EUROPROT +

Setting guide to the directional overcurrent protection

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Setting guide version information

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V1.0	21.10.2014	First edition	Petri

Contents

1 Example for application

The example in this guide supposes that the device is connected to instrument transformers and to the circuit breakers according to *Figure 1-1*.

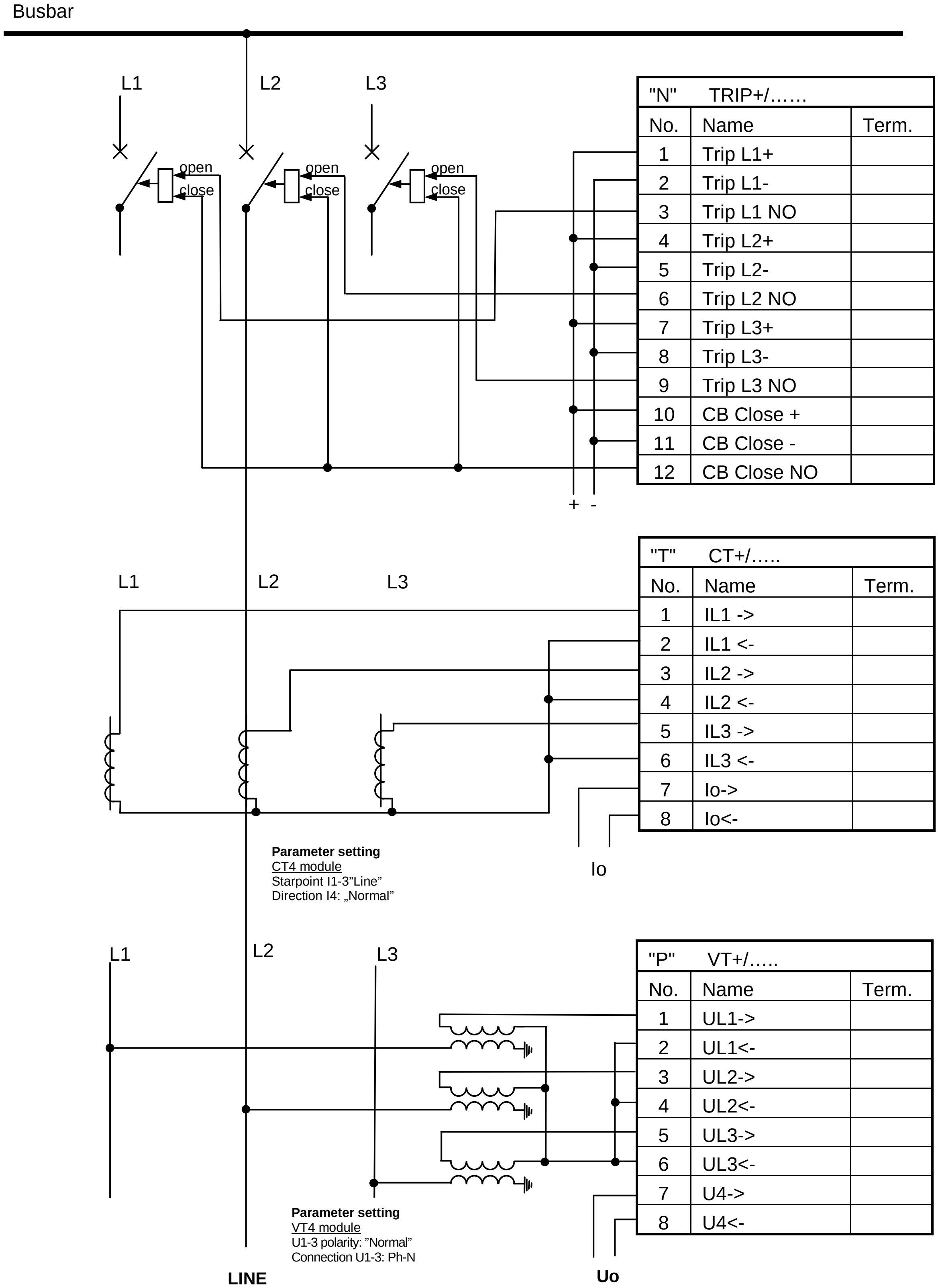

Figure 1-1 Connection example

The directional three-phase overcurrent protection function can be applied on solidly grounded networks, where the overcurrent protection must be supplemented with a directional decision. In these networks the fault is considered to be in “Forward” direction, if the measured fault impedance, using the positive directions shown in *Figure 1-2*, is inductive i.e. the calculated φ impedance angle is 0°≤φ≤90°.

