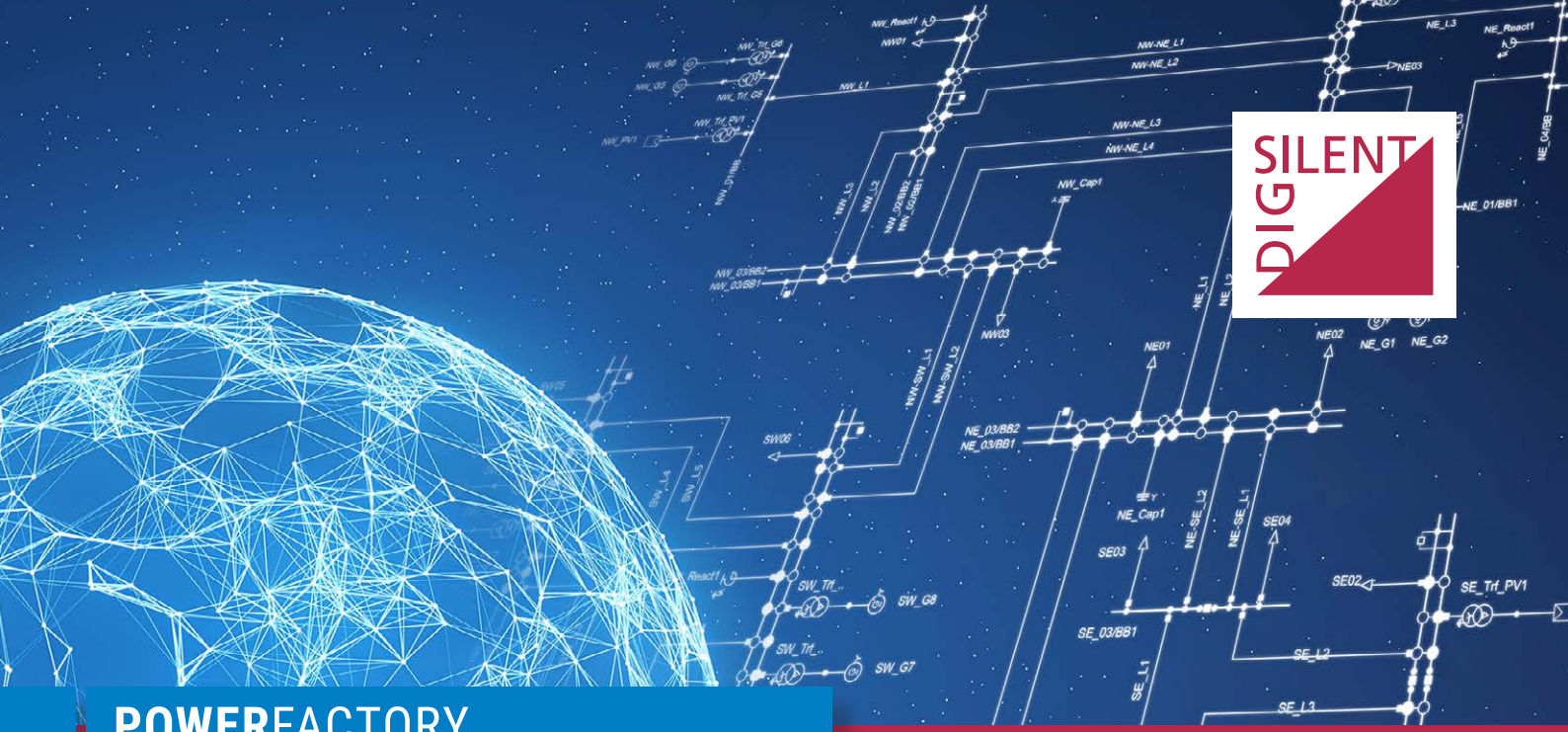

POWERFACTORY

PowerFactory 2021

Technical Reference

SEL Directional

RelSeldir, TypSeldir

PF2021

POWER SYSTEM SOLUTIONS

MADE IN GERMANY

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Contents

1 General Description

The *SEL Directional element* provides a detailed implementation of the directional logic used by the Schweitzer devices. The logic is based on the negative and the zero sequence impedances which allow to detect the direction of both the phase and the ground fault current.

The *SEL Directional Element* block is operational during short circuit, load flow and RMS/EMT simulations.

2 Features & User interface

2.1 SEL Directional Element (RelSeldir)

The user can change the block settings using the “SEL Directional element” dialog (“RelSeldir” class). The dialog consists of five tab pages: *Basic Settings*, *Negative sequence*, *Phase*, *Ground*, and *Description*.

2.1.1 Basic Settings

The “Basic Settings” tab page contains the following controls:

- An editbox which allows to insert a name to identify the *SEL Directional Element* (“loc_name” parameter).
- A pointer to a “SEL Directional Element type” object which defines the SEL Directional Element type and setting ranges (“typ_id”).
- A combobox which allows to select the ground direction element priority (“ORDER” parameter). This combobox is not visible if the selected directional type is *SEL321*.
- A set of combo boxes which allow to define the direction of each distance protection zone (4 zones and 5 only for the *SEL 421* type).
- 3 Combo boxes which define the directional trip logic for the phase, negative sequence , and residual current inverse time overcurrent elements (Only for the *SEL321* type).
- A check box to configure the logic in case of loss of potential (“ELOP” parameter).
- A check box which defines if the voltages comes from a 3 phase VT(*SEL351R* type only logic).

2.1.2 Negative sequence

The “Negative sequence” tab page contains the graphical controls which allow to configure the negative sequence impedance directional detection. The following graphical controls are showed:

- Two edit boxes which define the minimum negative sequence current release threshold in forward and reverse direction (“s50QF” and “s50QR” parameter).

- Two edit boxes which define the negative sequence impedance thresholds used by the directional logic to declare a fault as forward or as reverse (“Z2F” and “Z2R” parameter).
- An edit box which defines the positive sequence restraint factor a_2 (“a2”).
- An edit box which defines the zero sequence restraint factor a_2 (“k2”).
- Two edit boxes which defines the line positive sequence impedance magnitude and angle (“Zm” and “phi” parameter).

The graphical controls are combo boxes for ranges of discrete values (as defined in the “Distance Load Encroachment Type” dialog, see **??**) otherwise edit boxes.

2.1.3 Phase

The “Phase” tab page contains an unique edit box which defines the phase directional pickup threshold 50P32P (“s50P32P” parameter). The graphical control is visible and the relevant logic is active only when the SEL Directional type is *SEL351* or *SEL351R*.

2.1.4 Ground

The “Ground” tab page contains the graphical controls which allow to configure the negative sequence impedance directional detection. The following graphical controls are showed:

- A check box which allows to enable/disable the ground direction detection logic (“E32IV” parameter).
- Two edit boxes which define the minimum residual current release threshold in forward and reverse direction (“s50GF” and “s50GR” parameter).
- Two edit boxes which define the zero sequence impedance thresholds used by the directional logic to declare a fault as forward or as reverse (“Z0F” and “Z0R” parameter).
- An edit box which defines the zero sequence restraint factor a_0 (“a0”).
- An edit box which defines the load detection phase pickup threshold $50LP$ (“s50LP”).
- Two edit boxes which defines the line zero sequence impedance magnitude and angle (“Z0” and “phi0” parameter).

