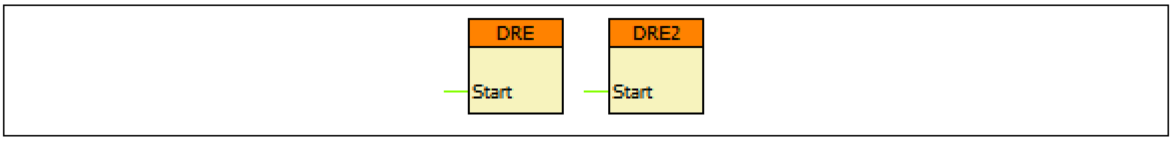


Figure 3-12 Graphic appearance of the function blocks of the disturbance recorder function

3.6.2.1 Settings

3.6.2.1.1 Parameters

The following parameters are the parameters of the Line Measurement and Frequency measurement functionblocks (LM and F variants). The other functions' parameters follow the pattern of the corresponding measured values.

Table 3-29 Parameters of the disturbance recorder function

TITLE	DIM*	RANGE**	STEP	DEFAULT	EXPLANATION
Operation	-	Off, On	-	Off	Enabling the function
Resolution	-	*1/1.kHz, 2/2.4kHz*	-	*1/1 kHz*	*Setting for 20 or 40 samples/cycle. This parameter is present only in the optional DRE2 function.*
Prefault	msec	100 – 1000	1	200	Pre-fault recording time calculated from the rising edge of the trigger signal
PostFault	msec	100 – 1000	1	200	Post-fault recording time calculated from the falling edge of the trigger signal
Max Recording Time*	msec	500 – 10000	1	1000	Overall fault recording time limit

NOTE: The device goes automatically in "Warning" state and sends a warning message (see the figure below) if the sum of the pre-fault time and post-fault time is longer than the overall-fault time. The corresponding message in the RDSP log file is: „Wrong DR settings. PreFault + PostFault must be less than MaxFault. Check the parameters."

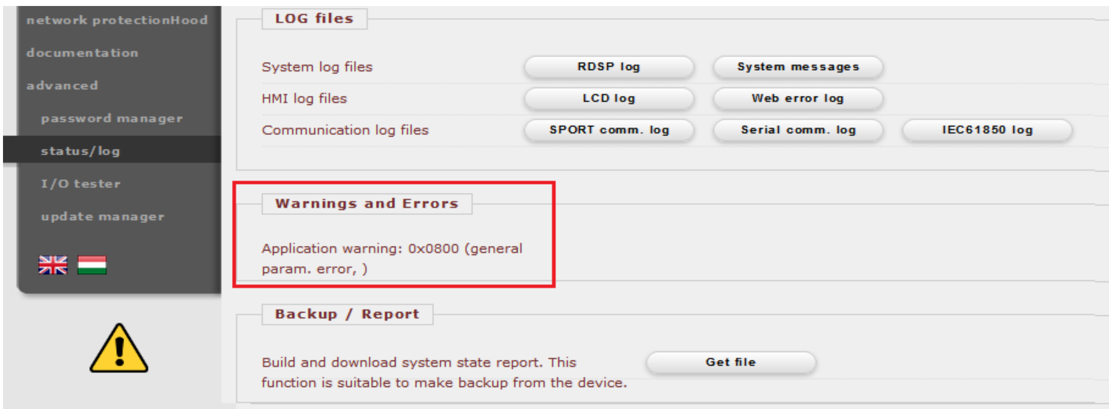


Figure 3-13 Warning message on wrong settings

3.6.2.2 Function I/O

This section describes briefly the analogue and digital inputs and outputs of the function block.

The function block itself has only one binary input and no other I/O.

Those analog and binary signals that are to be recorded, are configured using the EuroCAP software tool in the menu item “Software configuration/Disturbance recorder”. (The access level of the user must be at least “Master”.) The application of this software is described in detail in the EuroCAP manual.

3.6.2.2.1 Binary input signals (graphed output statuses)

BINARY INPUT SIGNAL	EXPLANATION
DRE_**Start**_GrO_	Output status of a graphic equation defined by the user to start the disturbance recorder function.

The recording is performed if the function is enabled by the parameter setting AND the triggering condition as defined by the user is “True” as well.