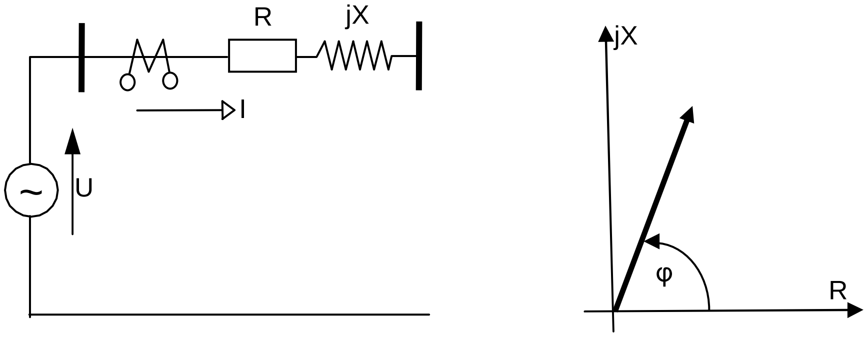

Figure 1-2 The fault impedance

The voltage and current vectors for this fault loop are shown in *Figure 1-3*.
In *Figure 1-3*.a), the voltage vector is the reference, the current lags relative to the voltage, the φ angle is negative. To change this angle to a positive value (as the value of the impedance angle is) the current is considered to be the reference. This is shown in *Figure 1-3*.b). The directional overcurrent protection function applies this coordinate system of *Figure 1-3*.b).

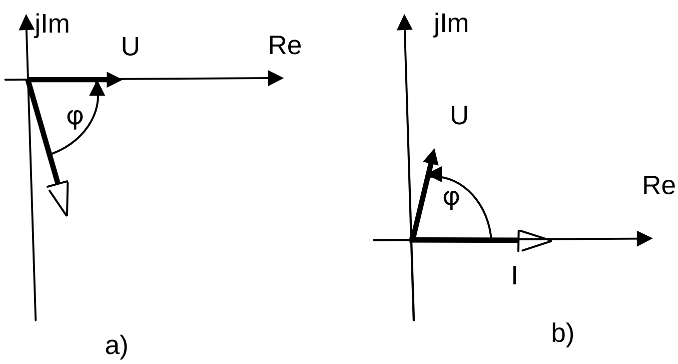

Figure 1-3 Voltage and current vectors in the faulty loop

Figure 1-4 below shows that the considered voltages are „loop” voltages and the considered currents are „loop” currents. The indicated operating range is valid if the “Direction” parameter is set “Forward”. If the direction parameter is set “Backward then the operation range is mirrored to the origin of *Figure 1-4*. The setting “NonDir” for this parameter means that only the magnitude of the current is considered, the phase angles are neglected.

The „loop” voltages and the „loop” currents are selected according to the smallest loop impedance, depending on the detected fault type, according to Table 1-1.

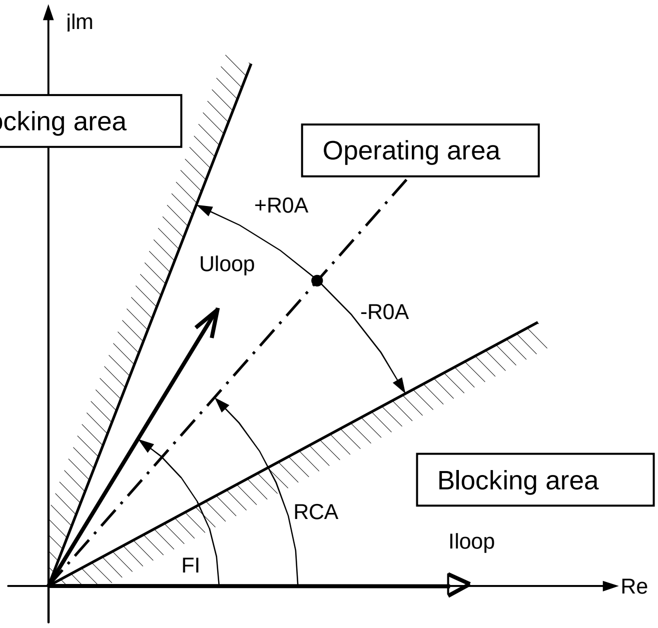

Figure 1-4 The directional decision

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.