2.1.5 Description

The *Description* tab page can be used to insert some information to identify the *Distance Load Encroachment* protective element (both with a generic string and with an unique textual string similar to the *Foreign Key* approach used in the relational databases) and to identify the source of the data used to create it.

2.2 SEL Directional Element Type (TypSeldir)

The *SEL Directional Element* block main characteristics must be configured in the “SEL Directional Element Type” dialog (*TypSeldir* class). The dialog consists of four tab pages: *Basic Settings*, *Negative sequence*, *Phase*, and *Ground*.

2.2.1 Basic Settings

The followings parameters can be set:

- A name which identifies the *SEL Directional Element* type ("loc_name" parameter).
- The SEL Directional Element type ("relaymodel" parameter).
- Four (or five for the *SEL421* type) comboboxes which define the options available in the "SEL Directional Element" dialog in the comboxes which are used by the user to set the direction of each protection zone.
- The *Pickup time* edit box ("Ts" parameter).

2.2.2 Negative sequence

The "Negative sequence" tab page contains the graphical controls which allow to configure the ranges of the negative sequence impedance directional detection parameters. The following graphical controls are showed:

- Two edit boxes which define the ranges of the minimum negative sequence current release threshold in forward and reverse direction ("rs50QF" and "rs50QR" parameter).
- Two edit boxes which define the ranges of the negative sequence impedance thresholds used by the directional logic to declare a fault as forward or as reverse ("rZ2F" and "rZ2R" parameter).
- An edit box which defines the range of the positive sequence restraint factor a_2 ("ra2").
- An edit box which defines the range of the zero sequence restraint factor a_2 ("rk2").
- Two edit boxes which defines the ranges of the line positive sequence impedance magnitude and angle ("rZm" and "rphi" parameter).

2.2.3 Phase

The "Phase" tab page contains an unique edit box which defines the range of the phase directional pickup threshold 50P32P ("s50P32P" parameter). The graphical control is visible and the relevant logic is active only when the SEL Directional type is *SEL351* or *SEL351R*.

2.2.4 Ground

The "Ground" tab page contains the graphical controls which allow to configure the ranges of the negative sequence impedance directional detection parameters. The following graphical controls are showed:

- Two edit boxes which define the ranges of the minimum residual current release threshold in forward and reverse direction ("rs50GF" and "rs50GR" parameter).
- Two edit boxes which define the ranges of the zero sequence impedance thresholds used by the directional logic to declare a fault as forward or as reverse ("rZ0F" and "rZ0R" parameter).

- An edit box which defines the range of the zero sequence restraint factor a_0 (“ra0”).
- An edit box which defines the range of the load detection phase pickup threshold $50LP$ (“rs50LP”).
- Two edit boxes which defines the ranges of the line zero sequence impedance magnitude and angle (“rZ0” and “rphi0” parameter).

2.3 Directional algorithms

The following directional algorithms are used to calculate the direction of the fault:

- Negative sequence impedance.
- Zero sequence impedance.
- Positive sequence impedance.
- Ground current neutral polarized.

The algorithms are evaluated using the order set in the “Ground Directional element priority” (“ORDER” parameter) combobox.

2.3.1 Negative sequence impedance algorithm

The negative sequence impedance directional equation is:

$Z_2 = \frac{Re[V_2(1\angle\Phi_{L2} * I_2)^*]}{{I_2}^2}$

where

V_2 = Negative-sequence voltage = $(V_A + a^2 V_B + a V_c)/3$
I_2 = Negative-sequence current $(I_A + a^2 I_B + a I_C)/3$
Φ_{L2} Line negative-sequence impedance angle

2.3.2 Zero sequence impedance algorithm

The zero sequence impedance directional equation is:

$Z_0 = \frac{Re[V_0(1\angle\Phi_{L0} * I_0)^*]}{{I_0}^2}$

where

V_0 = Zero-sequence voltage = $(V_A + V_B + V_c)/3$
I_0 = Zero-sequence current $(I_A + I_B + I_C)/3$
Φ_{L0} Line Zero-sequence impedance angle

2.3.3 Positive sequence impedance algorithm

The Positive sequence impedance directional equation is:

$T = cos(\angle Z_{1L} - \angle U1/I1)$

2.3.4 Ground current neutral polarized

The zero sequence current neutral current polarized directional equation is:

$T = Re[I_G * I_N^*]$

2.4 Ground direction element priority

The following priorities in the selection of the directional algorithm can be specified in the "Ground Directional element priority" ("ORDER" parameter) combo box in the *Basic Settings* tab page of the *SEL Directional Element* dialog.

- OFF
- Q
- V
- I
- Q V
- Q I
- V Q
- V I
- I V
- I Q
- Q V I
- Q I V
- V Q I
- V I Q
- I Q V
- I V Q

2.5 Supported relay models

The block can be configured using the "Relay Model" ("relymodel" parameter)setting as:

- SEL321
- SEL351
- SEL351R
- SEL311
- SEL411L
- SEL421

For each "Relay Model" a different set of directional algorithms and settings is available.

SEL321 :

- Negative sequence impedance directional.
- Torque control for phase (*51P*), residual (*51N*), and negative sequence (*51Q*).
- Four Levels of *Direction*.

SEL351 :

- Negative sequence impedance directional.
- Zero sequence impedance directional.
- Phase directional pickup current.
- Ground current neutral polarized directional.
- Four Levels of *Direction*.
- Ground directional element priority.

SEL351R :

- Negative sequence impedance directional.
- Zero sequence impedance directional.
- Phase directional pickup current.
- Ground current neutral polarized directional.
- Four Levels of *Direction*.
- Ground directional element priority.
- *True-3 phase voltage connected 3PVOLT* flag.

SEL311 :

- Negative sequence impedance directional.
- Zero sequence impedance directional.
- Torque control for phase (*51P*), residual (*51N*), and negative sequence (*51Q*).
- Four Levels of *Direction*.
- Ground directional element priority.

SEL411L :

- Negative sequence impedance directional.
- Zero sequence impedance directional.
- Five Levels of *Direction*.
- Ground directional element priority.

SEL421 :

- Negative sequence impedance directional.
- Zero sequence impedance directional.
- Five Levels of *Direction*.
- Ground directional element priority.

3 Logic

The directional detection logics are depicted hereby using simplified logic representations. For more details please refer to the relevant Schweitzer relay manuals.

