POWERFACTORY

PowerFactory 2021

Technical Reference

Directional Block

RelDir, TypDir

PF2021

POWER SYSTEM SOLUTIONS

MADE IN GERMANY

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1 General Description

The directional block (*RelDir*/*TypDir* class) is simulating the directional characteristic present inside the more common over current relays. It gets as input signals current and voltage values. The directional characteristic is determined by the operating quantity, usually the input current, and by the polarization quantity. The polarizing quantity is usually a voltage which is calculated rotating the input voltage by the maximum torque angle but also a current can be used. The block provides:

- A directional tripping signal; it can be set to trip in the forward or in the reverse condition; when it is connected it can be used to define the direction characteristic of a group of protection zones.
- A forward and a reverse signal for each phase. Using these signals the directional characteristic can be set in a independent way in each protection zone.

To figure out the fault direction the following directional measurement methods are supported:

- Phase comparison
- Active Power sign
- Reactive power sign

As polarizing values one of the following quantities can be used:

- the phase-phase voltages lagging 90° the operating phase current Voltage,Cross (90 deg)
- the phase-phase voltages lagging 30° the operating phase current Voltage,Cross (30 deg)
- the phase-ground voltage in phase with the operating phase current Voltage, Self
- the zero sequence voltage (3U/U0)
- the positive sequence voltage (U1)
- the negative sequence voltage (U2)
- a polarizing current
- both a voltage and a current (dual polarization)

The directional block can be 3 phases or single phase. It affects the available input and output signals. The number of phase is set by the *Type* setting which can be found inside the directional block type dialogue (*TypDir* class). The *type* can be: *3 phase*, *1 phase*, *Earth*, *Zero sequence*, *Negative sequence*, *Positive sequence*. To have a 3 phases directional block the *3 phase* type must be selected. All other types use a single phase directional block.

For each directional measurement method and each directional type only some of the available polarizing quantities can be used.

A minimum operating current threshold and a minimum polarizing voltage threshold can be set: the current is detected in the forward or in the reverse direction only if the operating current and the polarizing voltage are above the relevant threshold.

1.1 The directional measurement methods

1.1.1 The “Phase comparison” method

The directional block calculates the angle between the polarizing quantity and operating quantity. The polarizing quantity is rotated over the *Max torque angle*(*mtau* variable) first. The current is detected as forward current if the angle is smaller than the *angle operating sector* value (*phisec* variable).

When the *3 phase* or the *1 phase* type is set a *Voltage, Cross (90)*, a *Voltage,Cross (30)*, *Voltage, Self* or a *Positive sequence voltage* polarization must be used. Please note that when the *Positive sequence voltage* polarization is set the positive sequence voltage must be available at the phase A polarizing voltage input signals.

When the *Earth* or the *Zero sequence* or the *Negative sequence* type is set the *Negative sequence voltage* or the *Zero sequence voltage* or the *Current polarizing* polarization must be set. When the *Positive sequence* type is set the *Positive sequence voltage* polarization must be set.

1.1.2 The “Active power sign” method

The directional block calculates the active power using the operating quantity and the polarizing quantity rotated over the *Max torque angle*(*mtau* variable). The current direction is forward if the calculated active power is greater than 0. The used formula is:

$P = Iop \cdot (-Upol\angle MTA) \cdot cos\varphi$

where

I_{op} = operating current
$Upol\angle MTA$=polarizing voltage rotated over the MTA angle
φ= angle between I_{op} and U_{pol} after that U_{pol} has been rotated over the MTA angle

This method doesn’t support the *1 phase* and the *Positive sequence* type.

When the *Earth* or the *Zero sequence* or the *Negative sequence* type is set the *Negative sequence voltage* or the *Zero sequence voltage* polarization must be set.

1.1.3 The “Reactive power sign” method

The directional block calculates the reactive power using the operating quantity and the polarizing quantity rotated over the “Max torque angle”(“mtau” variable). The current direction is forward if the calculated reactive power is greater than 0. The used formula is:

$Q = Iop \cdot (-Upol\angle MTA) \cdot sin\varphi$

where

I_{op} = operating current
$Upol\angle MTA$=polarizing voltage rotated over the MTA angle
φ= angle between I_{op} and U_{pol} after that U_{pol} has been rotated over the MTA angle

This method doesn't support the *1 phase* and the *Positive sequence* type.

