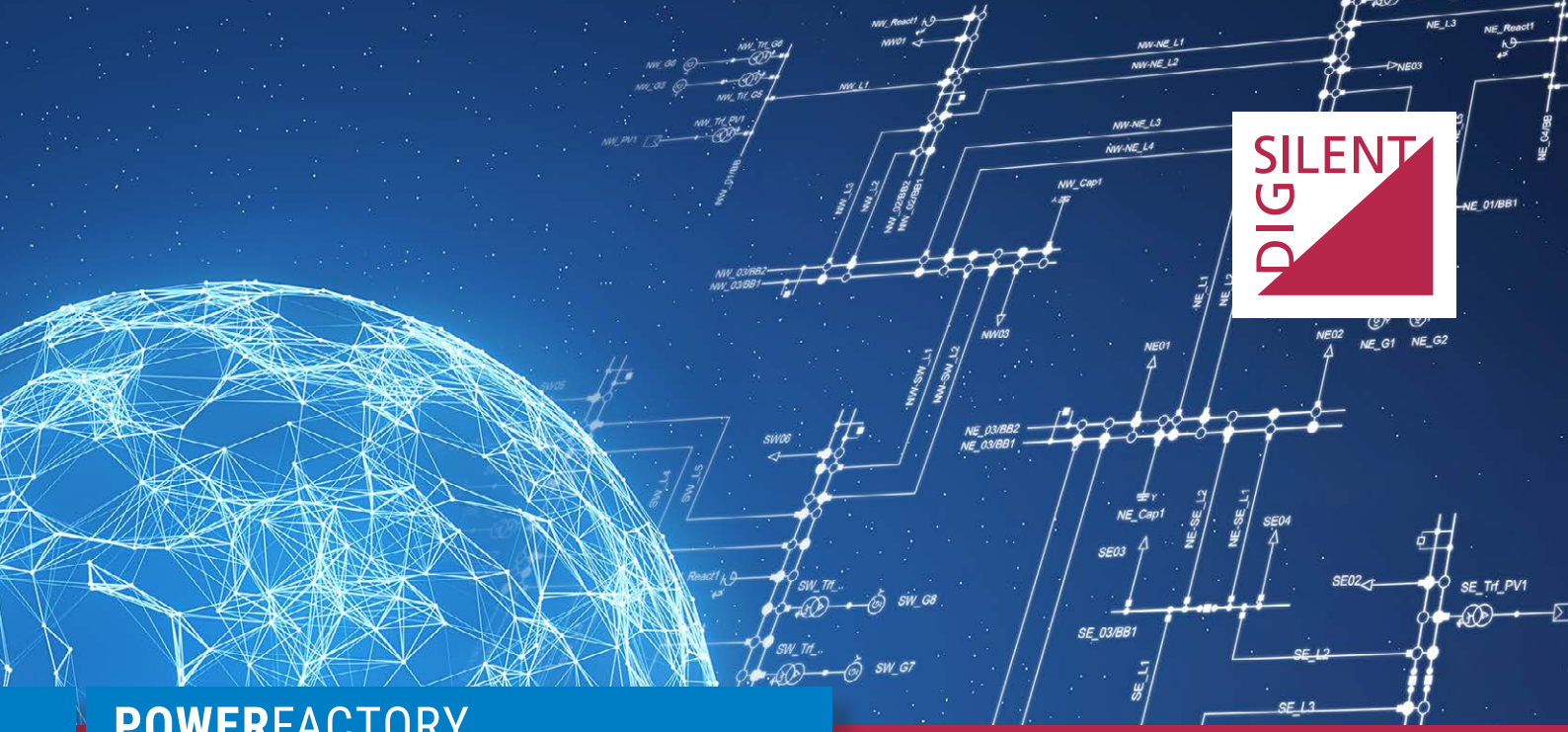

POWERFACTORY

# PowerFactory 2021

## Technical Reference

### ABB RET 670

PF2021

POWER SYSTEM SOLUTIONS

MADE IN GERMANY

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# Contents

# 1 Model information

**Manufacturer** ABB

**Model** RET 670

**Variants** The ABB RET 670 PowerFactory relay model can be used to simulate any version of the ABB RET 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 RET 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 RET 670 PowerFactory relay model consists of a main relay model and the following eleven sub relays:

- PDIF 87 (low and 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 RET 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 RET 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 RET 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, ”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 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).

### 3.3.1 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).

### 3.3.2 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.

### 3.3.3 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):

**T2WPDIF** :

| Address | Relay Setting | Model block | Model setting | Note |
|---|---|---|---|---|
| | Operation | T2WPDIF | Out of Service (outserv) | |
| | IBase | T2WPDIF | Differential Current (Itapr) | |
| | tAlarmDelay | T2WPDIF IdiffAlarm | Time Setting (Tdelay) | |
| | IDiffAlarm | T2WPDIF IdiffAlarm | Pickup Current (Ipset) | |
| | 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 Current (Itapr) | |
| | tAlarmDelay | T3WPDIF IdiffAlarm | Time Setting (Tdelay) | |
| | IDiffAlarm | T3WPDIF IdiffAlarm | Pickup Current (Ipset) | |
| | 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 | ZSCurrSubtrW3 (ZSCurrSubtrW3) | In the ”Logic” tab page |
| | | Ct2 W3 Earth Current Filter | ZSCurrSubtrW3 (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 Current (Itapr) | |
| | IdMin | REFPDIF | Release threshold (Idiffr2) | |
| | 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 |

## 3.4 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 (”Inner zone” and ”Outer 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 su brelay 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 fault direction is used by the ZMQPDIS sub relay (see 3.13)

### 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) | |
| | R1PP | ZDS1 | R1PP (R1PP) | |

| Address | Relay Setting | Model block | Model setting | Note |
|---|---|---|---|---|
| | 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 RET 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.

### 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) | |

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

| Address | Relay Setting | Model block | Model setting | Note |
|---|---|---|---|---|
| | 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) | |
| | 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 RET 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. 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) | |

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

| Address | Relay Setting | Model block | Model setting | Note |
|---|---|---|---|---|
| | 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 |
| | 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.

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

## 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 ”Diff & 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, ZMRAPDIS and ZDRDIR

# 5 References

[1] ABB Automation Products AB, Substation Automation Products, SE-721 59 Vasteras, Sweden. *Transformer protection RET670 Technical reference manual Document ID: 1MRK 504 113-UEN Issued: December 2012 Revision: C Product version: 1.2*, 2012.