DIgSILENT

POWERFACTORY

PowerFactory 2021

Technical Reference

Power Swing

RelDispspoly, TypDispspoly

PF2021

POWER SYSTEM SOLUTIONS

MADE IN GERMANY

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December 1, 2020
PowerFactory 2021
Revision 1

Contents

1 General Description

The *Power Swing* element, implemented by the “TypDispspoly” type class and the “RelDispspoly” element class , performs the following functions:

- a set of configurable blocking signals which are activated when a *Power Swing* condition has been detected.
- a trip command which is activated when an *Out of Step* (“OOS”) condition has been detected.

Both the *Power Swing* and the *Out of Step* detection require the definition of two separate shapes in the R-X plan: an *Inner zone* and an *Outer zone*. The *Inner zone* must be completely contained inside the *Outer zone*. The shapes can be defined by the *Distance Power Swing* parameters or by external elements. If external elements are used their trip signals must be connected to the *innerzonetrip* and to the *outerzonetrip* input signals. If the shapes are defined internally the model parameters must be inserted in the *Power Swing* element dialogue. The following shape types are available:

- ABB (R,X)
- Siemens (R,X)

The *ABB (R,X)*type simulates a distance characteristic with a shape similar to the characteristic represented in Figure 1.1:

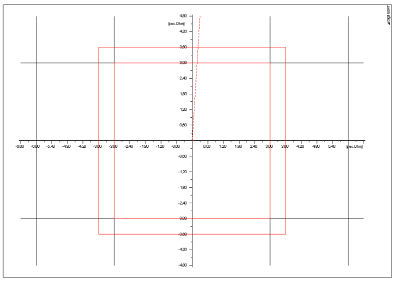

Figure 1.1: *DIgSILENT* The *Power Swing* ABB (R,X) distance characteristic.

The *Siemens (R,X)*type simulates a distance characteristic with a shape similar to the characteristic represented in Figure 1.2:

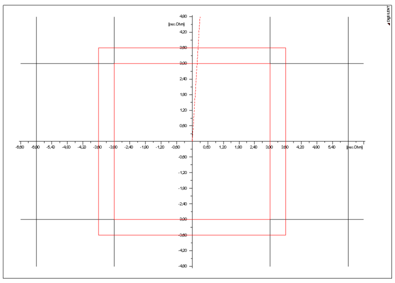

Figure 1.2: *DIgSILENT* The *Distance Power Swing* Siemens (R,X) distance characteristic.

The *Power Swing* “RelDispspoly” block is operational during RMS and EMT simulations. It doesn’t operate for short circuit or load flow calculations.

2 Features & User interface

2.1 Power Swing (RelDispspoly)

The user can change the block settings using the "Power Swing" dialogue ("RelDispspoly " class). The dialogue consists of 4 tab pages: *Basic data*, *External Polygons*, *Timers*, and *Description*. The main settings are located in the *Basic data* tab page.

2.1.1 Basic data

The block can be disabled using the "Out of service" ("outserv"parameter) check box.

If the *Polygonal Detection Configuration* ("ipolyconf" parameter in the *Power Swing Type* dialogue) is *Enabled* or is *User Configurable* and, in this last case, the *Polygonal Detection*("ipoly" parameter in the *Power Swing* dialogue) has been set, two settings allow to enter the resistance and the reactance value of the intersection points between the rectangular region (or the parallelogram for the *Siemens (R,X)* shape type) and the "X" and the "Y" axis in the R-X diagram. The resistance settings are *R1IN* for the *ABB(R,X)* type and *+R Reach* for the *Siemens(R,X)* type. The reactance settings are *X1IN* for the *ABB(R,X) type* and *+X Reach* for the *Siemens(R,X)* type. The blue text on the right provides additional info regarding the impedance thresholds in terms of primary impedance.
The graphical controls are combo boxes for ranges of discrete values or otherwise edit boxes.

The *PS, No. of Phases* setting ("nphases" parameter) represents the number of phase impedance trajectories which must pass through both the *Outer Zone* and the *Inner Zone* in the R-X diagram to declare an *Out of Step* condition.

If in the *Power Swing Type* dialogue the *OOS Configuration*("ioosconf" parameter) is *User Configurable* the *Out of Step* check box ("ioos" parameter) is showed. If the *Out of step* feature has been enabled, the number of times the system impedance trajectories (one for each phase) must pass through both the *Outer Zone* and the *Inner Zone* in the R-X diagram to declare an *Out of Step* condition can be entered in the *OOS, No. of Crossings* ("iooscrossnum" parameter); the *OOS leaving inner trip* check box allows to define the zone which must be crossed by the system impedance trajectories in order to initiate tripping of the element. The element can be configured to trip when the system impedance trajectories leave either the *Outer Zone* or the *Inner Zone*.

If a *Blocking Configuration* including at least one *User Configurable* option has been set in the *Power Swing Type* dialogue(see 2.2.4) the *Blocking configuration* combo box is displayed: it allows to define which blocking output signals are activated when an *Output of Step* condition has been declared.

2.1.2 External Polygons

The *External Polygons* tab page allows to insert the shifters and the multipliers applied to the *Inner Zone* reactive and resistive boundaries to obtain the *Outer Zone*.
They are visible only when the *Polygonal Detection Configuration* has been enabled moreover some of them are visible only when the *Siemens(R,X)* shape type has been selected and some of them only when the *ABB(R,X)* shape type has been selected.
The *Delta Z* setting ("dZ" parameter) represents the impedance value added to the *Inner Zone* reactive and resistive boundaries to obtain the *Outer Zone*. This input parameter is visible only when the *Siemens(R,X)* shape type has been selected.

The *KX* setting ("KX" parameter) represents the multiplier applied to the *Inner Zone* reactive boundaries to obtain the *Outer Zone*. The *KR* setting ("KR" parameter) represents the multiplier applied to the *Inner Zone* resistive boundaries to obtain the *Outer Zone*. Both the *KX* and the *KR* setting are visible only when the ABB (R,X) shape type has been selected.