When the *Earth* or the *Zero sequence* or the *Negative sequence* type is set the *Negative sequence voltage* or the *Zero sequence voltage* polarization must be set.

1.2 The polarizing methods

1.2.1 Voltage, Cross (90deg)

The following polarizing voltages are used:

phase A: U_{bc}
phase B: U_{ca}
phase C: U_{ab}

Please note that:
U_{bc} must be provided as phase B polarizing voltage input (Upol_B signals)
U_{ca} must be provided as phase C polarizing voltage input (Upol_C signals)
U_{ab} must be provided as phase A polarizing voltage input (Upol_A signals)

1.2.2 Voltage, Cross (30deg)

The following polarizing voltages are used:

phase A: U_{ac}
phase B: U_{ba}
phase C: U_{cb}

Please note that:
U_{ca} must be provided as phase C polarizing voltage input (Upol_C signals)
U_{ab} must be provided as phase A polarizing voltage input (Upol_A signals)
U_{bc} must be provided as phase B polarizing voltage input (Upol_B signals)

1.2.3 Voltage, Self

The following polarizing voltages are used:

phase A: U_a
phase B: U_b
phase C: U_c

1.2.4 Zero sequence voltage (3U0/U0)

It is a single phase block. It uses as polarizing voltage $-wU_{pol}$ (where wU_{pol} is the polarizing voltage input signal).

1.2.5 Positive sequence voltage(U1)

The following polarizing voltages are used:

phase A: U_1
phase B: $U_1 a * a$
phase C: $U_1 * a$

where $a = 1/2 + j^* \sqrt{3/2}$

1.2.6 Negative sequence voltage (U2)

It is a single phase block. It uses as polarizing voltage $-wU_{pol}$ (where wU_{pol} is the polarizing voltage input signal).

1.2.7 Dual

It uses at the same time a current polarizing signal ($-wI_{pol}$) and a voltage polarizing signal (-wU_{pol}). It is a single phase block. Please note that the "Dual" polarization can be set only when the *Type* is *Earth* or *Zero sequence* or *Negative sequence* and the measurement method is *Phase comparator*. When the "Dual" polarization is set the Dual Pol.Expression (dpolex variable) combo box is displayed inside the *TypDir* dialogue.

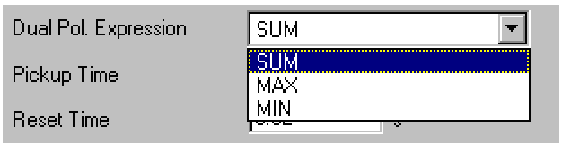

Figure 1.1: The Dual polarization Expression combo box

If the measurement method is *Phase comparator* it can be *MAX* or "MIN"; when it is *MAX* both the equations (the equation based on the current polarization and the equation based on the voltage polarization) must be verified the define the fault direction. When it is *MIN* at least one of the must be verified the define the fault direction. The *SUM* expression at the moment is not used.

2 Using the block

The directional type class name is *TypDir*; the directional element class name is *RelDir*. Here below the directional element dialogue. Please note the settings are arranged in 3 tab pages: "Basic Data", "Voltage Polarizing" and "Current polarizing". The "Current polarizing" tab page is active only when the "Dual" polarizing method has been set.

In the "Basic Data" tab page the *Tripping direction* combo box (*idir* variable)allows specifying in which direction the directional block must trip. In this way the zone elements can be also driven using the forward (*wfwd*) and the reverse (*wrev*) signals. Please note that the *Angle operating sector* (phisec variable) control is displayed only if the measurement method is *Phase comparator*.

