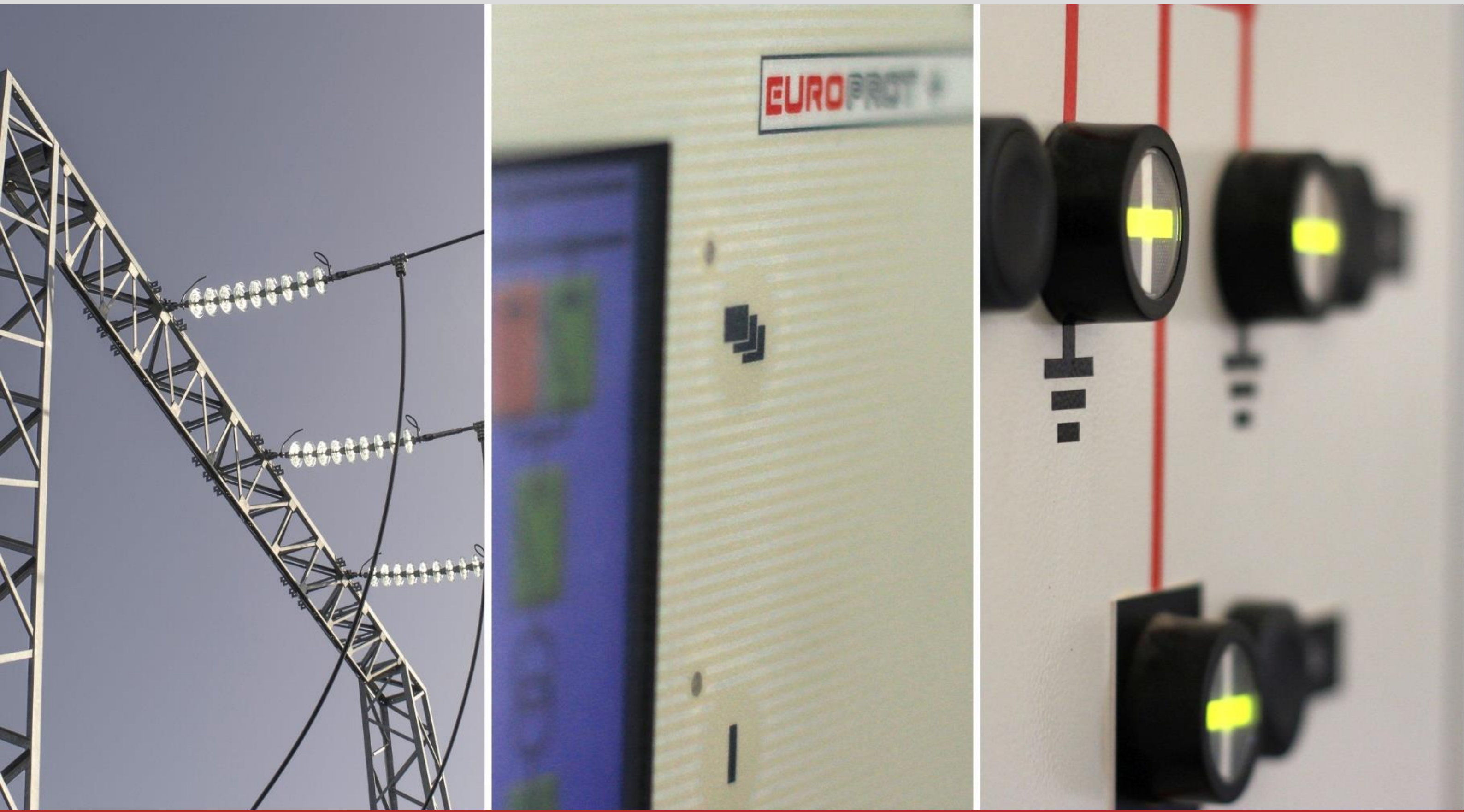


FUNCTION BLOCK DESCRIPTION

Directional Element function

PROTECTA HUNGARY

DOCUMENT ID: PP-13-23062
VERSION: 1.1
2025-07-11, BUDAPEST

PROTECTION, AUTOMATION AND CONTROL FOR POWER INDUSTRY

VERSION INFORMATION

VERSION	DATE	MODIFICATION	COMPILED BY
1.0	2025-01-17	First edition, based on the TOC67 function description	Erdős
1.1	2025-07-11	Minor corrections	Erdős

CONTENTS

USED SYMBOLS

Additional information

Useful information for settings.

