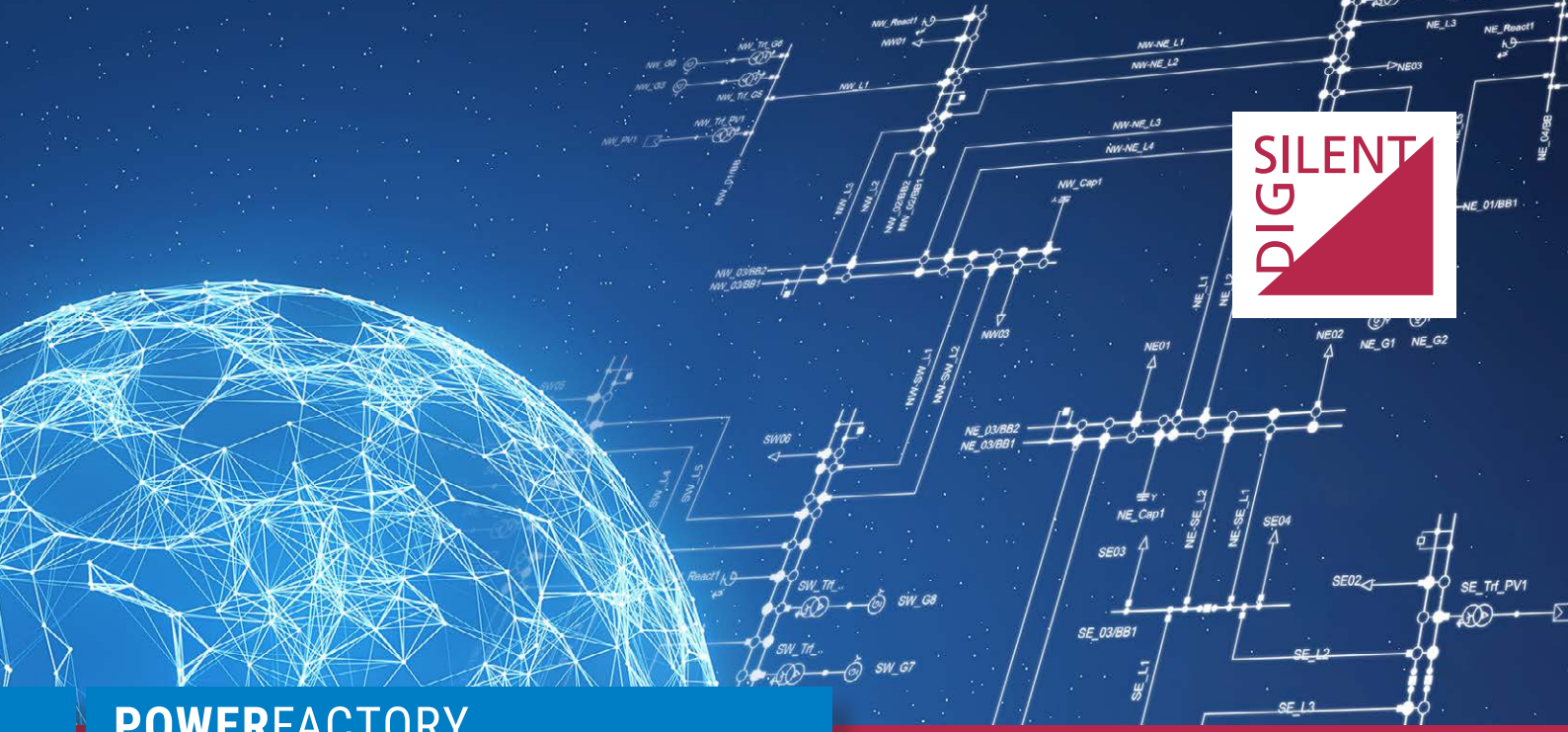

POWERFACTORY

PowerFactory 2021

Technical Reference

ABB REG 670

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POWER SYSTEM SOLUTIONS

MADE IN GERMANY

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Contents

1 Model information

Manufacturer ABB

Model REG 670

Variants The ABB REG 670 PowerFactory relay model can be used to simulate any version of the ABB REG 670 relay. However please consider that the model has been implemented with the features available in the V1.2 firmware version.

2 General description

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

- EF4PTOC (inverse time residual over current protective function)
- GENPDIF (generator differential protective function)
- LEXPDIS (loss of excitation protective function)
- NS4PTOC (inverse time negative sequence over current protective function)
- OC4PTOC (inverse time phase over current protective function)
- PIOC (instantaneous overcurrent protective functions)
- PSPPPAM (pole slip protection protective functions)
- SAPTUF SAPTOF SAPFRC (frequency protective function)
- T2WPDIF T3WPDIF REFPDIF HZPDIF (low and high impedance 2 & windings transformer differential protective function)
- TRPTTR (thermal image protective function)
- UV2PTUV OV2PTUV ROV2PTOV (voltage protective function)
- ZMHPDIS (mho distance protective function)

The ABB REG 670 PowerFactory relay model has been implemented trying to simulate the most commonly used protective functions.

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] .

3 Supported features

3.1 Measurement and acquisition

The voltage and the current are measured by six three phase current transformer (”Ct1 W1”, ”Ct2 W1”, ”Ct1 W2”, ”Ct2 W2”, ”Ct1 W3”, and ”Ct2 W3” block), one single phase current transformer (”Neutral Ct” block) and one three phase voltage transformer (”Vt” block).

Five teen measurement units (”Measure”, ”Delta Measure”, ”Measure Seq”, ”Measurement Ct2 W1”, ”Measurement Ct1 W2”, ”Measurement Ct2 W2”, ”Measurement Ct1 W3”, ”Measurement Ct2 W3”, ”Measure Seq Ct2 W1”, ”Measure Seq Ct1 W2”, ”Measure Seq Ct2 W2” , ”Measure Seq Ct1 W3”, ”Measure Seq Ct2 W3”, ”Neutral Measurement” and ”2nd harm Measure” block) are fed by this CT and this VT.