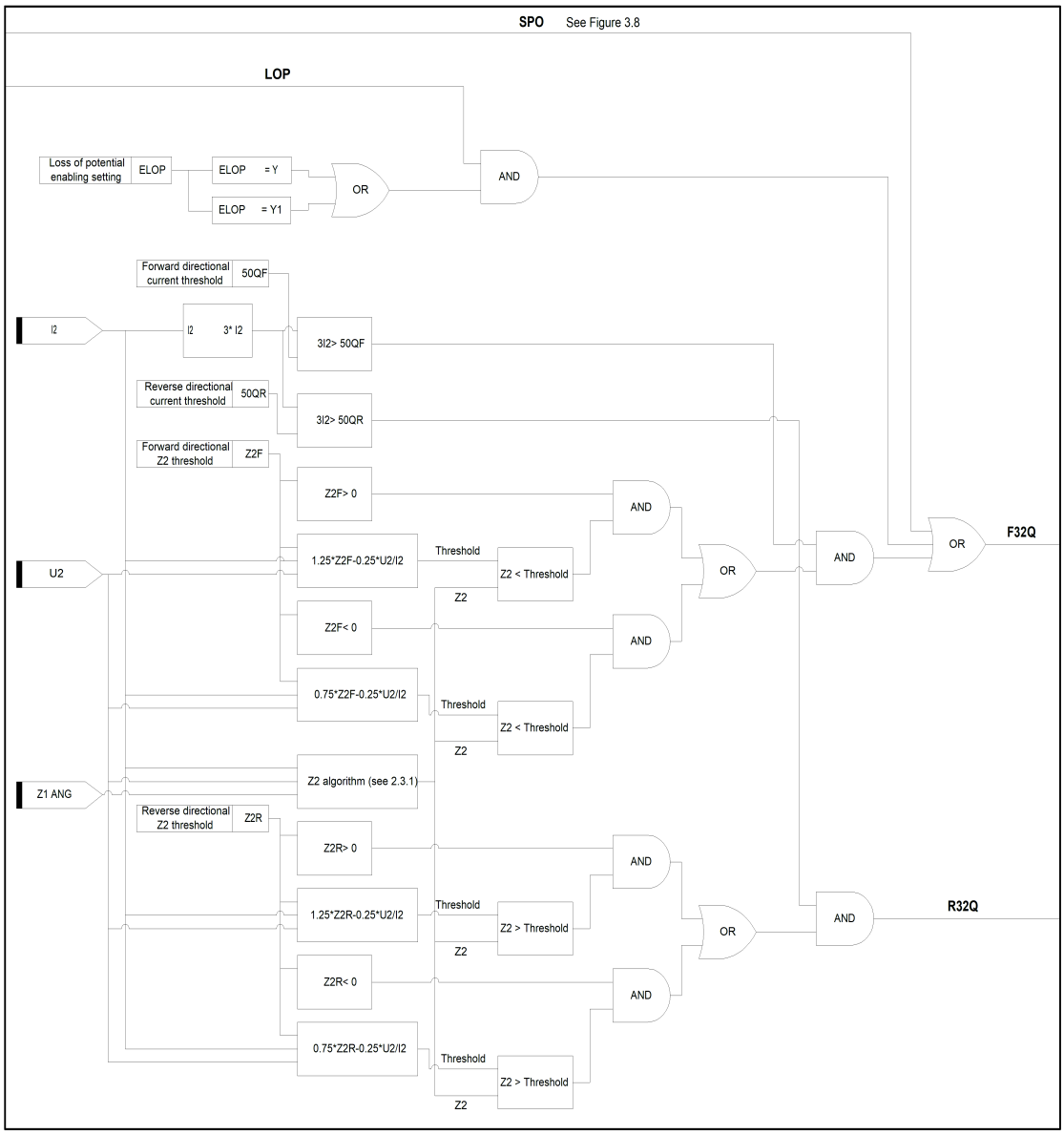
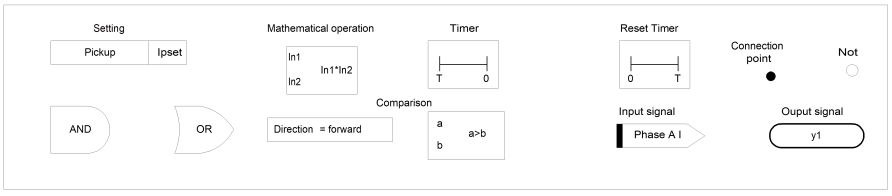


Figure 3.1: The *DIgSILENT PowerFactory SEL Directional element* Negative sequence impedance logic (“CalSeldir” class) block.



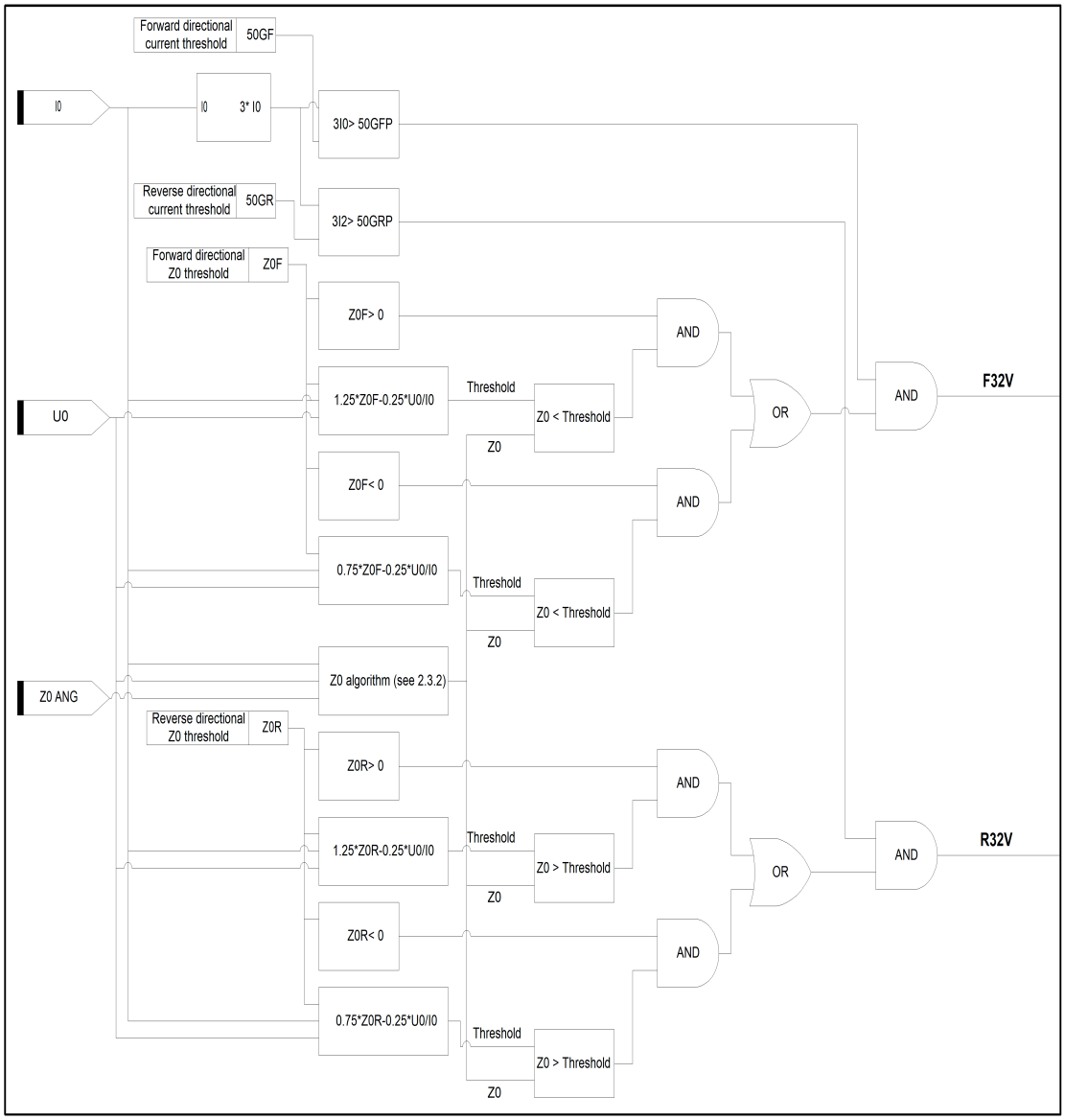
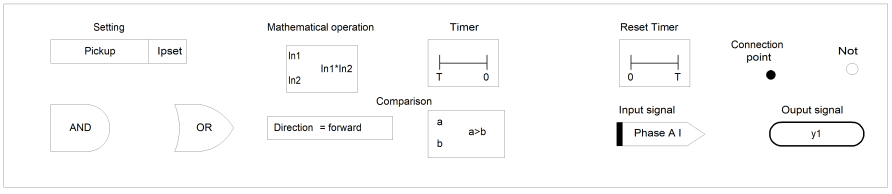