2.1.3 Timers

The *Timers* tab page allows to insert the delay values used in the logic which detect the *Power Swing* condition. The settings allow to configure the time the impedance trajectory must stay between the *Inner Zone* and the *Outer Zone* in the R-X diagram to declare a *Power Swing* condition (*tP1* ("tP1" parameter) and *tP2* ("tP2" parameter)) and the time the blocking output signals remain active after a *Power Swing* condition has been declared (*tH* ("tH" parameter)). The "tP2" value is visible only when the ABB (R,X) shape type is set and is used only after the first crossing of the *Outer Zone* and of the *Inner Zone* made by the system impedance trajectories and when the time elapsed since the first crossing is greater than *tW* ("tW"parameter).

2.1.4 Description

The *Description* tab page can be used to insert some information to identify the *Power Swing* 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 Power Swing Type(TypDispspoly)

The *Power Swing* block main characteristics must be configured in the "Power Swing Type" dialogue (*TypDispspoly* class). The dialogue consists of 5 tab pages: *Basic data*, *External Polygons*, *Timers*, *Blocking Configuration*, and *Advanced Settings*.

2.2.1 Basic data

The *Basic data* tab page contains most of the controls used to configure the *Power Swing* block.

The *Type* ("ichatp") combo box defines which shape type, between the internally defined shapes, is used by the *Power Swing* and by the *Out of Step* detection routines. The internal shapes are used only if *Polygonal Detection Configuration* ("ipolyconf" parameter) is *Enabled* or *User Configurable*. When it is *User Configurable* a check box (*Polygonal Detection*setting , "ipoly"parameter) is displayed in the element class dialogue (*Distance Power Swing* dialogue). The possible shape types are:

- ABB (R,X)
- Siemens (R,X)

The "ABB (R,X)" shape type defines two rectangular regions in the R-X diagram. The "Siemens (R,X)" shape type defines two parallelograms. Both the rectangles and the parallelograms are centred at the origin of the R-X diagram.
In the *Range Definitions* frame a set of settings allows to define the following ranges:

- X1IN (“rX1IN” parameter), and R1IN (“rR1IN” parameter) when the *ABB (R,X)* type has been selected.
- +X Reach (“rXmax” parameter), +R Reach (“rRmax” parameter), and *Relay Angle* (“phi” parameter) when the *Siemens (R,X)* type has been selected.

The *OOS Configuration*(“ioosconf” parameter) setting is a flag which defines the configuration of an *Out of Step* condition. When the feature is *Enabled* or *User Configurable* (and in this last case also the *Out of Step* check box, “ioos” parameter is showed) two additional parameters are displayed in the element class dialogue (*Distance Power Swing* dialogue):

- *OOS, No. of Crossings* edit box
- *OOS leaving inner trip* check box

The *OOS leaving inner trip* (“ioosintripconf” parameter) setting is a flag which enables or disables or makes user configurable the declaration of the zone which must be crossed by the system impedance trajectories in order to initiate tripping of the element. The element can be configured to trip when the system impedance trajectories leave either the *Outer Zone* or the *Inner Zone*. If the feature is disabled the *Out of Step* condition is declared when the system impedance trajectories leave the *Outer Zone* in the R-X diagram. When the feature is user configurable a check box (*OOS leaving inner trip*setting, “ioosintrip” parameter) is displayed in the element class dialogue (*Distance Power Swing* dialogue).

2.2.2 External Polygons

The *External Polygons* tab page contains the settings which allow to define the range of the shifters and the multipliers applied to the *Inner Zone* reactive and resistive boundaries to obtain the *Outer Zone* (see 2.1.2 for more details).

2.2.3 Timers

The *Timers* tab page contains the settings which allow to define the range of the timers used to detect the *Out of Step* condition (see 2.1.3 for more details).

2.2.4 Blocking Configuration

The *Blocking Configuration* tab page contains the settings which define how are configured the output signals that can be triggered when an *OOS* condition has been detected. The following output signals can be configured:

- Z1block
- Z2block
- Z3toZ5block

The available settings are:

- All Zones

- Z1
- Z1 & Z2
- $>=$Z2

Each of them can be set as

- Disabled
- Enabled
- User configurable

The *All Zones* setting defines as can be configured the *Z1block*, the *Z2block* and the *Z3toZ5block* output signal. The *Z1* setting defines how can be configured the *Z1block* output signal, the *Z1 & Z2* setting the *Z1block* and the *Z2block* output signal; the $>=$*Z2* setting defines how can be configured the *Z3toZ5block* output signal.

When a setting is *Disabled* the relevant configuration logic is inactive. When a setting is *Enabled* the relevant configuration logic is always active. It means that if an *OOS* condition has been detected the relevant output signal(s) is/are operated. When a setting is *User Configurable* the relevant configuration logic can be activated or deactivated in the *Power Swing* dialogue using a combo box (*Blocking Configuration*, “iblockconf” parameter).

2.2.5 Advanced Settings

The *Advanced Settings* tab page defines the pickup delay (*Measurement Time*“Ts” parameter), the *Reset Time* (“Tr” parameter) and the *Reset Ratio* (“Kr” parameter) of the *Power Swing* element.

2.3 Power Swing detection

The function performed by a *Distance Power Swing* element to detect a *Power Swing* condition depends on whether a static or a dynamic simulation is being carried out.

If a Load Flow or Short Circuit calculation is performed, a *Power Swing condition* is declared if the system impedance calculated by the Load Flow or by the Short Circuit calculation routine is between the *Outer Zone* and the *Inner Zone*.

If an RMS or an EMT simulation is run, a *Power Swing condition* is declared if the system impedance calculated by the simulation engine satisfies both the following conditions:

- The system impedance is between the *Outer Zone* and the *Inner Zone* for a period of time longer than a user configurable parameter.
- The system impedance trajectory is continuous.

The criteria used to declare the continuity of the system impedance trajectory are:

- Variation of the system resistance smaller than 0.1 Ω in 5 ms.
- Variation of the system reactance smaller than 0.1 Ω in 5 ms.

At the moment these criteria cannot be configured by the customer and are active only for the Siemens shape type ("Siemens (R,X)").

2.4 Out of Step

The function performed by a *Distance Power Swing* element to detect an *Out of Step* condition can operate only when a dynamic simulation is being carried out.

An *Out of Step* condition is declared when the system impedance calculated by the simulation engine passes through both the *Outer Zone* and the *Inner Zone* a given number of times. The user can configure :

- The number of times the system impedance passes through the zones.
- The number of phases which are monitored.
- When the trip must be triggered: the element can be configured to trip when the system impedance leaves the *Outer Zone* or the *Inner Zone*.