3.1.1 Available Units and Input Signals

- Six three phase current transformers (”Ct1 W1”, ”Ct2 W1”, ”Ct1 W2”, ”Ct2 W2”, ”Ct1 W3”, and ”Ct2 W3” block).
- One single phase current transformer (”Neutral Ct” block).
- One three phase voltage transformer (”Vt” block).
- One three phase measurement elements calculating both the current and voltage values (”Measure” block).
- One three phase measurement elements calculating the 2^{n}d harmonic current values(”2nd harm Measure” block).
- One three phase measurement elements calculating the phase to phase currents and the phase to phase voltages (”Delta Measure” block).
- Five three phase measurement elements calculating the phase currents (”Measurement Ct2 W1”, ”Measurement Ct1 W2”, ”Measurement Ct2 W2”, ”Measurement Ct1 W3”, ”Measurement Ct2 W3”, and ”Measure Seq Ct2 W1” block)
- Five three phase measurement elements calculating the negative sequence currents (”Measure Seq Ct2 W1”, ”Measure Seq Ct1 W2”, ”Measure Seq Ct2 W2” , ”Measure Seq Ct1 W3”, and ”Measure Seq Ct2 W3” 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 REG 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 ”Polarizing15” block). Please note that no user input is usually needed in these blocks.

3.2.2 Functionality

Starting element The ABB REG 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).

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. 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, a voltage memory buffer long 100 ms is automatically activated when the voltage drops below 4%U_n and deactivated when the voltage is again greater than 10%U_n, ”Polarizing15” 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.

Power swing element :

Address	Relay Setting	Model block	Model setting	Note
	Operation	Power Swing	Out of service(outserv)	
	Detection	Power Swing	Polygonal detection(ipoly)	
	X1IN	Power Swing	X1IN (X1IN)	
	R1IN	Power Swing	R1IN (R1IN)	
	KX	Power Swing	KX (KX)	
	KR	Power Swing	KR (KR)	
	tP1	Power Swing	tP1 (tP1)	
	tP2	Power Swing	tP2 (tP2)	
	tW	Power Swing	tW (tW)	
	tH	Power Swing	tH (tH)	

3.3 EF4PTOC sub relay

The ”EF4PTOC” 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.

3.3.1 Available Units

- Four directional inverse characteristic zero sequence over current element (”EF4PTOC 1”, ”EF4PTOC 2”, ”EF4PTOC 3” and ”EF4PTOC 4” block).
- One directional element (”Dir EF4PTOC” block).
- One 2^{nd} harmonic current restrain element (”2nd harmonic Stab” block).
- One logic block (”PTOC Output Logic” block).

3.3.2 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 or a negative sequence voltage and current phase comparison direction detection logic. The selection between the zero sequence and the negative sequence quantities is made by the ”U3P” block (”U3P_3U0”, and ”U3P_3U2” dip setting in the *DIP settings* tab page). Each inverse time element can be configured to be controlled by the 2^{nd} harmonic current restrain. The ”EF4PTOC 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

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

- Logarithmic inverse.TypChatoc
- RI inverse.TypChatoc

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.

3.3.3 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	EF4PTOC	Out of Service (outserv)	
	Ibase	EF4PTOC Ibase	Pickup Current (Ipsetr)	
	AngleRCA	Dir EF4PTOC	Max. Torque Angle (mtau)	In the ”Voltage Polarizing ” tab page
	UPolMin	Dir EF4PTOC	Polarizing Voltage (upolu)	In the ”Voltage Polarizing ” tab page
	IPolMin	Dir EF4PTOC	Operating Current (curopu)	In the ”Voltage Polarizing ” tab page
	2ndHarmStab	2nd harmonic Stab	Pickup Current (Ipset)	
	DirModen[2]	EF4PTOC n[2]	Tripping Direction (idir)	
	Characteristn[2]	EF4PTOC n[2]	Characteristic (pcharac)	
	INn[2]>	EF4PTOC n[2]	Current Setting (Ipset)	
	t1	EF4PTOC n[2]	Time Dial (Tpset)	Relay definite time delay
	k1	EF4PTOC n[2]	Time Dial (Tpset)	Relay time multiplier for the inverse characteristics
	t1Min	EF4PTOC n[2]	Min. Time(udeftimin)	
	HarmRestrainn[2]	EF4PTOC 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

3.4 GENPDIF sub relay

The ”GENPDIF” sub relay implements one low impedance two 3 phase windings generator differential protection (*GENPDIF* function block).

3.4.1 Available Units

- One 3 phase current magnitude 2 windings differential element(”GENPDIF” block).
- One negative sequence current angle comparison differential element(”GENPDIF NegSeqDiff” block).
- Two 3 phase definite time overcurrent elements (”GENPDIF IdiffAlarm”, and ”GENPDIF IdiffHSet” block).
- Four 3 phase adapters (”GENPDIF Ct1 W1 Adapter”, ”GENPDIFF Ct2 W1 Adapter”, ”GENPDIF Ct1 W2 Adapter”, and ”GENPDIF Ct2 W2 Adapter” block).
- Three 3 phase measurement elements (”GENPDIF H1 Diff Measure”, ”GENPDIF H2 Diff Measure”, and ”GENPDIF H5 Diff Measure” block).
- One single phase measurement element (”GENPDIF NegSeqDiff H1 Diff Measure” block).
- One single phase timer element (”GENPDIF NegSeqDiff delay” block).
- One logic block (”GENPDIF trip logic” block).

3.4.2 Functionality

Up to 12 current inputs (four 3 phase CT) are supported: the *GENPDIF* set of elements simulates a 2 windings differential feature. Each winding can be monitored by one or two CTs.

The elements simulating the *GENPDIF* features implement two 3 phase (phase segregated) current magnitude differentials (”GENPDIF” block) each of them with double slope bias current restraint and with 2^{nd} and 5^{th} harmonic restraint. Two unrestrained high set differential threshold are also available in the differential block; two differential alarm thresholds can be defined in the ”GENPDIF IdiffAlarm” block.

Two fault discriminators based on the negative sequence current analysis are available to distinguish between *external* and *internal faults* (”GENPDIF NegSeqDiff” block).

If the fault is declared as internal the harmonic restrain is inhibited; it’s means that any harmonic blocking is then overridden and a trip is declared if the phase differential element has started.

If the fault is declared as internal and the phase differential current is smaller than the user configurable phase differential threshold (*Differential Current* setting of the ”GENPDIF” block), an intern turn internal fault is assumed and a trip is declared if the negative sequence differential current remains in the starting condition for a time greater than a 1 cycle.

The elements simulating the *GENPDIF* protection function include four adapters, one for each winding considering up to two current inputs(CTs) for each winding.

