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Technical Reference

ABB REL 670

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POWER SYSTEM SOLUTIONS
MADE IN GERMANY

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1 Model information

Manufacturer ABB

Model REL 670

Variants The ABB REL 670 PowerFactory relay model can be used to simulate any version of the ABB REL 670 relay. However please consider that the model has been implemented with the features available in the V1.1 firmware version.

2 General description

The ABB REL 670 line distance protection terminal is a protective relay for HV and EHV line distance protection applications with additional differential functions. Special features to protect series compensated lines are also available. Additional protection functionality includes phase overcurrent, residual current, frequency and voltage functions.

The ABB REL 670 PowerFactory relay model consists of a main relay model and the following eleven sub relays:

- PDIF 87 (high impedance differential function)
- PIOC (instantaneous overcurrent functions)
- PTOC 51N67N (inverse time residual over current function)
- PTOC 51_67 (inverse time phase over current function)
- PTOF PTUF PFRC 81 (frequency function)
- PTUV 27 PTOV 59/59N (voltage function)
- RPSB 78 (power swing detection function)
- SC Dir-Z (directional logic for series compensated line elements)
- ZMCPDIS (polygonal distance function for series compensated line)
- ZMHPDIS (mho distance function)
- ZMQPDIS (polygonal distance function)

The ABB REL 670 PowerFactory relay model has been implemented trying to simulate the most commonly used protective functions. It can be used running a static calculation (Load Flow or Short Circuit) or running a simulation. Please notice that, running a short circuit, to get more accurate results, the ”Complete” calculation method is strongly suggested.

The main relay contains the measurement and acquisition units, the starting element, the polarizing elements, the directional element for the distance elements for no distance compensated lines, the output logic and all other sub relays.

The model implementation has been based on the information available in the relay manual [1] [2] .

3 Supported features

3.1 Measurement and acquisition

The voltage and the current are measured by two three phase current transformers (”Ct” and ”Remote Ct” block) and one three phase voltage transformer (”Vt” block). The ”Remote Ct” block represents a CT located at the other end of the power line; the current values measured by the ”Remote Ct’ are used by the differential element together with the ”Ct” block current values to calculate the differential current.

Four measurement units (”Measure”, ”Delta Measure”, ”Remote Measure” and ”2nd harm Measure” block) are fed by these CTs and this VT.

3.1.1 Available Units and Input Signals

- Two three phase current transformers (”Ct” and ”Remote Ct” block).
- One three phase voltage transformer (”Vt” block).
- One three phase measurement block calculating both the current and voltage values (”Measure” block).
- One three phase measurement block calculating the 2^{nd} harmonic current values(”2nd harm Measure” block).
- One three phase measurement block calculating the current values at the other end of the line(”Remote Measure” block).
- One three phase measurement block calculating the phase to phase currents and the phase to phase voltages (”Delta Measure” block).

3.1.2 Functionality

The input current and voltage values are sampled at 40 samples/cycle; for each signal the average values are calculated using groups of 2 samples. The average values are processed by a DFT filter, operating over a cycle, which then calculates the voltage and current values used by the protective elements.

The ”Delta Measure” block calculates the current and voltage ph-ph values used by the phase-phase loop distance elements.

3.1.3 Data input

The nominal current and the nominal voltage values MUST be entered in all the measurement blocks.

3.2 Main Relay protective elements

The starting element, the polarizing elements, the load encroachment element and the directional element for the lines without series compensation are working together to simulate the ABB REL 670 distance functionalities.

3.2.1 Available Units

- One starting unit implementing the phase selection logic (”Phase Selector” block).
- One load encroachment element (”PHS Load Area’ block).
- One directional element (”Dir-Z” block).
- Two polarizing blocks (’Polarizing” and ”Polarizing20” block). Please note that no user input is usually needed in these blocks.

3.2.2 Functionality

Starting element The ABB REL 670 relay model starting element (”Phase Selector” block) simulates the relay *FDPSPDIS* phase selection logic function which follows the impedance fault detection criteria. Moreover the phase preference setting is available (’Phase Preference Logic” tab page).
The phase-phase loop impedances are calculated by the following equations:

$$\underline{Z} = \underline{U}_{L1L2}/\underline{I}_{L1L2}$$

$$R = \Re(\underline{Z})$$
$$X = \Im(\underline{Z})$$

where:

$\underline{I}_{L1L2}$ is current difference between phase L1 and L2
$\underline{U}_{L1L2}$ is voltage difference between phase L1 and L2

The phase-earth loop impedances are calculated by the following equations:

$$\underline{Z} = \underline{U}_{L1}/\underline{I}_{L1}$$

$$R = \Re(\underline{Z})$$
$$X = \Im(\underline{Z})$$

where:

$\underline{I}_{L1}$ is phase current in phase L1
$\underline{U}_{L1}$ is phase voltage in phase L1

Load encroachment element The relay model load encroachment element (”PHS Load Area” block) reproduces the load encroachment characteristics which in the relay are part of the *FDPSPDIS* phase selection logic function. Please notice that the relationship between the load encroachment relay settings and the model load encroachment element parameters is showed together.

Directional element The directional element ("Dir-Z" block) is based on the use of a positive-sequence voltage for the respective fault loop. The polarizing voltage is the sum of 80% of the actual positive sequence voltage and of 20% of the positive voltage calculated 100 ms before. It simulates the *ZDRDIR* relay function. The following equations are used:

$$-alpha < arg(\frac{0.8*\underline{U}_{1_{L1}}+0.2*\underline{U}_{1_{L1M}}}{\underline{I}_{L1}}) < phi$$ *see equation 10 in the ABB REL 670 Technical Reference* [2]

$$-alpha < arg(\frac{0.8*\underline{U}_{1_{L1L2}}+0.2*\underline{U}_{1_{L1L2M}}}{\underline{I}_{L1L2}}) < phi$$ *see equation 11 in the ABB REL 670 Technical Reference* [2]

where:

$alpha$ the Directional Angle, Alpha parameter of the distance directional element ("Dir-Z" block)
phi the Directional Angle, Phi parameter of the distance directional element ("Dir-Z" block)
$\underline{U}_{1_{L1M}}$ is positive sequence memorized phase voltage in phase L1
$\underline{U}_{1_{L1}}$ is positive sequence phase voltage in phase L1
$\underline{I}_{L1}$ is phase current in phase L1
$\underline{U}_{1_{L1L2M}}$ is memorized voltage difference between phase L1 and L2 (L2 lagging L1)
$\underline{U}_{1_{L1L2}}$ is voltage difference between phase L1 and L2 (L2 lagging L1)
$\underline{I}_{L1L2}$ is current difference between phase L1 and L2 (L2 lagging L1)

This directional characteristic is not used by the distance elements present inside the "ZMCPDIS" sub relay but is used by the "ZMQPDIS' sub relay distance elements.

Polarizing elements The polarizing elements are calculating the voltage vectors used by the directional element. Two elements are available: "Polarizing" is calculating the actual positive sequence voltage, "Polarizing20" is working as a circular buffer storing the positive sequence voltage calculated during the last 100 ms and returning as output the positive voltage calculated 100 ms before.