Important part for proper usage.

1 Application

The Directional Element function can be applied on solidly grounded, compensated or isolated networks, where the overcurrent protection must be supplemented with a directional decision.

An additional feature of this function is the Fault Locator started by a binary signal.

1.1 Mode of operation

The inputs of the function are three-phase currents and voltages. For directional decision the Fourier basic harmonic components of the three phase currents and those of the three phase voltages are calculated.

The directional decision is similar to a distance protection function decision: Based on the measured voltages and currents, from among the six loops (L1L2, L2L3, L3L1, L1N, L2N, L3N) the block selects the one with the smallest calculated loop impedance. Based on the loop voltage and loop current of the selected loop the directional decision generates a signal of TRUE value if the voltage and the current is sufficient for directional decision, and the angle difference between the vectors is within the setting range. This decision enables the output start and trip signal of an overcurrent protection function block, based on the selected current. If the voltages of the selected loop are not sufficient for the directional decision, then healthy phase voltages (positive sequence), or pre-fault voltages stored in the memory are also applied.

The function is influenced an input binary signal:

- The Fault Locator feature is started by the “FLStart” input

NOTE: the input signals are assigned by the user, using the logic editor in the EuroCAP configuration software tool.

1.2 Structure of the Directional Element function algorithm

Figure 1-1 shows the structure of the Directional Element function working together with three-phase directional overcurrent protection (TOC67), as usually these two functions are applied together.

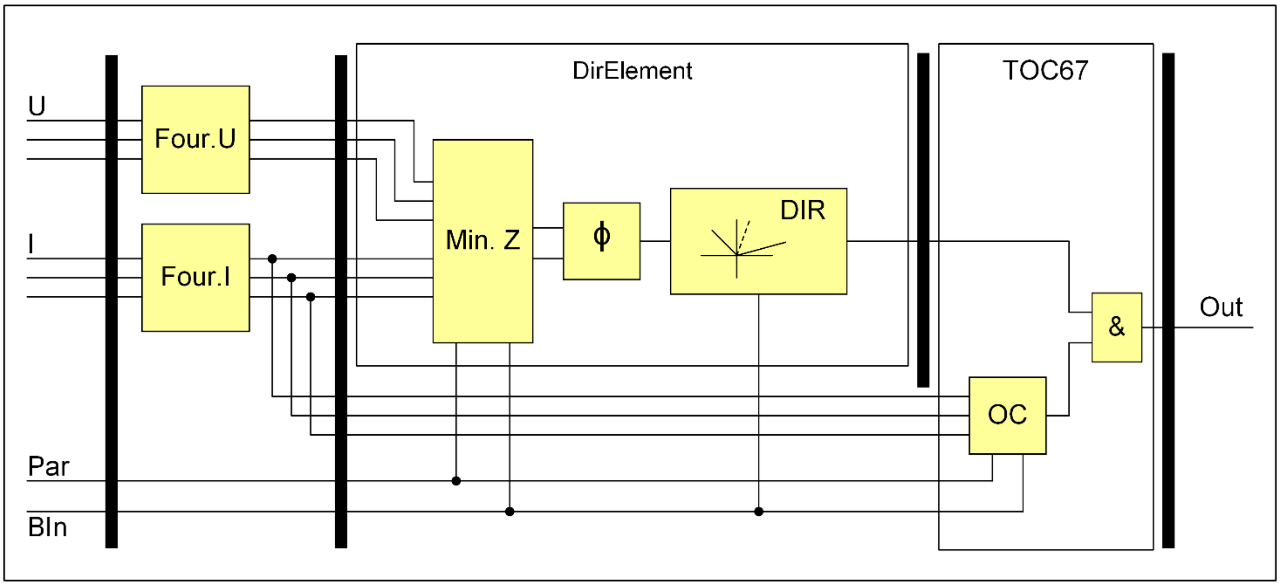


Figure 1-1 Structure of the Directional Element function algorithm

The **inputs** of the DirElement function are

- the RMS value of the fundamental Fourier component of the three phase currents (IL1, IL2, IL3). NOTE: The Fourier calculation is not part of the directional overcurrent function, it is performed by an external function block.
- the RMS value of the fundamental Fourier component of the three phase voltages (UL1, UL2, UL3). NOTE: The Fourier calculation is not part of the directional overcurrent function, it is performed by an external function block.
- the RMS value of the fundamental Fourier component of the three phase-to-phase voltages (UL1L2, UL2L3, UL3L1). NOTE: The phase-to-phase voltage calculation is not part of the directional overcurrent function, it is performed by an external function block.
- parameters,
- binary status signals.