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
	Operation	GENPDIF	Out of Service (outserv)	
	IBase	GENPDIF	Differential Current (Itapr)	
	tAlarmDelay	GENPDIF IdiffAlarm	Pickup Current (Ipset)	
	IDiffAlarm	GENPDIF IdiffAlarm	Time Setting (Tdelay)	
	IdMin	GENPDIF	Release threshold (Idiffr2)	
	IdUnre	GENPDIF	Unrestrained Differential Threshold (Idiffunrestr2)	
	CrossBlockEn	GENPDIF	Interblocking (h2interblock)	”Harmonic blocking” tab page
		GENPDIF	Interblocking (h5interblock)	”Harmonic blocking” tab page
	NegSeqDiffEn	GENPDIF NegSeqDiff	Out of Service (outserv)	
	IMinNegSeq	GENPDIF NegSeqDiff	Current Threshold (IM)	
	NegSeqROA	GENPDIF NegSeqDiff	Restraint region Angle (RestrAngle)	Set RestrAngle = 360 - 2* NegSeqROA
	EndSection1	GENPDIF	Restraint Current 1st threshold (Ipset1r2)	
	EndSection2	GENPDIF	Restraint Current 2nd threshold (Ipset2r2)	
	SlopeSection2	GENPDIF	Restrain percentage 1 (Irestrpercent1)	
	SlopeSection3	GENPDIF	Restrain percentage 2 (Irestrpercent2)	
	I2/I1Ratio	GENPDIF	2nd Harmonic blocking threshold (H2threshold)	”Harmonic blocking” tab page
	I5/I1Ratio	GENPDIF	5th Harmonic blocking threshold (H5threshold)	”Harmonic blocking” tab page
	RatedVoltageW1	GENPDIF Ct1 W1 Adapter	Nominal Terminal Line-Line Voltage (LLVolt)	
		GENPDIF Ct2 W1 Adapter	Nominal Terminal Line-Line Voltage (LLVolt)	
	RatedVoltageW2	GENPDIF Ct1 W2 Adapter	Nominal Terminal Line-Line Voltage (LLVolt)	
		GENPDIF Ct2 W2 Adapter	Nominal Terminal Line-Line Voltage (LLVolt)	
	ClockNumberW2	GENPDIF Ct1 W2 Adapter	Transformer Group(trasfgroup)	
	ClockNumberW2	GENPDIF Ct2 W2 Adapter	Transformer Group(trasfgroup)	
	ZSCurrSubtrW1	Ct1 W1 Earth Current Filter	ZSCurrSubtrW1 (ZSCurrSubtrW1)	In the ”Logic” tab page
		Ct2 W1 Earth Current Filter	ZSCurrSubtrW1 (ZSCurrSubtrW1)	In the ”Logic” tab page
	ZSCurrSubtrW2	Ct1 W2 Earth Current Filter	ZSCurrSubtrW2 (ZSCurrSubtrW2)	In the ”Logic” tab page
		Ct2 W2 Earth Current Filter	ZSCurrSubtrW2 (ZSCurrSubtrW2)	In the ”Logic” tab page
	CT1RatingW1	GENPDIF Ct1 W1 Adapter	Current Transformer Ratio (CTRatio)	
	CT2RatingW1	GENPDIF Ct2 W1 Adapter	Current Transformer Ratio (CTRatio)	
	CT1RatingW2	GENPDIF Ct1 W2 Adapter	Current Transformer Ratio (CTRatio)	
	CT2RatingW2	GENPDIF Ct2 W2 Adapter	Current Transformer Ratio (CTRatio)	

3.5 LEXPDIS sub relay

The ”LEXPDIS” sub relay implements two mho characteristics with directional supervision and independent time delays which are used to detect the loss of excitation condition.

3.5.1 Available Units

- One polarizing element (”Polarizing” block).
- Two 3 phase mho elements (”Z1”, and ”Z2” block).
- Two timers (”Z1 Timer”, and ”Z2 Timer” block).
- One directional supervisor (”Dir Superv” block)
- One relay trip element (”Output logic” block).

3.5.2 Functionality

The Loss of excitation protection in the ABB REG 670 relay model measures the apparent impedance seen out from the generator. The measurement loop of apparent impedance is the positive sequence loop. The *LEXPDIS* subrelay consists of two mho elements with separate time delays and underreactance element which acts as directional blinder and creates a restrain area. The center of both mho elements is set along the negative part of teh X axis in the RX diagram. When the apparent impedance reaches the zone Z1 this zone will operate, normally with a short delay. The zone is related to the dynamic stability of the generator. When the apparent impedance reaches the zone Z2 this zone will operate, normally with a longer delay. The zone is related to the static stability of the generator. If the directional restrain is set *Off* in the relay please set the *Reactance* setting of the ”Dir Superv” block to the max allowed value.

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	LEXPDIS	Out of Service (outserv)	
	OperationZ1	Z1	Out of Service (outserv)	
	XoffsetZ1	Z1	Impedance (Zoff)	In the ”Offset” frame
	Z1diameter	Z1	Replica Impedance (Zm)	
	tZ1	Z1	Time Setting (Tdelay)	
	OperationZ2	Z2	Out of Service (outserv)	
	XoffsetZ2	Z2	Impedance (Zoff)	In the ”Offset” frame
	Z2diameter	Z2	Replica Impedance (Zm)	
	tZ2	Z2	Time Setting (Tdelay)	
	DirSuperv	Dir Superv	Out of Service (outserv)	
	XoffsetDirLine	Dir Superv	Reactance (X)	
	DirAngle	Dir Superv	Relay Angle phi	

3.6 ZMHPDIS sub relay

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

3.6.1 Available Units

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

3.6.2 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[3]PP” and ”ZMHn[3]PP” block). The phase-phase loop and the phase-ground loop currents are evaluated by over current starting elements ((”ZMHn[3]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.

3.6.3 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
	ZMHPDIS Operation	ZMHn[4]PP	Out of Service (outserv)	
		ZMHn[4]PE	Out of Service (outserv)	
	ZMHPDIS Dir Mode	ZMHn[4]	Tripping Direction (idir)	
	ZMHPDIS LoadEncMode	PHS Load Area	Out of Service (outserv)	In the main relay. Unique for all mho zones
	ZMHPDIS OpModePE	ZMHn[4]PE	Out of Service (outserv)	

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

Address	Relay Setting	Model block	Model setting	Note
	ZMHPDIS ZPE	ZMHn^{4}PE	Replica Impedance (Zm)	
	ZMHPDIS ZAngPE	ZMHn^{4}PE	Relay Angle (phi)	
	ZMHPDIS KN	ZMHn^{4}KN	k0 (k0)	
	ZMHPDIS KNAng	ZMHn^{4}KN	Angle (phik0)	
	ZMHPDIS ZRevPE	ZMHn^{4}PE	Impedance (Zoff)	In the ”Offset” frame
	ZMHPDIS tPE	ZMHn^{4}tPE	Time Setting (Tdelay)	
	ZMHPDIS IMinOpPE	ZMHn^{4}IMinOp	Current, 3*i0 (ie)	
	ZMHPDIS OpModePP	ZMHn^{4}PP	Out of Service (outserv)	
	ZMHPDIS ZPP	ZMHn^{4}PP	Replica Impedance (Zm)	
	ZMHPDIS ZAngPP	ZMHn^{4}PP	Relay Angle (phi)	
	ZMHPDIS ZRevPP	ZMHn^{4}PP	Impedance (Zoff)	In the ”Offset” frame
	ZMHPDIS tPP	ZMHn^{4}tPP	Time Setting (Tdelay)	
	ZMHPDIS IMinOpPP	ZMHn^{4}IMinOp	Current I>> (ip2)	

No user input is required in the ”ZMHn^{4}logic” blocks.