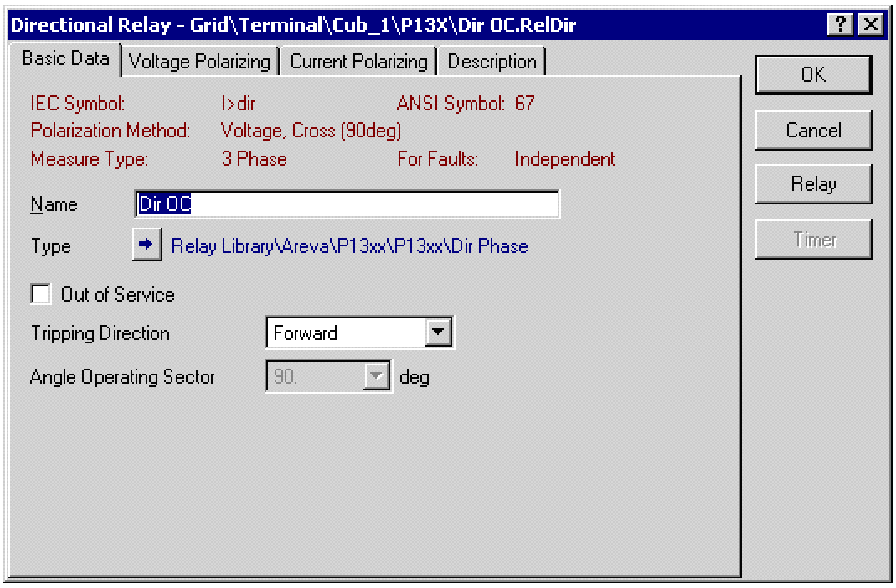

Figure 2.1: The directional element dialogue main page

The "Voltage Polarizing" tab page allows defining a minimum activation threshold for the operating current and for the polarizing voltage and the rotation angle (Max.Torque Angle control, mtau variable)applied to the polarizing voltage vector.

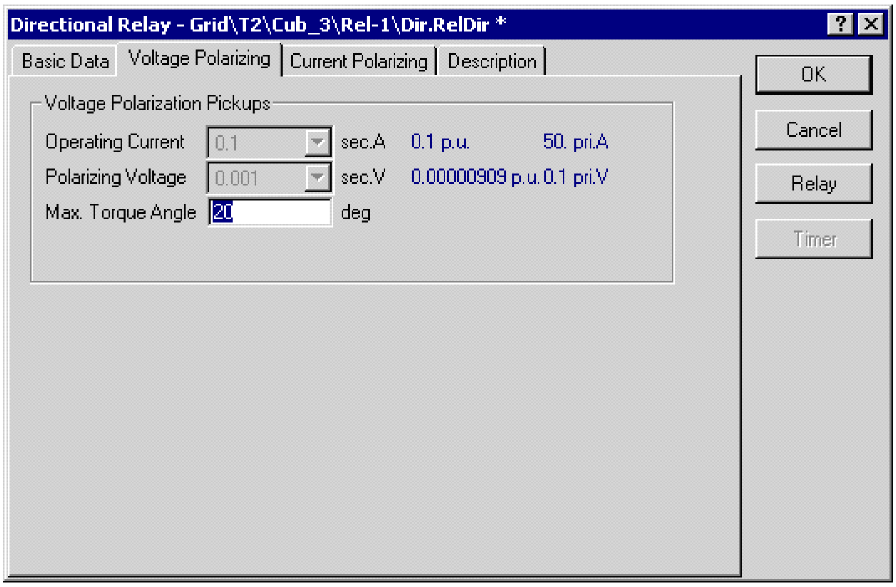

Figure 2.2: The directional element dialogue Voltage polarizing page

The “Current Polarizing” tab page allows defining a minimum activation threshold for the operating current and for the polarizing current and the rotation angle (Max.Torque Angle control, mtau variable)applied to the polarizing current vector.