3.2.3 Data input

The relationships between the relay settings and the model parameters can be found in the following tables (the relay model parameter names are listed between brackets):

Starting element :

Address	Relay Setting	Model block	Model setting	Note
	INBlockPP	Starting	INBlockPP (INBlockPP)	"Phase/ground fault conditions" tab page
	INReleasePE	Starting	INReleasePE (INReleasePE)	"Phase/ground fault conditions" tab page
	RLdFw	PHS Load Area	RLdFw (Rloadfw)	
	RLdRv	PHS Load Area	RLdRv (Rloadrev)	
	ArgLd	PHS Load Area	ARGLd (phiload)	
	Operation Z<	Starting	Impedance Z(iimped)	"Basic Data" tab page
	X1	Starting	X1PP (X1PP)	"Impedance Z" tab page
	X0	Starting	X0PE (X0PE)	"Impedance Z" tab page
	RFFwPP	Starting	RFPP (RFPP)	"Impedance Z" tab page
	RFRvPP	Starting	RFRvPP (RFRvPP)	"Impedance Z" tab page
	RFFwPE	Starting	RFPE (RFPE)	"Impedance Z" tab page
	RFRvPE	Starting	RFRvPE (RFRvPE)	"Impedance Z" tab page
	IMinOpPP	Starting	IMinOpPP (IMinOpPP)	"Impedance Z" tab page
	IMinOpPE	Starting	IMinOpPE (IMinOpPE)	"Impedance Z" tab page

Directional element :

Address	Relay Setting	Model block	Model setting	Note
	ArgDir	Dir-Z	Directional Angle, alpha (alpha)	
	ArgNegRes	Dir-Z	Directional Angle, phi (phi)	

Polarizing element :

No user input is required.

3.3 PDIF 87 sub relay

The ”PDIF 87” sub relay implements a 3 phase high impedance differential protection.

3.3.1 Available Units

- Two three phase overvoltages element (”U> Alarm” and ”U> Trip” block).
- One logic block (”Stabilizing R” block).

3.3.2 Functionality

”U> Trip” block implements the high impedance voltage threshold. The ”U> Alarm” block is a an additional alarm threshold; please notice that the associated output signal doesn’t trip the power breaker and is freely available for any control logic.
The ”Stabilizing R” block simulates the series resistor. The external voltage dependent resistor is not modeled and must be simulated by a separate additional element not part of this relay model.

3.3.3 Data input

The relationships between the relay settings and the model parameters can be found in the following table (the relay model parameter names are listed between brackets):

Address	Relay Setting	Model block	Model setting	Note
	Operation	Stabilizing R	Out of Service (outserv)	
	U>Alarm	U> Alarm	Pickup Voltage (Usetr)	
	tAlarm	U> Alarm	Time Delay (Tdel)	
	U>Trip	U> Trip	Pickup Voltage (Usetr)	
	SeriesResistor	Stabilizing R	R	Define the variable in the ”Logic” tab page

3.4 PIOC sub relay

The ”PIOC” sub relay protective functions operate on the basis of the phase current and of the residual current. An instantaneous phase overcurrent protection and an instantaneous residual overcurrent protection can be used to clear close-in faults and for fast back-up earth fault protection. This sub relay simulates the *Instantaneous phase overcurrent protection, PHPIOC* and the *Instantaneous residual overcurrent protection EFPIOC* relay function.

3.4.1 Available Units

- One time defined phase overcurrent element (”PIOC 50” block).
- One time defined residual overcurrent element (”PIOC 50N” block).
- One output element (”PIOC Output Logic” block).

3.4.2 Functionality

The model is simulating the two instantaneous elements present in the relay protective function.

The output block is collecting the element trip signals but isn’t operating the power breaker.

3.4.3 Data input

The relationships between the relay settings and the model parameters can be found in the following table (the relay model parameter names are listed between brackets):

Address	Relay Setting	Model block	Model setting	Note
	IP>>	Ioc Phase	Pickup Current (Ipset)	
	IN>>	Ioc Residual	Pickup Current (Ipset)	

3.5 PTOC 51N67N sub relay

The ”PTOC 51N67N” sub relay consists of four inverse and definite time delayed residual over current functions with directional feature and 2^{nd} harmonic blocking which can be used in solidly earthed systems to get a sensitive and fast fault clearance of phase to earth faults. This sub relay simulates the four step residual over current protection EF4PTOC relay function.

3.5.1 Available Units

- Four directional inverse characteristic zero sequence over current element (”PTOC 51N_67N 1”, ”PTOC 51N_67N 2”, ”PTOC 51N_67N 3” and ”PTOC 51N_67N 4” block).
- One directional element (”Dir PTOC N” block).
- One 2^{nd} harmonic current restrain element (”2nd harmonic Stab” block).
- One logic block (”PTOC Output Logic” block).

3.5.2 Functionality

Each inverse time element can be set as non directional, forward directional or reverse directional. The directional settings are unique and are stored in the ”Dir PTOC N” block which implements a zero sequence voltage and current phase comparison direction detection logic. Each inverse time element can be configured to be controlled by the 2^{nd} harmonic current restrain. The ”PTOC 51N_67N n[1]” blocks include the following inverse time characteristics:

- ANSI Extremely Inverse
- ANSI Inverse.TypChatoc
- ANSI Long time Extremly Inverse.TypChatoc
- ANSI Long time Inverse.TypChatoc
- ANSI Long time Very Inverse.TypChatoc
- ANSI Moderately Inverse.TypChatoc
- ANSI Very Inverse.TypChatoc
- Definite time TCC.TypChatoc
- IEC Extremely inverse.TypChatoc
- IEC Inverse.TypChatoc
- IEC Long time inverse.TypChatoc
- IEC Normal inverse.TypChatoc
- IEC Short time inverse.TypChatoc
- IEC Very inverse.TypChatoc
- Logarithmic inverse.TypChatoc
- RI inverse.TypChatoc

[1] n = 1,2,3,4

The inverse time element trip characteristic equations comply with the IEC 60255-3 and the ANSI standards.

The output logic block is used only to combine the logic signals and is not operating the breaker.

3.5.3 Data input

The relationships between the relay settings and the model parameters can be found in the following table (the relay model parameter names are listed between brackets):

Address	Relay Setting	Model block	Model setting	Note
	Operation	PTOC 51N67N	Out of Service (outserv)	
	AngleRCA	Dir PTOC N	Max. Torque Angle (mtau)	In the "Voltage Polarizing " tab page
	UPolMin	Dir PTOC N	Polarizing Voltage (upolu)	In the "Voltage Polarizing " tab page
	IPolMin	Dir PTOC N	Operating Current (curopu)	In the "Voltage Polarizing " tab page
	2ndHarmStab	2nd harmonic Stab	Pickup Current (Ipset)	
	DirModen[2]	PTOC 51N_67N n[2]	Tripping Direction (idir)	
	Characteristn[2]	PTOC 51N_67N n[2]	Characteristic (pcharac)	
	INn[2]>	PTOC 51N_67N n[2]	Current Setting (Ipset)	
	t1	PTOC 51N_67N n[2]	Time Dial (Tpset)	Relay definite time delay
	k1	PTOC 51N_67N n[2]	Time Dial (Tpset)	Relay time multiplier for the inverse characteristics
	t1Min	PTOC 51N_67N n[2]	Min. Time(udeftimin)	
	HarmRestrainn[2]	PTOC 51N_67N n[2]	Release Blocking Time (Trelblock)	

The inverse time element ability to be blocked by the 2^{nd} harmonic current restrain can be disabled setting equal to zero the "Release Blocking Time" setting in the "Blocking" tab page of the inverse time element dialog. Set the setting equal to "oo" to enable the 2^{nd} harmonic current restrain blocking feature. The harmonic blocking is enabled by default.

[2] n = 1,2,3,4

3.6 PTOC 51_67 sub relay

The ”PTOC 51_67” sub relay consists of four inverse and definite time delayed residual over current functions with directional feature and 2^{nd} harmonic blocking which can be used for backup short circuit protection. The sub relay simulates the four step phase over current protection OC4PTOC relay function.

