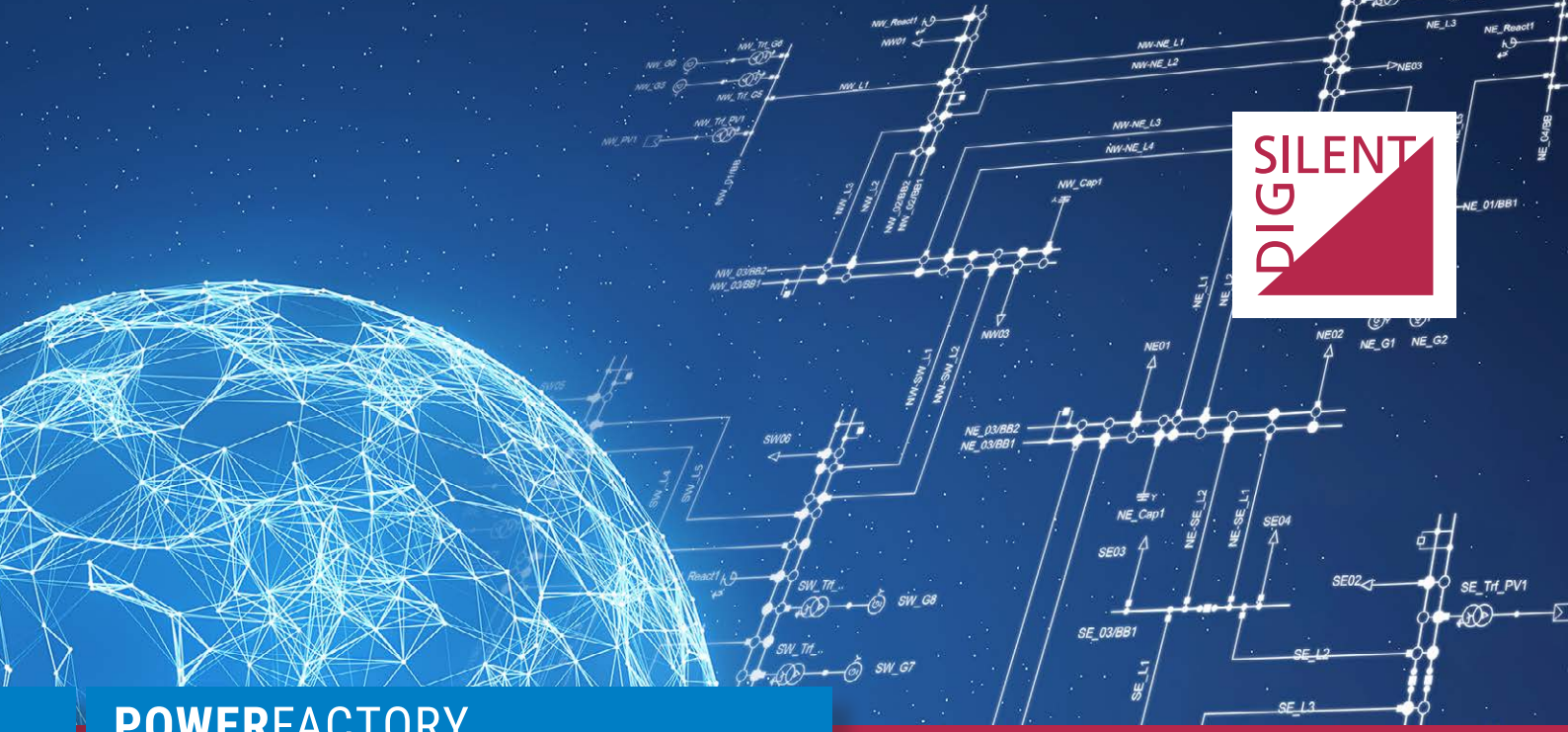

PowerFactory 2021

Technical Reference

SEL 487

PF2021

POWER SYSTEM SOLUTIONS

MADE IN GERMANY

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May 6, 2019
PowerFactory 2021
Revision 892

Contents

1 Model information

Manufacturer SEL

Model 487

Variants The SEL 487 PowerFactory relay models can be used to simulate the different firmware versions of the SEL 487 protective relays. The reference firmware version used to implement the model is . However please consider that the model has been implemented with a reduced set of the features available in the relays.

2 General description

The SEL-487 contains a variety of protective elements and control logic to protect two-, three-, four-, or five- windings power transformers, reactors, generators, and other apparatus. It includes current differential elements with percentage restraint and harmonic blocking elements, sensitive restricted earth-fault (REF) elements, one negative sequence differential element, and overcurrent, voltage and frequency elements.

