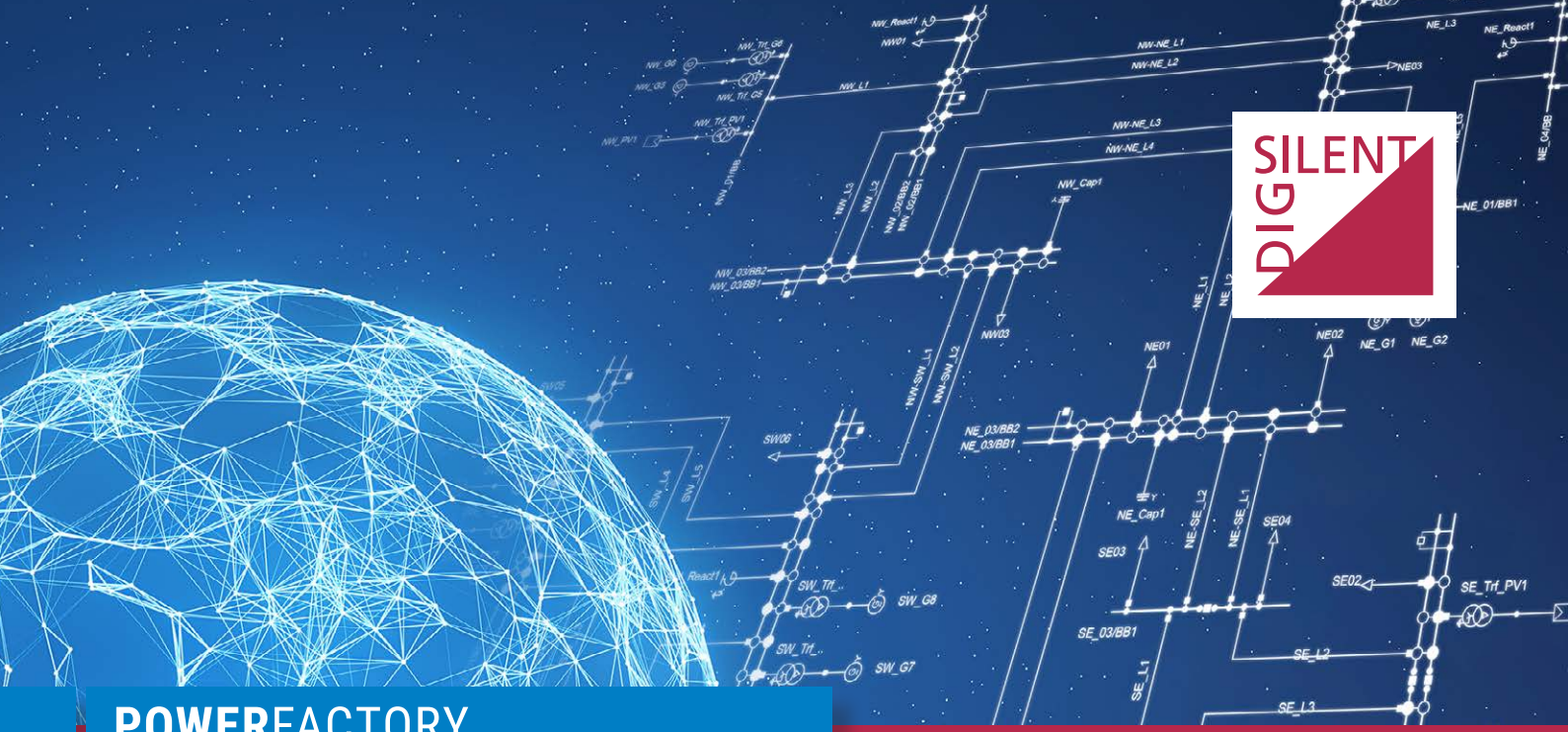

POWERFACTORY

PowerFactory 2021

Technical Reference

SEL 411L

PF2021

POWER SYSTEM SOLUTIONS

MADE IN GERMANY

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Contents

1 Model information

Manufacturer SEL

Model 411L

Variants The SEL 411L PowerFactory relay models can be used to simulate the different firmware versions of the SEL 411L protective relays. The reference firmware version used to implement the model is SEL-411L-R105-V0-Z002001-D20120228 and SEL-411L-1-R105-V0-Z002001-D20120228. 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 411L relay protects, controls, and monitors EHV, HV, and sub transmission lines. The relay contains all protective elements and control logic to protect any overhead transmission line.

The SEL 411L PowerFactory relay models consist of a main model and of the following five sub relays:

- *Differential* (containing the F87 elements)
- *Overcurrent* (hosting the F50 and the F51 elements)
- *Voltage* (containing the F27 and F59 elements)
- *Frequency* (hosting the F81 elements)
- *Out of step* (hosting the out of step logic)

The following model versions are available in the ”SEL 411L” folder:

- SEL 411L-1A
- SEL 411L-5A

For user convenience the ”SEL 411L Link” connection relay model is available in the ”SEL 411L” folder: it can be used to link two SEL 411L relay instances to implement the differential protection of a zone of the power system.