3.6.1 Available Units

- Four directional inverse characteristic 3 phase overcurrent element (”PTOC 51_67 1”, ”PTOC 51_67 2”, ”PTOC 51_67 3” and ”PTOC 51_67 4” block).
- One 3 phase directional element (”Dir PTOC ” block).
- One 2^{nd} harmonic current restrain element (”2nd harmonic Stab” block).
- One logic block (”PTOC Output Logic” block).

3.6.2 Functionality

Each inverse time element can be set as non directional, forward directional or reverse directional. The directional settings are unique and are stored in the ”Dir PTOC” block. Each inverse time element can be configured to be controlled by the 2^{nd} harmonic current restrain.

The ”PTOC 51_67 n[3]” blocks include the following inverse time characteristics:

- ANSI Extremely Inverse
- ANSI Inverse.TypChatoc
- ANSI Long time Extremely Inverse.TypChatoc
- ANSI Long time Inverse.TypChatoc
- ANSI Long time Very Inverse.TypChatoc
- ANSI Moderately Inverse.TypChatoc
- ANSI Very Inverse.TypChatoc
- Definite time TCC.TypChatoc
- IEC Extremely inverse.TypChatoc
- IEC Inverse.TypChatoc
- IEC Long time inverse.TypChatoc
- IEC Normal inverse.TypChatoc
- IEC Short time inverse.TypChatoc
- IEC Very inverse.TypChatoc
- Logarithmic inverse.TypChatoc
- RI inverse.TypChatoc

[3] n = 1,2,3,4

The inverse time element trip characteristic equations comply with the IEC 60255-3 and the ANSI standards.

The output logic block is used only to combine the logic signals and is not operating the breaker.

3.6.3 Data input

The relationships between the relay settings and the model parameters can be found in the following table (the relay model parameter names are listed between brackets):

Address	Relay Setting	Model block	Model setting	Note
	Operation	PTOC 51_67	Out of Service (outserv)	
	AngleRCA	Dir PTOC	Max. Torque Angle (mtau)	In the "Voltage Polarizing " tab page
	UPolMin	Dir PTOC	Polarizing Voltage (upolu)	In the "Voltage Polarizing " tab page
	IPolMin	Dir PTOC	Operating Current (curopu)	In the "Voltage Polarizing " tab page
	2ndHarmStab	2nd harmonic Stab	Pickup Current (Ipset)	
	DirModen[4]	PTOC 51_67 n[4]	Tripping Direction (idir)	
	Characteristn[4]	PTOC 51_67 n[4]	Characteristic (pcharac)	
	In[4]>	PTOC 51_67 n[4]	Current Setting (Ipset)	
	t1	PTOC 51_67 n[4]	Time Dial (Tpset)	Relay definite time delay
	k1	PTOC 51_67 n[4]	Time Dial (Tpset)	Relay time multiplier for the inverse characteristics
	t1Min	PTOC 51_67 n[4]	Min. Time(udeftimin)	
	HarmRestrainn[4]	PTOC 51_67 n[4]	Release Blocking Time (Trelblock)	

The inverse time element ability to be blocked by the 2^{nd} harmonic current restrain can be disabled setting equal to zero the "Release Blocking Time" setting in the "Blocking" tab page of the inverse time element dialog. Set the setting equal to "oo" to enable the 2^{nd} harmonic current restrain blocking feature. The harmonic blocking is enabled by default.

[4] n = 1,2,3,4

3.7 PTOF PTUF PFRC 81 sub relay

The ”PTOF PTUF PFRC 81” sub relay consists of two under frequency, one over frequency and two rate of change frequency elements. This sub relay simulates two *SAPTUF*, one *SAPTOF* and two *SAPFRC* relay functions.

3.7.1 Available Units

- One frequency measurement element (”Meas Freq” block).
- Two under frequency elements (”TUF 1” and ”TUF 2” block).
- Two minimum voltage elements controlling the under frequency elements(”TUF1 intBlock-Level” and ”TUF2 intBlockLevel” block).
- One over frequency elements (”TOF” block).
- One minimum voltage element controlling the over frequency element(”TOF intBlockLevel” block).
- Two rate of change frequency elements (”FRC1” and ”FRC1” block).
- Two minimum voltage elements controlling the rate of change frequency elements(”FRC1 intBlockLevel” and ”FRC1 intBlockLevel” block).
- One logic block (”Frequency Output Logic” block).

3.7.2 Functionality

Each frequency and rate of change frequency element is controlled by a minimum voltage threshold element

The output logic block is used only to combine the logic signals and is not operating the breaker.

3.7.3 Data input

The relationships between the relay settings and the model parameters can be found in the following table (the relay model parameter names are listed between brackets):

Address	Relay Setting	Model block	Model setting	Note
	SAPTUF Operation	TUF 1	Out of Service (outserv)	
	SAPTUF Start Frequency	TUF 1	Frequency (Fset)	
	SAPTUF IntBlockLevel	TUF1 intBlockLevel	Pickup Voltage (Uset)	
	SAPTUF TimeDlyOperate	TUF 1	Time Delay (Tdel)	
	SAPTUF Operation	TUF 2	Out of Service (outserv)	
	SAPTUF Start Frequency	TUF 2	Frequency (Fset)	
	SAPTUF IntBlockLevel	TUF2 intBlockLevel	Pickup Voltage (Uset)	
	SAPTUF TimeDlyOperate	TUF 2	Time Delay (Tdel)	
	SAPTOF Operation	TOF 1	Out of Service (outserv)	
	SAPTOF Start Frequency	TOF 1	Frequency (Fset)	
	SAPTOF IntBlockLevel	TOF1 intBlockLevel	Pickup Voltage (Uset)	
	SAPTOF TimeDlyOperate	TOF 1	Time Delay (Tdel)	
	SAPFRC Operation	TUF 1	Out of Service (outserv)	
	SAPFRC StartFreqGrad	FRC1 1	Frequency (Fset)	

Address	Relay Setting	Model block	Model setting	Note
	SAPFRC IntBlockLevel	FRC1 intBlockLevel	Pickup Voltage (Uset)	
	SAPFRC tTrip	FRC1 1	Time Delay (Tdel)	
	SAPFRC Operation	TUF 1	Out of Service (outserv)	
	SAPFRC StartFreqGrad	FRC2 1	Frequency (Fset)	
	SAPFRC IntBlockLevel	FRC2 intBlockLevel	Pickup Voltage (Uset)	
	SAPFRC tTrip	FRC2 1	Time Delay (Tdel)	

3.8 PTUV 27 PTOV 59/59N sub relay

The ”PTUV 27 PTOV 59/59N” sub relay consists of two inverse time 3 phase under voltage, two inverse time 3 phase over voltage and two inverse time residual overvoltage elements. The sub relay simulates one *PTUV, 27*, one *PTOV, 59* and two *SAPFRC* relay functions.

3.8.1 Available Units

- Two inverse time 3 phase under voltage elements (”U1<” and ”U2<” block).
- Two inverse time 3 phase over voltage elements (”U1>” and ”U2>” block).
- Two inverse time residual over voltage elements (”U1N>” and ”U2N>” block).
- One logic block (”Voltage Output Logic” block).

3.8.2 Functionality

This sub relay is providing the basic features of the relay voltage functions.

The under voltage elements support the following inverse time trip characteristics:

- Definite time (27/59-2)
- Inverse curve A (59)
- Inverse curve B (27)
- Programmable curve B (27)

The ”Programmable curve B” is an additional characteristic which can be defined by the user inserting a set of voltage versus time points. Please notice that an unique user programmable characteristic is available for the two under voltage elements.