Figure 3.2: The *DIgSILENT PowerFactory SEL Directional element* Zero sequence impedance logic (“CalSeldir” class) block.



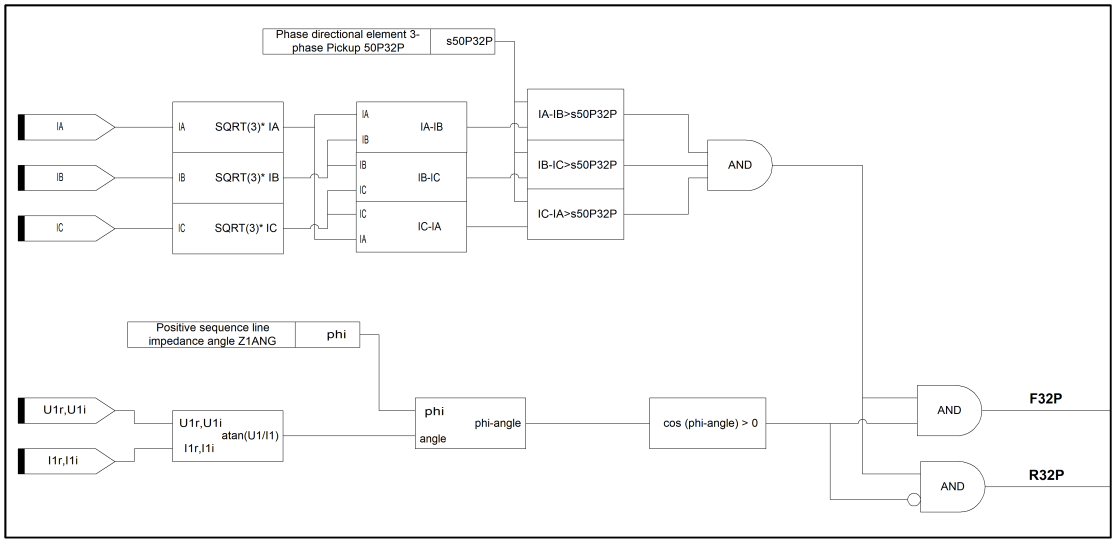


Figure 3.3: The *DIgSILENT PowerFactory SEL Directional element* Positive sequence impedance logic (“CalSeldir” class) block.

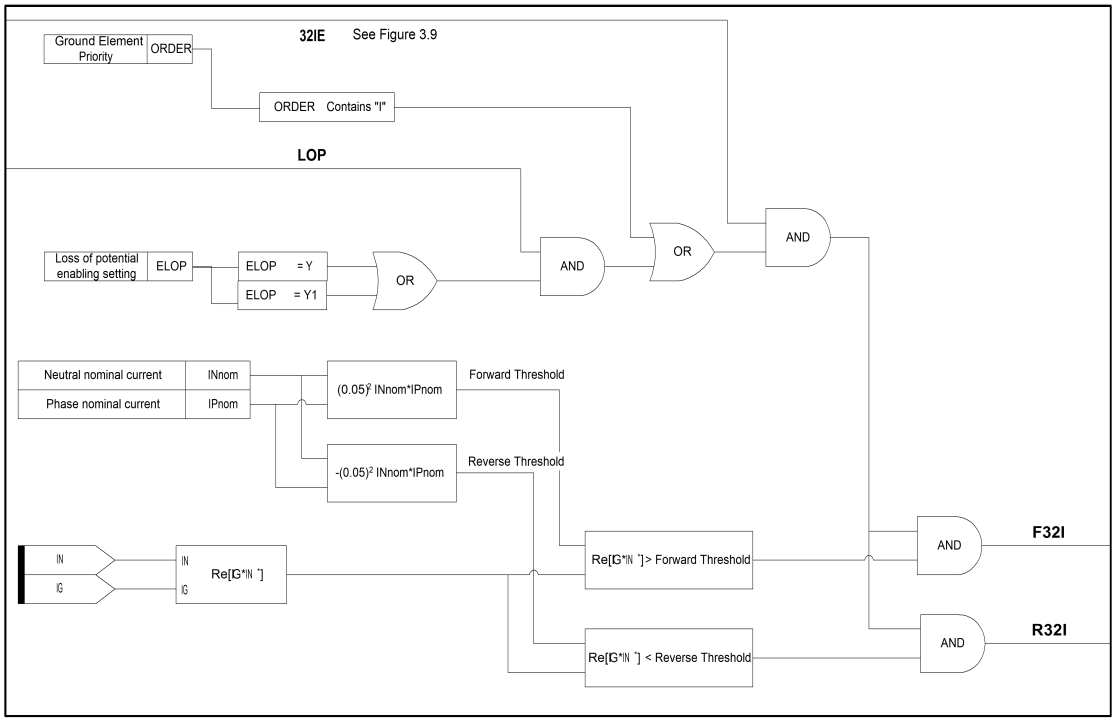
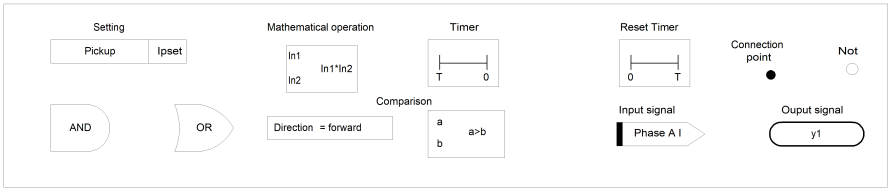


Figure 3.4: The *DIgSILENT PowerFactory SEL Directional element* Zero sequence current neutral current polarized logic (“CalSeldir” class) block.