The SEL 487 PowerFactory relay models consist of a main model and a set of subrelays hosting the protective for each transformer winding.

The following model versions are available:

- SEL 487-1A
- SEL 487-5A

The relay models have been implemented trying to simulate the most commonly used protective functions.

The relay models contain the phase differential element with its measurement elements, 27 subrelays, and the output logic.

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

3 Supported features

3.1 Measurement and acquisition

The currents and the voltages are converted by five 3 phase current transformers (”S Ct”, ”T Ct”, ”U Ct”, ”W Ct”, and ”X Ct” block) and by three core current transformers (”S Ct-3I0”, ”T Ct-3I0”, and ”U Ct-3I0” block). The voltages are measured by two 3 phase voltage transformers (”V Vt-3P” and ”Z Vt-3P” block).

The currents and the voltages converted by the CTs and the VTs and then sent to a set of subrelays which contains the elements which model the relay digital filtering and calculate the RMS values of the phase current and voltage, the sequence component values and the harmonic content of the phase currents. The following measurement subrelays are available:

- Five current measurement subrelays, one for each winding(”S Meas”, ”T Meas”, ”U Meas”, ”W Meas”, and ”X Meas” subrelay).
- Two voltage measurement subrelays, one for each voltage channel (”V Meas”, and ”Z Meas” subrelay).

3.1.1 Available Units

- Five 3 phase current transformers (”S Ct”, ”T Ct”, ”U Ct”, ”W Ct”, and ”X Ct” block).
- Three core current transformers (”S Ct-3I0”, ”T Ct-3I0”, and ”U Ct-3I0” block)
- Two 3 phase voltage transformers (”V Vt-3P” and ”Z Vt-3P” block).

Current Measurement subrelay Please refer to 3.3 for more details about the Current Measurement subrelay.

Voltage Measurement subrelay Please refer to 3.4 for more details about the Voltage Measurement subrelay.

3.1.2 Functionality

The input current values are sampled at 24 samples/cycle. The values are processed by a cosine filter, operating over a cycle, which then calculates the current and the voltage values used by the protective elements. Additional measurement elements calculate the phase and voltage RMS values using the integral of the input wave.

3.1.3 Data input

No manual data input is required in the measurement elements but accordingly with the CT secondary rated current (1A or 5A) the correct SEL 487 relay model version must be selected.

3.2 Main Relay

The main relay scheme contains the subrelays, the differential element and the output logic. The following subrelays are located here:

- ”Frequency Elements F81” (frequency elements subrelay)
- ”Negative seq differential and REF” (negative sequence differential and restricted earth fault subrelay)
- ”Overflux F24” (overflux subrelay)
- ”S Meas” (”S” winding measurement subrelay)
- ”S OC” (”S” winding overcurrent subrelay)
- ”Selectable Time-Overcurrent Elements (51)”
- ”T Meas” (”T” winding measurement subrelay)
- ”T OC” (”T” winding overcurrent subrelay)
- ”Terminal Selector 5101” (selector for the Selectable Time-Overcurrent Element *51O1*)
- ”Terminal Selector 5102” (selector for the Selectable Time-Overcurrent Element *51O2*)
- ”Terminal Selector 5103” (selector for the Selectable Time-Overcurrent Element *51O3*)
- ”Terminal Selector 5104” (selector for the Selectable Time-Overcurrent Element *51O4*)
- ”Terminal Selector 5105” (selector for the Selectable Time-Overcurrent Element *51O5*)
- ”Terminal Selector 5106” (selector for the Selectable Time-Overcurrent Element *51O6*)
- ”Terminal Selector 5107” (selector for the Selectable Time-Overcurrent Element *51O7*)
- ”Terminal Selector 5108” (selector for the Selectable Time-Overcurrent Element *51O8*)
- ”Terminal Selector 5109” (selector for the Selectable Time-Overcurrent Element *51O9*)
- ”Terminal Selector 5110” (selector for the Selectable Time-Overcurrent Element *51O10*)
- ”U Meas” (”U” winding measurement subrelay)
- ”U OC” (”U” winding overcurrent subrelay)
- ”V Meas” (”V” voltage channel subrelay)
- ”Voltage elements F27/59” (voltage elements subrelay)
- ”W Meas” (”W” winding measurement subrelay)
- ”W OC” (”W” winding overcurrent subrelay)
- ”X Meas” (”X” winding measurement subrelay)
- ”X OC” (”X” winding overcurrent subrelay)
- ”Z Meas” (”Z” voltage channel subrelay)

3.2.1 Available Units

- One 3 phase differential element (”Differential” block).
- 27 subrelays
- One output logic element (”Logic” block).
- Four measurement element ancillary to the differential element (”Diff RMS Meas”, ”Diff RMS Meas-2nd-H”, ”Diff RMS Meas-4th-H”, and ”Diff RMS Meas-5th-H” block).