The over voltage elements support the following inverse time trip characteristics:

- Definite time (27/59-1+)
- Inverse curve A (59)
- Inverse curve B (59)
- Inverse curve C (59)
- Programmable curve C (59)

The "Programmable curve C" is an additional characteristic which can be defined by the user inserting a set of voltage versus time points. Please notice that an unique user programmable characteristic is available for the two over voltage elements.

The output logic block is used only to combine the logic signals and is not operating the breaker.

3.8.3 Data input

The relationships between the relay settings and the model parameters can be found in the following table (the relay model parameter names are listed between brackets):

Address	Relay Setting	Model block	Model setting	Note
	PTUV, 27 Operation	U1<	Out of Service (outserv)	
		U2<	Out of Service (outserv)	
	PTUV, 27 OperationStep1	U1<	Out of Service (outserv)	
	PTUV, 27 Characterist1	U1<	Characteristic (pcharac)	
	PTUV, 27 U1<	U1<	Input Setting (Ipset)	
	PTUV, 27 t1	U1<	Time Dial (Tpset)	Relay definite time delay
	PTUV, 27 k1	U1<	Time Dial (Tpset)	Relay time multiplier inverse time
	PTUV, 27 OperationStep2	U2<	Out of Service (outserv)	
	PTUV, 27 Characterist2	U2<	Characteristic (pcharac)	
	PTUV, 27 U2<	U2<	Input Setting (Ipset)	
	PTUV, 27 t2	U2<	Time Dial (Tpset)	Relay definite time delay
	PTUV, 27 k2	U2<	Time Dial (Tpset)	Relay time multiplier inverse time
	PTUV, 59 Operation	U1>	Out of Service (outserv)	
		U2>	Out of Service (outserv)	
	PTUV, 59 OperationStep1	U1>	Out of Service (outserv)	
	PTUV, 59 Characterist1	U1>	Characteristic (pcharac)	
	PTUV, 59 U1>	U1>	Input Setting (Ipset)	
	PTUV, 59 t1	U1>	Time Dial (Tpset)	Relay definite time delay
	PTUV, 59 k1	U1>	Time Dial (Tpset)	Relay time multiplier inverse time
	PTUV, 59 OperationStep2	U2>	Out of Service (outserv)	
	PTUV, 59 Characterist2	U2>	Characteristic (pcharac)	
	PTUV, 59 U2>	U2>	Input Setting (Ipset)	
	PTUV, 59 t2	U2>	Time Dial (Tpset)	Relay definite time delay
	PTUV, 59 k2	U2>	Time Dial (Tpset)	Relay time multiplier inverse time
	PTOV, 59N Operation	U1N>	Out of Service (outserv)	
		U2N>	Out of Service (outserv)	
	PTOV, 59N OperationStep1	U1N>	Out of Service (outserv)	
	PTOV, 59N Characterist1	U1N>	Characteristic (pcharac)	
	PTOV, 59N U1>	U1N>	Input Setting (Ipset)	
	PTOV, 59N t1	U1N>	Time Dial (Tpset)	Relay definite time delay
	PTOV, 59N k1	U1N>	Time Dial (Tpset)	Relay time multiplier inverse time
	PTOV, 59N OperationStep2	U2N>	Out of Service (outserv)	
	PTOV, 59N Characterist2	U2N>	Characteristic (pcharac)	
	PTOV, 59N U2>	U2N>	Input Setting (Ipset)	
	PTOV, 59N t2	U2N>	Time Dial (Tpset)	Relay definite time delay
	PTOV, 59N k2	U2N>	Time Dial (Tpset)	Relay time multiplier inverse time

3.9 RPSB 78 sub relay

The ”RPSB 78” sub relay simulates the *Power swing detection (RPSB, 78)* relay function.

3.9.1 Available Units

- Two polygonal distance zone elements (”Outer zone” and ”Inner zone” block).
- Two load encroachment elements (”Inner Load Area” and ”Outer Load Area” block).
- One power swing detection element (”Power Swing” block).
- One logic block (”outlogic” block).

3.9.2 Functionality

This sub relay is providing the basic features of the power swing detection function. The output signal is on when a power swing condition has been detected.

3.9.3 Data input

The relationships between the relay settings and the model parameters can be found in the following table (the relay model parameter names are listed between brackets):

Address	Relay Setting	Model block	Model setting	Note
	Operation	Power Swing	Out of Service (outserv)	
	X1InFw	Outer zone	X1PP (X1PP)	
	R1LIn	Outer zone	R1PP (R1PP)	
	R1FInFw	Outer zone	RFPP (RFPP)	
	X1InRv	Outer zone	X1RvPP (X1RvPP)	
	R1FInRv	Outer zone	RFRvPP (RFRvPP)	
	OperationLdCh	Outer Load Area	Out of Service (outserv)	
	RLdOutFw	Outer Load Area	RLdFw (Rloadfw)	
	ArgLd	Outer Load Area	ARGLd (phiload)	
	RLdOutRv	Outer Load Area	RLdRv (Rloadrev)	
	kLdRFw	Inner Load Area	KRFw (KRFw)	
		Inner Zone	KR (KR)	
		Inner Zone	KX (KX)	
	kLdRRv	Inner Load Area	KRRv (KRRv)	
	tP1	Power Swing	tP1 (tP1)	in the Timers tab page
	tP2	Power Swing	tP2 (tP2)	in the Timers tab page
	tW	Power Swing	tW (tW)	in the Timers tab page
	tH	Power Swing	tH (tH)	in the Timers tab page

3.10 SC Dir-Z sub relay

The ”SC Dir-Z” sub relay simulates the *directional impedance quadrilateral,including series compensation (ZDSRDIR)* relay function. The subrelay implements the special features which have implemented in the relay to allow the fault direction detection when the relay is protecting a series compensated line.

3.10.1 Available Units

- One polygonal zone element(”ZDS1” block).
- One load encroachment element (”Load Area ZDS1” block).
- One phase-phase current starting element (”ZDS1 IMinOpPP” block).
- One phase-ground current starting element (”ZDS1 IMinOpPE” block).
- One ancillary logic block (”ZDS1logicst” block).
- One polarizing block (”Polarizing” block).
- One distance directional block (”Dir-Z” block).

3.10.2 Functionality

The fault direction determination implemented in this sub relay consists of an overcurrent fault detector for the phase-phase loops (”ZDS1 IMinOpPP” block) and of an overcurrent fault detector for the phase-ground loops (”ZDS1 IMinOpPE” block) which control an impedance starting zone (”ZDS1” block) and a load encroachment zone (”Load Area ZDS1” block) which in turn are identifying the faulted loops. The faulted loops information is used by the polarization block to activate a voltage memory buffer and stabilize during the fault transitory the polarizing voltage vectors provided to the distance directional element (”Dir-Z” block) which is calculating the fault direction. The distance directional element (”Dir-Z” block) uses the following equations:

$-alpha < arg(\frac{\underline{U}_{1_{L1M}}}{\underline{I}_{L1}}) < phi$ *see equation 21 in the ABB REL 670 Technical Reference* [2]

$-alpha < arg(\frac{\underline{U}_{1_{L1L2M}}}{\underline{I}_{L1L2}}) < phi$ *see equation 22 in the ABB REL 670 Technical Reference* [2]

where:

$alpha$ the Directional Angle, Alpha parameter of the distance directional element (”Dir-Z” block)
phi the Directional Angle, Phi parameter of the distance directional element (”Dir-Z” block)
$\underline{U}_{1_{L1M}}$ is positive sequence memorized phase voltage in phase L1
$\underline{I}_{L1}$ is phase current in phase L1
$\underline{U}_{1_{L1L2M}}$ is memorized voltage difference between phase L1 and L2 (L2 lagging L1)
$\underline{I}_{L1L2}$ is current difference between phase L1 and L2 (L2 lagging L1)