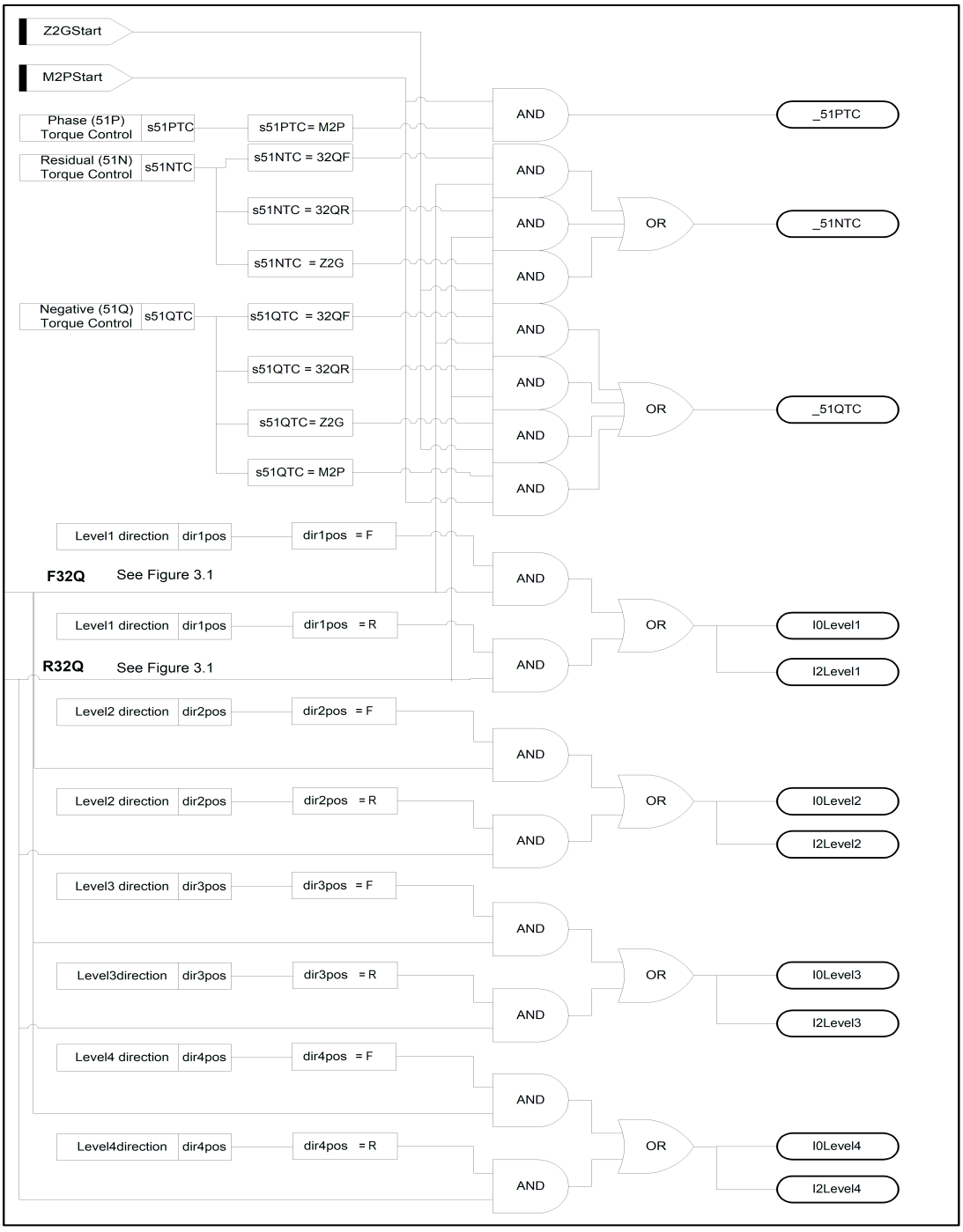
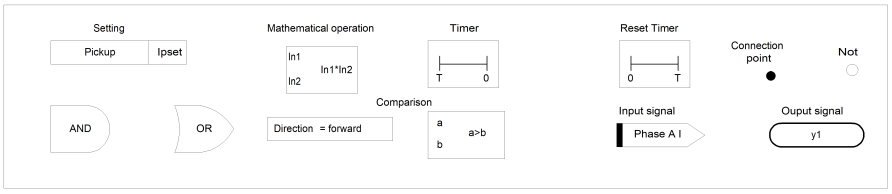


Figure 3.5: The *DIgSILENT PowerFactory SEL Directional element* SEL 321 Directional Logic ("CalSeldir" class) block.



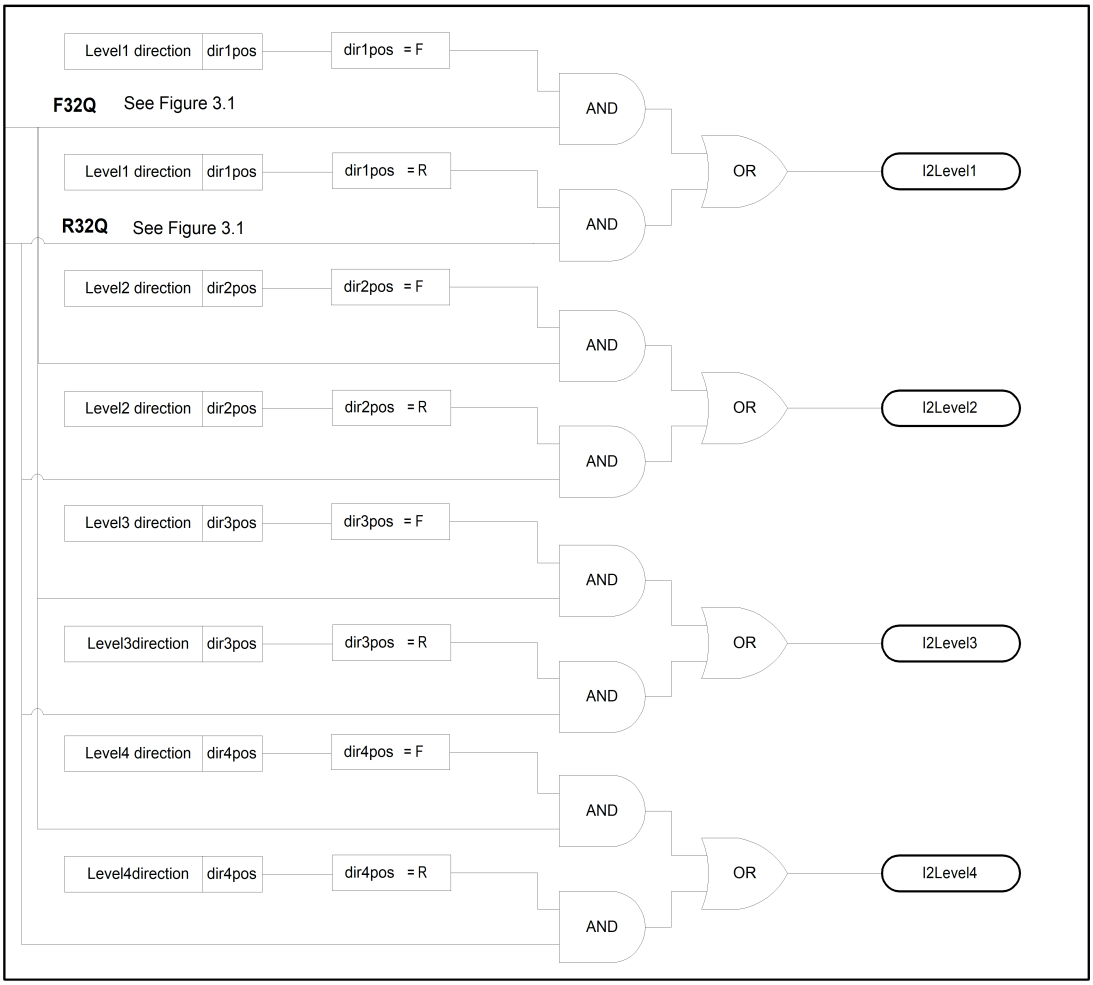
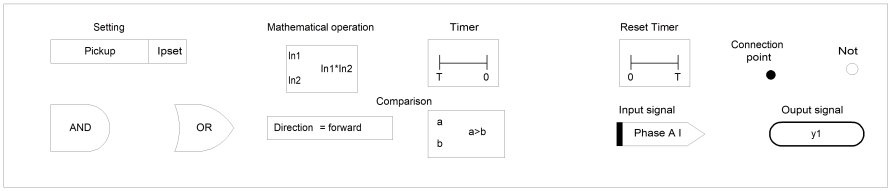