3.2.2 Functionality

The phase differential logic is modeled by the ”Differential” element. The element defines a different *tap value* for each winding. The differential element is harmonic blocked by the 2^{nd}, 3^{rd} and 4^{th} harmonic content; no harmonic restraint algorithm is available. The differential characteristic has a double current biased slope; an additional unblocked constant threshold differential element is available. Please notice that the external/internal fault detection algorithm is not available, for this reason the *slope 2* differential characteristic is always active.

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):

Address	Relay Setting	Model block	Model setting	Note
	O87P	Differential	Release Threshold (Idiffr2)	
	SLP1	Differential	Restrain Percentage 1 (Irestrpercent1)	
	SLP2	Differential	Restrain Percentage 2 (Irestrpercent2)	
	U87P	Differential	Unrestrained Differential threshold (Idiffunrestr2)	
	E87HB	Differential	Disable Harmonic Blocking (harmblockdisable)	In the ”Harmonic Blocking” tab page
	PCT2	Differential	Blocking threshold (H2threshold)	In the ”2nd Harmonic” frame in the ”Harmonic blocking” tab page
	PCT4	Differential	Blocking threshold (H4threshold)	In the ”4th Harmonic” frame in the ”Harmonic blocking” tab page
	PCT5	Differential	Blocking threshold (H5threshold)	In the ”5th Harmonic” frame in the ”Harmonic blocking” tab page
	TAP1	Differential	Tap 1 (tap1)	In the ”Tap” tab page
	TAP2	Differential	Tap 2 (tap2)	In the ”Tap” tab page
	TAP3	Differential	Tap 3 (tap3)	In the ”Tap” tab page
	TAP4	Differential	Tap 4 (tap4)	In the ”Tap” tab page
	TAP5	Differential	Tap 5 (tap5)	In the ”Tap” tab page
	MVA	Differential	Max rated power (maxpower)	In the ”Tap” tab page

3.3 Current measurement subrelay Type

Five *Current measurement* subrelay instances (”S Meas”, ”T Meas”, ”U Meas”, ”W Meas”, and ”X Meas”) are present in the SEL 487 main relay scheme. Each of them measure the currents converted to the CTs set along the wirings connected to a different winding.

3.3.1 Available Units

- One 3 phase current measurement element with cosine filter (”Measure DFT” block).
- One 3 phase delta currents measurement element with cosine filter (”Measure Delta DFT” block).
- One negative sequence measurement element (”Meas Seq” block).
- One 2^{nd} harmonic current measurement element (”Meas-2nd-H” block).
- One 4^{th} harmonic current measurement element (”Meas-4th-H” block).
- One 5^{th} harmonic current measurement element (”Meas-5th-H” block).
- One 3 phase current sequence element with cosine filter (”Measure Seq” block).
- One 3 phase current measurement element with wave integration (”Measure RMS” block).
- One 3 phase delta currents measurement element with wave integration (”Measure Delta RMS” block).
- One winding current adaptation element (”Wd Adapter” block).
- Two current signals packing elements (”I Calc”, and ”Delta I calc” block).

3.3.2 Functionality

The ”Measure DFT” element calculates the fundamental frequency phase currents using a cosine filter; the ”Measure Delta DFT” element performs the same operation for the phase-phase current. The ”Meas Seq” element calculates the phase currents zero, negative, and positive sequence component. The ”Meas-2nd-H” element, the ”Meas-4th-H” element, and the ”Meas-5th-H” element calculate the 2^{nd}, the 4^{th} and the 5^{th} harmonic component of the phase currents. The ”Measure RMS” element calculates the RMS value of the phase currents integrating the phase current wave form; the ”Measure Delta RMS” element performs the same operation for the phase-phase current.

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
	CTRm[1]	Wd Adapter	Current Transformer Ratio (CTratio)	
	CTCONm[1]	Wd Adapter	Current Transformer Connection (icon-type)	
	Tm[1] CTC	Wd Adapter	Transformer Group (trasfgroup)	
	VTERMm[1]	Wd Adapter	Nominal Terminal Line-Line Voltage (LLVolt)	

[1] m = S,T,U,W,X

3.4 Voltage measurement subrelay Type

Two *Voltage measurement* subrelay instances (”V Meas”, and ”Z Meas”) are present in the SEL 487 main relay scheme. Each of them measures the voltages converted by one VT input channel. Two Voltage input channels are available.