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

The relay models contain the measurement and acquisition units, the polarizing elements, the directional elements for the distance elements, the mho and the polygonal distance elements, a set of timers, the sub relays, the output logic.

The model implementation has been based on the information available in the relay manual [1] [2] [3] [4].

3 Supported features

3.1 Measurement and acquisition

The voltage and the current are measured by two 3 phase current transformer (”Ct 1” and ”Ct 2” block) and two 3 phase voltage transformer (”Vt 1” and ”Vt 2” block).

Three measurement units (”M-I/U Ct1”, ”M-Iab/Ibc/Ica Ct1” and ”Meas seq Ct1” block) are fed by the ”Ct 1” current transformer and by the ”Vt 1” voltage transformer. Three additional measurements (”M-I/U Ct2”, ”M-Iab/Ibc/Ica Ct2” and ”Meas seq Ct2” block) units process the current and voltage values converted by the ”Ct 2” current transformer and by the ”Vt 2” voltage transformer.

A set of input signals carries the phase, ground and negative sequence current values measured by 3 remote relays.

3.1.1 Available Units and Input Signals

- Two 3 phase current transformers measuring the phase current (”Ct 1” and ”Ct 2”lock).
- Two 3 phase voltage transformers measuring the phase voltages(”Vt 1” and ”Vt 2” block).
- Two 3 phase measurement elements calculating both the current and voltage values (”M-I/U Ct1” and ”M-I/U Ct2” block).
- One 3 phase measurement element calculating the phase to phase currents (”M-Iab/Ibc/Ica Ct1” block).
- Two 3 phase measurement elements calculating the current and the voltage sequence vectors (”Meas RMS seq Ct1” and ”Meas RMS seq Ct2” block).

Input signals:

- External_Relay_1_ phase
- External_Relay_2_phase
- External_Relay_3_phase
- External_Relay_1_ground
- External_Relay_2_ground
- External_Relay_3_ground
- External_Relay_1_negseq
- External_Relay_2_negseq
- External_Relay_3_negseq

3.1.2 Functionality

The input current and voltage values are sampled at 20 samples/cycle. The values are processed by a Cosine filter, operating over a cycle, which then calculates the voltage and current values used by the protective elements.

The ”M-Iab/Ibc/Ica Ct1” block calculates the phase-phase current values used by the phase-phase loop distance elements.

The input signals are used by the *Differential* subrelay. The ”External_Relay_1_phase, the ”External_Relay_2_phase”, and the ”External_Relay_3_phase” signal carry for each phase the RMS value and the instantaneous values (real part and imaginary part). The ”External_Relay_1_ground, the ”External_Relay_2_ground”, and the ”External_Relay_3_ground” signal carry the zero sequence (3I0) current RMS value and the instantaneous values (real part and imaginary part). The ”External_Relay_1_negseq, the ”External_Relay_2_negseq”, and the ”External_Relay_3_negseq” signal carry the negative sequence (3I2) current RMS value and the instantaneous values (real part and imaginary part).

3.1.3 Data input

Select the relay model version taking account of the required CT secondary rated current.

3.2 Main Relay protective elements

The overcurrent starting elements, polarizing elements, the directional element, the load encroachment element, the polygonal and the mho distance elements are working together to simulate the SEL 411L distance functionalities.

3.2.1 Available Units

- One phase starting element (”50PP Starting” block).
- One ground starting element (”50G/50L” block)
- Two polarizing elements (”Polarizing” and ”Polarizing Z1” block).
- One load encroachment element (”Load Encroachment” block).
- One directional element (”Sel Dir” block).
- Five mho distance elements for the phase loops (”Z1P”, ”Z2P”, ”Z3P”, ”Z4P” and ”Z5P” block).
- Five timers associated to the phase mho elements (”Z1PD”, ”Z2PD”, ”Z3PD”, ”Z4PD”, and ”Z5PD” block).
- Five mho distance elements for the ground loops (”Z1MG” , ”Z2MG”, ”Z3MG” , ”Z4MG” and ”Z5MG” block).
- Five polygonal distance elements for the ground loops (”Ph-Q1” , ”Ph-Q2”, ”Ph-Q3”, ”Ph-Q4” and ”Ph-Q5” block).
- Five timers associated to the ground polygonal and to the mho elements (”Z1GD”, ”Z2GD”, ”Z3GD”, ”Z4GD” and ”Z5GD” block).

3.2.2 Functionality

Overcurrent starting elements Separated overcurrent starting elements are available for the phase-phase and for the phase-ground loops. An unique overcurrent starting element is available for the phase-phase distance zones and an unique overcurrent starting element is available for the phase-ground distance zones. The phase-ground loop starting element has both a ground and a phase current threshold.