3 Integration in the relay scheme

The *Power Swing*“RelDispspoly ” element can be used as

- Stand alone block which defines two polygonal zones accordingly with the *ABB(R,X)* or the *Siemens(R,X)* type and settings.
- Together with two sets of polygonal, mho, load encroachment and blinder elements which define an inner and an outer powerswing/out of step detection zone.

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Figure 3.1 illustrates a typical power swing detection application where the power swing blocks together with some other distance elements.

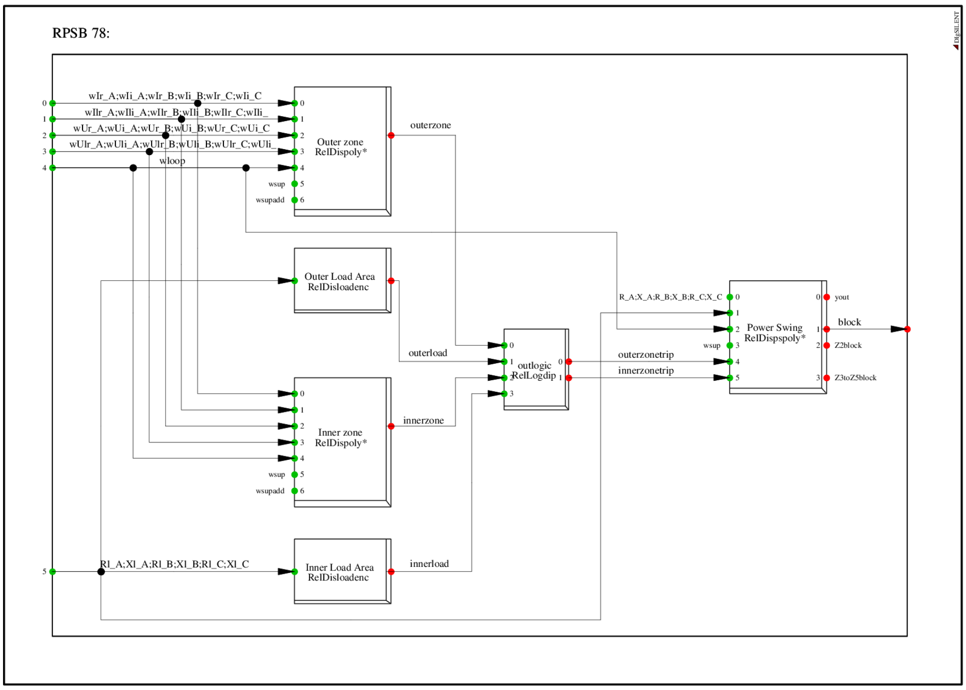


Figure 3.1: Typical application scheme of a Distance Power Swing element with external definition of the *Outer zone* and of the *Inner zone*

Both the *Outer zone* and the *Inner zone* are defined by two shapes modelled by a polygonal region and a load encroachment region. The “outlogic” block combines the trip signals of the polygonal and of the load encroachment blocks and returns the trip signal of the *Outer zone* and of the *Inner zone*. Such trip signals are then sent to the “Power Swing” block which represents an instance of the *Power Swing* element.

Figure 3.2 illustrates a power swing detection application where the power swing element works as stand alone block.

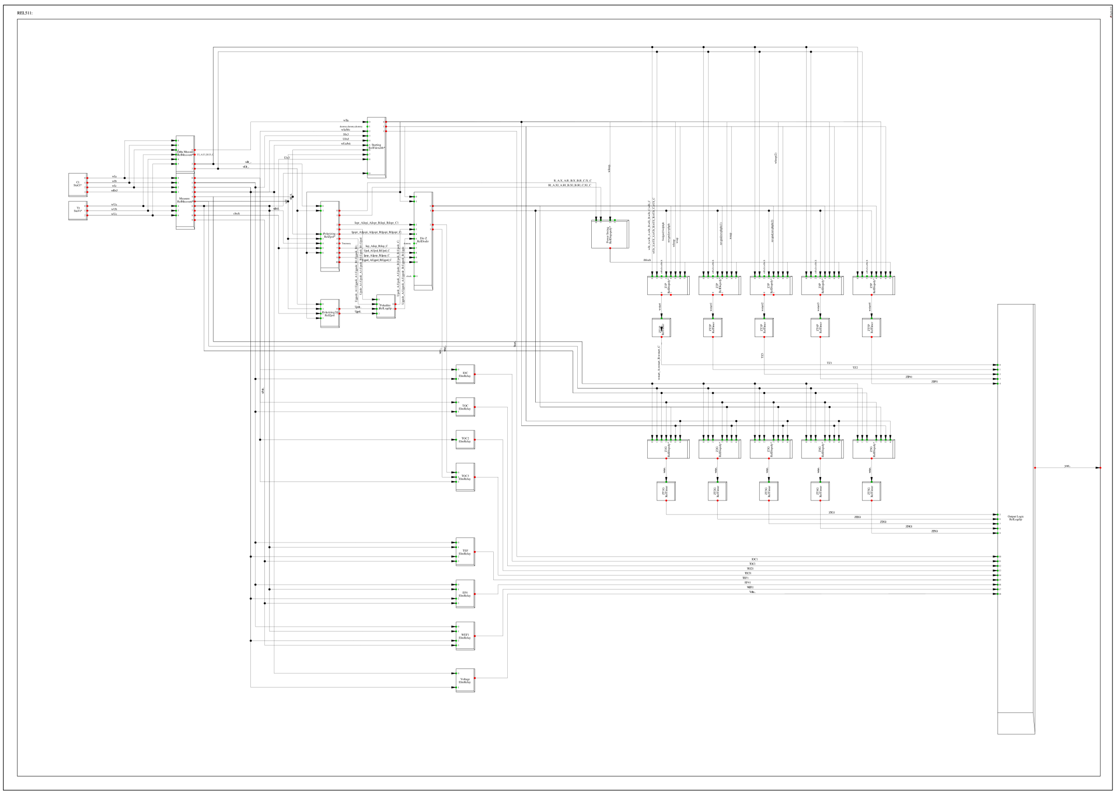


Figure 3.2: Typical application scheme of a Distance Power Swing element set as stand alone bock