The impedance starting zone (”ZDS1” block) calculates the phase-phase loop fault impedances using the following equations:

$\underline{Z} = \underline{U_{L1L2}}/\underline{I_{L1L2}}$

$R = \Re(\underline{Z})$

$X = \Im(\underline{Z})$

where:

$\underline{I}_{L1L2}$ is current difference between phase L1 and L2

$\underline{U}_{L1L2}$ is voltage difference between phase L1 and L2

The phase-earth loop fault impedances are calculated using the following equations:

$$R = \Re(\underline{Z}) = l * (R1PE + (R0PE - R1PE)/3) + R_f$$

$$X = \Im(\underline{Z}) = l * (X1PE + (X0PE - X1PE)/3)$$

with

$$l = (\Re(\underline{U}_{L1}) * \Im(\underline{I}_f) - \Im(\underline{U}_{L1}) * \Re(\underline{I}_f))/dU_z$$

$$dU_z = \Re(\underline{U}_d) * \Im(\underline{I}_f) - \Im(\underline{U}_d) * Re(I_f)$$

$$\underline{U}_d = R1PE * (\underline{I}_{L1} + K0r * \underline{I0x3}) + JX1PE * (\underline{I}_{L1} + K0i * \underline{I0x3})$$

$$K0r = \frac{(R0PE - R1PE)}{(3 * R1PE)} \qquad K0i = \frac{(X0PE - X1PE)}{(3 * X1PE)}$$

$$R_f = \Im(\underline{U}_{L1}) - l * \Im(\underline{U}_d)/\Im(\underline{I}_f) \qquad \text{when } |\Im(\underline{I}_f)| > |\Re(\underline{I}_f)|$$

$$R_f = \Re(\underline{U}_{L1}) - l * \Re(\underline{U}_d)/\Re(\underline{I}_f) \qquad \text{when } |\Im(\underline{I}_f)| < |\Re(\underline{I}_f)|$$

where:

R0PE is zero sequence resistance ph-earth loops (*R0PE* dialog parameter)

R1PE is positive sequence resistance ph-earth loops (*R1PE* dialog parameter)

X0PE is zero sequence reactance ph-earth loops (*X0PE* dialog parameter)

X1PE is positive sequence reactance ph-earth loops (*X1PE* dialog parameter)

$\underline{I}_{L1}$ is phase current in phase L1

$\underline{I}_f$ is fault current

$\underline{U}_{L1}$ is phase voltage in phase L1

$\underline{I0x3}$ is the neutral current

The fault direction is used by the ZMCPDIS sub relay (see 3.11)

3.10.3 Data input

The relationships between the relay settings and the model parameters can be found in the following table (the relay model parameter names are listed between brackets):

Address	Relay Setting	Model block	Model setting	Note
	OperationSC	Dir-Z	Out of Service (outserv)	
	IMinOpPE	ZDS1 IMinOpPE	Current I>> (ip2)	
	IMinOpPP	ZDS1 IMinOpPP	Current I>> (ip2)	
	ArgNegRes	Dir-Z	Directional Angle, phi (phi)	
	ArgDir	Dir-Z	Directional Angle, Alpha (alpha)	
	OperationLdCh	Load Area ZDS1	Out of Service (outserv)	
	RLdFw	Load Area ZDS1	RLdFw (Rloadfw)	
	RLdRv	Load Area ZDS1	RLdRv (Rloadrev)	
	ArgLd	Load Area ZDS1	ARGLd (phiload)	
	X1FwPP	ZDS1	X1PP (X1PP)	

Address	Relay Setting	Model block	Model setting	Note
	R1PP	ZDS1	R1PP (R1PP)	
	RFFwPP	ZDS1	RFPP (RFPP)	
	X1RvPP	ZDS1	X1RvPP (X1RvPP)	
	RFRvPP	ZDS1	RFRvPP (RFRvPP)	
	X1FwPE	ZDS1	X1PE (1:X1PE)	
	R1PE	ZDS1	R1PE (1:R1PE)	
	X0FwPE	ZDS1	X0PE (X0PE)	
	R0PE	ZDS1	R0PE (R0PE)	
	RFFwPE	ZDS1	RFPE (RFPE)	
	X1RvPE	ZDS1	X1RvPE (X1RvPE)	
	X0RvPE	ZDS1	X0RvPE (X0RvPE)	
	RFRvPE	ZDS1	RFRvPE (RFRvPE)	

No user input is required in the ”Polarizing” and in the ”ZDS1logicst” block.

3.11 ZMCPDIS sub relay

The "ZMCPDIS" sub relay simulates the *Distance measuring zone, quadrilateral characteristic for series compensated lines (ZMCAPDIS)* relay function.

3.11.1 Available Units

- One zero sequence starting element ("ZMC1 IMinOpN" block).
- Five phase-phase current starting elements ("ZMC1 IMinOpPP", "ZMC2 IMinOpPP", "ZMC3 IMinOpPP", "ZMC4 IMinOpPP" and "ZMC5 IMinOpPP" block).
- Five phase current starting elements ("ZMC1 IMinOpPE", "ZMC2 IMinOpPE", "ZMC3 IMinOpPE", "ZMC4 IMinOpPE" and "ZMC5 IMinOpPE" block).
- Five phase-phase and phase-ground loop polygonal distance zones elements ("ZMC1", "ZMC2", "ZMC3", "ZMC4" and "ZMC5" block).
- Five timer element for the phase-phase loops starting signals ("ZMC1 tPP", "ZMC2 tPP", "ZMC3 tPP", "ZMC4 tPP" and "ZMC5 tPP" block).
- Five timer element for the phase-ground loops starting signals ("ZMC1 tPE", "ZMC2 tPE", "ZMC3 tPE", "ZMC4 tPE" and "ZMC5 tPE" block).
- Ten ancillary logic elements ("ZMC1logic", "ZMC2logic", "ZMC3logic", "ZMC4logic", "ZMC5logic", "ZMC1 logic", "ZMC2 logic", "ZMC3 logic", "ZMC4 logic" and "ZMC5 logic" block).

3.11.2 Functionality

This sub relay simulate the behavior of the ABB REL 670 polygonal distance zones used to protect series compensated lines.
Each polygonal distance zone is calculating both the phase-phase and the phase-ground loop impedances. The phase-phase loop and the phase-ground loop have separated over current starting elements (("ZMCn[5]IMinOpPP" for the phase-phase loops and "ZMCn[5]IMinOpPE" for the phase-ground loops). The first polygonal zone have also an additional zero sequence overcurrent starting element ("ZMC1 IMinOpN" block) to achieve better sensitivity. Separated timers are connected to the phase-phase loops and to the phase-ground loops distance zones starting signals.