Directional elements The directional element simulate in detail the SEL 411L phase, ground and negative sequence direction detection logic. The direction of the five distance elements and of the overcurrent elements must be set in the directional element dialog. For each inverse time overcurrent element the following full set of available direction logics is present:

- Phase directional logic when in the 51Oxx[1] block the LIAFIM or the B1IAFIM or the LIMAXM or the B1IMAXM or the B2IAFIM or the B2IMAXM or the LI1FIM or the _87IAFM or the _87I1FM flag is equal to 1.
- Ground directional logic when in the 51Oxx[1] block the B2IGFIM or the _87IGFM flag is equal to 1.
- Negative sequence directional logic when in the 51Oxx[1] block the L3I2FIM or the _87IQFM flag is equal to 1.

Please notice that only one directional logic can be enabled at the same time.

The ”Loss of potential” logic is also supported.

Polarizing element The polarizing elements are calculating the operating current and voltage and the polarizing voltage vectors used by the polygonal and the mho elements. Separated elements are available for the 1^{st} zone (”Polarizing Z1” block) and for the other zones (”Polarizing” block).

Mho elements Separated set of mho elements are monitoring the phase-ground and the phase-phase loops. The starting of the mho elements is controlled by the overcurrent starting elements.

Polygonal elements A set of polygonal elements can be sued to monitor the phase-ground loops. The starting of the ground polygonal elements is controlled by the overcurrent starting elements.

Load encroachment element The model load encroachment element simulate exactly the shape of the relay feature. When a load encroachment condition is detected it blocks the phase mho elements.

Timers The timers are connected to the mho and to the polygonal output signals. Separated timers are available for the phase and the ground loops. The ground mho and the ground polygonal elements share the same timers.

[1] xx = 1,2,3,4,5,6,7,8,9,10

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 elements :

Address	Relay Setting	Model block	Model setting	Note
	50PP	50PP Starting	Current I>> (Ip2)	
	50L	50G/50L	Current I>> (Ip2)	
	50G	50G/50L	Current, 3*I0 (Ie)	

Polarizing element :

Address	Relay Setting	Model block	Model setting	Note
	k01M	Polarizing Z1	k0 (k0)	
	k01A	Polarizing Z1	Angle (phik0)	
	k0M	Polarizing	k0 (k0)	
	k0A	Polarizing	Angle (phik0)	

Mho impedance elements :

Address	Relay Setting	Model block	Model setting	Note
	PMHOZ	Z1P	Out of Service (outserv)	
		Z2P	Out of Service (outserv)	
		Z3P	Out of Service (outserv)	
		Z4P	Out of Service (outserv)	
		Z5P	Out of Service (outserv)	
	Z1P	Z1P	Replica Impedance (Zm)	
	Z2P	Z2P	Replica Impedance (Zm)	
	Z3P	Z3P	Replica Impedance (Zm)	
	Z4P	Z4P	Replica Impedance (Zm)	
	Z5P	Z5P	Replica Impedance (Zm)	
	GMHOZ	Z1MG	Out of Service (outserv)	
		Z2MG	Out of Service (outserv)	
		Z3MG	Out of Service (outserv)	
		Z4MG	Out of Service (outserv)	
		Z5MG	Out of Service (outserv)	
	Z1MG	Z1MG	Replica Impedance (Zm)	
	Z2MG	Z2MG	Replica Impedance (Zm)	
	Z3MG	Z3MG	Replica Impedance (Zm)	
	Z4MG	Z4MG	Replica Impedance (Zm)	
	Z5MG	Z5MG	Replica Impedance (Zm)	
	Positive-Seq.Line Impedance Angle	Z1P	Relay angle (phi)	
		Z2P	Relay angle (phi)	
		Z3P	Relay angle (phi)	
		Z4P	Relay angle (phi)	
		Z5P	Relay angle (phi)	
	Zero-Seq.Line Impedance Angle	Z1MG	Relay angle (phi)	
		Z2MG	Relay angle (phi)	

Address	Relay Setting	Model block	Model setting	Note
		Z3MG	Relay angle (phi)	
		Z4MG	Relay angle (phi)	
		Z5MG	Relay angle (phi)	

Polygonal impedance elements :