The function can be enabled or disabled by a parameter. The status signal of the VTS (voltage transformer supervision) function can also disable the directional operation.

The **outputs** are

- the directional current
- calculated fault reactance and distance

The **software modules** of the three-phase directional overcurrent protection function are as follows:

MinZ

This module selects the faulty loop for directional decision. Using the pre-processing modules, from among the six loops (L1L2, L2L3, L3L1, L1N, L2N, L3N) this module selects the measuring loop with the smallest calculated loop impedance. The logic forwards the selected loop voltage and the loop current to the phase angle calculation module.

FI calculation (φ)

This module calculates the vector angle between the selected loop voltage and the loop current.

FAULT LOCATOR

This module calculates the distance to fault when activated.

1.2.1 Selection logic (MinZ)

Using calculated information of the pre-processing modules, in case of solidly grounded networks, from among the six loops (L1L2, L2L3, L3L1, L1N, L2N, L3N) this module selects the measuring loop with the smallest calculated loop impedance. The voltage must be above 5% of the rated voltage and the current must also be measurable (min. 8%). In compensated or isolated networks, the single phase-to-ground faults are supposed not to generate high fault currents. For these networks, the line-to-line loops (L1L2, L2L3, L3L1) are evaluated only.

Enumerated parameter for fault loop selection

Table 1-1 The enumerated parameter of the network type selection

PARAMETER NAME	TITLE	SELECTION RANGE	DEFAULT
Network neutral grounding selection			
TOC67_NetType_EPar_	Network type	Solidly Earthed, Isolated	Solidly earthed

NOTE: For compensated networks, select “Isolated” option.

The **input signals are** the RMS values of the fundamental Fourier components of the three-phase currents and three phase voltages and the three line-to-line voltages.

The **internal output status signal** for enabling the directional decision is true if both the three-phase voltages and the three-phase currents are meet the minimum requirements above.

The RMS voltage and current values of the fundamental Fourier components of the selected loop are forwarded to angle calculation for further processing.

1.2.2 Calculation of the vector angle (FI calculation)

This module calculates the phase angle between the loop voltage and the loop current.

The **input signals are** the fundamental Fourier components of the loop current and loop voltage.

The **internal output signal** is the calculated phase angle.

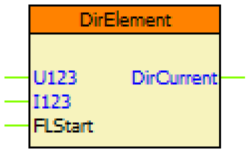
1.2.3 The distance-to-fault calculation (FAULT LOCATOR)

The function selects the faulty loop impedance (its positive sequence component) and calculates the distance to fault based on the measured positive sequence reactance and the total reactance of the line. This reference value is given as a parameter setting **Line reactance**. The calculated percentage value facilitates displaying the distance in kilometers if the total length of the line is correctly set by the parameter **Line length**.

The fault locator works if the input “FLStart” is activated.

2 Directional Element function overview

The function block of the Directional Element function is shown in Figure 2-1. This block shows all binary input and output status signals that are applicable in the graphic equation editor. The legacy 2.8 version is on the left, while the new one is on the right.



2-1. Figure The function block of the Directional Element function

2.1 Settings

2.1.1 Parameters

The available parameters are listed below in order of their appearance in the *parameters* menu.
If the setting range of a parameter should be extended, contact Protecta Support.

Table 2-1 The available parameters of the Directional Element function

TITLE	DIM.	RANGE	STEP	DEFAULT	EXPLANATION
Network type	-	Solidly Earthed, Isolated	-	Solidly Earthed	Network neutral grounding selection.
Line length	km	0.1 – 1000.0	0.1	100.0	Length of the line for the Fault Locator.
Line reactance	ohm	0.01 – 200.00	0.01	10.00	Reactance (***X***) of the line. The Fault Locator is using the reactance of the fault and the line to calculate the distance.

2.2 Function I/O

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

2.2.1 Analogue inputs

The function uses the Fourier values of the three-phase currents and voltages. This is defined in the configuration.