The "ZMC1", "ZMC2", "ZMC3", "ZMC4" and "ZMC5" block calculate the phase-phase loop fault impedances using the following equations:

$$\underline{Z} = \underline{U_{L1L2}}/\underline{I_{L1L2}}$$

$$R = \Re(\underline{Z})$$

$$X = \Im(\underline{Z})$$

where:

$\underline{I}_{L1}$	is current difference between phase L1 and L2
$\underline{U}_{L1}$	is voltage difference between phase L1 and L2

[5] n = 1,2,3,4,5

The phase-earth loop fault impedances are calculated using the following equations:

$$R = \Re(\underline{Z}) = l * (R1PE + (R0PE - R1PE)/3) + R_f$$

$$X = \Im(\underline{Z}) = l * (X1PE + (X0PE - X1PE)/3)$$

with

$$l = (\Re(\underline{U}_{L1}) * \Im(\underline{I}_f) - \Im(\underline{U}_{L1}) * \Re(\underline{I}_f))/dU_z$$

$$dU_z = \Re(\underline{U}_d) * \Im(\underline{I}_f) - \Im(\underline{U}_d) * Re(I_f)$$

$$\underline{U}_d = R1PE * (\underline{I}_{L1} + K0r * \underline{I0x3}) + JX1PE * (\underline{I}_{L1} + K0i * \underline{I0x3})$$

$$K0r = \frac{(R0PE-R1PE)}{(3*R1PE)} \qquad K0i = \frac{(X0PE-X1PE)}{(3*X1PE)}$$

$R_f = \Im(\underline{U}_{L1}) - l * \Im(\underline{U}_d)/\Im(\underline{I}_f)$ when $|\Im(\underline{I}_f)| > |\Re(\underline{I}_f)|$

$R_f = \Re(\underline{U}_{L1}) - l * \Re(\underline{U}_d)/\Re(\underline{I}_f)$ when $|\Im(\underline{I}_f)| < |\Re(\underline{I}_f)|$

where:
R0PE is zero sequence resistance ph-earth loops (*R0PE* dialog parameter)
R1PE is positive sequence resistance ph-earth loops (*R1PE* dialog parameter)
X0PE is zero sequence reactance ph-earth loops (*X0PE* dialog parameter)
X1PE is positive sequence reactance ph-earth loops (*X1PE* dialog parameter)
$\underline{I}_{L1}$ is phase current in phase L1
$\underline{I}_f$ is fault current
$\underline{U}_{L1}$ is phase voltage in phase L1
$\underline{I0x3}$ is the neutral current

The impedance values depend up on the R0PE,R1PE,X0PE,X1PE parameters which can be defined with different values in each block. This is the reason why each polygonal block displays its phase-earth loop impedances.

3.11.3 Data input

The relationships between the relay settings and the model parameters can be found in the following table (the relay model parameter names are listed between brackets):

Address	Relay Setting	Model block	Model setting	Note
	ZMCPDIS Operation	ZMC1	Out of Service (outserv)	
	ZMCPDIS OperationDir	ZMC1	Tripping Direction (idir)	
	ZMCPDIS OperationPP	ZMC1 IMinOpPP	Out of Service (outserv)	To set from the command line
	ZMCPDIS X1FwPP	ZMC1	X1PP (X1PP)	
	ZMCPDIS R1PP	ZMC1	R1PP (R1PP)	
	ZMCPDIS RFFwPP	ZMC1	RFPP (RFPP)	
	ZMCPDIS X1RvPP	ZMC1	X1RvPP (X1RvPP)	
	ZMCPDIS RFRvPP	ZMC1	RFRvPP (RFRvPP)	
	ZMCPDIS Timer tPP	ZMC1 tPP	Out of Service (outserv)	
	ZMCPDIS tPP	ZMC1 tPP	Time Setting (Tdelay)	
	ZMCPDIS OperationPE	ZMC1 IMinOpPE	Out of Service (outserv)	To set from the command line
		ZMC1 IMinOpIN	Out of Service (outserv)	To set from the command line
	ZMCPDIS X1FwPE	ZMC1	X1PE (X1PE)	
	ZMCPDIS R1PE	ZMC1	R1PE (R1PE)	

Address	Relay Setting	Model block	Model setting	Note
	ZMCPDIS X0PE	ZMC1	X0PE (X0PE)	
	ZMCPDIS R0PE	ZMC1	R0PE (R0PE)	
	ZMCPDIS RFFwPE	ZMC1	RFPE (RFPE)	
	ZMCPDIS X1RvPE	ZMC1	X1RvPE (X1RvPE)	
	ZMCPDIS RFRvPE	ZMC1	RFRvPE (RFRvPE)	
	ZMCPDIS Timer tPE	ZMC1 tPE	Out of Service (outserv)	
	ZMCPDIS tPE	ZMC1 tPE	Time Setting (Tdelay)	
	ZMCPDIS IMinOpPP	ZMC1 IMinOpPP	Current I>> (ip2)	
	ZMCPDIS IMinOpPE	ZMC1 IMinOpPE	Current I>> (ip2)	
	ZMCPDIS IMinOpIN	ZMC1 IMinOpIN	Current, 3*i0 (ie)	
	ZMCAPDIS Operation	ZMCn[6]	Out of Service (outserv)	
	ZMCAPDIS OperationDir	ZMCn[6]	Tripping Direction (idir)	
	ZMCAPDIS OperationPP	ZMCn[6]IMinOpPP	Out of Service (outserv)	To set from the command line
	ZMCAPDIS X1FwPP	ZMCn[6]	X1PP (X1PP)	
	ZMCAPDIS R1PP	ZMCn[6]	R1PP (R1PP)	
	ZMCAPDIS RFFwPP	ZMCn[6]	RFPP (RFPP)	
	ZMCAPDIS X1RvPP	ZMCn[6]	X1RvPP (X1RvPP)	
	ZMCAPDIS RFRvPP	ZMCn[6]	RFRvPP (RFRvPP)	
	ZMCAPDIS Timer tPP	ZMCn[6]tPP	Out of Service (outserv)	
	ZMCAPDIS tPP	ZMCn[6]tPP	Time Setting (Tdelay)	
	ZMCAPDIS OperationPE	ZMCn[6]IMinOpPE	Out of Service (outserv)	To set from the command line
		ZMCn[6]IMinOpIN	Out of Service (outserv)	To set from the command line
	ZMCAPDIS X1FwPE	ZMCn[6]	X1PE (X1PE)	
	ZMCAPDIS R1PE	ZMCn[6]	R1PE (R1PE)	
	ZMCAPDIS X0PE	ZMCn[6]	X0PE (X0PE)	
	ZMCAPDIS R0PE	ZMCn[6]	R0PE (R0PE)	
	ZMCAPDIS RFFwPE	ZMCn[6]	RFPE (RFPE)	
	ZMCAPDIS X1RvPE	ZMCn[6]	X1RvPE (X1RvPE)	
	ZMCAPDIS RFRvPE	ZMCn[6]	RFRvPE (RFRvPE)	
	ZMCAPDIS Timer tPE	ZMCn[6]tPE	Out of Service (outserv)	
	ZMCAPDIS tPE	ZMCn[6]tPE	Time Setting (Tdelay)	
	ZMCAPDIS IMinOpPP	ZMCn[6]IMinOpPP	Current I>> (ip2)	
	ZMCAPDIS IMinOpPE	ZMCn[6]IMinOpPE	Current I>> (ip2)	

No user input is required in the ”ZMCn[6]logic” and in the ”ZMCn[6] logic” block.

[6] n = 2,3,4,5

3.12 ZMHPDIS sub relay

The ”ZMHPDIS” sub relay simulates the *Full-scheme distance measuring, Mho characteristic (ZMHPDIS)* relay function.

3.12.1 Available Units

- Five phase-phase current and phase current starting elements (”ZMH1 IMinOp”, ”ZMH2 IMinOp”, ”ZMH3 IMinOp”, ”ZMH4 IMinOp” and ”ZMH5 IMinOp” block).
- Five phase-phase loop mho elements (”ZMH1 PP”, ”ZMH2 PP”, ”ZMH3 PP”, ”ZMH4 PP” and ”ZMH5 PP” block).
- Five phase-ground loop mho elements (”ZMH1 PE”, ”ZMH2 PE”, ”ZMH3 PE”, ”ZMH4 PE” and ”ZMH5 PE” block).
- Five polarizing elements (”ZMH1 KN”, ”ZMH2 KN”, ”ZMH3 KN”, ”ZMH4 KN” and ”ZMH5 KN” block).
- Five timer element for the phase-phase loops mho starting signals (”ZMH1 tPP”, ”ZMH2 tPP”, ”ZMH3 tPP”, ”ZMH4 tPP” and ”ZMH5 tPP” block).
- Five timer element for the phase-ground loops mho starting signals (”ZMH1 tPE”, ”ZMH2 tPE”, ”ZMH3 tPE”, ”ZMH4 tPE” and ”ZMH5 tPE” block).
- Five ancillary logic elements (”ZMH1 logic”, ”ZMH2 logic”, ”ZMH3 logic”, ”ZMH4 logic” and ”ZMH5 logic” block).