Address	Relay Setting	Model block	Model setting	Note
	QUADZ	Ph-Q1	Out of Service (outserv)	
		Ph-Q2	Out of Service (outserv)	
		Ph-Q3	Out of Service (outserv)	
		Ph-Q4	Out of Service (outserv)	
		Ph-Q5	Out of Service (outserv)	
	XG1	Ph-Q1	+X Reach (Xmax)	
	XG2	Ph-Q2	+X Reach (Xmax)	
	XG3	Ph-Q3	+X Reach (Xmax)	
	XG4	Ph-Q4	+X Reach (Xmax)	
	XG5	Ph-Q5	+X Reach (Xmax)	
	RG1	Ph-Q1	+R Resistance (Rmax)	
	RG2	Ph-Q2	+R Resistance (Rmax)	
	RG3	Ph-Q3	+R Resistance (Rmax)	
	RG4	Ph-Q4	+R Resistance (Rmax)	
	RG5	Ph-Q5	+R Resistance (Rmax)	
	Zero-Seq.Line Impedance Angle	Ph-Q1	Relay angle (phi)	
		Ph-Q2	Relay angle (phi)	
		Ph-Q3	Relay angle (phi)	
		Ph-Q4	Relay angle (phi)	
		Ph-Q5	Relay angle (phi)	
	TANG	Ph-Q1	+X Angle (beta)	
		Ph-Q2	+X Angle (beta)	
		Ph-Q3	+X Angle (beta)	
		Ph-Q4	+X Angle (beta)	

Timers :

Address	Relay Setting	Model block	Model setting	Note
	Z1PD	Z1PD	Time Setting (Tcdelay)	
	Z2PD	Z2PD	Time Setting (Tcdelay)	
	Z3PD	Z3PD	Time Setting (Tcdelay)	
	Z4PD	Z4PD	Time Setting (Tcdelay)	
	Z5PD	Z5PD	Time Setting (Tcdelay)	
	Z1GD	Z1GD	Time Setting (Tcdelay)	
	Z2GD	Z2GD	Time Setting (Tcdelay)	
	Z3GD	Z3GD	Time Setting (Tcdelay)	
	Z4GD	Z4GD	Time Setting (Tcdelay)	
	Z5GD	Z5GD	Time Setting (Tcdelay)	

Load Encroachment :

Address	Relay Setting	Model block	Model setting	Note
	ELE	Load Encroachment	Out of Service (outserv)	
	ZLF	Load Encroachment	ZLF	
	ZLR	Load Encroachment	ZLR	
	PLAF	Load Encroachment	PLAF	
	NLAF	Load Encroachment	NLAF	
	PLAR	Load Encroachment	PLAR	
	NLAR	Load Encroachment	NLAR	

Directional element (”Sel Dir”) :

Address	Relay Setting	Model block	Model setting	Note
	ORDER	Sel Dir	Ground directional element priority(ORDER)	
	DIR1	Sel Dir	Level 1 direction (DIR1)	In the ”Basic settings" tab page
	DIR2	Sel Dir	Level 2 direction (DIR2)	In the ”Basic settings" tab page
	DIR3	Sel Dir	Level 3 direction (DIR3)	In the ”Basic settings" tab page
	DIR4	Sel Dir	Level 4 direction (DIR4)	In the ”Basic settings" tab page
	Z2F	Sel Dir	Forward directional Z2 threshold Z2F	In the ”Negative sequence” tab page
	50QF	Sel Dir	Forward directional current threshold (s50QF)	In the ”Negative sequence” tab page
	Z2R	Sel Dir	Reverse directional Z2 threshold Z2R	In the ”Negative sequence” tab page
	50QR	Sel Dir	Reverse directional current threshold (s50QR)	In the ”Negative sequence” tab page
	a2	Sel Dir	Positive sequence current restraint factor a2=I2/I1	In the ”Negative sequence” tab page
	a0	Sel Dir	Zero sequence current restraint factor a0=I0/I1	In the ”Ground” tab page
	k2	Sel Dir	Zero sequence current restraint factor k2=I2/I0	In the ”Negative sequence” tab page
	ELOP	Sel Dir	Loss Of Potential enable setting (ELOP)	In the ”Basic settings" tab page
	Z1MAG	Sel Dir	Positive sequence line impedance magnitude Z1MAG (Zm)	In the ”Negative sequence” tab page
	Z1ANG	Sel Dir	Positive sequence line impedance angle Z1ANG (phi)	In the ”Negative sequence” tab page
	50GFP	Sel Dir	Forward directional residual ground pickup 50GFP (s50GFP)	In the ”Ground” tab page
	50GRP	Sel Dir	Reverse directional residual ground pickup 50GRP (s50GRP)	In the ”Ground” tab page
	Z0F	Sel Dir	Forward directional Z0 threshold Z0F	In the ”Ground” tab page
	Z0R	Sel Dir	Reverse directional Z0 threshold Z0R	In the ”Ground” tab page
	Z0MAG	Sel Dir	Zero sequence line impedance magnitude Z0MAG (Z0)	In the ”Ground” tab page
	Z0ANG	Sel Dir	Zero sequence line impedance angle Z0ANG (phi0)	In the ”Ground” tab page

3.3 Differential subrelay

The *Differential* subrelay stores the three differential elements together with the CT adapters and the harmonic measurement elements.