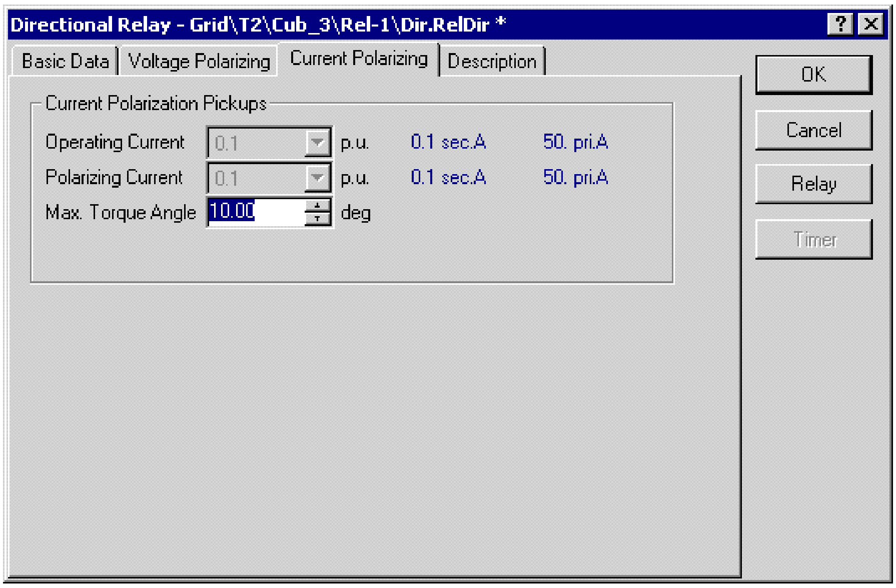

Figure 2.3: The directional element dialogue Current polarizing page

Please note that the “Current polarizing” tab page is available only when the “Dual” polarizing method has been set.

The element behaviour can be customized using the directional type dialogue (*TypDir* class). This dialogue has three tab pages: “Basic data”, “Voltage Polarizing” and “Current Polarizing”.

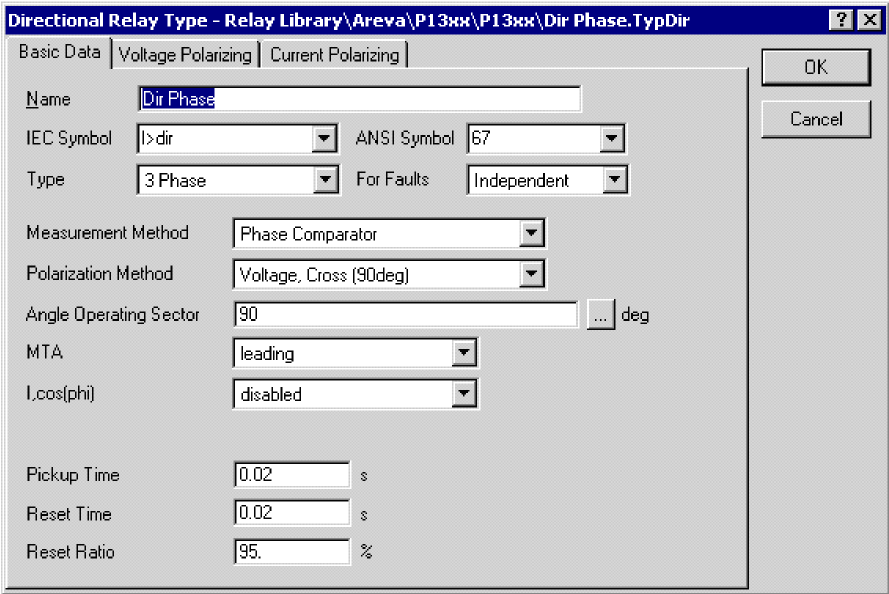

Figure 2.4: The directional type dialogue main page

As you can see, in this tab page the main control configuration can be set: the type of directional element(*3 phase*, *1phase*, *Earth* etc atype variable), the measurement method (*P, cos phi*, *Q, sinphi* etc ameastp variable) and the polarizing type (*Voltage cross, 90*, *Voltage cross, 30* , *dual* etc apol variable). The MTA combo box setting represent the versus of the rotation applied to the polarizing quantity by the *Max torque angle*(*mtau* variable located in the *Polarizing voltage* tab page).

The *I,cos(phi)* combo box allows configuring the behaviour of the logic checking if the operating current is greater that the minimum operating threshold. It contains the following options: *disabled*, *always enabled* and *configurable*. When *configurable* is set the *I, cos phi* check box is displayed in the directional dialogue, *Basic Data* tab page. When *always enabled* is set or *configurable* is set and the user checked the *I, cos phi* check box the operating current input signal value is multiplied by cos φ before being compared to the minimum operating threshold (*operating current setting* located in the *voltage polarizing* tab page, curopu variable). When *disabled* is set the operating current input signal value is directly compared to the minimum operating threshold.