Figure 3.6: The *DIgSILENT PowerFactory SEL Directional element* SEL 351 Negative Sequence Directional Logic (“CalSeldir” class) block.



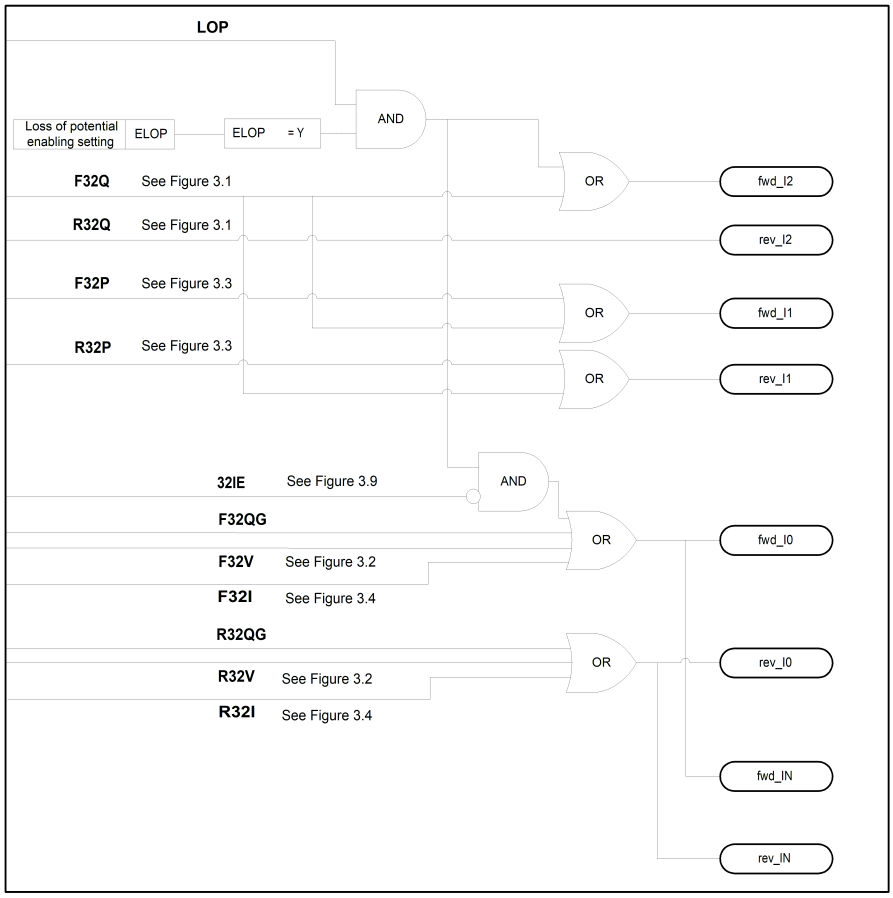


Figure 3.7: The *DIgSILENT PowerFactory SEL Directional element* output logic (“CalSeldir” class) block.

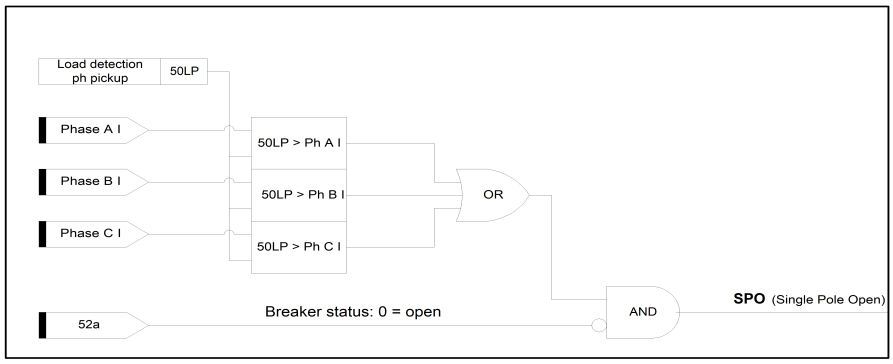
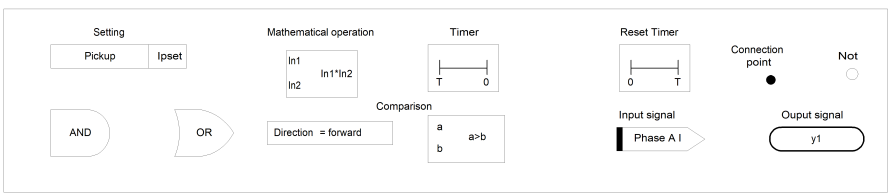


Figure 3.8: The *DIgSILENT PowerFactory SEL Directional element* Pole Open logic (“CalSeldir” class) block.