3.7 NS4PTOC sub relay

The ”NS4PTOC” sub relay consists of four inverse and definite time delayed negative sequence 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 negative sequence over current protection *NS4PTOC* relay function.

3.7.1 Available Units

- Four directional inverse characteristic negative sequence over current element (”NS4PTOC 1”, ”NS4PTOC 2”, ”NS4PTOC 3” and ”NS4PTOC 4” block).
- One directional element (”Dir NS4PTOC” block).
- One 2^{nd} harmonic current restrain element (”2nd harmonic Stab” block).
- One logic block (”PTOC Output Logic” block).

3.7.2 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 NS4PTOC” block which implements a negative sequence voltage and current phase comparison detection logic. Each inverse time element can be configured to be controlled by the 2^{nd} harmonic current restrain. The ”NS4PTOC n[5]” 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

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

- RI inverse.TypChatoc

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.

3.7.3 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
	Operation	NS4PTOC	Out of Service (outserv)	
	Ibase	NS4PTOC Ibase	Pickup Current (Ipsetr)	
	AngleRCA	Dir NS4PTOC	Max. Torque Angle (mtau)	In the ”Voltage Polarizing ” tab page
	UPolMin	Dir NS4PTOC	Polarizing Voltage (upolu)	In the ”Voltage Polarizing ” tab page
	IPolMin	Dir NS4PTOC	Operating Current (curopu)	In the ”Voltage Polarizing ” tab page
	2ndHarmStab	2nd harmonic Stab	Pickup Current (Ipset)	
	DirModen[6]	NS4PTOC n[6]	Tripping Direction (idir)	
	Characteristn[6]	NS4PTOC n[6]	Characteristic (pcharac)	
	INn[6]>	NS4PTOC n[6]	Current Setting (Ipset)	
	t1	NS4PTOC n[6]	Time Dial (Tpset)	Relay definite time delay
	k1	NS4PTOC n[6]	Time Dial (Tpset)	Relay time multiplier for the inverse characteristics
	t1Min	NS4PTOC n[6]	Min. Time(udeftimin)	
	HarmRestrainn[6]	NS4PTOC n[6]	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.

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

3.8 OC4PTOC sub relay

The ”OC4PTOC” 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.

3.8.1 Available Units

- Four directional inverse characteristic 3 phase overcurrent element (”OC4PTOC 1”, ”OC4PTOC 2”, ”OC4PTOC 3” and ”OC4PTOC 4” block).
- One 3 phase directional element (”Dir OC4PTOC” block).
- One 2^{nd} harmonic current restrain element (”2nd harmonic Stab” block).
- One logic block (”OC4PTOC Output Logic” block).

3.8.2 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 inverse time elements trip logic is affected by the *StartPhSel* parameter (”OC4PTOC Output Logic” block) value: if the parameter is set to *1 out of 3* any phase trip signal will be activated. If the parameter is set to *2 out of 3* at least two phase signals must be activated for trip. If the parameter is set to *3 out of 3* all phase signals must be activated for trip.

The ”OC4PTOC n[7]” 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

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

- IEC Very inverse.TypChatoc
- Logarithmic inverse.TypChatoc
- RI inverse.TypChatoc

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.

3.8.3 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
	Operation	OC4PTOC	Out of Service (outserv)	
	Ibase	OC4PTOC Ibase	Pickup Current (Ipsetr)	
	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[8]	OC4PTOC n[8]	Tripping Direction (idir)	
	Characteristn[8]	OC4PTOC n[8]	Characteristic (pcharac)	
	In[8]>	OC4PTOC n[8]	Current Setting (Ipset)	
	t1	OC4PTOC n[8]	Time Dial (Tpset)	Relay definite time delay
	k1	OC4PTOC n[8]	Time Dial (Tpset)	Relay time multiplier for the inverse characteristics
	t1Min	OC4PTOC n[8]	Min. Time(udeftimin)	
	HarmRestrainn[8]	OC4PTOC n[8]	Release Blocking Time (Trelblock)	
	StartPhSel	C4PTOC Output Logic	StartPhSel_1_out_of_3	Set the *OpMode_1_out_of_3* dip in the *Dip Setting* tab page
			StartPhSel_2_out_of_3	Set the *OpMode_2_out_of_3* dip in the *Dip Setting* tab page
			StartPhSel_3_out_of_3	Set the *OpMode_3_out_of_3* dip in the *Dip Setting* tab page

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.

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

3.9 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.

3.9.1 Available Units

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

3.9.2 Functionality

The model is simulating the two instantaneous elements present in the relay protective function. The instantaneous phase overcurrent element (”PHPIOC” block) trip logic is affected by the *OpMode* parameter (”PIOC Output Logic” block) value: if the parameter is set to *1 out of 3* any phase trip signal will be activated. If the parameter is set to *2 out of 3* at least two phase signals must be activated for trip.

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

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
	Ibase	PHPIOC Ibase	Pickup Current (Ipsetr)	
	Ibase	EFPIOC Ibase	Pickup Current (Ipsetr)	
	IP>>	Ioc Phase	Pickup Current (Ipset)	
	IN>>	Ioc Residual	Pickup Current (Ipset)	
	OpMode	PIOC Output Logic	OpMode_1_out_of_3	Set the *OpMode_1_out_of_3* dip in the *Dip Setting* tab page
			OpMode_2_out_of_3	Set the *OpMode_2_out_of_3* dip in the *Dip Setting* tab page

3.10 PSPPPAM sub relay

The ”PSPPPAM” sub relay protective functions simulate the ABB REG 670 Pole slip protection features.