4 Power Swing Detection Logic

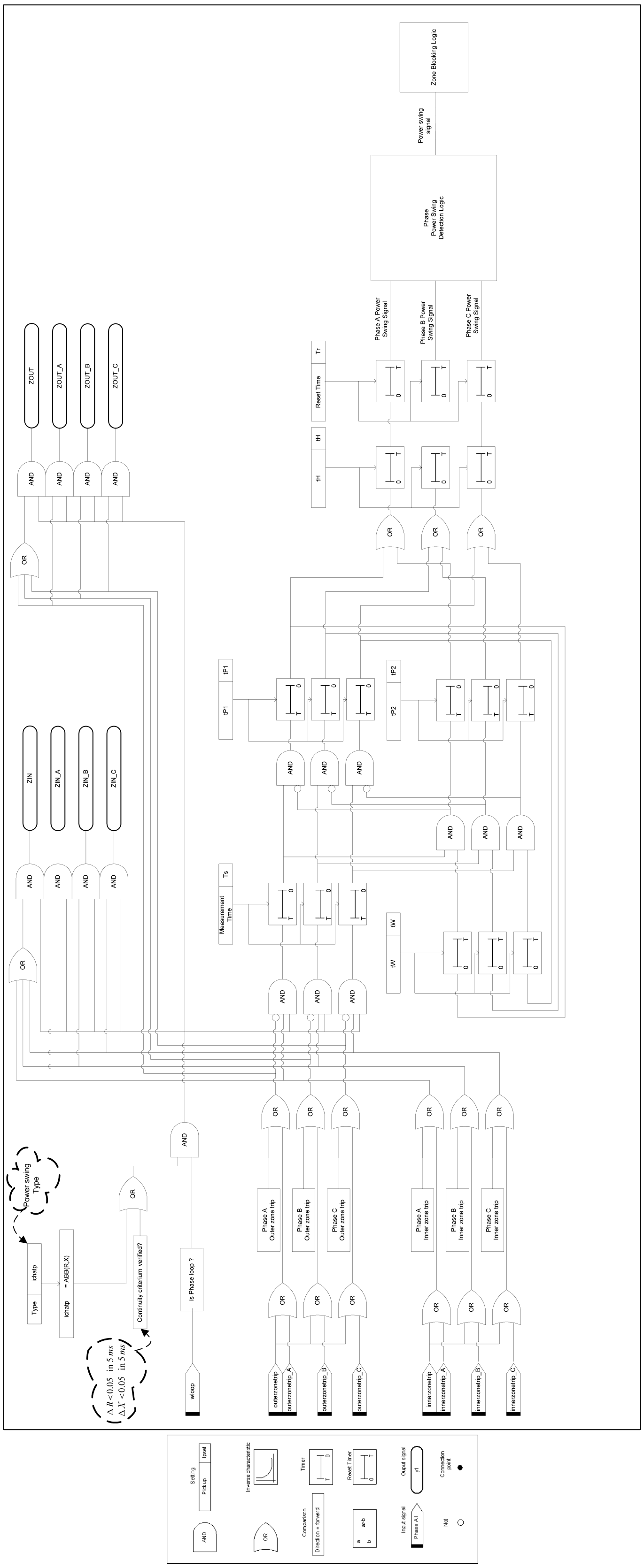


Figure 4.1: The *Power Swing (RelDispspoly) logic*

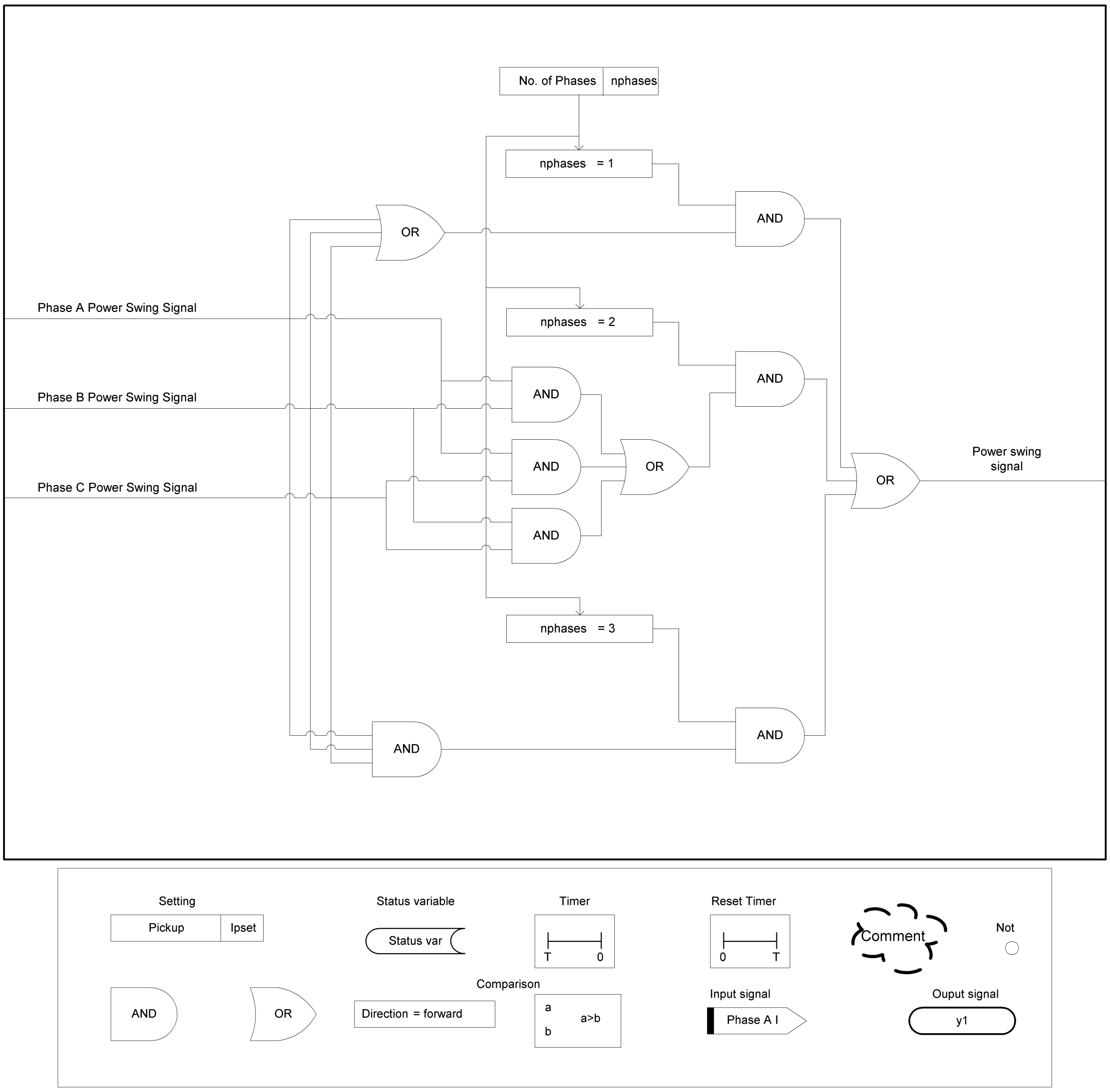


