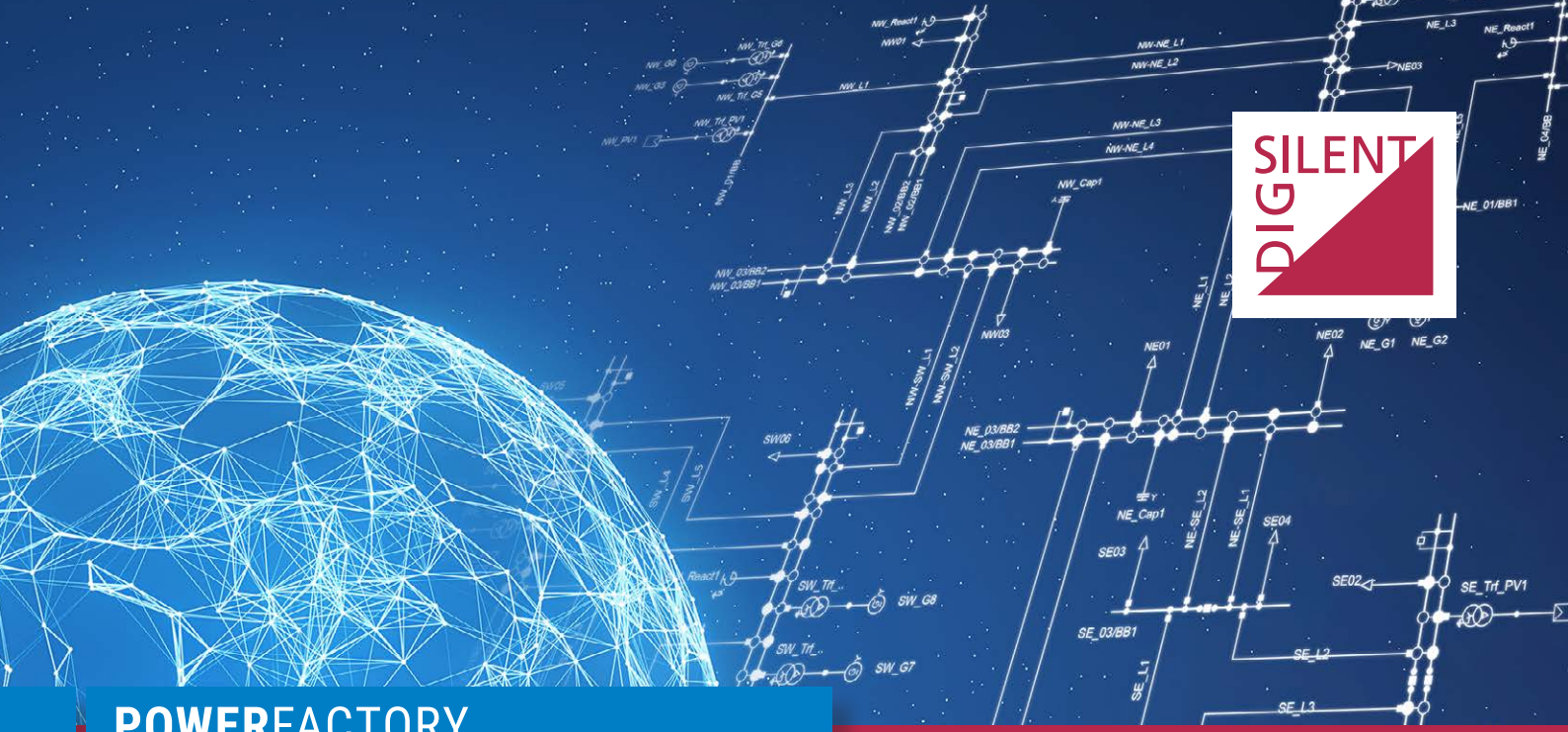

PowerFactory 2021

Technical Reference

ABB REL 561

PF2021

POWER SYSTEM SOLUTIONS

MADE IN GERMANY

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Contents

1 Model information

Manufacturer ABB

Model REL 561

Variants The ABB REL 561 PowerFactory relay model can be used to simulate any version of the ABB REL 561 relay but please consider that the model has been implemented with the feature available in the V2.3 firmware version.