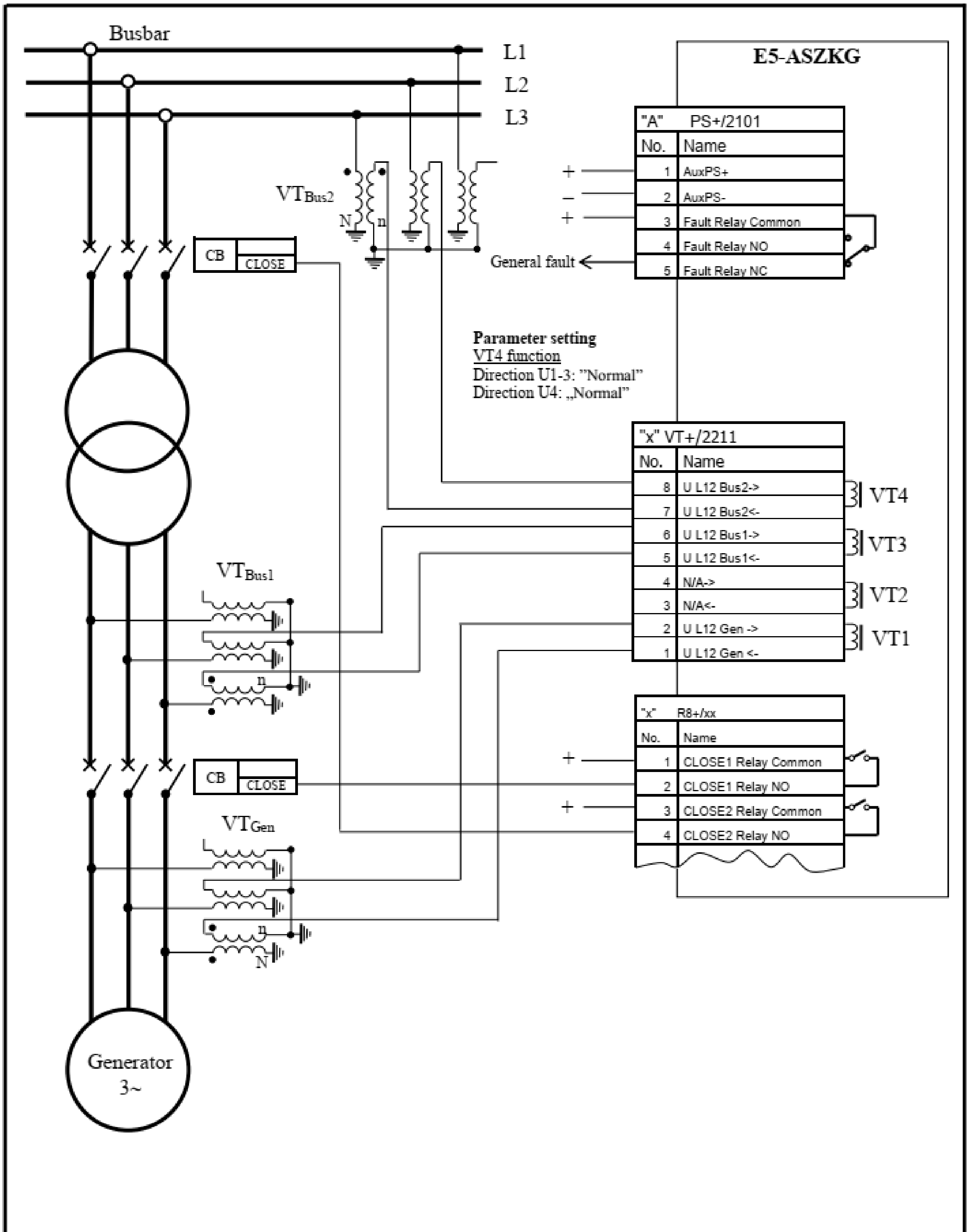
3.6.2.3 Notes for testing

The disturbance recorder is disabled by default. If there are no records at all, it is advised to check its “Operation” parameter to be “On”. If there are still no records, the logic of the Start input must be checked.

It takes time for the DSP processor to generate a disturbance record, after the trigger has fallen off. The duration might go from several seconds to several ten seconds, depending on the size of the record.

If there is another start signal during this period, a new record is being made, but note that only three records can be processed at the same time. This might result in a lower number of records when generating a lot of start signals in a short time span. E.g. during a characteristics test for a function on multiple points, where there would be multiple trips in several seconds, and each trip would result in record as well, it is likely that there will be no records for each individual trip. Keep this in mind during tests where a disturbance record is essential.

4 External connections



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