In the “Voltage polarizing” tab page the range of the *Operating Current*, the range of the *Polarizing Voltage* and the range of the *Maximum Torque angle* applied to the polarizing voltage can be set.

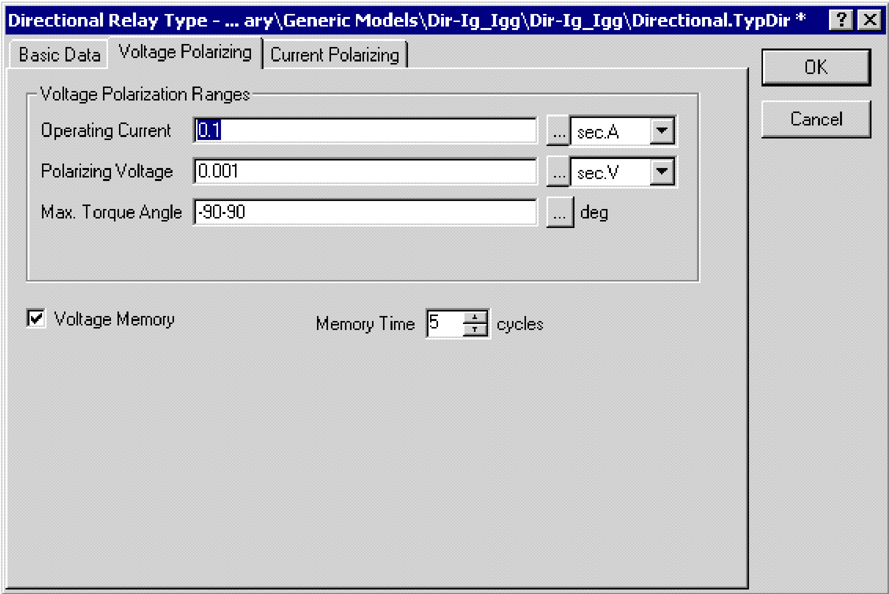

Figure 2.5: The directional type dialogue Voltage polarizing page

Please note that the *Voltage memory* check box (imem variable) allows enabling a voltage buffer storing the voltage value before the fault for the number of cycles set in the *Memory time* edit box (tmem variable). This feature is used by many relay models to maintain the direction for a close fault.

It the “Current Poalrizing” tab page the range of the *Operating Current*, the range of *Polarizing Current* and the range of the *Maximum Torque angle* applied to the polarizing current can be set.