Figure 4.2: The *Phase Power Swing Detection Logic*

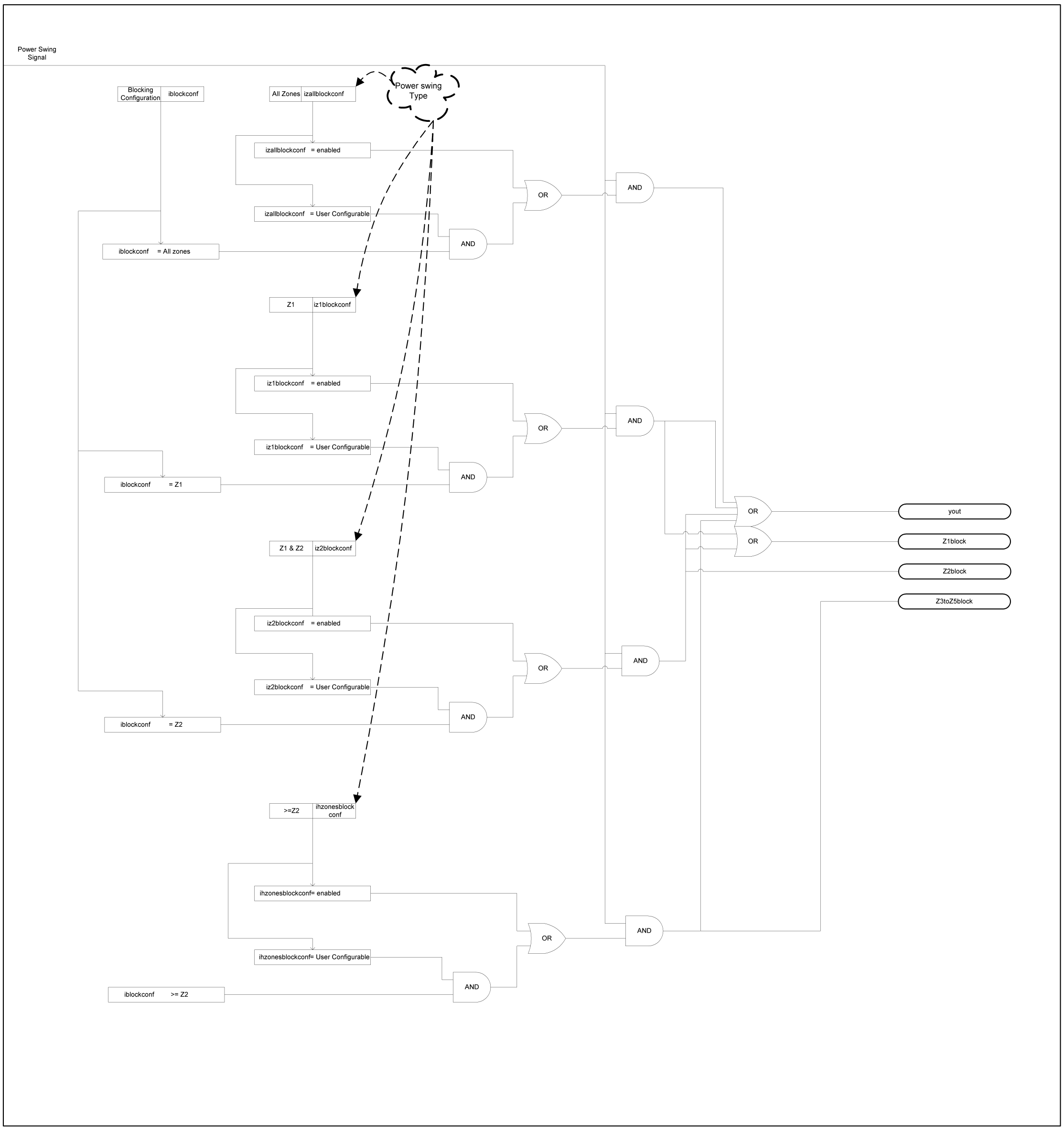
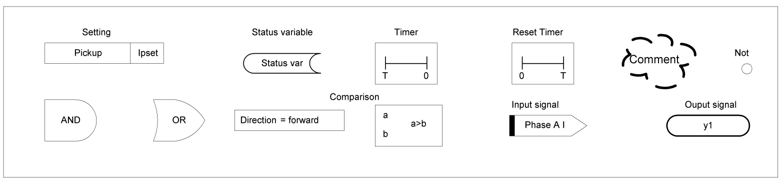