3.4.1 Available Units

Each Voltage Measurement subrelay contains the following elements:

- One 3 phase voltage measurement element with cosine filter (”Measure DFT” block).
- One 3 phase voltage measurement element with wave integration (”Measure RMS” block).
- One 3 phase-phase voltage measurement element with cosine filter (”Measure Ph-Ph DFT” block).
- One 3 phase-phase voltage measurement element with wave integration (”Measure Ph-Ph RMS” block).
- One 3 phase voltage sequence element with cosine filter (”Measure Seq” block).
- One current signals packing element (”Logic” block).

3.4.2 Functionality

The ”Measure DFT” element calculates the fundamental frequency phase voltages using a cosine filter; the ”Measure Ph-Ph DFT” element performs the same operation for the phase-phase current. The ”Meas Seq” element calculates the phase voltages zero, negative, and positive sequence component. The ”Meas-2nd-H” element, the ”Meas-4th-H” element, and the ”Meas-5th-H” element calculate the 2^{nd}, the 4^{th} and the 5^{th} harmonic component of the phase currents.
The ”Measure RMS” element calculates the RMS value of the phase currents integrating the phase current wave form; the ”Measure Delta RMS” element performs the same operation for the phase-phase current.

3.5 Overcurrent subrelay Type

Five *Overcurrent* subrelays (”S OC”, ”T OC”, ”U OC”,”W OC”, and ”X OC”) are available in the SEL 487 main relay scheme. Each of them contains the phase, the negative sequence and the zero sequence definite time overcurrent elements which monitor the currents of a single winding.

3.5.1 Available Units

- Three 3 phase definite time overcurrent elements (”50P1”, ”50P2”, and ”50P3” block).
- Three negative sequence definite time overcurrent elements (”50Q1”, ”50Q2”, and ”50Q3” block).
- Three ground definite time overcurrent elements (”50G1”, ”50G2”, and ”50G3” block).
- One directional element (”Directional Control” block).
- One voltage selector (”VRef” block).
- Two auxiliary logic elements (”Dir adapter” and ”Const” block).

3.5.2 Functionality

Each phase overcurrent element monitor separately the fundamental frequency component of each phase current.
The negative sequence elements control the value of the negative sequence current calculated by a cosine filter.
The ground elements are sensitive to three time the zero sequence current (3I0) calculate by a cosine filter.
Each definite time overcurrent element has a directional characteristic. The directional settings must be set in the ”Directional Control” block. The voltage channel used to figure out the direction must be set in the ”VRef” block.

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
	E50	S OC	Out of Service (outserv)	
		T OC	Out of Service (outserv)	
		U OC	Out of Service (outserv)	
		W OC	Out of Service (outserv)	
		Z OC	Out of Service (outserv)	
	E50m[2]	50P1	Out of Service (outserv)	
		50P2	Out of Service (outserv)	
		50P3	Out of Service (outserv)	
		50Q1	Out of Service (outserv)	
		50Q2	Out of Service (outserv)	
		50Q3	Out of Service (outserv)	
		50G1	Out of Service (outserv)	