3.10.1 Available Units

- One frequency measurement element (”Meas Freq” block).
- Two rate of frequency change elements (”0.2 hz”, and ”8 hz” block).
- One single phase definite time overcurrent element (”Imin > 10%” block).
- One single phase undervoltage element (”Umax < 92%” block).
- One 3 phase polarizing element (”Polarizing” block).
- Two 3 phase mho elements (”Start Angle”, and ”Trip Angle” block).
- Three 3 phase distance blinders (”Impedance ZA - ZB (1)”, ”Impedance ZA - ZB (2)”, and ”Impedance ZC” block).
- Two out of step detection elements (”N1 Limit”, and ”N2 Limit” block).
- Two logic elements making calculations (”Umaxcalc”, and ”Imincalc” block).
- Two logic elements (”Supervision logic”, and ”Zone logic” block).
- One subrelay output logic element (”Output Logic” block).

3.10.2 Functionality

The ”Umaxcalc” block calculates the greater phase voltage, the ”Imincalc” block calculates the smaller phase current. The greater phase voltage value is then passed to the ”Umax < 92%” block which evaluates if the value is smaller than 92 % Un. The smaller phase current is passed to the ”Imin > 10%” block which evaluates if the value is greater than 10% In.
The ”Meas Freq” block calculates the rate of change of the frequency value which is passed to the ”0.2 hz” and to the ”8 hz” block. The ”Supervision logic” enable the distance elements only if all the following conditions are satisfied:

- The smaller phase current is greater than 10%In.
- The greater phase voltage value is smaller than 92% Un.
- the rate of change of the frequency is between 0.2Hz/s and 8Hz/s.

The ”Polarizing” block calculates the positive sequence polarizing voltages and operating current used by the distance mho (”Start Angle”, and ”Trip Angle” block) and blinders (”Impedance ZA - ZB (1)”, ”Impedance ZA - ZB (2)”, and ”Impedance ZC” block). Both the *trip1* and the *trip2* distance characteristics are modeled.
The combination of mho and blinders trips is evaluated by the ’Zone logic” block which figure out the trip signals evaluated by the power swing detection elements (”N1 Limit”, and ”N2 Limit” block). The power swing detection elements trip the relay when number of detected power loop is equal to the user defined count limits for trip 1 and trip2. Separated count limits can be set for for trip 1 and trip2.

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
	Operation	PSPPPAM	Out of Service (outserv)	
	OperationZ1	Zone logic	OperationZ1 (OperationZ1)	In the ”Logic” tab page
	OperationZ2	Zone logic	OperationZ2 (OperationZ2)	In the ”Logic” tab page
	ImpedanceZA	Start Angle	Replica Impedance (Zm)	
		Trip Angle	Replica Impedance (Zm)	
	ImpedanceZB	Start Angle	Impedance (Zoff)	In the ”Offset” frame
		Trip Angle	Impedance (Zoff)	In the ”Offset” frame
	ImpedanceZC	Impedance ZC	Reactance (X)	X = ImpedanceZC / cos(AnglePhi)
	AnglePhi	Start Angle	Relay Angle (phi)	
		TripAngle	Relay Angle (phi)	
		Impedance ZA - ZB (1)	Relay Angle (phi)	
		Impedance ZA - ZB (2)	Relay Angle (phi)	
		Impedance ZC	Relay Angle (phi)	
	StartAngle	Start Angle	Character. Angle (alpha)	
	TripAngle	TripAngle	Character. Angle (alpha)	
	N1Limit	N1 limit	OOS, No. of Crossings (iooscrossnum)	
	N2Limit	N2 limit	OOS, No. of Crossings (iooscrossnum)	

3.11 SAPTUF SAPTOF SAPFRC sub relay

The ”SAPTUF SAPTOF SAPFRC” sub relay consists of one under frequency, one over frequency and one rate of change frequency elements. This sub relay simulates the *SAPTUF*, the *SAPTOF* and the *SAPFRC* relay function.

3.11.1 Available Units

- One frequency measurement element (”Meas Freq” block).
- One under frequency element (”SAPTUF” block).
- One minimum voltage element controlling the under frequency element(”SAPTUF intBlockLevel” block).
- One operation mode selection element (”SAPTUF timer operation” block).
- One under frequency voltage dependent characteristic (”SAPTUF V dep timer”, and ”V filter” block).
- One over frequency elements (”SAPTOF” block).
- One minimum voltage element controlling the over frequency element(”SAPTOF intBlockLevel” block).
- One rate of change frequency element (”SAPFRC” block).
- One minimum voltage elements controlling the rate of change frequency element(”SAPFRC intBlockLevel” block).
- One logic block (”Frequency Output Logic” block).

3.11.2 Functionality

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

The underfrequency element (”SAPTUF” block) can be set to operate with a definite time operation characteristic or with a voltage dependent characteristic. The selection of the characteristic is made by the ”SAPTUF timer operation” block.

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

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
	SAPTUF Operation	SAPTUF	Out of Service (outserv)	
	SAPTUF TimerOperation Mode Selector	SAPTUF timer operation	volt_based_timer (volt_based_timer)	In the ”DIP Settings” tab page
	SAPTUF Start Frequency	SAPTUF	Frequency (Fset)	
	SAPTUF IntBlockLevel	SAPTUF intBlockLevel	Pickup Voltage (Uset)	
	SAPTUF TimeDlyOperate	SAPTUF	Time Delay (Tdel)	

Address	Relay Setting	Model block	Model setting	Note
	SAPTUF Exponent	V filter	Exponent (Exponent)	
	SAPTUF Unom	V filter	Unom (Unom)	
	SAPTUF Umin	V filter	Input Setting (Ipset)	
	SAPTUF tMin	SAPTUF V dep timer	Min.Time (udeftmin)	
	SAPTUF tMax	SAPTUF V dep timer	Max.Time (udeftmax)	
	SAPTOF Operation	SAPTOF	Out of Service (outserv)	
	SAPTOF Start Frequency	SAPTOF	Frequency (Fset)	
	SAPTOF IntBlockLevel	SAPTOF intBlockLevel	Pickup Voltage (Uset)	
	SAPTOF TimeDlyOperate	SAPTOF	Time Delay (Tdel)	
	SAPFRC Operation	SAPTUF	Out of Service (outserv)	
	SAPFRC StartFreqGrad	SAPFRC	Frequency (Fset)	
	SAPFRC IntBlockLevel	SAPFRC intBlockLevel	Pickup Voltage (Uset)	
	SAPFRC tTrip	SAPFRC	Time Delay (Tdel)	
	SAPFRC Operation	SAPTUF	Out of Service (outserv)	

3.12 T2WPDIF T3WPDIF REFPDIF HZPDIF sub relay

The ”T2WPDIF T3WPDIF REFPDIF HZPDIF” sub relay implements one low impedance 2 windings transformer differential protection (*T2WPDIF* function block), one low impedance 3 windings transformer differential protection (*T3WPDIF* function block), one restricted earth fault with directional control (*REFPDIF* function block), and a 3 phase high impedance differential protection (*HZPDIF* function block).