Figure 4.3: The *Zone Blocking Logic logic*



5 Out of Step Detection Logic

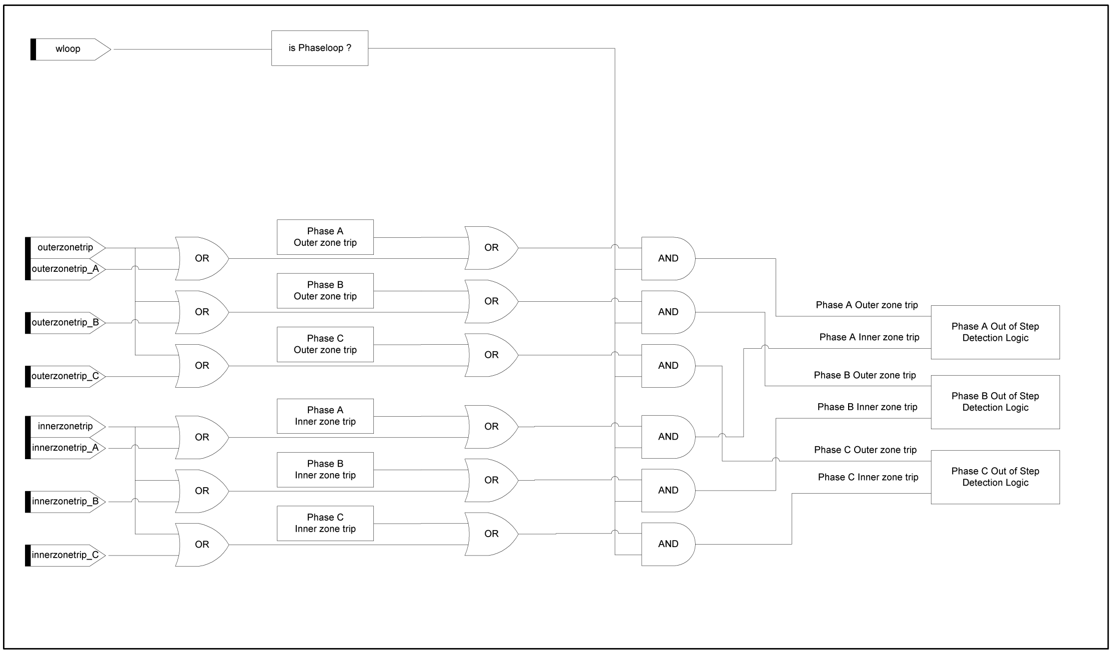


Figure 5.1: The *Out of Step (RelDispspoly) logic*

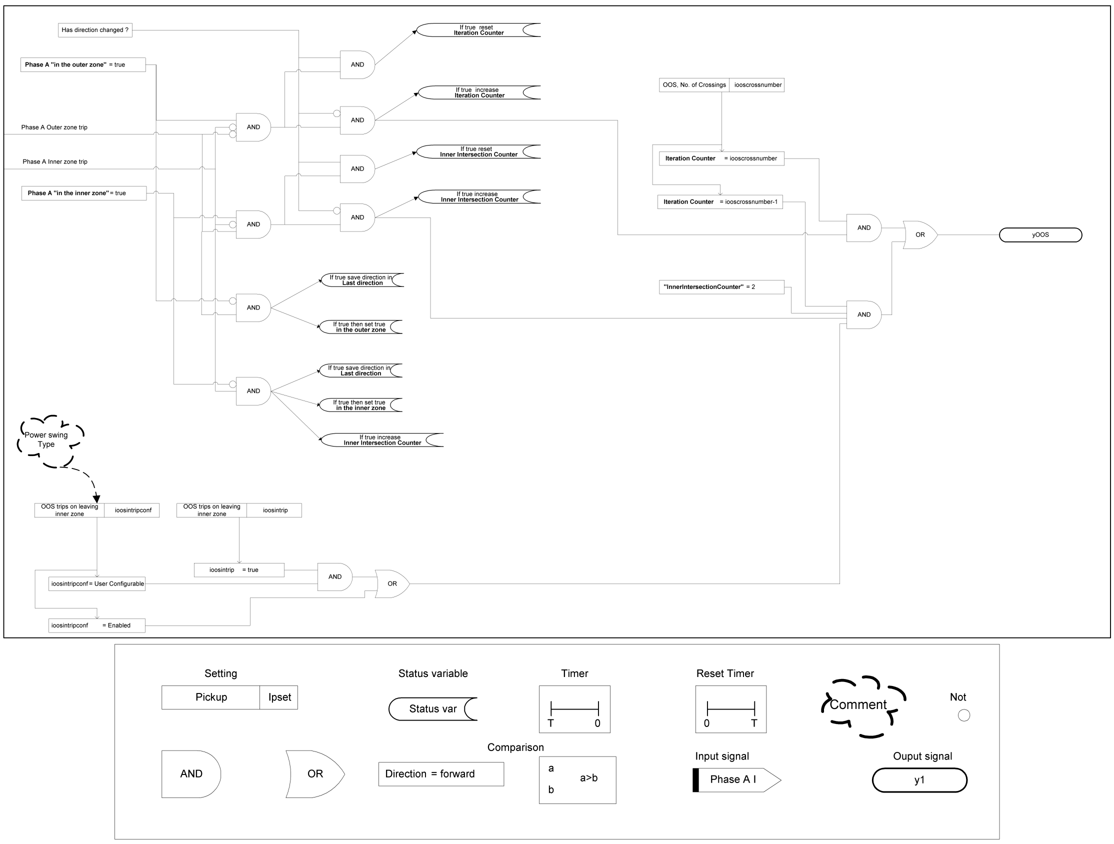


Figure 5.2: The *Phase A Out of Step logic*

5.1 Polygonal calculation logic

The *Power Swing* block must get directly as input signal the impedance values of the power system working point. To detect if the point is inside or outside the shape the generic "even-odd" algorithm is used.
A general enunciation of the algorithm can be "the rule determines the insideness of a point on the canvas by drawing a ray from that point to infinity in any direction and counting the number of path segments from the given shape that the ray crosses. If this number is odd, the point is inside; if even, the point is outside". Considering that our polygon is a simple polygon, the *DIgSILENT PowerFactory* implementation of the ray casting algorithm consecutively checks intersections of a ray with all sides of the polygon in turn.
More info about such algorithm can be found on Internet
(i.e. http://en.wikipedia.org/wiki/Point_in_polygon).