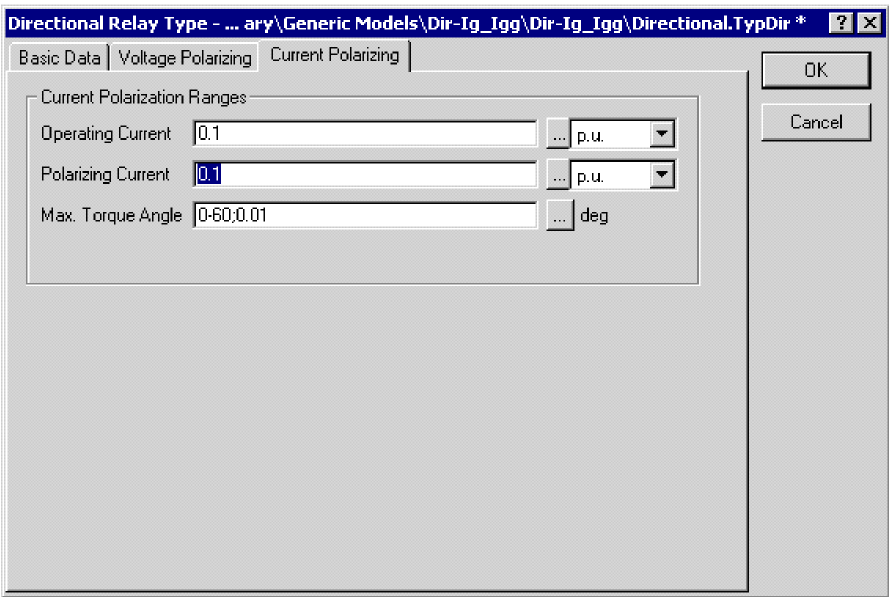

Figure 2.6: The directional type dialogue Voltage polarizing page

3 Input Parameters definition

3.1 Directional Type (TypDir)

Parameter	Description	Unit
loc_name	The directional type block name	Text
sfiec	IEC Symbol (default values:"I->", "Ie->", "I>dir", "P>", "t" but any kind of string can be typed directly inside the combo box) that will be displayed in the *RelDir* dialogue	Text
sfansi	ANSI Symbol(Default values "67", "67N", "32" but any kind of string can be typed directly inside the combo box) that will be displayed in the *RelDir* dialogue	Text
atype	Directional type: it can be "3 phase", "1 phase", "earth", "zeros sequence", "Negative sequence", "Positive sequence"	Text
apol	Polarization Method: it can be "Voltage, Cross (90deg)", "Voltage, Cross (30deg)" "Voltage, Self", "Current", "Dual", "Zero Sequence Voltage (3U0/U0)" "Negative Sequence Voltage (U2)", "Positive Sequence Voltage (U1)", " "	Text
aunit	For which kind of faults the directional unit operates. It can be: "Independent" (it operates for any kind of fault),"A-B-C", "A or B or C","A-B", "B-C", "C-A"	Text
ameastp	Measurement Method. It can be "P, cos phi/Q ,sin phi", "P, cos phi", "Q, sin phi", "Phase Comparator"	Text
awattcon	Tripping Condition. It can be "I > Is∗cos(phi)", " I > Is∗cos(phi), U > Us ", "I > Is,U >"Us, "P > 3∗Us∗Is", "I > Is,U > Us, P > Us∗Is", "P > Ps"	Text
imtadir	Maximum torque angle (MTA) direction. It can be: "Leading" or "lagging"	Integer
iicosphi	"I,cos(phi)" option. It allows defining if the I vector must be projected on the U vector. It can be: "disabled", "always enabled", "configurable"	Integer
rphisec	Angle operating sector range. It defines 1/2 of the direction detection sector	Text
dpolex	The logical expression used when the "Dual" polarizing method is used. It can be "SUM", "MAX" or "MIN"	Integer
rcuropu	Operating current range(voltage polarization)	Text
iunitc	Operating current unit. It can be "sec.A" (secondary Amperes) or "p.u."	Integer
rupolu	Polarizing Voltage range (voltage polarization)	Text
iunitu	Polarizing voltage unit. It can be "sec.U"(secondary Volts) or "p.u."	Integer
rmtau	Max. Torque Angle range (voltage polarization)	Text
rprodu	Polarizing voltage Product(used when the Tripping condition is "P > Ps" and the Measurement Method is "P, cos phi/Q ,sin phi", "P, cos phi", "Q, sin phi")	Text
iunitpu	Polarizing voltage "Product" unit. It can be "p.u" or "sec.VA"	Integer
imem	Flag to enable/disable the voltage memory	Integer
tmem	Memory voltage buffer length	cycles
rcuropc	Operating Current range (current polarization)	Text
rcpolc	Polarizing Current range (current polarization)	Text
rmtac	Max. Torque Angle range (current polarization)	Text
rprodc	Polarizing current Product(at the moment never used).	Text
iunitpc	Polarizing current "Product" unit. (at the moment never used)	Integer