[2] m = S,T,U,W,X

Address	Relay Setting	Model block	Model setting	Note
		50G2	Out of Service (outserv)	
		50G3	Out of Service (outserv)	
	50m^{2}P1P	50P1	Pickup Current (Ipsetr)	
	50m^{2}P2P	50P2	Pickup Current (Ipsetr)	
	50m^{2}P3P	50P3	Pickup Current (Ipsetr)	
	67m^{2}P1TC	50P1	Tripping Direction (idir)	
	67m^{2}P2TC	50P2	Tripping Direction (idir)	
	67m^{2}P3TC	50P3	Tripping Direction (idir)	
	67m^{2}P1D	50P1	Time Setting (cTset)	
	67m^{2}P2D	50P2	Time Setting (cTset)	
	67m^{2}P3D	50P3	Time Setting (cTset)	
	50m^{2}Q1P	50Q1	Pickup Current (Ipsetr)	
	50m^{2}Q2P	50Q2	Pickup Current (Ipsetr)	
	50m^{2}Q3P	50Q3	Pickup Current (Ipsetr)	
	67m^{2}Q1TC	50Q1	Tripping Direction (idir)	
	67m^{2}Q2TC	50Q2	Tripping Direction (idir)	
	67m^{2}Q3TC	50Q3	Tripping Direction (idir)	
	67m^{2}Q1D	50Q1	Time Setting (cTset)	
	67m^{2}Q2D	50Q2	Time Setting (cTset)	
	67m^{2}Q3D	50Q3	Time Setting (cTset)	
	50m^{2}G1P	50G1	Pickup Current (Ipsetr)	
	50m^{2}G2P	50G2	Pickup Current (Ipsetr)	
	50m^{2}G3P	50G3	Pickup Current (Ipsetr)	
	67m^{2}G1TC	50G1	Tripping Direction (idir)	
	67m^{2}G2TC	50G2	Tripping Direction (idir)	
	67m^{2}G3TC	50G3	Tripping Direction (idir)	
	67m^{2}G1D	50G1	Time Setting (cTset)	
	67m^{2}G2D	50G2	Time Setting (cTset)	
	67m^{2}G3D	50G3	Time Setting (cTset)	
	E67m^2	50P1	Tripping Direction (idir)	Set ”None”
		50P2	Tripping Direction (idir)	Set ”None”
		50P3	Tripping Direction (idir)	Set ”None”
		50Q1	Tripping Direction (idir)	Set ”None”
		50Q2	Tripping Direction (idir)	Set ”None”
		50Q3	Tripping Direction (idir)	Set ”None”
		50G1	Tripping Direction (idir)	Set ”None”
		50G2	Tripping Direction (idir)	Set ”None”
		50G3	Tripping Direction (idir)	Set ”None”
	Z1ANGm^2	Directional Control	Positive Sequence line impedance magnitude Z1MAG (Zm)	In the ”Negative sequence” tab page
	Z0ANGm^2	Directional Control	Zero Sequence line impedance magnitude Z0MAG (Z0)	In the ”Ground” tab page
	50FPm^2	Directional Control	Forward directional current threshold (s50QF)	In the ”Negative sequence” tab page
	50RPm^2	Directional Control	Reverse directional current threshold (s50QR)	In the ”Negative sequence” tab page
	Z2Fm^2	Directional Control	Forward directional Z2 threshold Z2F (Z2F)	In the ”Negative sequence” tab page
	Z2Rm^2	Directional Control	Reverse directional Z2 threshold Z2R (Z2R)	In the ”Negative sequence” tab page
	a2m^2	Directional Control	Positive sequence current restraint factor a2=I2/I1 (a2)	In the ”Negative sequence” tab page
	ORDERm^2	Directional Control	Ground directional element priority (ORDER)	In the ”Basic settings” tab page
	k2m	Directional Control	Zero sequence current restraint factor k2=I2/I0 (k2)	In the ”Negative sequence” tab page
	Z0Fm^2	Directional Control	Forward directional Z0 threshold Z0F (Z0F)	In the ”Ground sequence” tab page

Address	Relay Setting	Model block	Model setting	Note
	Z0Rm[2]	Directional Control	Reverse directional Z0 threshold Z0R (Z0R)	In the "Ground sequence" tab page
	a0m[2]	Directional Control	Zero sequence current restraint factor a0=I0/I1 (a2)	In the "Ground sequence" tab page

3.6 Selectable Time-Overcurrent Elements (51) subrelay

The SEL 487 relay model includes 10 unassigned time-overcurrent elements, each with the choice of five U.S. and five IEC operating curves. Unassigned means that the 51 elements are not assigned to a specific transformer winding, but they are available for assignment. Moreover the operating quantities are not assigned and can be selected from many phase and sequence quantities, either fundamental or root mean square (rms). The same operating quantities available in the relay are also available in the model.

3.6.1 Available Units

- Ten inverse time overcurrent elements (”51O1”, ”51O2”... ”51O10” block).
- Ten operating quantities selectors (”51O1”, ”51O2” ... ”51O10” block).
- One auxiliary logic element (”Const” block).

3.6.2 Functionality

The inverse time overcurrent elements (”5101”, ”51O2”...”51O10” block) support the following inverse time trip characteristics:

- C1 - IEC Class A (Standard Inverse)
- C2 - IEC Class B (Very Inverse)
- C3 - IEC Class C (Extremely Inverse)
- C4 - IEC Long Time Inverse
- C5 - IEC Short Time Inverse
- U1 - U.S. Moderately Inverse
- U2 - U.S. Inverse
- U3 - U.S. Very Inverse
- U4 - U.S. Extremly Inverse
- U5 - U.S. Short Time Inverse

Each trip characteristic is associated to the relevant reset characteristic. The reset can set to be instantaneous or delayed accordingly to such reset characteristic.
The inverse time element trip characteristic equations comply with the IEC and ANSI standard equations.