3.3.1 Available Units

- One 3 phase differential element(”87LP”block).
- One zero sequence current differential element(”87LG”block).
- One negative sequence current differential element(”87LQ”block).
- Five 3 phase 2^{nd} harmonic measurement elements (”Terminal W - 2nd Harmonic”, ”Terminal X - 2nd Harmonic”, ”Remote Relay 1 - 2nd Harmonic”, ”Remote Relay 2 - 2nd Harmonic”, and ”Remote Relay 3 - 2nd Harmonic” block).
- Five 3 phase 4^{th} harmonic measurement elements (”Terminal W - 4th Harmonic”, ”Terminal X - 4th Harmonic”, ”Remote Relay 1 - 4th Harmonic”, ”Remote Relay 2 - 4th Harmonic”, and ”Remote Relay 3 - 4th Harmonic” block).
- Five 3 phase 5^{th} harmonic measurement elements (”Terminal W - 5th Harmonic”, ”Terminal X - 5th Harmonic”, ”Remote Relay 1 - 5th Harmonic”, ”Remote Relay 2 - 5th Harmonic”, and ”Remote Relay 3 - 5th Harmonic” block).
- Five 3 phase CT adapters (”Terminal W Adapter”, ”Terminal X Adapter”, ”Remote Relay 1 Adapter”, ”Remote Relay 2 Adapter”, and ”Remote Relay 3 Adapter” block).
- Ten single phase CT adapters (”Terminal W IG Adapter”, ”Terminal X IG Adapter”, ”Remote Relay 1 IG Adapter”, ”Remote Relay 2 IG Adapter”, ”Remote Relay 3 IG Adapter”, ”Terminal W IQ Adapter”, ”Terminal X IQ Adapter”, ”Remote Relay 1 IQ Adapter”, ”Remote Relay 2 IQ Adapter”, and ”Remote Relay 3 IQ Adapter” block).
- Two 3 phase measurement elements (”87LP RMS Measure” and ”87LP Seq Measure” block).
- Two single phase measurement elements (”87LG RMS Measure” and ”87LQ RMS Measure” block).

3.3.2 Functionality

The *Differential* subrelay contains the following differential elements:

- Phase line current differential with Generalized Alpha Plane principle and user configurable 2^{nd}, 4^{th}, and 5^{th} harmonic restraint (”87 In Line Transformer (RM)” mode).
- Negative sequence current differential with Generalized Alpha Plane principle.
- Zero sequence current differential with Generalized Alpha Plane principle.

The *Generalized Alpha Plane* characteristic is delimited by a ”Restrain Area” defined by a *Radius* and by a *Restrain Angle*.

Each differential element is feed by two local CTs (”Terminal W” and ”Terminal X”) and by up to three remote relay CTs (”Remote Relay 1”, ”Remote Relay 2”, and ”Remote Relay 3”). The remote relays must be connected to the relay using a interconnection scheme like the ”SEL 411L

Link" available in the "SEL 411L" relay model folder.
A set of elements allows to compensate different CT ratios and, when a power transformer is part of the protected zone, different voltage levels and winding connections("Adapter" elements).

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
	CTRW	Terminal W Adapter	Current Transformer Ratio (CTratio)	In the "Basic settings" tab page
	CTRX	Terminal X Adapter	Current Transformer Ratio (CTratio)	In the "Basic settings" tab page
	87CTP1R	Remote Relay 1 Adapter	Current Transformer Ratio (CTratio)	In the "Basic settings" tab page
	87CTP2R	Remote Relay 2 Adapter	Current Transformer Ratio (CTratio)	In the "Basic settings" tab page
	87CTP3R	Remote Relay 3 Adapter	Current Transformer Ratio (CTratio)	In the "Basic settings" tab page
	87LPU	87LP	Unrestrained Differential threshold (Idiffunrest)	
	87LPP	87LP	Differential Current base threshold (Idiff)	
	87LPR	87LP	Restraint region Radius (RestrRadius)	
	87LPA	87LP	Restraint region Angle (RestrAngle)	
	87LQP	87LQ	Differential Current base threshold (Idiff)	
	87LQR	87LQ	Restraint region Radius (RestrRadius)	
	87LQA	87LQ	Restraint region Angle (RestrAngle)	
	87LGP	87LG	Differential Current base threshold (Idiff)	
	87LGR	87LG	Restraint region Radius (RestrRadius)	
	87LGA	87LG	Restraint region Angle (RestrAngle)	
	87CTCWL	Terminal W Adapter	Transformer Group	
	87VTWL	Terminal W Adapter	Nominal Terminal Line-Line Voltage (LLVolt)	
	87CTCXL	Terminal X Adapter	Transformer Group	
	87VTXL	Terminal X Adapter	Nominal Terminal Line-Line Voltage (LLVolt)	
	E87HB	87LP	Disable harmonic blocking (harmblockdisable)	in the "Harmonic blocking" tab page
	87PCT2	87LP	2nd Harmonic Blocking Threshold (H2threshold)	in the "Harmonic blocking" tab page
	87PCT4	87LP	4th Harmonic Blocking Threshold (H2threshold)	in the "Harmonic blocking" tab page
	87PCT5	87LP	5th Harmonic Blocking Threshold (H2threshold)	in the "Harmonic blocking" tab page