3.12.2 Functionality

This sub relay simulate the behavior of the mho used to protect transmission and sub-transmission lines.
Separate mho elements are calculating the phase-phase loop and the phase-ground loop impedances (”ZMHn[7]PP” and ”ZMHn[7]PP” block). The phase-phase loop and the phase-ground loop currents are evaluated by over current starting elements ((”ZMHn[7]IMinOp” blocks) which enable the mho elements impedance measurement. Each over current starting element controls a phase-phase loop mho element and a phase-ground loop mho element. Separated timers are connected to the phase-phase loops and to the phase-ground loops mho starting signals.

3.12.3 Data input

The relationships between the relay settings and the model parameters can be found in the following table (the relay model parameter names are listed between brackets):

Address	Relay Setting	Model block	Model setting	Note
	ZMHPDIS Operation	ZMHn[8]PP	Out of Service (outserv)	
		ZMHn[8]PE	Out of Service (outserv)	
	ZMHPDIS Dir Mode	ZMHn[8]	Tripping Direction (idir)	
	ZMHPDIS LoadEncMode	PHS Load Area	Out of Service (outserv)	In the main relay. Unique for all mho zones

[7] n = 1,2,3,4,5
[8] n = 1,2,3,4

Address	Relay Setting	Model block	Model setting	Note
	ZMHPDIS OpModePE	ZMHn^{8}PE	Out of Service (outserv)	
	ZMHPDIS ZPE	ZMHn^{8}PE	Replica Impedance (Zm)	
	ZMHPDIS ZAngPE	ZMHn^{8}PE	Relay Angle (phi)	
	ZMHPDIS KN	ZMHn^{8}KN	k0 (k0)	
	ZMHPDIS KNAng	ZMHn^{8}KN	Angle (phik0)	
	ZMHPDIS ZRevPE	ZMHn^{8}PE	Impedance (Zoff)	In the ”Offset” frame
	ZMHPDIS tPE	ZMHn^{8}tPE	Time Setting (Tdelay)	
	ZMHPDIS IMinOpPE	ZMHn^{8}IMinOp	Current, 3*i0 (ie)	
	ZMHPDIS OpModePP	ZMHn^{8}PP	Out of Service (outserv)	
	ZMHPDIS ZPP	ZMHn^{8}PP	Replica Impedance (Zm)	
	ZMHPDIS ZAngPP	ZMHn^{8}PP	Relay Angle (phi)	
	ZMHPDIS ZRevPP	ZMHn^{8}PP	Impedance (Zoff)	In the ”Offset” frame
	ZMHPDIS tPP	ZMHn^{8}tPP	Time Setting (Tdelay)	
	ZMHPDIS IMinOpPP	ZMHn^{8}IMinOp	Current I>> (ip2)	

No user input is required in the ”ZMHn^{8}logic” blocks.

3.13 ZMQPDIS sub relay

The ”ZMQPDIS” sub relay simulates the *Distance measuring zones, quadrilateral characteristic (ZMQPDIS,ZMQAPDIS)* relay function.

3.13.1 Available Units

- One zero sequence starting element (”ZMQ1 IMinOpN” block).
- Five phase-phase current starting elements (”ZMQ1 IMinOpPP”, ”ZMQ2 IMinOpPP”, ”ZMQ3 IMinOpPP”, ”ZMQ4 IMinOpPP” and ”ZMQ5 IMinOpPP” block).
- Five phase current starting elements (”ZMQ1 IMinOpPE”, ”ZMQ2 IMinOpPE”, ”ZMQ3 IMinOpPE”, ”ZMQ4 IMinOpPE” and ”ZMQ5 IMinOpPE” block).
- Five phase-phase and phase-ground loop polygonal distance zones elements (”ZMQ1”, ”ZMQ2”, ”ZMQ3”, ”ZMQ4” and ”ZMQ5” block).
- Five timer element for the phase-phase loops starting signals (”ZMQ1 tPP”, ”ZMQ2 tPP”, ”ZMQ3 tPP”, ”ZMQ4 tPP” and ”ZMQ5 tPP” block).
- Five timer element for the phase-ground loops starting signals (”ZMQ1 tPE”, ”ZMQ2 tPE”, ”ZMQ3 tPE”, ”ZMQ4 tPE” and ”ZMQ5 tPE” block).
- Ten ancillary logic elements (”ZMQ1logic”, ”ZMQ2logic”, ”ZMQ3logic”, ”ZMQ4logic”, ”ZMQ5logic”, ”ZMQ1 logic”, ”ZMQ2 logic”, ”ZMQ3 logic”, ”ZMQ4 logic” and ”ZMQ5 logic” block).

3.13.2 Functionality

This sub relay simulate the behavior of the ABB REL 670 polygonal distance zones used to protect non compensated transmission and sub-transmission lines.
Each polygonal distance zone is calculating both the phase-phase and the phase-ground loop impedances. The phase-phase loop and the phase-ground loop have separated over current starting elements ((”ZMQn[9]IMinOpPP” for the phase-phase loops and ”ZMQn[9]IMinOpPE” for the phase-ground loops). The first polygonal zone have also an additional zero sequence overcurrent starting element (”ZMQ1 IMinOpN” block) to achieve better sensitivity.

The polygonal distance elements (’ZMQ1”, ”ZMQ2”, ”ZMQ3”, ”ZMQ4” and ”ZMQ5” block) calculates the phase-phase loop fault impedances using the following equations:

$$\underline{Z} = \underline{U}_{L1L2}/\underline{I}_{L1L2}$$

$$R = \Re(\underline{Z})$$

$$X = \Im(\underline{Z})$$

where:

$\underline{I}_{L1L2}$	is current difference between phase L1 and L2
$\underline{U}_{L1L2}$	is voltage difference between phase L1 and L2

The phase-earth loop fault impedances are calculated using the following equations:

$$\underline{Z} = \underline{U}_{L1}/(\underline{I}_{L1} + K_N * \underline{I}_N)$$

[9] n = 1,2,3,4,5

$R = \Re(\underline{Z})$

$X = \Im(\underline{Z})$

with

$K_N = \frac{(X0-X1)}{(3X1)}$

where:

X0 is zero sequence reactance ph-earth loops (*X0* dialog parameter)
X1 is positive sequence reactance ph-earth loops (*X1* dialog parameter)
$\underline{I}_{L1}$ is phase current in phase L1
$\underline{U}_{L1}$ is phase voltage in phase L1
$\underline{I}_N$ is the neutral current

Separated timers are connected to the phase-phase loops and to the phase-ground loops distance zones starting signals.