2 General description

The ABB REL 561 line differential and distance protection terminal is a protective relay for HV and EHV line distance protection applications. Additional protection functionality includes phase overcurrent, residual current and voltage functions.

The ABB REL 561 PowerFactory relay model consists of a main relay model and the following sub relays:

- EF4
- IOC
- TEF
- TOC
- TOC2
- TOC3
- Voltage
- WEF1

The ABB REL 561 PowerFactory relay model has been implemented trying to simulate the protective functions more commonly used.

The main relay contains the measurement and acquisition units, the starting element, the polarizing elements, the differential element, the distance elements, the directional element for the distance elements, 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 two three phase current transformer (”Ct” and ”CT remote” block) and one three phase voltage transformer (”Vt” block).

Two measurement units (”Measure” and ”Delta Measure” block) are fed by this CT and this VT. An additional measurement block is used by the differential block to calculate the differential currents RMS value (”Diff RMS Meas” block).

3.1.1 Available Units

- two three phase current transformers (”Ct” and ”Ct remote” block)
- one three phase voltage transformer (”Vt” block)
- one three phase measurement block calculating both the phase and voltage values (”Measure” block)
- one three phase measurement block calculating the phase to phase currents and the phase to phase voltages (”Delta Measure” block)
- one three phase measurement block calculating the currents measured at the remote terminal of the line (”Remote Measure” block)
- one auxiliary three phase measurement block used by the differential element (”Diff RMS Meas” block)

3.1.2 Functionality

The input signals are sampled at 16 samples/cycle; a DFT filter operating over a cycle calculates then the voltage and current values used by the protective elements.

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

The ”Ct remote” and the ”Remote Measure” block provide the current values measured at the other end of the line. They are processed by the differential function together with the current values measured at the line terminal where the protective relay is.

3.1.3 Data input

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

Set in the ”Ct remote’ slot the current transformer located at the remote terminal of the line.

3.2 Main Relay protective elements

The starting element, the polarizing element and the distance elements are working together to simulate the ABB REL 561 distance functionalities.

3.2.1 Available Units

- One differential element with CT ratio correction (”Differential” and ”CTFactor” block)
- One starting element implementing the *GFC* phase selection logic (”Starting” block)
- One directional element (”Dir-Z” block).
- Two polarizing elements (”Polarizing” and ”Polarizing20” block).
- Five distance trip zones using the phase loop impedances(”Z1P”, ”Z2P”, ”Z3P”, ”Z4P” and ”Z5P” block)
- Five timers associated to the phase distance trip zones (”ZT1P”, ”ZT2P”, ”ZT3P”, ”ZT4P” and ”ZT5P” block)
- Five distance trip zones using the ground loop impedances(”Z1G”, ”Z2G”, ”Z3G”, ”Z4G” and ”Z5G” block)
- Five timers associated to the ground distance trip zones(”ZT1G”, ”ZT2G”, ”ZT3G”, ”ZT4G” and ”ZT5G” block)
- One power swing element (”Power Swing” block)

3.2.2 Functionality

Differential element The ABB REL 561 relay model differential element is a phase segregated current differential evaluating both current magnitude and angle. A current restraint differential characteristic with double slope is available. Different CT ratios can be compensated using a scalar factor ("CTFactor" block).

Starting element The starting element is simulating the relay PHS phase selection logic function which is using the impedance fault detection criteria. Moreover the advanced phase/ground discrimination settings are available.

Directional element The directional element 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.

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.

Distance trip zones Separated polygonal distance elements monitoring the phase and the ground loops are used in the model; each loop is evaluated separately. All distance elements are directional and the direction can be set for each distance element. Independent timers are available for each distance element.

The phase loop polygonal distance elements can be blocked by the power swing detection element when a power swing condition has been detected.

Power Swing The Power Swing function comprises an inner and an outer quadrilateral measurement characteristic. Its principle of operation is based on the measurement of the time it takes a power swing transient impedance to pass through the impedance area between the outer and the inner characteristics. Power swings are identified by transition times longer than timer settings.