Graphic Analogue inputs ***(only from firmware version 2.10.2.3010 and up)***

The sources of the analogue inputs are defined by the user, applying the graphic equation editor (*Logic Editor*). Parts written in **bold** are seen on the left side of the function block in the Logic editor.

The function uses the following analogue signals as inputs:

Table 2-2 Analogue input signals of the Directional Element function

ANALOGUE INPUT SIGNAL	SIGNAL TITLE	EXPLANATION
Imp4Dir_**U123**_AnIn_	3phase voltage	Input for 3-phase voltages
Imp4Dir_**I123**_AnIn_	3phase current	Input for 3-phase currents

The applied analogue connectors must be identical to the analogue input type (i.e. voltage to voltage input etc.), Invalid connections are not allowed.

2.2.2 Analogue outputs (measurements)

These outputs can be used in *EuroCAP logic editor* to generate signals that will be assigned to any function blocks that require the directional current measurement as an input (e.g. TOC67).

Parts written in **bold** are seen on the function block in the logic editor

Table 2-3 Analogue output signal of the Directional Element function

ANALOGUE INPUT SIGNAL	EXPLANATION
Imp4Dir_**DirCurrent**_AnSrc_	Directional current signal created by the DirElement function

2.2.3 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 2-4 The binary input signal of the Directional Element function

BINARY INPUT SIGNALS	EXPLANATION
Imp4Dir_**FLStart**_GrO_	Triggering input for the Fault Locator.

2.2.4 Binary output signals (graphed input statuses)

The function does not binary output signals.

2.2.5 On-line data

Visible values on the on-line data page:

Table 2-5 On-line data of the Directional Element function

SIGNAL TITLE	DIMENSION	EXPLANATION	IEC61850 DATA OBJECTS
Fault location	km	Calculated distance of the fault when the function was triggered	FLORFLO1MXFltDiskm
Fault reactance	ohm	Calculated reactance of the fault when the function was triggered	FLORFLO1MXFltZ
Voltage input assignment	-	*Status of the graphical analogue input (if exists) (Complete if OK, Missing if not connected)*	
Current input assignment	-	*Status of the graphical analogue input (if exists) (Complete if OK, Missing if not connected)*	

2.2.6 Events

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

The events in grey are not actually shown in the event list, as they only represent the triggers for the IEC61850 measurement reporting. See the On-Line data chapter above for them.

Table 2-6 Events of the Directional Element function

EVENT	VALUE	EXPLANATION	IEC61850 DATA ATTRIBUTES
Fault Loc. km	[…] km	Calculated distance based on the measurements when the trigger was activated	FLORFLO1MXFltDiskmmagf
Fault Loc. ohm	[…] ohm	Calculated reactance based on the measurements when the trigger was activated	FLORFLO1MXFltZ$cVal$mag$f

2.3 Technical data

Table 2-7 Technical data of the Directional Element function

FUNCTION	VALUE
Characteristic accuracy ε_X Un = 57,74V In = 1A; fn = 50 Hz Un = 57,74V In = 1A; fn = 60 Hz	 ± 1,6 % ± 1,8 %
Characteristic accuracy ε_R Un = 57,74V In = 1A; fn = 50 Hz Un = 57,74V In = 1A; fn = 60 Hz	 ± 3,6 % ± 2,8 %
Basic directional accuracy	± 0,9°

2.3.1 Notes for testing

Since the Fault Locator’s operation is based on the reactance (X) measurement and its accuracy depends on all three accuracy factors described in Table 2-7, one exact accuracy value cannot be assigned to it. It must be kept in mind that the more resistance (R) the line has (related to its reactance (X), the less accurate the fault locator will become.

Additional notes for Graphic Analogue inputs *(from firmware version 2.10.2.3010 and up):*

Starting from the firmware version **2.10.2.3010**, the majority of the function blocks can be updated to be equipped with graphic analogue inputs which **allow the user to assign the functions’ analogue inputs by applying the graphic equation editor**.

The analogue connections of these functions can be checked by examining the source that is connected to their inputs (just like examining the source of a logic signal).

These functions must be placed in the Logic Editor and their graphic analogue inputs must be connected to make them operate. If a connection is intact, the online status of the corresponding analogue input will show “Complete”. If it is missing, the status will be “Missing” and the function will not operate.

Note that these graphical inputs do not exist in the earlier firmware/function versions! Checking and modifying the analogue assignments in these cases are done by using the EuroCAP Software Configuration menu.