5.1.1 Siemens(R,X)

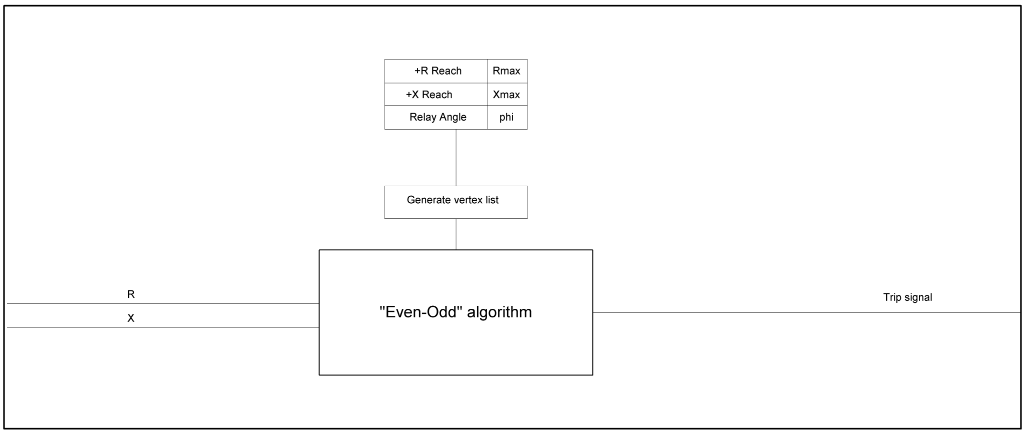


Figure 5.3: The *DIgSILENT Polygonal Siemens(R,X) calculation logic*

5.1.2 ABB(R,X)

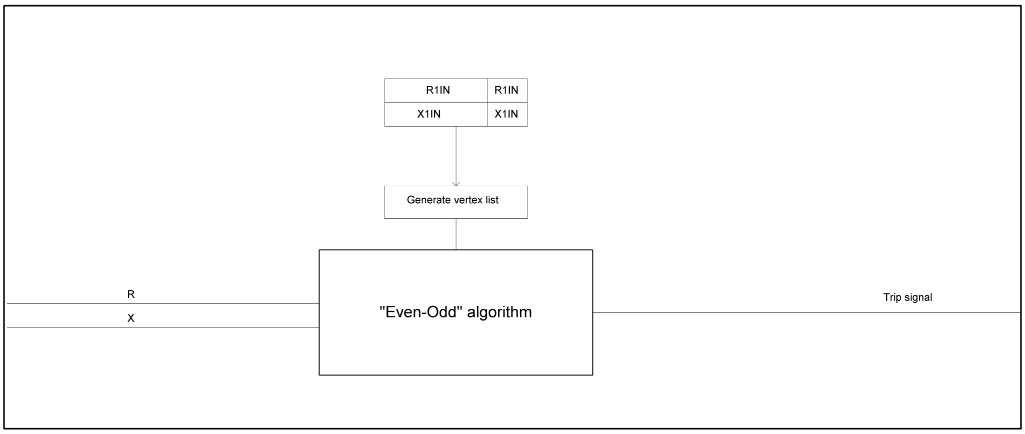


Figure 5.4: The *DIgSILENT Polygonal ABB(R,X) calculation logic*

A Parameter Definitions

A.1 Power Swing Type (TypDispspoly)

Table A.1: Input parameters of the Dispspoly type (*TypDispspoly*)

Parameter	Description	Unit
iphases	Number of Phases	Integer
ichatype	Type of Power swing detection type	Integer
rXmax	Range of the +X Reach (Reactive reach of the power swing detection internal zone (Siemens(R,X) only))	Text
rRmax	Range of the +R Reach (Resistive reach of the power swing detection internal zone (Siemens(R,X) only))	Text
rX1IN	Range of the X1IN (Reactive each of the power swing detection internal zone (ABB (R,X) only) (positive sequence reactance))	Text
rR1IN	Range of the R1IN (Resistive reach of the power swing detection internal zone (ABB (R,X) only) (positive sequence resistance)	Text
ioosconf	Flag to enable/disable the OOS detection feature	Integer
riooscrossnum	Range of the Out of Step number of Crossings parameter	Text
ipolyconf	Flag to enable/disable the Polygonal Detection Configuration	Integer
rnphases	Range of the Power Swing Number of Phases parameter (number of phase impedance trajectories which must pass through both the *Outer Zone* and the *Inner Zone* in the R-X diagram to declare an *Out of Step* condition)	Text
ioosintripconf	How the *OOS leaving inner trip* parameter can be configured (always Enable, Disabled, User Configurable)	Integer
rKX	Range of the KX parameter (multiplier applied to the internal zone reactive values to calculate the external zone)	Text
rKR	Range of the KR parameter (multiplier applied to the internal zone resistive values to calculate the external zone)	Text
rdZ	Range of the Delta Z (shift factor applied to the internal zone resistive and reactive values to calculate the external zone)	Text
rtP1	Range of the tP1 parameter (minimum time spent by the impedance point between the *Inner Zone* and the *Outer Zone* to declare a *Power Swing* condition during the first crossing, active only for the *ABB (R,X)* type)	Text
rtP2	Range of the tP2 parameter (minimum time spent by the impedance point between the *Inner Zone* and the *Outer Zone* to declare a *Power Swing* condition during the following crossings, active only for the *ABB (R,X)* type)	Text
rtW	Range of the tW parameter (time the "tP1" parameter is used instead of "tP2", active only for the *ABB (R,X)* type))	Text
rtH	Range of the tH parameter (time the blocking output signals remain active after a *Power Swing* condition has been declared)	Text
izallblockconf	All zones blocking Configuration	Integer
iz1blockconf	Z1 blocking Configuration	Integer
iz2blockconf	Z1 & Z2 blocking Configuration	Integer
ihzonesblockconf	Z2>= blocking Configuration	Integer
Ts	Measurement Time	float
Tr	Reset Time	float
Kr	Reset Ratio	float
gnrl_modif	Object modified	Integer
gnrl_modby	Object modified by	Text
loc_name	Name	Text

A.2 Power Swing Element (RelDispspoly)

Table A.2: Input parameters of Dipspoly element (*RelDispspoly*)