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):

Differential element :

Address	Relay Setting	Model block	Model setting	Note
	Current scaling, CTFactor	CTFactor	CTFact	In the ”Logic” tab page
	Minimum operate current, IMinOp	Differential	Differential Current Base Threshold (Idiff)	In the ”Basic Data” tab page
	Slope 1	Differential	Restrain Percentage 1(Irestr-percent1)	In the ”Basic Data” tab page
	Slope 2	Differential	Restrain Percentage 2(Irestr-percent2)	In the ”Basic Data” tab page
	Slope 1/Slope 2 intersection	Differential	Restraint Current 2nd threshold (Ipset2)	In the ”Basic Data” tab page

Starting element :

Address	Relay Setting	Model block	Model setting	Note
	INReleasePE	Starting	INReleasePE (INReleasePE)	”Phase/ground fault conditions” tab page
	INBlockPP	Starting	INBlockPP (INBlockPP)	”Phase/ground fault conditions” tab page
	Operation Z<	Starting	Impedance Z(iimped)	”Basic Data” tab page
	IMinOp	Starting	IMinOp (IMinOp)	”Impedance Z” tab page
	X1PP	Starting	X1PP (X1PP)	”Impedance Z” tab page
	RFPP	Starting	RFPP (RFPP)	”Impedance Z” tab page
	X1PE	Starting	X1PE (X1PE)	”Impedance Z” tab page
	X0PE	Starting	X0PE (X0PE)	”Impedance Z” tab page
	RFPE	Starting	RFPE (RFPE)	”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)	

Distance trip zones :

Address	Relay Setting	Model block	Model setting	Note
	Operation	Z1P,Z1G,Z2P, Z2G,Z3P,Z3G	Tripping Direction(idir)	
	ZM*n*[1]Operation PP	Z*n*[1]P	Out of Service (outserv)	
	ZM*n*[1]X1PP	Z*n*[1]P	X1PP(X1PP)	
	ZM*n*[1]R1PP	Z*n*[1]P	R1PP(R1PP)	
	ZM*n*[1]RFPP	Z*n*[1]P	RFPP(RFPP)	
	Timert*n*[1]PP	ZT*n*[1]P	Out of Service(outserv)	
	t*n*[1]PP	ZT*n*[1]P	Time Setting(Tdelay)	
	ZM*n*[1]X1PE	Z*n*[1]G	X1PE(X1PE)	
	ZM*n*[1]R1PE	Z*n*[1]G	R1PE(R1PE)	
	ZM*n*[1]X0PE	Z*n*[1]G	X0PE(X0PE)	
	ZM*n*[1]R0PE	Z*n*[1]G	R0PE(R0PE)	
	ZM*n*[1]RFPE	Z*n*[1]G	RFPE(RFPE)	
	Timert*n*[1]PE	ZT*n*[1]G	Out of Service(outserv)	
	t*n*[1]PE	ZT*n*[1]G	Time Setting(Tdelay)	
	Operation ZM4	Z4P,Z4G	Tripping Direction(idir)	
	Operation ZM5	Z5P,Z5G	Tripping Direction(idir)	

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

3.3 EF4 subrelay

This relay protective function operates on the basis of the residual current and voltage measurement. The function has four directional steps with individual settings (current, delay, directionality). Step 1, 2 and 3 have independent time delay. The time delay for step 4 can be selected between definite or inverse mode of operation.

3.3.1 Available Units

- Three directional time defined zero sequence overcurrent elements (”EF4 Step 1”, ”EF4 Step 2” and ”EF4 Step 3” block)
- One directional inverse characteristic zero sequence overcurrent element with minimum activation threshold and additional trip delay (”EF4 Step 4”, ”EF4 tLow” and ”EF4 Step 4 Imin” block)
- One directional element (”EF4 Dir” block)
- One output element (”EF4 Output Logic” block)

3.3.2 Functionality

The main features of this relay protective function are modeled.

The start level for directional operation is implemented by the directional element.

Step 4 model includes a minimum activation current threshold and a inverse time minimum delay mocked up by the ”EF4 Step 4 Imin” block and an additional time delay mocked up by the ”EF4 tLow” block.