3.4 Overcurrent subrelay

The *Overcurrent* subrelay stores the phase, ground and negative sequence inverse time and definite time overcurrent elements.

subsubsectionAvailable Units

- Ten inverse time overcurrent elements with user selectable input quantity (”5101”, ”5102”, ”5103”, ”5104”, ”5105”, ”5106”, ”5107”, ”5108”, ”5109”, and ”5110” block).
- Ten logic blocks selecting the input quantity for the inverse time overcurrent elements (”51O01”, ”51O02”, ”51O03”, ”51O04”, ”51O05”, ”51O06”, ”51O07”, ”51O08”, ”51O09”, and ”51O10” block).
- Four definite time directional phase overcurrent elements(”50/67P1”, ”50/67P2”, ”50/67P3”, and ”50/67P4” block).
- Four definite time directional ground overcurrent elements(”50/67G1”, ”50/67G2”, ”50/67G3”, and ”50/67G4” block).
- Four definite time directional negative sequence overcurrent elements(”50/67Q1”, ”50/67Q2”, ”50/67Q3”, and ”50/67Q4” block).

3.4.1 Functionality

The input quantity used by each inverse time overcurrent element can be set in the relevant logic block (i.e. in the ”51O01” logic block for the ”5101” overcurrent element). The following input quantities can be activated setting equal to ”1” in the ”Logic” tab page the variables listed between brackets.

- Filtered Instantaneous A-Phase Current RMS Magnitude (LIAFIM)
- Filtered Instantaneous B-Phase Current RMS Magnitude (LIBFIM)
- Filtered Instantaneous C-Phase Current RMS Magnitude (LICFIM)
- Filtered Instantaneous Breaker 1 A-Phase Current RMS Magnitude (B1IAFIM)
- Filtered Instantaneous Breaker 1 B-Phase Current RMS Magnitude (B1IBFIM)
- Filtered Instantaneous Breaker 1 C-Phase Current RMS Magnitude (B1ICFIM)
- Filtered Instantaneous Breaker 2 A-Phase Current RMS Magnitude (B2IAFIM)
- Filtered Instantaneous Breaker 2 B-Phase Current RMS Magnitude (B2IBFIM)
- Filtered Instantaneous Breaker 2 C-Phase Current RMS Magnitude (B2ICFIM)
- Positive-sequence instantaneous current RMS magnitude (LI1FIM)
- Negative-sequence instantaneous current RMS magnitude (L3I2FIM)
- Zero-sequence instantaneous current RMS magnitude (LIGFIM)
- Breaker 1 Zero-sequence Instantaneous Current RMS Magnitude (B1IGFIM)
- Breaker 2 Zero-sequence Instantaneous Current RMS Magnitude (B2IGFIM)
- Filtered Instantaneous Maximum Phase Current RMS Magnitude (LIMAXM)

- Breaker 1 Filtered Instantaneous Maximum RMS Phase Current (B1IMAXM)
- Breaker 2 Filtered Instantaneous Maximum RMS Phase Current (B2IMAXM)
- Differential current RMS magnitude, full-cycle cosine filtered, phase A (87IAFM)
- Differential current RMS magnitude, full-cycle cosine filtered, phase B (87IBFM)
- Differential current RMS magnitude, full-cycle cosine filtered, phase C (87ICFM)
- Positive sequence differential current RMS magnitude (87I1FM)
- Negative-sequence differential current (3I2) RMS magnitude, full-cycle cosine filtered (87IQFM)
- Zero-sequence differential current (3I0) RMS magnitude, full-cycle cosine filtered (87IGFM)

The inverse time elements are supporting the following inverse time trip characteristics which comply with the ANSI/IEEE and IEC standard equations:

- 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 an inverse time reset characteristic which can be enabled or disabled by the user.

3.4.2 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[2]	51Oxx[2]	see 3.4.1	In the ”Logic” tab page
	51Pxx[2]	51xx[2]	Current Setting (Ipsetr)	
	51Cxx[2]	51xx[2]	Characteristic(pcharac)	
	51TDxx[2]	51xx[2]	Time Dial (Tpset)	
	51RSxx[2]	51xx[2]	Reset Characteristic (resetdis)	
	51TCxx[2]	Sel Dir	Phase(51P) Torque Control (s51PTC)	Set if IAn or IBn or ICn or IMAXn
		Sel Dir	Phase(51P) Torque Control (s51PTC)	Set if I1L