Ts	Pickup Time	Real
Tr	Reset time	Real
Kr	Reset ratio	Real

3.2 Directional Element(RelDir)

Parameter	**Description**	**Unit**
loc_name	The directional block name	Text
typ_id	A reference to the directional type block	Pointer
outserv	Flag to enable/disable the block	Y/N
idir	Tripping direction (it can be “forward” or “reverse”)	Integer
phisec	Angle operating sector. It defines 1/2 of the direction detection sector	Real
curopu	Operating current (voltage polarization) in p.u.	Real
curopur	Operating current (voltage polarization) in secondary Amperes	Real
upolu	Polarizing Voltage range (voltage polarization) in p.u.	Real
upolur	Polarizing Voltage range (voltage polarization) in secondary Volts	Real
mtau	Max. Torque Angle (voltage polarization)	Real
produ	Polarizing voltage Product(used when the Tripping condition is “P > Ps” and the Measurement Method is “P, cos phi/Q ,sin phi”, “P, cos phi”, “Q, sin phi”) in p.u.	Real
produr	Polarizing voltage Product(used when the Tripping condition is “P > Ps” and the Measurement Method is “P, cos phi/Q ,sin phi”, “P, cos phi”, “Q, sin phi”) in secondary VA.	Real
curopc	Operating Current (current polarization) in p.u.	Real
curopcr	Operating Current (current polarization) in secondary Amperes	Real
cpolc	Polarizing Current (current polarization) in p.u.	Real
cpolcr	Polarizing Current (current polarization) in secondary Amperes	Real
mtac	Max. Torque Angle (current polarization)	Real
prodc	Polarizing current Product(at the moment never used) in p.u.	Real
prodcr	Polarizing current Product(at the moment never used) in secondary Amperes $*$ secondary Amperes	Real
idpol	Used Polarization. It can be “Voltage”, “Current”, or “Dual”	Integer
imeasure	The measurement method. It can be “P, cos phi” or “Q, sin phi”	Integer
icosphi	Flag to enable/disable the “I, cos(phi)” feature	Integer

4 Input/Output signals definition

4.1 Single phase signals definition

Input Signal	Description	Unit
Iop	Operating Current RMS value	Amperes
Iopr	Operating Current real part	Amperes
Iopi	Operating Current imaginary part	Amperes
Upol	Polarizing voltage RMS value	Volts
Upolr	Polarizing voltage real part	Volts
Upoli	Polarizing voltage imaginary part	Volts
wsup	Supervision signal	Seconds (or 1/0 during the simulation)

Output Signal	Description	Unit
yout	directional element trip signal	Seconds (or 1/0 during the simulation)
forward	Signal on when the element detects a forward condition	Seconds (or 1/0 during the simulation)
reverse	Signal on when the element detects a reverse condition	Seconds (or 1/0 during the simulation)
yIop	Operating current calculated using the cosphi (RMS value)	Amperes

4.2 Single phase - dual polarization signals definition

Input Signal	Description	Unit
Iop	Operating Current RMS value	Amperes
Iopr	Operating Current real part	Amperes
Iopi	Operating Current imaginary part	Amperes
Upol	Polarizing voltage RMS value	Volts
Upolr	Polarizing voltage real part	Volts
Upoli	Polarizing voltage imaginary part	Volts
Ipol	Polarizing Current RMS value	Amperes
Ipolr	Polarizing Current real part	Amperes
Ipoli	Polarizing Current imaginary part	Amperes
wsup	Supervision signal	Seconds (or 1/0 during the simulation)

Output Signal	Description	Unit
yout	directional element trip signal	Seconds (or 1/0 during the simulation)
forward	Signal on when the element detects a forward condition	Seconds (or 1/0 during the simulation)
reverse	Signal on when the element detects a reverse condition	Seconds (or 1/0 during the simulation)

4.3 Single phase - dual polarization signals definition (“P, cos phi/Q ,sin phi”, “P, cos phi”, “Q, sin phi” measurement method)

Input Signal	Description	Unit
Iop	Operating Current RMS value	Amperes
Iopr	Operating Current real part	Amperes
Iopi	Operating Current imaginary part	Amperes
Upol	Polarizing voltage RMS value	Volts
Upolr	Polarizing voltage real part	Volts
Upoli	Polarizing voltage imaginary part	Volts
Ipol	Polarizing Current RMS value	Amperes
Ipolr	Polarizing Current real part	Amperes
Ipoli	Polarizing Current imaginary part	Amperes
wsup	Supervision signal	Seconds (or 1/0 during the simulation)

Output Signal	Description	Unit
yout	directional element trip signal	Seconds (or 1/0 during the simulation)

4.4 Single phase - watt measurement signals definition

Input Signal	Description	Unit
Iop	Operating Current RMS value	Amperes
Iopr	Operating Current real part	Amperes
Iopi	Operating Current imaginary part	Amperes
Upol	Polarizing voltage RMS value	Volts
Upolr	Polarizing voltage real part	Volts
Upoli	Polarizing voltage imaginary part	Volts
wsup	Supervision signal	Seconds (or 1/0 during the simulation)

Output Signal	Description	Unit
yout	directional element trip signal	Seconds (or 1/0 during the simulation)
forward	Signal on when the element detects a forward condition	Seconds (or 1/0 during the simulation)
reverse	Signal on when the element detects a reverse condition	Seconds (or 1/0 during the simulation)
power	Apparent Power (RMS value)	VA