The ”EF4 Step 4” block includes the following inverse time characteristics:

- Logarithmic inverse
- IEC extremely inverse
- IEC inverse
- IEC very inverse
- Definite time TCC

The output block is collecting the element trip signals but isn’t operating the power 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	EF4 Step 1, EF4 Step 2, EF4 Step 3, EF4 Step 4	Out of Service (outserv)	

Address	Relay Setting	Model block	Model setting	Note
	Stepn^2	EF4 Step n^2	Tripping Direction (idir)	
	Stepn^2IN1>	EF4 Step n^2	Pickup Current (Ipset)	
	Stepn^2t1	EF4 Step n^2	Time Setting (Tset)	
	Step 4	EF4 Step 4	Tripping Direction (idir)	
	Characteristic	EF4 Step 4	Characteristic (pcharac)	
	IN>Inv	EF4 Step 4	Current Setting (Ipset)	
	k	EF4 Step 4	Time Dial (Tpset)	
	IN4>	EF4 Step 4 Imin	Pickup Current (Ipset)	
	t4	EF4 tLow	Time Setting (Tdelay)	
	t4Min	EF4 Step 4 Imin	Time Setting (Tset)	
	IN> Dir	EF4 Dir	Operating Current (curopu)	In the ”Voltage Polarizing” tab page

[2] n = 1,2,3

3.4 IOC subrelay

This relay protective function operates 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 clear close-in faults and for fast back-up earth fault protection.

3.4.1 Available Units

- One time defined phase overcurrent element (”Ioc Phase” block)
- One time defined residual overcurrent element (”Ioc residual” block)
- One output element (”IOC 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 TEF subrelay

It consists of an inverse and definite time delayed residual overcurrent function which can be used in solidly earthed systems to get a sensitive and fast fault clearance of phase to earth faults

3.5.1 Available Units

- One directional inverse characteristic zero sequence overcurrent element with minimum activation threshold and additional trip delay (”TEF”, ”TEF tLow” and ”TEF Imin” block)
- One directional element (”TEF Dir” block)
- One logic block (”TEF Output Logic” block)

3.5.2 Functionality

The main features of this relay protective function are modeled.

The start level for directional operation is implemented by the directional element.

TEF model includes a minimum activation current threshold and a inverse time minimum delay mocked up by the ”TEF Imin” block and an additional time delay mocked up by the ”TEF tLow” block.

The ”TEF” block includes the following inverse time characteristics:

- RI inverse
- IEC extremely inverse
- IEC inverse
- IEC very inverse
- Definite time TCC

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	TEF	Out of Service (outserv)	
	Direction	TEF	Tripping Direction (idir)	
	Characteristic	TEF	Characteristic (pcharac)	
	IN>	TEF	Current Setting (Ipset)	
	k	TEF	Time Dial (Tpset)	
	IMin	TEF Imin	Pickup Current (Ipset)	
	t1	TEF tLow	Time Setting (Tdelay)	
	tMin	TEF Imin	Time Setting (Tset)	
	IN> Dir	TEF Dir	Operating Current (curopu)	In the ”Voltage Polarizing” tab page

3.6 TOC subrelay

The time delayed non directional overcurrent protection, TOC, operates at different system conditions for currents exceeding the preset value and which remains high for longer than the delay time set on the corresponding timer. The function can also be used for supervision and fault detector.

3.6.1 Available Units

- One time defined three phase overcurrent element (”TOC Phase” block)
- One time defined residual overcurrent element (”TOC Residual” block)
- One output block (”Toc Output Logic” block)

3.6.2 Functionality

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

The output block is collecting the element trip signals but isn’t operating the power 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
	IP>	Toc Phase	Pickup Current (Ipset)	
	tP	Toc Phase	Time Setting (Tset)	
	IN>	Toc Residual	Pickup Current (Ipset)	
	tN	Toc Residual	Time Setting (Tset)	

3.7 TOC2 subrelay

The two current/time stages of overcurrent protection TOC2 are usually used to get fast operation for nearby faults by using a high set current stage with short time delay. The low current stage is set with appropriate time delay to get selectivity with the adjacent relays in the system.