Fault	Uloop	Iloop
L1L2L3(N)	$U_{loop} = U_{L2} - U_{L3}$	$I_{loop} = I_{L2} - I_{L3}$
L1L2	$U_{loop} = U_{L1} - U_{L2}$	$I_{loop} = I_{L1} - I_{L2}$
L2L3	$U_{loop} = U_{L2} - U_{L3}$	$I_{loop} = I_{L2} - I_{L3}$
L3L1	$U_{loop} = U_{L3} - U_{L1}$	$I_{loop} = I_{L3} - I_{L1}$
L1L2N	$U_{loop} = U_{L1} - U_{L1}$	$I_{loop} = I_{L1} - I_{L2}$
L2L3N	$U_{loop} = U_{L2} - U_{L3}$	$I_{loop} = I_{L2} - I_{L3}$
L3L1N	$U_{loop} = U_{L3} - U_{L1}$	$I_{loop} = I_{L3} - I_{L1}$
L1N	$U_{loop} = U_{L1}$	$I_{loop} = I_{L1} + 3I_o K_N$
L2N	$U_{loop} = U_{L2}$	$I_{loop} = I_{L2} + 3I_o K_N$
L3N	$U_{loop} = U_{L3}$	$I_{loop} = I_{L3} + 3I_o K_N$

Table 1-1 Loop voltage and current selection

In Table 1-1 I_o is the zero sequence current component, and the zero sequence current compensation factor is:

$$K_N = \frac{Z_o - Z_1}{3Z_1} = \frac{1}{3}\left(\frac{Z_o}{Z_1} - 1\right)$$

If the device configuration includes also the distance protection, then this value is set for the distance protection function block. If the distance protection function is not applied then

$$K_N = 1$$

The function applies also the polarization method used for the distance protection:

- If the loop voltage is above 5% of the rated voltage input, then this loop voltage is applied for the decision.
- If the loop voltage is below 5% of the rated voltage input and there is healthy voltage available, then the healthy voltage is applied for the directional decision.
- If the loop voltage is below 5% of the rated voltage input and there is no healthy voltage available, then the voltage vectors stored in the memory are applied for the directional decision.
- If the loop voltage is below 5% of the rated voltage input and there is no healthy voltage available, and there are no voltage vectors stored in the memory then no decision is performed.

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 signals of an overcurrent protection function block, based on the selected current.

The description above indicates that the basic concept of the directionality is the impedance angle, detected in the faulty loop.

2 Parameter setting

Parameters can be set in the parameter screen of a WEB browser, when there is Internet connection with the device. For details about this communication see the Protecta document "***Remote user interface description***" available in Protecta WEB site www.protecta.hu.

NOTE: the parameters can be set also using the local LCD touch-screen of the device, if no internet connection is available. For details about this communication see the Protecta document "***LCD touchscreen interface description***" available in Protecta WEB site www.protecta.hu.

2.1 Setting the CT4 input function block

In the EuroProt+ devices the CT inputs are assigned to CT function blocks. They need parameter setting and also displaying functions are assigned to them.

The parameters of the current input function are explained in the following tables.

Enumerated parameters

Parameter name	Title	Selection range	Default
Rated secondary current of the first three input channels. 1A or 5A is selected by parameter setting, no hardware modification is needed.			
CT4_Ch13Nom_EPar_	Rated Secondary I1-3	1A,5A	1A
Rated secondary current of the fourth input channel. 1A or 5A (0.2A, 1A) is selected by parameter setting, no hardware modification is needed.			
CT4_Ch4Nom_EPar_	Rated Secondary I4	1A,5A (0.2A, 1A)	1A
Definition of the positive direction of the first three currents, given by location of the secondary star connection point			
CT4_Ch13Dir_EPar_	Starpoint I1-3	Line,Bus	Line
Definition of the positive direction of the fourth current, given as normal or inverted			
CT4_Ch4Dir_EPar_	Direction I4	Normal,Inverted	Normal

Table 2-1 The enumerated parameters of the current input function

Floating point parameters

Parameter name	Title	Dim.	Min	Max	Default
Rated primary current of channel1-3					
CT4_PriI13_FPar_	Rated Primary I1-3	A	100	4000	1000
Rated primary current of channel4					
CT4_PriI4_FPar_	Rated Primary I4	A	100	4000	1000

Table 2-2 The floating point parameters of the current input function

NOTE: The rated primary current of the channels is not needed for the current input function block itself. These values are passed on to the subsequent function blocks.

Using the information given in the connection example above, the following setting values are assigned:

CT4:

Rated Secondary I1-3	1A	Selected, according to the CT applied .
Rated Secondary I4	1A	Not applied, the value is not considered.
Starpoint I1-3	Line	"Line" in this case means that the starpoint of the CT-s is "Toward protected object = Line" (See *Figure 1-1*)
Direction I4		Not applied, the value is not considered.
Rated Primary I1-3	1000	Setting, according to the CT applied at the primary side. This parameter is used for scaling the displayed values only.
Rated Primary I4		Not applied, the value is not considered.