4.5 Three phases signals definition

Input Signal	Description	Unit
Iop_A	Phase A operating Current RMS value	Amperes
Iop_B	Phase B operating Current RMS value	Amperes
Iop_C	Phase C operating Current RMS value	Amperes
Iopr_A	Phase A operating Current real part	Amperes
Iopr_B	Phase B operating Current real part	Amperes
Iopr_C	Phase C operating Current real part	Amperes
Iopi_A	Phase A operating Current imaginary part	Amperes
Iopi_B	Phase B operating Current imaginary part	Amperes
Iopi_C	Phase C operating Current imaginary part	Amperes
Upol_A	Phase A polarizing voltage RMS value	Volts
Upol_B	Phase B polarizing voltage RMS value	Volts
Upol_C	Phase C polarizing voltage RMS value	Volts
Upolr_A	Phase A polarizing voltage real part	Volts
Upolr_B	Phase B polarizing voltage real part	Volts
Upolr_C	Phase C polarizing voltage real part	Volts
Upoli_A	Phase A polarizing voltage imaginary part	Volts
Upoli_B	Phase B polarizing voltage imaginary part	Volts
Upoli_C	Phase C polarizing voltage imaginary part	Volts
wsup_A	Phase A supervision signal	Seconds (or 1/0 during the simulation)
wsup_B	Phase B supervision signal	Seconds (or 1/0 during the simulation)
wsup_C	Phase C supervision signal	Seconds (or 1/0 during the simulation)

Output Signal	Description	Unit
yout	Directional element trip signal	Seconds (or 1/0 during the simulation)
yout_A	Phase A directional element trip signal	Seconds (or 1/0 during the simulation)
yout_B	Phase B directional element trip signal	Seconds (or 1/0 during the simulation)
yout_C	Phase C directional element trip signal	Seconds (or 1/0 during the simulation)
fwd_A	Signal on when the element detects a Phase A forward condition	Seconds (or 1/0 during the simulation)
fwd_B	Signal on when the element detects a Phase B forward condition	Seconds (or 1/0 during the simulation)
fwd_C	Signal on when the element detects a Phase C forward condition	Seconds (or 1/0 during the simulation)
rev_A	Signal on when the element detects a Phase A reverse condition	Seconds (or 1/0 during the simulation)
rev_B	Signal on when the element detects a Phase B reverse condition	Seconds (or 1/0 during the simulation)
rev_C	Signal on when the element detects a Phase C reverse condition	Seconds (or 1/0 during the simulation)
yIop_A	Phase A operating current calculated using the cosphi (RMS value)	Amperes
yIop_B	Phase B operating current calculated using the cosphi (RMS value)	Amperes
yIop_C	Phase C operating current calculated using the cosphi (RMS value)	Amperes

4.6 Three phases signals definition (“P, cos phi/Q ,sin phi”, “P, cos phi”, “Q, sin phi” measurement method)

Input Signal	Description	Unit
Iopr_A	Phase A operating Current real part	Amperes
Iopr_B	Phase B operating Current real part	Amperes
Iopr_C	Phase C operating Current real part	Amperes
Iopi_A	Phase A operating Current imaginary part	Amperes
Iopi_B	Phase B operating Current imaginary part	Amperes
Iopi_C	Phase C operating Current imaginary part	Amperes
Upolr_A	Phase A polarizing voltage real part	Volts
Upolr_B	Phase B polarizing voltage real part	Volts
Upolr_C	Phase C polarizing voltage real part	Volts
Upoli_A	Phase A polarizing voltage imaginary part	Volts
Upoli_B	Phase B polarizing voltage imaginary part	Volts
Upoli_C	Phase C polarizing voltage imaginary part	Volts
wsup	Supervision signal	Seconds (or 1/0 during the simulation)

Output Signal	Description	Unit
yout	directional element trip signal	Seconds (or 1/0 during the simulation)
forward	Signal on when the element detects a forward condition	Seconds (or 1/0 during the simulation)
reverse	Signal on when the element detects a reverse condition	Seconds (or 1/0 during the simulation)