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
	51Oxx[3]	51Oxx[3]	Dip Settings (aDipSet)	In the ”Dip Settings” tab page
	51Pxx[3]	51xx[3]	Current Setting (Ipsetr)	
	51Cxx[3]	51xx[3]	Characteristic (pcharac)	
	51TDxx[3]	51xx[3]	Time Dial (Tpset)	
	51RSxx[3]	51xx[3]	Reset Characteristic (resetdis)	

[3] xx = 01-10

3.7 Terminal Selector subrelay Type

Ten instances of the *Terminal Selector subrelay Type*, one for each *Selectable Time-Overcurrent Element* are present in the SEL 487 relay model. They allow to select which winding each *Selectable Time-Overcurrent Element* protects.

3.7.1 Available Units

- One terminal selector (”Terminal Selector”’ block).
- Nine logic element (”Terminal S”, ”Terminal T”, ”Terminal U”, ”Terminal W”, ”Terminal x”, ”Adder ST”, ”Adder UW”, ”Adder STUW”, ”Adder STUWX” block).
- One auxiliary logic element (”Const” block).

3.7.2 Functionality

The purpose of the *Terminal Selector subrelay Type* is to allow the user to select the windings associated to each *Selectable Time-Overcurrent Element* . Moreover some logic blocks combine the current signals measured on all available windings to create the signal containing the currents measured on the selected winding

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
	51Oxx[4]	51Oxx[3]	Dip Settings (aDipSet)	In the ”Dip Settings” tab page

[4] xx = 01-10

3.8 Frequency subrelay

The *Frequency* subrelay simulates the set of overfrequency , underfrequency elements which monitor the frequency measured using one of the available voltage input channels.

3.8.1 Available Units

- Six definite time over/under frequency elements (”81D1”, ”81D2”, ”81D3”, ”81D4”, ”81D5”, and ”81D6” block).
- One voltage minimum activation threshold (”81UVSP” block).
- One voltage input channel selector (”Terminal Selector” block).
- One frequency calculation element (”Meas Freq” block).
- One output logic element (”Output Logic” block).
- One auxiliary logic element (”Const” block).

3.8.2 Functionality

The voltage input channel (”V” or ”Z”) can be selected using the ”Terminal selector” voltage selector. The selector calculates also voltage values used by the frequency calculator as

$VF = VF_A - 0.5 * (VF_B + VF_C)$
where VF_A, VF_B, VF_C are the phase voltages of the active voltage channel

The frequency is calculated by the ”Meas Freq”block which uses by default the phase A-phase B voltage for its calculation (the parameter is user configurable). The calculated frequency value is then used by the overfrequency/underfrequency elements and by the rate of change of frequency elements.
The each frequency element operates as over frequency elements when the frequency threshold is greater than the system rated frequency, as under frequency element when the frequency threshold is smaller than the system rated frequency.

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
	E81	81D1	Out of Service (outserv)	
		81D2	Out of Service (outserv)	
		81D3	Out of Service (outserv)	
		81D4	Out of Service (outserv)	
		81D5	Out of Service (outserv)	
		81D6	Out of Service (outserv)	
	81UVSP	81UVSP	Pickup Voltage (Uset)	
	81Dn[5]P	81Dn[5]	Frequency (Fset)	
	81Dn[5]D	81Dn[5]	Time Delay (Tdel)	

[5] n = 1,2,3,4,5,6

3.9 Negative seq differential and REF subrelay

The *Negative seq differential and REF* subrelay contains

- One negative sequence differential element.
- Three restricted earth fault (REF) elements.

3.9.1 Available Units

- One negative differential element (”Negative Seq Differential” block).
- Three restricted earth fault (REF) elements (”REF 1”, ”REF 2”, and ”REF 3” block).
- Four differential ancillary single phase measurement elements (”Negative Seq Differential RMS Measure”, ”REF RMS Measure 1”, ”REF RMS Measure 2”, ”REF RMS Measure 3” block).
- Three inverse time characteristic elements (”REF 1 TOC”, ”REF 2 TOC”, and ”REF 3 TOC” block).
- Three terminal selectors (”REFRF1”, ”REFRF2”, and ”REFRF3” block).
- Three earth current directional elements(”REF 1 angle”, ”REF 2 angle”, and ”REF 3 angle” block).
- One subrelay output logic element (”Output Logic” block).
- One auxiliary logic element (”Const” block).

3.9.2 Functionality

The negative sequence differential element implement a single phase differential with single slope bias restraint characteristic.
Each restricted earth fault element implements two constant thresholds differential feature with definite time delay and inverse time delay characteristic. The ”REF 1” elements is fed by the neutral current converted by the ”S Ct-3I0” core CT, ”REF 2” by the ”T Ct-3I0” core CT, ”REF 3” by the ”U Ct-3I0” core CT. The inverse time delay is implemented by the ”REF 1 TOC”, ”REF 2 TOC”, and ”REF 3 TOC” block. Please notice that the restricted earth fault differential thresholds must be manually inserted in the differential element (i.e. ”REF 1”) and in the inverse time delay element (”REF 1 TOC”).