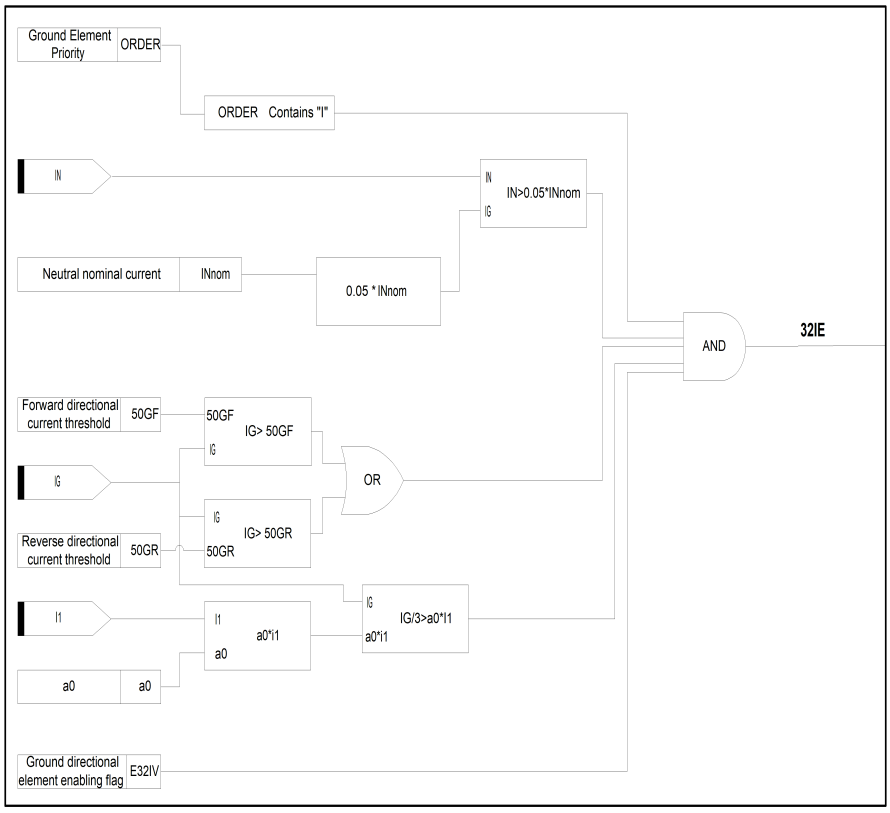
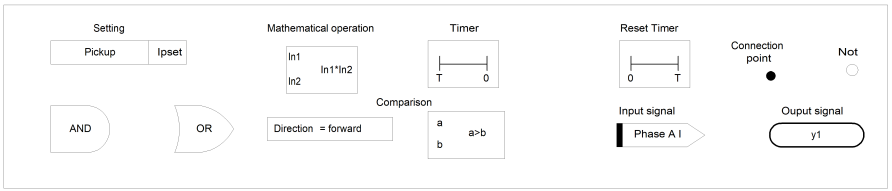


Figure 3.9: The *DIgSILENT PowerFactory SEL Directional element* Internal enabling logic for the Zero sequence current neutral current polarized logic(“CalSeldir” class) block.



4 Integration in the relay scheme

An instance of *SEL Directional Element* element (*RelSeldir* class) must be put in the relay scheme. There is an unique versions of the block. The typical connection of the *SEL Directional Element* (“RelSeldir”class) block is showed in Figure 4.1.

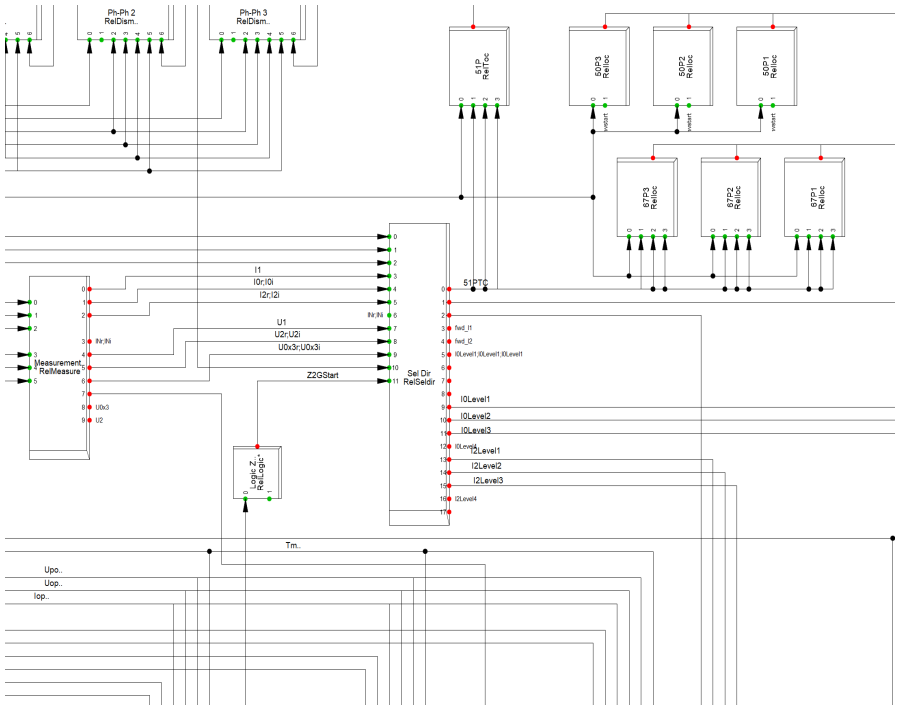


Figure 4.1: The *DIgSILENT PowerFactory* typical connection scheme of a *SEL Directional element* (“RelSeldir” class) block.

The “51PTC” output signal of the “SEL Directional Element” block is connected to the “wfwd” input signal of the “51P” block which is the phase inverse time element; moreover the “I0Level1”, “I0Level2”, “I0Level3”, “I2Level1”, “I2Level2”, “I2Level3” signals are connected to the “wfwd” input signals of the “67Q1”, “67Q2”, “67Q3”, “67G1”, “67G2”, and “67G3” block which are directional definite time elements. The “SEL Directional Element” block gets the zero and the negative sequence voltages and currents from the “Measurement” block.

A Parameter Definitions

A.1 SEL Directional Element Type (TypSeldir)

Table A.1: Input parameters of SEL Directional Element type (*TypSeldir*)