3.12.1 Available Units

T2WPDIF

- One 3 phase current magnitude 2 windings differential element(”T2WPDIF” block).
- One negative sequence current angle comparison differential element(”T2WPDIF NegSeqDiff” block).
- Two 3 phase definite time overcurrent elements (”T2WPDIF IdiffAlarm”, and ”T2WPDIF IdiffHSet” block).
- Four 3 phase adapters (”T2WPDIF Ct1 W1 Adapter”, ”T2WPDIF Ct2 W1 Adapter”, ”T2WPDIF Ct1 W2 Adapter”, and ”T2WPDIF Ct2 W2 Adapter” block).
- Three 3 phase measurement elements (”T2WPDIF H1 Diff Measure”, ”T2WPDIF H2 Diff Measure”, and ”T2WPDIF H5 Diff Measure” block).
- One single phase measurement element (”T2WPDIF NegSeqDiff H1 Diff Measure” block).
- One single phase timer element (”T2WPDIF NegSeqDiff delay” block).
- One logic block (”T2WPDIF trip logic” block).

T3WPDIF

- One 3 phase current magnitude 3 windings differential element(”T3WPDIF” block).
- One negative sequence current angle comparison differential element(”T3WPDIF NegSeqDiff” block).
- Two 3 phase definite time overcurrent elements (”T3WPDIF IdiffAlarm”, and ”T3WPDIF IdiffHSet” block).
- Six 3 phase adapters (”T3WPDIF Ct1 W1 Adapter”, ”T3WPDIF Ct2 W1 Adapter”, ”T3WPDIF Ct1 W2 Adapter”, ”T3WPDIF Ct2 W2 Adapter”, ”T3WPDIF Ct1 W3 Adapter” and ”T3WPDIF Ct2 W3 Adapter” block).
- Three 3 phase measurement elements (”T3WPDIF H1 Diff Measure”, ”T3WPDIF H2 Diff Measure”, and ”T3WPDIF H5 Diff Measure” block).
- One single phase measurement element (”T3WPDIF NegSeqDiff H1 Diff Measure” block).
- One single phase timer element (”T3WPDIF NegSeqDiff delay” block).
- One logic block (”T3WPDIF trip logic” block).

REFPDIF

- One restricted earth fault element (”REFPDIF” block).
- Four single phase adapters(”REFPDIF Ct1 W1 Adapter”, ”REFPDIF Ct2 W1 Adapter”, ”REFPDIF Ct1 W2 Adapter”, and ”REFPDIF Ct2 W2 Adapter” block).
- Two Directional elements (”REFPDIF W1 ROA” and ”REFPDIF W2 ROA”).
- Two single phase measurement elements (”REFPDIF H1 Diff Measure”, and ”REFPDIF H2 Diff Measure” block).

HZPDIF

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

3.12.2 Functionality

T2WPDIF and T3WPDIF *T2WPDIF* and *T3WPDIF* are identical except for the number of current inputs and *adapters* block. Up to 18 current inputs (six 3 phase CT) are supported: the *T2WPDIF* set of elements simulates a 2 windings differential feature and the *T3WPDIF* set of elements simulates a 3 windings differential feature. In both case each windings can be monitored by one or two CTs.

The elements simulating the *T2WPDIF* and *T3WPDIF* features implement two 3 phase (phase segregated) current magnitude differentials (”T2WPDIF” and ”T3WPDIF” block) each of them with double slope bias current restraint and with 2^{nd} and 5^{th} harmonic restraint. Two unrestrained high set differential threshold are also available in the differential block; two differential alarm thresholds can be defined in the ”T2WPDIF IdiffAlarm” and in the ”T3WPDIF IdiffAlarm” block.

Two fault discriminators based on the negative sequence current analysis are available to distinguish between *external* and *internal faults* (”T2WPDIF NegSeqDiff” and ”T3WPDIF NegSeqDiff” block).

If the fault is declared as internal the harmonic restrain is inhibited; it’s means that any harmonic blocking is then overridden and a trip is declared if the phase differential element has started.

If the fault is declared as internal and the phase differential current is smaller than the user configurable phase differential threshold (*Differential Current* setting of the ”T2WPDIF” and of the ”T3WPDIF” block), an intern turn internal fault is assumed and a trip is declared if the negative sequence differential current remains in the starting condition for a time greater than a 1 cycle.

The elements simulating the *T2WPDIF* and the *T3WPDIF* protection function include four and six adapters, one for each winding considering up to two current inputs(CTs) for each winding.

REFPDIF The ”REFPDIF” block simulates a restricted earth fault protective function with double slope bias current restraint and with 2^{nd}harmonic restraint. An additional control regarding the earth fault direction is performed: a earth fault directional element in each winding compares the angular position of the earth fault current phasor with the angular position of the neutral current phasor; the ”REFPDIF” block is enabled only if at least one directional element detects a reverse current direction condition.

HZPDIF ”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.

3.12.3 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):

T2WPDIF :