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
	EREF REFRFa[6]	Negative Seq Differential REFRFa[6]	Out of Service (outserv) Dip Settings (aDipSet)	outserv=1 when ”N” In the ”Dip Settings” tab page

[6] a = 1,2,3

Address	Relay Setting	Model block	Model setting	Note
	REF50Ga[6]	REF a[6]	Operating Current (curopu)	In the ”Voltage Polarizing” tab page
	REF50Pa[6]	Negative Seq Differential	Release Threshold (Idiffr)	
	REF50Da[6]	Negative Seq Differential	Time Setting (cTset)	
	REF51Pa[6]	REF a[6]TOC	Current Setting (Ipset)	
	REF51Ca[6]	REF a[6]TOC	Characteristic (pcharac)	
	RF51TDa	REF a[6]TOC	Time Dial (Tpset)	
	RF51RSa	REF a[6]TOC	Reset Characteristic (resetdis)	
	87QP	Negative Seq Differential	Release Threshold (Idiffr)	
	SLPQ1	Negative Seq Differential	Restraint 1st Slope (Irestrpercent1)	
	87QD	Negative Seq Differential	Time Setting (cTset)	

3.10 Overflux subrelay

The *Overflux* subrelay simulates the overfluxing protective elements.

3.10.1 Available Units

- One inverse time over flux elements (”24D1” block).
- One definite time over flux element (”24D2” block).
- One voltage input channel selector (”Terminal Selector” block).
- One frequency calculation element (”Meas Freq” block).
- One flux calculation element (”V/Hz calculator” block).
- One sub relay output logic element (”Output Logic” block).
- One auxiliary logic element (”Const” block).
- One max voltage calculation element (”Max U” block).

3.10.2 Functionality

The frequency is calculated by the ”Meas Freq”block which uses by default the phase A-phase B voltage for its calculation (the parameter is user configurable). The voltage input channel (”V” or ”Z”) can be selected using the ”Terminal selector” voltage selector. The calculated frequency value is then used by the ”V/Hz calculator” block to calculate the flux value.
The flux is calculated using the highest voltage value which is calculated by the ”Max U” block.

Two user configurable characteristics are available and can be used in the ”24D1” block.

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
	24VSRC	Terminal Selector	Dip Settings (aDipSet)	In the ”Dip Settings” tab page
	24D1P	24D1	Input Setting (Ipsetr)	
	24D1D	24D1	Time Dial (Tpset)	
	24D2P1	24D1	Input Setting (Ipsetr)	
	24D2D1	24D1	Time Dial (Tpset)	
	24D2P2	24D2	Input Setting (Ipsetr)	
	24D2D2	24D2	Time Dial (Tpset)	
	24U1xxa	24 U1	Values	In the ”TCCs” folder.Add freely the points in the matrix.
	24U1CR	24D1	Reset Delay (ResetT)	
	24U2xxa	24 U2	Values	In the ”TCCs” folder.Add freely the points in the matrix.
	24U2CR	24D2	Reset Delay (ResetT)	

The ”24D1” and the ”24D2” element must be enabled or disabled accordingly with the *24CCS* value. When *24CCS* is equal to ’OFF’ disable the ”24D2” block and select the *24 DD* characteristic in the ”24D1” block. When *24CCS* is equal to ’DD’ enable both the”24D1” and the ”24D2” block and select the *24 DD* characteristic in the ”24D1” block. When *24CCS* is equal to ’U1’ disable the ”24D2” block and select the *24U1* characteristic in the ”24D1” block. When *24CCS* is equal to ’U2’ disable the ”24D2” block and select the *24U2* characteristic in the ”24D1” block.

3.11 Voltage subrelay

The *Voltage* subrelay simulates the set of definite time over and under voltage protective features: a total of 5 sets of under voltage and 5 sets of over voltage elements are available. Each set consists of two thresholds.