[2] xx = 1,2,3,4,5,6,7,8,9,10

Address	Relay Setting	Model block	Model setting	Note
		Sel Dir	Negative Sequence(51Q) Torque Control (s51PTC)	Set if 3I2L
		Sel Dir	Residual(51N) Torque Control (s51PTC)	Set if 3I0L
	E50P	50/67P1	Out of Service (outserv)	Active if E50P >0
		50/67P2	Out of Service (outserv)	Active if E50P >1
		50/67P3	Out of Service (outserv)	Active if E50P >2
		50/67P4	Out of Service (outserv)	Active if E50P >3
	50P1P	50/67P1	Pickup Current (Ipsetr)	
	50P2P	50/67P2	Pickup Current (Ipsetr)	
	50P3P	50/67P3	Pickup Current (Ipsetr)	
	50P4P	50/67P4	Pickup Current (Ipsetr)	
	67P1D	50/67P1	Time Setting (cTset)	
	67P2D	50/67P2	Time Setting (cTset)	
	67P3D	50/67P3	Time Setting (cTset)	
	67P4D	50/67P4	Time Setting (cTset)	
	67P1TC	50/67P1	Tripping Direction (idir)	
	67P2TC	50/67P2	Tripping Direction (idir)	
	67P3TC	50/67P3	Tripping Direction (idir)	
	67P4TC	50/67P4	Tripping Direction (idir)	
	E50Q	50/67Q1	Out of Service (outserv)	Active if E50Q >0
		50/67Q2	Out of Service (outserv)	Active if E50Q >1
		50/67Q3	Out of Service (outserv)	Active if E50Q >2
		50/67Q4	Out of Service (outserv)	Active if E50Q >3
	50Q1Q	50/67Q1	Qickup Current (Ipsetr)	
	50Q2Q	50/67Q2	Qickup Current (Ipsetr)	
	50Q3Q	50/67Q3	Qickup Current (Ipsetr)	
	50Q4Q	50/67Q4	Qickup Current (Ipsetr)	
	67Q1D	50/67Q1	Time Setting (cTset)	
	67Q2D	50/67Q2	Time Setting (cTset)	
	67Q3D	50/67Q3	Time Setting (cTset)	
	67Q4D	50/67Q4	Time Setting (cTset)	
	67Q1TC	50/67Q1	Tripping Direction (idir)	
	67Q2TC	50/67Q2	Tripping Direction (idir)	
	67Q3TC	50/67Q3	Tripping Direction (idir)	
	67Q4TC	50/67Q4	Tripping Direction (idir)	
	E50G	50/67G1	Out of Service (outserv)	Active if E50G >0
		50/67G2	Out of Service (outserv)	Active if E50G >1
		50/67G3	Out of Service (outserv)	Active if E50G >2
		50/67G4	Out of Service (outserv)	Active if E50G >3
	50G1G	50/67G1	Gickup Current (Ipsetr)	
	50G2G	50/67G2	Gickup Current (Ipsetr)	
	50G3G	50/67G3	Gickup Current (Ipsetr)	
	50G4G	50/67G4	Gickup Current (Ipsetr)	
	67G1D	50/67G1	Time Setting (cTset)	
	67G2D	50/67G2	Time Setting (cTset)	
	67G3D	50/67G3	Time Setting (cTset)	
	67G4D	50/67G4	Time Setting (cTset)	
	67G1TC	50/67G1	Tripping Direction (idir)	
	67G2TC	50/67G2	Tripping Direction (idir)	
	67G3TC	50/67G3	Tripping Direction (idir)	
	67G4TC	50/67G4	Tripping Direction (idir)	

3.5 Voltage subrelay

The *Voltage* subrelay stores the overvoltage and the undervoltage definite time elements.

3.5.1 Available Units

- Six definite time undervoltage elements with double trip threshold and user selectable input quantity (”271P1”, ”271P2”, ”272P1”, ”272P2”, ”273P1”, ”273P2”, ”274P1”, ”274P2”, ”275P1”, ”275P2”, ”276P1”, and ”276P2” block).
- Six logic blocks selecting the input quantity for the undervoltage elements (”27O1”, ”27O2”, ”27O3”, ”27O4”, ”27O5”, and ”27O6” block).
- Six definite time overvoltage elements with double trip threshold and user selectable input quantity (”591P1”, ”591P2”, ”592P1”, ”592P2”, ”593P1”, ”593P2”, ”594P1”, ”594P2”, ”595P1”, ”595P2”, ”596P1”, ”596P2”, block).
- Six logic blocks selecting the input quantity for the overvoltage elements (”59O1”, ”59O2”, ”59O3”, ”59O4”, ”59O5”, and ”59O6” block).

3.5.2 Functionality

Two blocks simulate the behavior of delayed trip threshold and of the instantaneous trip threshold of the overvoltage or undervoltage elements (i.e. the ”271P1” and the ”271P2” block model the ”27P1P1” and the ”27P1P2” undervoltage element).

The input quantity used by each definite time overvoltage or undervoltage element can be set in the relevant logic block (i.e. in the ”27O1” logic block for the ”271P1” and the ”’271P2’ undervoltage element). The following input quantities can be activated for the undervoltage elements setting equal to ”1” in the ”Logic” tab page the variables listed between brackets.