Address	Relay Setting	Model block	Model setting	Note
	Operation	T2WPDIF	Out of Service (outserv)	
	IBase	T2WPDIF	Differential Current (Itapr)	
	tAlarmDelay	T2WPDIF IdiffAlarm	Pickup Current (Ipset)	
	IDiffAlarm	T2WPDIF IdiffAlarm	Time Setting (Tdelay)	
	IdMin	T2WPDIF	Release threshold (Idiffr2)	
	IdUnre	T2WPDIF	Unrestrained Differential Threshold (Idiffunrestr2)	
	CrossBlockEn	T2WPDIF	Interblocking (h2interblock)	”Harmonic blocking” tab page
		T2WPDIF	Interblocking (h5interblock)	”Harmonic blocking” tab page
	NegSeqDiffEn	T2WPDIF NegSeqDiff	Out of Service (outserv)	
	IMinNegSeq	T2WPDIF NegSeqDiff	Current Threshold (IM)	
	NegSeqROA	T2WPDIF NegSeqDiff	Restraint region Angle (RestrAngle)	Set RestrAngle = 360 - 2* NegSeqROA
	EndSection1	T2WPDIF	Restraint Current 1st threshold (Ipset1r2)	
	EndSection2	T2WPDIF	Restraint Current 2nd threshold (Ipset2r2)	
	SlopeSection2	T2WPDIF	Restrain percentage 1 (Irestrpercent1)	
	SlopeSection3	T2WPDIF	Restrain percentage 2 (Irestrpercent2)	
	I2/I1Ratio	T2WPDIF	2nd Harmonic blocking threshold (H2threshold)	”Harmonic blocking” tab page
	I5/I1Ratio	T2WPDIF	5th Harmonic blocking threshold (H5threshold)	”Harmonic blocking” tab page
	RatedVoltageW1	T2WPDIF Ct1 W1 Adapter	Nominal Terminal Line-Line Voltage (LLVolt)	
		T2WPDIF Ct2 W1 Adapter	Nominal Terminal Line-Line Voltage (LLVolt)	
	RatedVoltageW2	T2WPDIF Ct1 W2 Adapter	Nominal Terminal Line-Line Voltage (LLVolt)	
		T2WPDIF Ct2 W2 Adapter	Nominal Terminal Line-Line Voltage (LLVolt)	
	ClockNumberW2	T2WPDIF Ct1 W2 Adapter	Transformer Group(trasfgroup)	
	ClockNumberW2	T2WPDIF Ct2 W2 Adapter	Transformer Group(trasfgroup)	
	ZSCurrSubtrW1	Ct1 W1 Earth Current Filter	ZSCurrSubtrW1 (ZSCurrSubtrW1)	In the ”Logic” tab page
		Ct2 W1 Earth Current Filter	ZSCurrSubtrW1 (ZSCurrSubtrW1)	In the ”Logic” tab page
	ZSCurrSubtrW2	Ct1 W2 Earth Current Filter	ZSCurrSubtrW2 (ZSCurrSubtrW2)	In the ”Logic” tab page
		Ct2 W2 Earth Current Filter	ZSCurrSubtrW2 (ZSCurrSubtrW2)	In the ”Logic” tab page
	CT1RatingW1	T2WPDIF Ct1 W1 Adapter	Current Transformer Ratio (CTRatio)	
	CT2RatingW1	T2WPDIF Ct2 W1 Adapter	Current Transformer Ratio (CTRatio)	
	CT1RatingW2	T2WPDIF Ct1 W2 Adapter	Current Transformer Ratio (CTRatio)	

Address	Relay Setting	Model block	Model setting	Note
	CT2RatingW2	T2WPDIF Ct2 W2 Adapter	Current Transformer Ratio (CTRatio)	

T3WPDIF :

Address	Relay Setting	Model block	Model setting	Note
	Operation	T3WPDIF	Out of Service (outserv)	
	IBase	T3WPDIF	Differential tap (Itapr)	
	tAlarmDelay	T3WPDIF IdiffAlarm	Pickup Current (Ipset)	
	IDiffAlarm	T3WPDIF IdiffAlarm	Time Setting (Tdelay)	
	IdMin	T3WPDIF	Differential Current base threshold (Idiffr)	
	IdUnre	T3WPDIF	Unrestrained Differential threshold (Idiffunrestr)	
	CrossBlockEn	T3WPDIF	Interblocking (h2interblock)	”Harmonic blocking” tab page
		T3WPDIF	Interblocking (h5interblock)	”Harmonic blocking” tab page
	NegSeqDiffEn	T3WPDIF NegSeqDiff	Out of Service (outserv)	
	IMinNegSeq	T3WPDIF NegSeqDiff	Current Threshold (IM)	
	NegSeqROA	T3WPDIF NegSeqDiff	Restraint region Angle (RestrAngle)	Set RestrAngle = 360 - 2* NegSeqROA
	EndSection1	T3WPDIF	Restraint Current 1st threshold (Ipset1r2)	
	EndSection2	T3WPDIF	Restraint Current 2nd threshold (Ipset2r2)	
	SlopeSection2	T3WPDIF	Restrain percentage 1 (Irestrpercent1)	
	SlopeSection3	T3WPDIF	Restrain percentage 2 (Irestrpercent2)	
	I2/I1Ratio	T3WPDIF	2nd Harmonic blocking threshold (H2threshold)	”Harmonic blocking” tab page
	I5/I1Ratio	T3WPDIF	5th Harmonic blocking threshold (H5threshold)	”Harmonic blocking” tab page
	RatedVoltageW1	T3WPDIF Ct1 W1 Adapter	Nominal Terminal Line-Line Voltage (LLVolt)	
		T3WPDIF Ct2 W1 Adapter	Nominal Terminal Line-Line Voltage (LLVolt)	
	RatedVoltageW2	T3WPDIF Ct1 W2 Adapter	Nominal Terminal Line-Line Voltage (LLVolt)	
		T3WPDIF Ct2 W2 Adapter	Nominal Terminal Line-Line Voltage (LLVolt)	
	RatedVoltageW3	T3WPDIF Ct1 W3 Adapter	Nominal Terminal Line-Line Voltage (LLVolt)	
		T3WPDIF Ct2 W3 Adapter	Nominal Terminal Line-Line Voltage (LLVolt)	
	ClockNumberW2	T3WPDIF Ct1 W2 Adapter	Transformer Group(trasfgroup)	
	ClockNumberW2	T3WPDIF Ct2 W2 Adapter	Transformer Group(trasfgroup)	
	ZSCurrSubtrW1	Ct1 W1 Earth Current Filter	ZSCurrSubtrW1 (ZSCurrSubtrW1)	In the ”Logic” tab page
		Ct2 W1 Earth Current Filter	ZSCurrSubtrW1 (ZSCurrSubtrW1)	In the ”Logic” tab page
	ZSCurrSubtrW2	Ct1 W2 Earth Current Filter	ZSCurrSubtrW2 (ZSCurrSubtrW2)	In the ”Logic” tab page
		Ct2 W2 Earth Current Filter	ZSCurrSubtrW2 (ZSCurrSubtrW2)	In the ”Logic” tab page
	ZSCurrSubtrW3	Ct1 W3 Earth Current Filter	ZSCurrSubtrW2 (ZSCurrSubtrW3)	In the ”Logic” tab page
		Ct2 W3 Earth Current Filter	ZSCurrSubtrW2 (ZSCurrSubtrW3)	In the ”Logic” tab page
	CT1RatingW1	T3WPDIF Ct1 W1 Adapter	Current Transformer Ratio (CTRatio)	

Address	Relay Setting	Model block	Model setting	Note
	CT2RatingW1	T3WPDIF Ct2 W1 Adapter	Current Transformer Ratio (CTRatio)	
	CT1RatingW2	T3WPDIF Ct1 W2 Adapter	Current Transformer Ratio (CTRatio)	
	CT2RatingW2	T3WPDIF Ct2 W2 Adapter	Current Transformer Ratio (CTRatio)	
	CT1RatingW3	T3WPDIF Ct1 W3 Adapter	Current Transformer Ratio (CTRatio)	
	CT2RatingW3	T3WPDIF Ct2 W3 Adapter	Current Transformer Ratio (CTRatio)	