Table 2-3 *Example of the CT parameter setting*

2.2 Setting the VT4 input function blocks

In the EuroProt+ devices the VT inputs are assigned to VT function blocks. They need parameter setting and also displaying functions are assigned to them.

The parameters of the voltage input function are explained in the following tables.

Enumerated parameters

Parameter name	**Title**	**Selection range**	**Default**
Rated secondary voltage of the input channels. 100 V or 200V is selected by parameter setting, no hardware modification is needed.			
VT4_Type_EPar_	Range	Type 100,Type 200	Type 100
Connection of the first three voltage inputs (main VT secondary)			
VT4_Ch13Nom_EPar_	Connection U1-3	Ph-N, Ph-Ph, Ph-N-Isolated	Ph-N
Selection of the fourth channel input: phase-to-neutral or phase-to-phase voltage			
VT4_Ch4Nom_EPar_	Connection U4	Ph-N,Ph-Ph	Ph-Ph
Definition of the positive direction of the first three input channels, given as normal or inverted			
VT4_Ch13Dir_EPar_	Direction U1-3	Normal,Inverted	Normal
Definition of the positive direction of the fourth voltage, given as normal or inverted			
VT4_Ch4Dir_EPar_	Direction U4	Normal,Inverted	Normal

Table 2-4 *The enumerated parameters of the voltage input function*

Integer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Voltage correction						
VT4_CorrFact_IPar_	VT correction	%	100	115	1	100

Table 2-5 The integer parameter of the voltage input function

Floating point parameters

Parameter name	Title	Dim.	Min	Max	Default
Rated primary voltage of channel1					
VT4_PriU13_FPar	Rated Primary U1-3	kV	1	1000	100
Rated primary voltage of channel4					
VT4_PriU4_FPar	Rated Primary U4	kV	1	1000	100

Table 2-6 The floating point parameters of the voltage input function

NOTE: 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.

VT4:

Range	Type 100	The type indicates the rated secondary voltage of the VT. This can be 100 V (in this example) or 200V
Connection U1-3	Ph-N	This indicates that the VT primary is connected between the conductor and the ground (in this example). This could be Ph-Ph in other application. (NOTE: If the neutral of the system is not grounded, select Ph-N-Isolated)
Connection U4		Not applied, the selection is not considered.
Direction U1-3	Normal	*Figure 1-1* shows the normal VT connection. Select “Inverted” in case of inverted connection. NOTE: The inversion can be solved also when setting the directional overcurrent protection function, see below.
Direction U4		Not applied, the selection is not considered.
VT correction	100	If the rated secondary value of the VT is e.g. 110 V then select this correction value to 110
Rated Primary U1-3	120	Setting, according to the VT applied at the primary side. This parameter is used for scaling the displayed values only.
Rated Primary U4		Not applied, the selection is not considered.

Table 2-7 Example of the VT parameter setting

2.3 Parameter setting for the directional overcurrent protection function

Enumerated parameters

Parameter name	Title	Selection range	Default
Directionality of the function			
TOC67_Dir_EPar_	Direction	NonDir, Forward, Backward	Forward
Operating characteristic selection of the TOC51 module			
TOC67_Oper_EPar_	Operation	Off,DefiniteTime,IEC Inv,IEC VeryInv,IEC ExtInv,IEC LongInv,ANSI Inv,ANSI ModInv,ANSI VeryInv,ANSI ExtInv,ANSI LongInv,ANSI LongVeryInv,ANSI LongExtInv	DefiniteTime

Table 2-8 The enumerated parameters of the directional three-phase overcurrent protection function

Integer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Operating angle (See *Figure 1-4*)						
TOC67_ROA_IPar_	Operating Angle	deg	30	80	1	60
Characteristic angle (See *Figure 1-4*)						
TOC67_RCA_IPar_	Characteristic Angle	deg	40	90	1	60
Start current (OC module), related to the rated input current of the device, in %						
TOC67_StCurr_IPar_	Start Current	%	10	1000	1	50

Table 2-9 Integer parameters of the directional three-phase overcurrent protection function

Float parameters

Parameter name	Title	Unit	Min	Max	Digits	Default
Time multiplier of the inverse characteristics (OC module)						
TOC67_Multip_FPar_	Time Multiplier		0.05	999	-2	1.0

Table 2-10 Float parameters of the directional three-phase overcurrent protection function