3.7.1 Available Units

- One non directional inverse characteristic phase overcurrent element with minimum activation threshold and additional trip delay (”Toc2”, ”Toc2 tLow” and ”Toc2 I>Low” block)
- One non directional time defined phase overcurrent element (”Toc2 I>High” block)
- One output element(”Toc2 Output Logic” block)

3.7.2 Functionality

The main features of this relay protective function are modeled.

The TOC2 subrelay includes a minimum activation current threshold and a inverse time minimum delay mocked up by the ”Toc2 I>Low” block and an additional time delay mocked up by the ”Toc2 tLow” block.

The ”Toc2” block includes the following inverse time characteristics:

- RI inverse
- IEC extremely inverse
- IEC inverse
- IEC very inverse
- Definite time TCC

The output block is collecting the element trip signals but isn’t operating the power 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	Toc2, Toc2 I>High	Out of Service (outserv)	
	Operation Low	Toc2	Out of Service (outserv)	
	Characteristic	Toc2	Characteristic (pcharac)	
	I>Inv	Toc2	Current Setting (Ipset)	
	k	Toc2	Time Dial (Tpset)	
	tMinInv	Toc2 I>Low	Time Setting (Tset)	
	I>Low	Toc2 I>Low	Pickup Current (Ipset)	
	tLow	Toc2 tLow	Time Setting (Tdelay)	
	Operation High	Toc2 I>High	Out of Service (outserv)	
	I>High	Toc2 I>High	Pickup Current (Ipset)	
	tHigh	Toc2 I>High	Time Setting (Tset)	

3.8 TOC3 subrelay

The two current/time stages of the TOC3 overcurrent protection relay, both with optional directional or non-directional function, improve the possibility to obtain selective function of the overcurrent protection relative other relays even in meshed networks.

3.8.1 Available Units

- One directional inverse characteristic phase overcurrent element with minimum activation threshold and additional trip delay (”Toc3”, ”Toc3 tLow” and ”Toc3 I>Low” block)
- One directional time defined phase overcurrent element (”Toc3 I>High” block)
- One output element(”Toc3 Output Logic” block)

3.8.2 Functionality

The main features of this relay protective function are modeled.

The directional operation is implemented by ”Dir-Z” block in the main relay.

The TOC3 subrelay includes a minimum activation current threshold and a inverse time minimum delay mocked up by the ”Toc3 I>Low” block and an additional time delay mocked up by the ”Toc3 tLow” block.

The ”Toc3” block includes the following inverse time characteristics:

- RI inverse
- IEC extremely inverse
- IEC inverse
- IEC very inverse
- Definite time TCC

The output block is collecting the element trip signals but isn’t operating the power 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	Toc3, Toc3 I>High	Out of Service (outserv)	
	Operation Low	Toc3	Out of Service (outserv)	
	Characteristic	Toc3	Characteristic (pcharac)	
	I>Inv	Toc3	Current Setting (Ipset)	
	k	Toc3	Time Dial (Tpset)	
	tMinInv	Toc3 I>Low	Time Setting (Tset)	
	I>Low	Toc3 I>Low	Pickup Current (Ipset)	

Address	Relay Setting	Model block	Model setting	Note
	tLow	Toc3 tLow	Time Setting (Tdelay)	
	Operation High	Toc3 I>High	Out of Service (outserv)	
	I>High	Toc3 I>High	Pickup Current (Ipset)	
	tHigh	Toc3 I>High	Time Setting (Tset)	
	ArgDir	Dir-Z	Directional Angle, alpha (alpha)	
	ArgNegRes	Dir-Z	Directional Angle, phi (phi)	

3.9 Voltage subrelay

This relay part consists of some voltage protection functions.
The time delayed undervoltage protection function, *TUV*, is applicable in all situations, where reliable detection of low phase voltages is necessary.
The time delayed phase overvoltage protection, *TOV*, is used to protect the electrical equipment and its insulation against overvoltage by measuring three phase voltages.
The residual overvoltage protection function, *TOV Ground*, is mainly used in distribution networks, mainly as a backup protection for the residual overcurrent protection

3.9.1 Available Units

- One 3 phase overvoltage time defined element (”TOV Phase” block)
- One zero sequence overvoltage time defined element (”TOV Ground” block)
- One phase undervoltage time defined element (”TUV Phase” block)

3.9.2 Functionality

This subrelay simulates any overvoltage and the undervoltage relay protective function available in the relay.