3.11.1 Available Units

- Ten definite time under voltage elements (”27P1P1”, ”27P1P2”, ”27P2P1”, ”27P2P2”,”27P3P1”, ”27P3P2”,”27P4P1”, ”27P4P2”,”27P5P1”, and ”27P5P2” block).
- Ten definite time over voltage elements (”59P1P1”, ”59P1P2”, ”59P2P1”, ”59P2P2”,”59P3P1”, ”59P3P2”,”59P4P1”, ”59P4P2”,”59P5P1”, and ”59P5P2”).
- Ten terminal selectors (”27O1 Terminal”, ”27O2 Terminal”, ... , and ”27O10 Terminal” block)
- Ten input quantity selectors (”27O1”, ”27O2”, ... , and ”27O10” block).
- One output logic element (”Output Logic” block).
- One auxiliary logic element (”Const” block).

3.11.2 Functionality

Ten under voltage and ten over voltage elements are available. The over voltage and the undervoltage elements are grouped two by two in 5 sets of under and over voltage elements. Each set can be set to use different operating quantities using the ”27On[7]” and the ”59On[7] ” operating quantity selectors. Such quantities can be fundamental or RMS values. The same operating quantities available in the relay are also available in the model.
The voltage input channel (”V” or ”Z”) can be selected using the ”27On[7] Terminal” and the ”59On[4] Terminal” voltage selectors.

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
	E59	59P1P1	Out of Service (outserv)	
		59P1P2	Out of Service (outserv)	
		59P2P1	Out of Service (outserv)	
		59P2P2	Out of Service (outserv)	
		59P3P1	Out of Service (outserv)	
		59P3P2	Out of Service (outserv)	
		59P4P1	Out of Service (outserv)	
		59P4P2	Out of Service (outserv)	
		59P5P1	Out of Service (outserv)	
		59P5P2	Out of Service (outserv)	
	E27	27P1P1	Out of Service (outserv)	
		27P1P2	Out of Service (outserv)	
		27P2P1	Out of Service (outserv)	

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

Address	Relay Setting	Model block	Model setting	Note
		27P2P2	Out of Service (outserv)	
		27P3P1	Out of Service (outserv)	
		27P3P2	Out of Service (outserv)	
		27P4P1	Out of Service (outserv)	
		27P4P2	Out of Service (outserv)	
		27P5P1	Out of Service (outserv)	
		27P5P2	Out of Service (outserv)	
	27On[8]	27On[8]	Dip Settings (aDipSet)	In the ”Dip Settings” tab page
	27Pn[8] 1P	27n[8] P1	Pickup Voltage(Upsetr)	
	27Pn[8] 2P	27n[8] P2	Pickup Voltage(Upsetr)	
	27Pn[8] D1	27n[8] P1	Time Delay (cTdel)	
	59On[8]	59On[8]	Dip Settings (aDipSet)	In the ”Dip Settings” tab page
	59Pn[8] 1P	59n[8] P1	Pickup Voltage(Upsetr)	
	59Pn[8] 2P	59n[8] P2	Pickup Voltage(Upsetr)	
	59Pn[8] D1	59n[8] P1	Time Delay (cTdel)	

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

3.12 Output logic

The output logic is the interface between the relay and the power system. A set of relay output signals is available and can be configured by the user to implement any control logic.

3.12.1 Available Units and Signals

The trip logic is implemented by the "Logic" block. Eleven relay output signals are available (”OUT1”, ”OUT2”, ”OUT3” . . . ”OUT11”)

By default the unique active relay output signal is ”OUT1”.

3.12.2 Functionality

The ”Logic” block operates the power breaker when a trip command has been issued by any protective element. The block output signal used to operate the breaker is ”OUT1”. The ”Logic” block gets from the definite time overcurrent elements both the trip signals and the starting signals. The trip logic provided with the default model considers also the status of the starting signals. The behavior of the other output signals and the trip logic can be configured in the "Logic" tab page of the "Logic" block dialog.

3.12.3 Data input

Please disable the ”Logic” block to disable the relay model ability to open the power circuit.

4 Features not supported

The following features are not supported:

- Harmonic restraint.
- Phase differential internal/external fault detection algorithm.
- Combined Time-Overcurrent Elements (51).
- Selectable Time-Overcurrent Elements (51) directional feature.
- Breaker Failure Instantaneous Overcurrent.
- Directional Overpower/Underpower Element.
- Synchrophasor.

5 References

[1] SCHWEITZER ENGINEERING LABORATORIES, 2350 NE HOPKINS COURT PULLMAN, WA USA 99163-5603. *SEL-487E-3, -4 Transformer Differential Relay Three-Phase Transformer Protection, Automation, and Control System Data Sheet Date Code 20140416*, April 2014.

[2] SCHWEITZER ENGINEERING LABORATORIES, 2350 NE HOPKINS COURT PULLMAN, WA USA 99163-5603. *SEL-487E-3, -4 Relay Current Differential and Voltage Protection Instruction Manual Date Code 20130107*, January 2013.