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Minimal time delay for the inverse characteristics (OC module):						
TOC67_MinDel_TPar_	Min. Time	msec	50	60000	1	100
Definite time delay for the inverse characteristics (OC module):						
TOC67_DefDel_TPar_	Definite Time	msec	0	60000	1	100
Reset time delay for the inverse characteristics (OC module):						
TOC67_Reset_TPar_	Reset Time	msec	0	60000	1	100

Table 2-11 Timer parameters of the directional three-phase overcurrent protection function

The parameters with the selected settings for the example application for the differential protection function are summarized in Table *2-12* below. Some parameters need basic considerations some of them need also calculation. This is explained in the paragraphs below:

According to the example above the following setting is proposed.

Direction	Forward	If the connection of *Figure 1-1* is applied, select "Forward". If the direction should be inverted, select "Backward". When "NonDir" is selected then the angle is not evaluated. NOTE: The direction can be inverted also: • With CT connection • in CT input module, parameter setting Starpoit ="Bus", • with VT connection • in VT input module parameter setting Direction= U1-3 "Inverted"
Operation	Definite Time	This is the default setting. If any of the inverse characteristics should be applied, select accordingly
Operating Angle	80	This is the "opening" of the directional characteristic, defining the trip range
Characteristic Angle	45	This is theoretically the angle of the protected positive sequence impedance, considering additional fault resistance
Start Current	250	This means 250% of the rated current input. When 1 A is selected for parameter "Rated Secondary I1-3" then this means that above 2500mA secondary "loop" current value the function is operable.
Time Multiplier		In the example this parameter has no meaning, it is applied for inverse type operating mode only
Min. Time		In the example this parameter has no meaning, it is applied for inverse type operating mode only, this is the IDMT minimum type
Definite Time	500	This definite time should be coordinated to other protections of the network. (For inverse characteristics this parameter has no meaning.)
Reset Time		In the example this parameter has no meaning, it is applied for inverse type operating mode only, this is the reset time

Table 2-12 Example of the directional overcurrent function parameter setting

2.3.1 Setting the directionality

The directionality depends on several factors:

- The physical connection of the CT-s (See example in *Figure 1-1*)
- CT parameter setting (See 2.1)
- The physical connection of the VT-s (See example in *Figure 1-1*)
- VT parameter setting (See 2.2)
- Setting the "Direction" parameter "Forward or Backward" (
- Setting the parameter "Characteristic Angle"
- Setting the parameter "Operating Angle"

Figure 1-1 illustrates the following setting:

- Direction=Forward
- Characteristic Angle=45 degrees
- Operating Angle=20 degrees

Based on the example setting, all other variations can be realized.

2.3.2 Setting the "Start current"

The correct value for the „Start Current" parameter is calculated by fault simulation procedure. The setting is correct if the function starts in any case when fault occurs within the protected zone, considering also the highest possible fault resistance at the fault location. The setting value should be below the calculated minimal fault current, considering the usual tolerance band. The setting is correct only if the maximum load current does not result starting the function.

These setting considerations of the „Start Current" are valid also for any IDMT type characteristics.

2.3.3 Setting the "Operation" operating mode and related parameters

When any of the IDMT type characteristics is selected then the details of the selected characteristic, including the parameter values and the formulas for the mathematical description, are described in the document TOC 51 „Three-phase overcurrent protection function block description". When selecting one of the available eleven IDMT characteristics, the operating curve is to be matched to all other overcurrent protections of the network. The available characteristic types are: IEC Inv, IEC VeryInv, IEC ExtInv, IEC LongInv, ANSI Inv, ANSI ModInv, ANSI VeryInv, ANSI ExtInv, ANSI LongInv, ANSI LongVeryInv, ANSI LongExtInv.

For coordination of the selected IDMT characteristic to all other similar protection of the network, the correct setting of the following parameters are needed: „Start Current" as it is described above, for shifting the characteristic along the current axis, the „Time Multiplier" parameter to compress or expand the characteristic along the time axis, „Min Time Delay" to limit the fastest operation, and additionally „Reset time" to control the reset behavior of the function. NOTE: When selecting „DefiniteTime" characteristic, only the parameter „Start Current" and "Definite time" time delay are considered, all other parameters mentioned in this paragraph are automatically neglected.

Binary status signal	**Title**	**Explanation**
TOC67_Blk_GrO_	Block	Blocking input status signal
TOC67_VTS_GrO_	Block from VTS	Blocking input status signal from the voltage transformer supervision function

Table 2-13 The binary input signal of the directional three-phase overcurrent protection function