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
	TUV Operation	TUV	Out of Service (outserv)	
	TUV UPE<	TUV	Pickup Voltage (Uset)	
	TUV t	TUV	Time Delay (Tdel)	
	TOV Operation	TOV Phase	Out of Service (outserv)	
		TOV Ground	Out of Service (outserv)	
	TOV UPE>	TOV Phase	Pickup Voltage (Uset)	
	TOV t	TOV Phase	Time Delay (Tdel)	
	TOV 3U0>	TOV Ground	Pickup Voltage (Uset)	
	TOV t	TOV Ground	Time Delay (Tdel)	

3.10 WEF1 subrelay

This protective function is a sensitive directional residual overcurrent protection.

3.10.1 Available Units

- One directional time defined characteristic zero sequence overcurrent element (”WEF1 Dir” block)
- One time delay element (”WEF1 delay” block)

3.10.2 Functionality

The function measures the residual current and voltage. The angle between the residual voltage and residual current (angle between 3I0 and -3U0 i.e U0 is 180 degrees adjusted) is calculated. This angle is used in two functions namely first to determine if the fault is in forward or reverse direction, and secondly to calculate the residual current component in the characteristic angle direction.

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	WEF1 Dir	Out of Service (outserv)	
	Direction	WEF1 Dir	Tripping Direction (idir)	
	INcosPhi>	WEF1 Dir	Operating Current (curopu)	in the ”Voltage Polarizing” tab page
	UN>	WEF1 Dir	Polarizing Voltage (Upolu)	in the ”Voltage Polarizing” tab page
	RCA>	WEF1 Dir	Max Torque Angle (mtau)	in the ”Voltage Polarizing” tab page
	tTrip	WEF1 delay	Time Setting (Tset)	

3.11 Output logic

3.11.1 Available Units

The output logic is implemented by the <subrelay name >+ ”Ouput Logic” block located in each subrelay and by the ”Logic” block located in the main relay.

3.11.2 Functionality

The ”Logic” block located in the main relay is operating the breaker.
The relay output signals which can be used to operate the breaker are ”yout”, ”yout_A”, ”yout_B” and ”yout_C”.

Moreover the ”Logic” blocks implements the single phase and the two phases trip logic.

3.11.3 Data input

Please disable the ”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 dialog. 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 dialog. The two phases trip logic can be activated setting equal to ”TRIP” the ”two_poles_trip” parameter in the ”Logic” tab page of the ”Logic” block dialog.

4 Features not supported

4.1 Main relay

The following features are not supported:

- line differential protection with charging current compensation (DIFL with CCC)
- CT saturation detector
- automatic reclosing feature
- pole slip protection
- pole discordance protection (RPLD, 52 PD)
- synchrocheck
- current reversal and WEI logic for distance protection (ZCAL)
- scheme communication logic for distance protection (ZCOM)
- breaker failure protection (BFP)
- power system and secondary system supervision

4.2 EF4 subrelay and TEF subrelay

The following features are not supported:

- scheme communication logic for residual overcurrent protection
- current reversal and weak end infeed logic for residual overcurrent protection
- harmonic restraint

4.3 TOC subrelay, TOC2 subrelay and TOC3 subrelay

The following features are not supported:

- thermal overloadprotection (THOL)
- unbalance protection for capacitor banks (TOCC)
- overload supervision (OVLD)
- radial feeder protection (PAP)

4.4 Voltage subrelay

The following features are not supported:

- loss of voltage check(LOD)
- voltage transformer supervision (TCT)
- fuse failure supervision (FUSE)
- broken conductor check (PTOC, 46)

4.5 WEF1 subrelay

The following features are not supported:

- directional sensitive power protection (WEF2)

5 References

[1] ABB Automation Products AB, Substation Automation Division, SE-721 59 Vasteras, Sweden. *Application Manual REL 561*2.3 Line differential and distance protection terminal Document No: 1MRK 506 113-UEN Issued: August 2003 Revision: B*, 2003.