3.13.3 Data input

The relationships between the relay settings and the model parameters can be found in the following table (the relay model parameter names are listed between brackets):

Address	Relay Setting	Model block	Model setting	Note
	ZMQPDIS Operation	ZMQ1	Out of Service (outserv)	
	ZMQPDIS OperationDir	ZMQ1	Tripping Direction (idir)	
	ZMQPDIS OperationPP	ZMQ1 IMinOpPP	Out of Service (outserv)	To set from the command line
	ZMQPDIS X1	ZMQ1	X1 (X1)	
	ZMQPDIS R1	ZMQ1	R1 (R1)	
	ZMQPDIS RFPP	ZMQ1	RFPP (RFPP)	
	ZMQPDIS Timer tPP	ZMQ1 tPP	Out of Service (outserv)	
	ZMQPDIS tPP	ZMQ1 tPP	Time Setting (Tdelay)	
	ZMQPDIS OperationPE	ZMQ1 IMinOpPE	Out of Service (outserv)	To set from the command line
		ZMQ1 IMinOpIN	Out of Service (outserv)	To set from the command line
	ZMQPDIS X0PE	ZMQ1	X0PE (X0PE)	
	ZMQPDIS R0PE	ZMQ1	R0PE (R0PE)	
	ZMQPDIS RFPE	ZMQ1	RFPE (RFPE)	
	ZMQPDIS Timer tPE	ZMQ1 tPE	Out of Service (outserv)	
	ZMQPDIS tPE	ZMQ1 tPE	Time Setting (Tdelay)	
	ZMQPDIS IMinOpPP	ZMQ1 IMinOpPP	Current I>> (ip2)	
	ZMQPDIS IMinOpPE	ZMQ1 IMinOpPE	Current I>> (ip2)	
	ZMQPDIS IMinOpIN	ZMQ1 IMinOpIN	Current, 3*i0 (ie)	
	ZMQAPDIS Operation	ZMQn[10]	Out of Service (outserv)	
	ZMQAPDIS OperationDir	ZMQn[10]	Tripping Direction (idir)	
	ZMQAPDIS OperationPP	ZMQn[10]IMinOpPP	Out of Service (outserv)	To set from the command line
	ZMQAPDIS X1PP	ZMQn[10]	X1PP (X1PP)	
	ZMQAPDIS R1PP	ZMQn[10]	R1PP (R1PP)	
	ZMQAPDIS RFPP	ZMQn[10]	RFPP (RFPP)	
	ZMQAPDIS Timer tPP	ZMQn[10]tPP	Out of Service (outserv)	
	ZMQAPDIS tPP	ZMQn[10]tPP	Time Setting (Tdelay)	
	ZMQAPDIS OperationPE	ZMQn[10]IMinOpPE	Out of Service (outserv)	To set from the command line
		ZMQn[10]IMinOpIN	Out of Service (outserv)	To set from the command line

[10] n = 2,3,4,5

Address	Relay Setting	Model block	Model setting	Note
	ZMQAPDIS X0PE	ZMQn[10]	X0PE (X0PE)	
	ZMQAPDIS R0PE	ZMQn[10]	R0PE (R0PE)	
	ZMQAPDIS RFPE	ZMQn[10]	RFPE (RFPE)	
	ZMQAPDIS Timer tPE	ZMQn[10]tPE	Out of Service (outserv)	
	ZMQAPDIS tPE	ZMQn[10]tPE	Time Setting (Tdelay)	
	ZMQAPDIS IMinOpPP	ZMQn[10]IMinOpPP	Current I>> (ip2)	
	ZMQAPDIS IMinOpPE	ZMQn[10]IMinOpPE	Current I>> (ip2)	

No user input is required in the ”ZMQn[10]logic” and in the ”ZMQn[10] logic” block.

3.14 Output logic

3.14.1 Available Units

The output logic is implemented by a set of logic blocks located in the main relay.

Four logic blocks are available:

- ”ZMCPDIS Output Logic” connected to the ”ZMCPDIS” subrelay output signals.
- ”ZMHPDIS Output Logic” connected to the ”ZMHPDIS” subrelay output signals.
- ”ZMQPDIS Output Logic” connected to the ”ZMQPDIS” subrelay output signals.
- ”I & V & f Output Logic” connected to the ”PTOC 51_67”, ”PTOC 51N67N”, ”PTOF PTUF PFRC 81” , ”PTUV 27 PTOV 59/59N” and to the ”PDIF 87” subrelay output signals.

3.14.2 Functionality

Each logic block located in the main relay can operate the power breaker.
The output signals which can be used to operate the breaker are ”yout”, ”yout_A”, ”yout_B” and ”yout_C”. Please notice that ”yout_A”, ”yout_B” and ”yout_C” are not connected to any relay output signals.

The logic blocks implement the three phase, single phase and the two phases trip logic.

3.14.3 Data input

Please disable the ”ZMCPDIS Output Logic”, ”ZMHPDIS Output Logic”, ”ZMQPDIS Output Logic” and ”I & V & f Output Logic” block in the main relay to disable the relay model ability to open the power circuit.

The ”yout”, ”yout_A”, ”yout_B” and ”yout_C” relay output signals can be set to operate the breaker using the ”Tripping signal” (”sTripsig”) parameter in the ”Basic Data” tab page of the logic block dialogs. By default all of them are operating the breaker.

The single phase trip logic can be activated setting equal to ”TRIP” the ”single_pole_trip” parameter in the ”Logic” tab page of the logic block dialogs. The two phases trip logic can be activated setting equal to ”TRIP” the ”two_poles_trip” parameters. By default the three phase trip logic is enabled.

4 Features not supported

4.1 Main features

The following features are not supported:

- Automatic switch onto fault logic, voltage and current based, ZCVPSOF.
- Breaker failure protection, CCRBRF.
- Four step directional negative phase sequence overcurrent protection NS4PTOC.
- Pole slip protection, PSPPPAM.
- Scheme communication logic for distance protection, ZCOM.
- Stub protection, STBPTOC.
- Pole discordance protection, CCRPLD.
- Directional underpower protection, GUPPDUP.
- Directional overpower protection, GOPPDOP.
- Broken conductor check, BRCPTOC.
- General current and voltage protection, CVGAPC.
- Power system and secondary system supervision.
- Synchrocheck, energizing check, and synchronizing, SESRSYN.
- Autorecloser, SMBRREC.
- Current circuit supervision, CCSRDIF.
- Fuse failure supervision SDDRFUF.
- Interlocking logics.

4.2 PTOC 51N67N sub relay

The following features are not supported:

- Switch On To Fault.
- Sensitive directional residual overcurrent and power protection SDEPSDE.

4.3 PTOC 51_67 sub relay

The following features are not supported:

- Switch On To Fault.
- Thermal overload protection, one time constant LPTTR

4.4 PTUV 27 PTOV 59/59N sub relay

The following features are not supported:

- Overexcitation protection OEXPVPH
- Voltage differential protection VDCPTOV
- Loss of voltage check LOVPTUV

4.5 SC Dir-Z sub relay

The following features are not supported:

- INReleasePE/INBlockPP relay setting

4.6 ZMHPDIS sub relay

The following features are not supported:

- Mho impedance supervision logic, ZSMGAPC

4.7 ZMQPDIS sub relay

The following features are not supported:

- Full-scheme distance protection, quadrilateral for earth faults ZMMPDIS, ZMMAPDIS
- Additional distance protection directional function for earth faults, ZDARDIR
- Distance protection zone, quadrilateral characteristic, separate settings ZMRPDIS, ZM-RAPDIS and ZDRDIR

5 References

[1] ABB AB, Substation Automation Products, SE-721 59 Vasteras, Sweden. *Line distance protection REL670 Application Manual Document No: 1MRK 506 315-UEN Issued: April 2011 Revision: A*, 2011.

[2] ABB Automation Products AB, Substation Automation Products, SE-721 59 Vasteras, Sweden. *Technical Reference Manual Line distance protection IED REL 670 Document No: 1MRK506275-UEN Issued: December 2007 Revision: B*, 2007.