Parameter	Description	Unit
loc_name	The name assigned by the user to the SEL Directional type object	Text
relaymodel	Relay model (it can be *SEL321*, *SEL351*, *SEL351R*, *SEL311*, *SEL411L*, *SEL421*)	Text
dir1pos	Level 1 direction (available items *F,R,N* or *F,R* or *F,N* or *R,N* or *F*, or *N*)	Integer
dir2pos	Level 2 direction (available items *F,R,N* or *F,R* or *F,N* or *R,N* or *F*, or *N*)	Integer
dir3pos	Level 3 direction (available items *F,R,N* or *F,R* or *F,N* or *R,N* or *F*, or *N*)	Integer
dir4pos	Level 4 direction (available items *F,R,N* or *F,R* or *F,N* or *R,N* or *F*, or *N*)	Integer
rs50P32P	Range of the phase directional element 3-phase pickup threshold	Text
rs50GFP	Range of the forward directional residual ground pickup threshold	Text
rs50GRP	Range of the reverse directional residual ground pickup threshold	Text
Ts	Pickup Time	Seconds
rZ0F	Range of the forward directional Z0 threshold	Text
rZ0R	Range of the reverse directional Z0 threshold	Text
rZ0	Range of the zero sequence line impedance magnitude threshold	Text
Rphi0	Range of the zero sequence line impedance angle threshold	Text
rs50LP	Range of the load detection phase pickup threshold	Text
ra0	Range of the zero sequence current restraint factor a0 = I0/I1	Text
rs50QF	Range of the forward directional current threshold	Text
rs50QR	Range of the reverse directional current threshold	Text
rZ2F	Range of the forward directional Z2 threshold	Text
rZ2R	Range of the reverse directional Z2 threshold	Text
RZm	Range of the positive sequence line impedance magnitude threshold	Text
Rphi	Range of the positive sequence line impedance angle threshold	Text
ra2	Range of the positive sequence current restraint factor a2 = I2/I1	Text
rk2	Range of the zero sequence current restraint factor k2 = I2/I0	Text

A.2 SEL Directional Element (RelSeldir)

Table A.2: Input parameters of SEL Directional element (*RelSeldir*))

Parameter	Description	Unit
loc_name	The name assigned by the user to the SEL Directional element object	Text
typ_id	Pointer to the relevant TypSeldir object	Pointer
ORDER	Ground directional element priority (available items: *OFF* , *Q* , *V* , *I* , *Q V* , *Q I* , *V Q* , *V I* , I V , Q , Q V I, Q I V, V Q I , V I Q , I Q V,I V Q)	Text
DIR1	Level 1 direction (available items: *F*,*R*,*N*)	Text
DIR2	Level 2 direction (available items: *F*,*R*,*N*)	Text
DIR3	Level 3 direction (available items: *F*,*R*,*N*)	Text
DIR4	Level 4 direction (available items: *F*,*R*,*N*)	Text
s51PTC	Phase(51P) Torque Control (available items: *M2P*,*N*)	Text
s51NTC	Residual(51N) Torque Control (available items: *32QF*,*32QR*,*Z2G*,*N*)	Text
s51QTC	Negative sequence(51Q) Torque Control (available items: *32QF*,*32QR*,*M2P*,*Z2G*,*N*)	Text
ELOP	Loss Of Potential enable setting (available items: *Y*,*Y1*,*N*)	Text
s3PVOLT	True 3-phase voltage connected 3PVOLT (flag: 1/0)	Integer
E32IV	Ground directional element enabling (flag: 1/0)	Integer
s50P32P	Phase directional element 3-phase pickup threshold	Sec Amps
s50GFP	Forward directional residual ground pickup threshold	Sec Amps
s50GRP	Reverse directional residual ground pickup theshold	Sec Amps
Z0F	Forward directional Z0 threshold	Sec Ohm
Z0R	Reverse directional Z0 threshold	Sec Ohm
Z0	Zero sequence line impedance magnitude threshold	Sec Ohm
phi0	Zero sequence line impedance angle threshold	Sec Ohm
s50LP	Load detection phase pickup threshold	Sec Amps
a0	Zero sequence current restraint factor a0 = I0/I1	Sec Amps
s50QF	Forward directional current threshold	Sec Amps
s50QR	Reverse directional current threshold	Sec Amps
Z2F	Forward directional Z2 threshold	Sec Ohm
Z2R	Reverse directional Z2 threshold	Sec Ohm
Zm	Positive sequence line impedance magnitude threshold	Sec Ohm
Phi	Positive sequence line impedance angle threshold	Deg
a2	Positive sequence current restraint factor a2 = I2/I1	Real Number
k2	Zero sequence current restraint factor k2 = I2/I0	Real Number

B Signal Definitions

Table B.1: Input/output signals of the SEL Directional Element (*CalSeldir*)

Name	Description	Unit	Type	Model
I1	Positive sequence Current	Sec Amps	IN	Any
I0r	Zero sequence current real part	Sec Amps	IN	Any
I0i	Zero sequence current imaginary part	Sec Amps	IN	Any
I2r	Negative sequence current real part	Sec Amps	IN	Any
I2i	Negative sequence current imaginary part	Sec Amps	IN	Any
Inr	Neutral current real part	Sec Amps	IN	Any
Ini	Neutral current imaginary part	Sec Amps	IN	Any
I1r	Positive sequence current real part	Sec Amps	IN	Any
I1i	Positive sequence current imaginary part	Sec Amps	IN	Any
U1	Positive sequence voltage	Sec Volt	IN	Any
U2r	Negative sequence voltage real part	Sec Volt	IN	Any
U2i	Negative sequence voltage imaginary part	Sec Volt	IN	Any
U0x3r	Zero sequence voltage real part	Sec Volt	IN	Any
U0x3i	Zero sequence voltage imaginary part	Sec Volt	IN	Any
U1r	Positive sequence voltage real part	Sec Volt	IN	Any
U1i	Positive sequence voltage imaginary part	Sec Volt	IN	Any
M2PStart	Starting signal coming from the phase (Mho) zone #2	Seconds(or 1/0 RMS/EMT simulation)	IN	Any
Z2GStart	Starting signal coming from the ground zone #2	Seconds(or 1/0 RMS/EMT simulation)	IN	Any
BreakerStatus	Breaker status signal (1 = closed,0 = open). At the moment not used	1/0	IN	Any
fwd_I1	Positive sequence forward fault	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
fwd_I2	Negative sequence element forward fault	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
fwd_I0	Zero sequence element forward fault	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
fwd_IN	Signal on when the neutral current element detects a forward fault	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
rev_I1	Signal on when the positive sequence element detects a reverse fault	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
rev_I2	Signal on when the negative sequence element detects a reverse fault	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
rev_I0	Signal on when the zero sequence element detects a reverse fault	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
rev_IN	Signal on when the neutral current element detects a reverse fault	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
I0Level1	I0 level 1 enabling signal	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
I0Level2	I0 level 2 enabling signal	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
I0Level3	I0 level 3 enabling signal	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
I0Level4	I0 level 4 enabling signal	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
INLevel1	IN level 1 enabling signal	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
INLevel2	IN level 2 enabling signal	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
INLevel3	IN level 3 enabling signal	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
INLevel4	IN level 4 enabling signal	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
I1Level1	I1 level 1 enabling signal	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
I1Level2	I1 level 2 enabling signal	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
I1Level3	I1 level 3 enabling signal	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
I1Level4	I1 level 4 enabling signal	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
I2Level1	I2 level 1 enabling signal	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
I2Level2	I2 level 2 enabling signal	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
I2Level3	I2 level 3 enabling signal	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
I2Level4	I2 level 4 enabling signal	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
_51PTC	Signal enabling the phase overcurrent element (51P)	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
_51NTC	Signal enabling the neutral overcurrent element (51N)	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any
_51QTC	Signal enabling the negative sequence overcurrent element (51Q)	Seconds(or 1/0 RMS/EMT simulation)	OUT	Any

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