REFPDIF :

Address	Relay Setting	Model block	Model setting	Note
	Operation	REFPDIF	Out of Service (outserv)	
	IBase	REFPDIF	Differential tap (Itapr)	
	IdMin	REFPDIF	Differential Current base threshold (Idiffr)	
	CTFactorPri1	REFPDIF Ct1 W1 Adapter	Current Transformer Ratio (CTRatio)	
	CTFactorPri2	REFPDIF Ct2 W1 Adapter	Current Transformer Ratio (CTRatio)	
	CTFactorSec1	REFPDIF Ct1 W2 Adapter	Current Transformer Ratio (CTRatio)	
	CTFactorSec2	REFPDIF Ct2 W2 Adapter	Current Transformer Ratio (CTRatio)	
	ROA	REFPDIF W1 ROA	Operating Sector Angle(phisec)	
		REFPDIF W2 ROA	Operating Sector Angle(phisec)	

HZPDIF :

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

3.13 TRPTTR sub relay

The ”TRPTTR” sub relay consists of two thermal image elements. A simplified version of the ”TRPTTR” relay feature is modeled.

3.13.1 Available Units

- Two thermal image elements (”Ith1>”, and ”Ith2>” block).
- One interface element which stores the *base current* (”TRPTTR Ibase” block).
- One logic block (”TRPTTROC Output Logic” block).

3.13.2 Functionality

The thermal image thresholds refers to the *Ibase* parameter. Each thermal image element simulate a separate heating time constant with independent trip threshold.

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
	Operation	TRPTTR	Out of Service (outserv)	
	IBase	TRPTTR Ibase	Pickup Current (Ipsetr)	
	IBase1	Ith1>	Current Setting (Ipset)	
	IBase2	Ith2>	Current Setting (Ipset)	
	Tau1	Ith1>	Time Dial (Tpset)	
	Tau2	Ith2>	Time Dial (Tpset)	

3.14 UV2PTUV OV2PTUV ROV2PTOV sub relay

The ”UV2PTUV OV2PTUV ROV2PTOV” 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.

3.14.1 Available Units

- Two inverse time 3 phase under voltage elements (”UV2PTUV1” and ”UV2PTUV2” block).
- Two inverse time 3 phase over voltage elements (”OV2PTOV1” and ”OV2PTOV2” block).
- Two inverse time residual over voltage elements (”ROV2PTOV1” and ”ROV2PTOV2” block).
- One logic block (”Voltage Output Logic” block).

3.14.2 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.

3.14.3 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
	UV2PTUV, 27 Operation	U1<	Out of Service (outserv)	
		U2<	Out of Service (outserv)	
	UV2PTUV, 27 OperationStep1	U1<	Out of Service (outserv)	
	UV2PTUV, 27 Characterist1	U1<	Characteristic (pcharac)	
	UV2PTUV, 27 U1<	U1<	Input Setting (Ipset)	
	UV2PTUV, 27 t1	U1<	Time Dial (Tpset)	Relay definite time delay
	UV2PTUV, 27 k1	U1<	Time Dial (Tpset)	Relay time multiplier inverse time
	UV2PTUV, 27 OperationStep2	U2<	Out of Service (outserv)	
	UV2PTUV, 27 Characterist2	U2<	Characteristic (pcharac)	
	UV2PTUV, 27 U2<	U2<	Input Setting (Ipset)	
	UV2PTUV, 27 t2	U2<	Time Dial (Tpset)	Relay definite time delay
	UV2PTUV, 27 k2	U2<	Time Dial (Tpset)	Relay time multiplier inverse time
	OV2PTOV, 59 Operation	U1>	Out of Service (outserv)	
		U2>	Out of Service (outserv)	
	OV2PTOV, 59 OperationStep1	U1>	Out of Service (outserv)	
	OV2PTOV, 59 Characterist1	U1>	Characteristic (pcharac)	
	OV2PTOV, 59 U1>	U1>	Input Setting (Ipset)	
	OV2PTOV, 59 t1	U1>	Time Dial (Tpset)	Relay definite time delay
	OV2PTOV, 59 k1	U1>	Time Dial (Tpset)	Relay time multiplier inverse time
	OV2PTOV, 59 OperationStep2	U2>	Out of Service (outserv)	
	OV2PTOV, 59 Characterist2	U2>	Characteristic (pcharac)	
	OV2PTOV, 59 U2>	U2>	Input Setting (Ipset)	
	OV2PTOV, 59 t2	U2>	Time Dial (Tpset)	Relay definite time delay
	OV2PTOV, 59 k2	U2>	Time Dial (Tpset)	Relay time multiplier inverse time
	ROV2PTOV, 59N Operation	U1N>	Out of Service (outserv)	
		U2N>	Out of Service (outserv)	
	ROV2PTOV, 59N OperationStep1	U1N>	Out of Service (outserv)	
	ROV2PTOV, 59N Characterist1	U1N>	Characteristic (pcharac)	
	ROV2PTOV, 59N U1>	U1N>	Input Setting (Ipset)	
	ROV2PTOV, 59N t1	U1N>	Time Dial (Tpset)	Relay definite time delay
	ROV2PTOV, 59N k1	U1N>	Time Dial (Tpset)	Relay time multiplier inverse time
	ROV2PTOV, 59N OperationStep2	U2N>	Out of Service (outserv)	
	ROV2PTOV, 59N Characterist2	U2N>	Characteristic (pcharac)	
	ROV2PTOV, 59N U2>	U2N>	Input Setting (Ipset)	
	ROV2PTOV, 59N t2	U2N>	Time Dial (Tpset)	Relay definite time delay
	ROV2PTOV, 59N k2	U2N>	Time Dial (Tpset)	Relay time multiplier inverse time

3.15 Output logic

3.15.1 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 ”OC4PTOC”, ”PTOC 51N67N”, ”PTOF PTUF PFRC 81” , ”PTUV 27 PTOV 59/59N” and to the ”PDIF 87” subrelay output signals.

3.15.2 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.

3.15.3 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.
- 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 EF4PTOC sub relay

The following features are not supported:

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

4.3 OC4PTOC sub relay

The following features are not supported:

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

4.4 UV2PTUV OV2PTUV ROV2PTOV sub relay

The following features are not supported:

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

4.5 ZMHPDIS sub relay

The following features are not supported:

- Mho impedance supervision logic, ZSMGAPC

5 References

[1] ABB Automation Products AB, Substation Automation Products, SE-721 59 Vasteras, Sweden. *Generator protection REG670 Technical reference manual Document ID: 1MRK 502 027-UEN Issued: December 2012 Revision: B Product version: 1.2*, 2012.