Parameter	Description	Unit
loc_name	Name assigned to the user to the block element	Text
typ_id	Pointer to the relevant TyIoc object	Pointer
outserv	Flag to put out of service the block	Y/N
Xmax	+X Reactive reach of the power swing detection internal zone (Siemens(R,X) only)	Sec.Ohm
Rmax	+R Resistive reach of the power swing detection internal zone (Siemens(R,X) only)	Sec.Ohm
X1IN	X1IN Reactive each of the power swing detection internal zone (ABB (R,X) only) (positive sequence reactance)	Sec.Ohm
R1IN	R1IN Resistive reach of the power swing detection internal zone (ABB (R,X) only) (positive sequence resistence)	Sec.Ohm
iooscrossnum	Out of step, Number of Crossing (Number of times the system impedance trajectories (one for each phase) must pass through both the *Outer Zone* and the *Inner Zone* in the R-X diagram to declare an *Out of Step* condition)	Integer
nphases	Power Swing, Number of Phases (number of phase impedance trajectories which must pass through both the *Outer Zone* and the *Inner Zone* in the R-X diagram to declare an *Out of Step* condition)	Integer
KX	KX (multiplier applied to the internal zone reactive values to calculate the external zone)	Real number
KR	KR (multiplier applied to the internal zone resistive values to calculate the external zone)	Real number
dZ	Delta Z (shift factor applied to the internal zone resistive and reactive values to calculate the external zone)	Sec.Ohm
tP1	tP1 (minimum time spent by the impedance point between the *Inner Zone* and the *Outer Zone* to declare a *Power Swing* condition during the first crossing, active only for the *ABB (R,X)* type)	Seconds
tP2	tP2 (minimum time spent by the impedance point between the *Inner Zone* and the *Outer Zone* to declare a *Power Swing* condition during the following crossings, active only for the *ABB (R,X)* type)	Seconds
tW	tW (time the “tP1” parameter is used instead of “tP2”, active only for the *ABB (R,X)* type)	Seconds
tH	tH (time the blocking output signals remain active after a *Power Swing* condition has been declared)	Seconds
iblockconf	Blocking Configuration	Y/N
ioos	Out of Step	Y/N
ipoly	Polygonal Detection	Y/N
ioosintrip	OOS leaving inner trip	Y/N
gnrl_modby	Object modified by	Text
chr_name	Characteristic Name	Text
dat_src	Data source	Text
for_name	Foreign Key	Text

B Signal Definitions

Table B.1: Input/output signals of the Power Swing element (*CalDisrxps*)

Name	Description	Unit	Type	Model
R_A	Phase A-ground impedance real part (Resistance)	Secondary Ohm	IN	any
X_A	Phase A-ground impedance imaginary part (Reactance)	Secondary Ohm	IN	any
R_B	Phase B-ground impedance real part (Resistance)	Secondary Ohm	IN	any
X_B	Phase B-ground impedance imaginary part (Reactance)	Secondary Ohm	IN	any
R_C	Phase C-ground impedance real part (Resistance)	Secondary Ohm	IN	any
X_C	Phase C-ground impedance imaginary part (Reactance)	Secondary Ohm	IN	any
Rl_A	Phase A-phase B impedance real part (Resistance)	Secondary Ohm	IN	any
Xl_A	Phase A-phase B impedance imaginary part (Reactance)	Secondary Ohm	IN	any
Rl_B	Phase B-phase C impedance real part (Resistance)	Secondary Ohm	IN	any
Xl_B	Phase B-phase C impedance imaginary part (Reactance)	Secondary Ohm	IN	any
Rl_C	Phase C-phase A impedance real part (Resistance)	Secondary Ohm	IN	any
Xl_C	Phase C-phase A impedance imaginary part (Reactance)	Secondary Ohm	IN	any
wloop	ID of the faulted loops	Numerical value	IN	any
innerzonetrip	At least one phase impedance is inside the inner zone (inner zone trip signal)	Seconds (LDF/SHC), 0/1 (RMS/EMT simulation)	IN	any
innerzonetrip_A	Phase A is inside the inner zone (inner zone trip signal)	Seconds (LDF/SHC), 0/1 (RMS/EMT simulation)	IN	any
innerzonetrip_B	Phase B is inside the inner zone (inner zone trip signal)	Seconds (LDF/SHC), 0/1 (RMS/EMT simulation)	IN	any
innerzonetrip_C	Phase C is inside the inner zone (inner zone trip signal)	Seconds (LDF/SHC), 0/1 (RMS/EMT simulation)	IN	any
outerzonetrip	At least one phase impedance is inside the outer zone (outer zone trip signal)	Seconds (LDF/SHC), 0/1 (RMS/EMT simulation)	IN	any
outerzonetrip_A	Phase A is inside the outer zone (outer zone trip signal)	Seconds (LDF/SHC), 0/1 (RMS/EMT simulation)	IN	any
outerzonetrip_B	Phase B is inside the outer zone (outer zone trip signal)	Seconds (LDF/SHC), 0/1 (RMS/EMT simulation)	IN	any
outerzonetrip_C	Phase C is inside the outer zone (outer zone trip signal)	Seconds (LDF/SHC), 0/1 (RMS/EMT simulation)	IN	any
yout	Generic blocking signal, *on* when a power swing condition has been detected	Seconds (LDF/SHC), 0/1 (RMS/EMT simulation)	OUT	any
ZIN	Flag signal, *on* when at least one phase impedance is inside the inner zone	0/1	OUT	any
ZIN_A	Flag signal, *on* when the phase A impedance is inside the inner zone	0/1	OUT	any
ZIN_B	Flag signal, *on* when the phase B impedance is inside the inner zone	0/1	OUT	any
ZIN_C	Flag signal, *on* when the phase C impedance is inside the inner zone	0/1	OUT	any
ZOUT	Flag signal, *on* when at least one phase impedance is inside the outer zone	0/1	OUT	any
ZOUT_A	Flag signal, *on* when the phase A impedance is inside the outer zone	0/1	OUT	any
ZOUT_B	Flag signal, *on* when the phase B impedance is inside the outer zone	0/1	OUT	any
ZOUT_C	Flag signal, *on* when the phase C impedance is inside the outer zone	0/1	OUT	any
Z1block	Zone 1 blocking signal, *on* when a power swing condition has been detected and "Z1 blocking" is active	Seconds (LDF/SHC), 0/1 (RMS/EMT simulation))	OUT	any

Table B.1: Input/output signals of the Power Swing element (*CalDisrxps*)

Name	Description	Unit	Type	Model
Z2block	Zone 2 blocking signal, *on* when a power swing condition has been detected and “Z1 blocking” or “Z1&Z2 blocking” or “Z2$>=$ blocking” is active	Seconds (LDF/SHC), 0/1 (RMS/EMT simulation))	OUT	any
Z3toZ5block	Zone 3, 4 , 5 etc blocking signal , *on* when a power swing condition has been detected and “Z2 $>=$ blocking” is active	Seconds (LDF/SHC), 0/1 (RMS/EMT simulation)	OUT	any
yOOS	Out Of Step trip signal	0/1 (RMS/EMT simulation))	OUT	any

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