- A-Phase Filtered instantaneous phase voltage RMS magnitude (VAFIM)
- B-Phase Filtered instantaneous phase voltage RMS magnitude (VBFIM)
- C-Phase Filtered instantaneous phase voltage RMS magnitude (VCFIM)
- Positive-sequence instantaneous voltage RMS magnitude (V1FIM)

The following input quantities can be activated for the overvoltage elements setting equal to ”1” in the ”Logic” tab page the variables listed between brackets.

- A-Phase Filtered instantaneous phase voltage RMS magnitude (VAFIM)
- B-Phase Filtered instantaneous phase voltage RMS magnitude (VBFIM)
- C-Phase Filtered instantaneous phase voltage RMS magnitude (VCFIM)
- Positive-sequence instantaneous voltage RMS magnitude (V1FIM)
- Negative-sequence instantaneous voltage RMS magnitude (_3V2FIM)
- Zero-sequence instantaneous voltage RMS magnitude (_3V0FIM)

3.5.3 Data input

The relationships between the relay settings and the model parameters can be found in the following table:

Address	Relay Setting	Model block	Model setting	Note
	E27	27x[3]P1	Out of Service (outserv)	
		27x[3]P2	Out of Service (outserv)	
	27O[n][4]	27Ox[3]	VAFIM,VBFIM,VCFIM,V1FIM	In the ”Logic” tab page
	27P[k][5]P1	27x[3]P1	Pickup Voltage (Usetr)	
	27P[k][5]P2	27x[3]P2	Pickup Voltage (Usetr)	
	27P[k][5]D1	27x[3]P1	Time Delay (cTdel)	
	E59	59x[3]P1	Out of Service (outserv)	
		59x[3]P2	Out of Service (outserv)	
	59O[n][4]	59Ox[3]	VAFIM,VBFIM,VCFIM,V1FIM, _3V2FIM,_3V0FIM	In the ”Logic” tab page
	59P[k][5]P1	59x[3]P1	Pickup Voltage (Usetr)	
	59P[k][5]P2	59x[3]P2	Pickup Voltage (Usetr)	
	59P[k][5]D1	59x[3]P1	Time Delay (cTdel)	

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

3.6 Frequency subrelay

The *Frequency* subrelay stores the overfrequency and the underfrequency definite time elements.

3.6.1 Available Units

- One undervoltage blocking element (”81UVSP” block).
- Six definite time overfrequency or underfrequency elements (”81D1”, ”81D2”, ”81D2”, ”81D3”, ”81D4”, ”81D5”, and ”81D6” block).

3.6.2 Functionality

Each frequency element can be used as an overfrequency element inserting a frequency trip threshold greater than the system rated frequency or as an underfrequency element setting a frequency trip threshold smaller than the system rated frequency. The frequency elements are blocked by a undervoltage element when the system positive sequence voltage is smaller than the voltage trip threshold. Such threshold is unique for all frequency elements.

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
	E81	81Dx[6]	Out of Service (outserv)	
	81UVSP	81UVSP	Pickup Voltage (Usetr)	
	81D[n[6]]P	81Dx[6]	Frequency (Fset)	
	81D[n[6]]D	81Dx[6]	Time Delay (Tdel)	

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

3.7 Out of Step subrelay

The *Out of Step* subrelay implements the out of step and the power swing detection logic.

3.7.1 Available Units

- Two polygonal zones defining the power swing detection area (”Zone 5” and ”Zone 6” block).
- One minimum current activation threshold (”I supervision” block).
- One power swing and out of step detection element (”Out Of Step” block).
- One timer associated to the out of step trip signal (”OS Time Delay” block).

3.7.2 Functionality

The power swing detection area is defined by two polygonal zones: please notice that one zone (”Zone 6”) contains the second one (”Zone 5”) and no intersection is present between the zones. The power swing condition is declared when the system impedance point is in the area defined between the two polygonal zones for a time greater than an user definable setting (”tP1” in the "Timers" tab of the ”OS Time Delay” element dialog). The power swing block is disabled after 2 seconds. The number of the distance zones blocked by the power swing detector can be configured by the user. The out of step condition is declared when the system impedance point intersects in sequence both the internal and the external polygonal zone. The out of step trip signal can be delayed by an additional timer (”OS Time Delay”).

3.7.3 Data input

The relationships between the relay settings and the model parameters can be found in the following table:

Address	Relay Setting	Model block	Model setting	Note
	EOOS	Out Of Step	Out of Step (ioos)	
	OOSB1	Out Of Step	Blocking Configuration (iblockconf)	Select ”All zones Blocking Configuration” or ”Z1 Blocking Configuration” or ”Z1 & Z2 Blocking Configuration”
	OOSB2	Out Of Step	Blocking Configuration (iblockconf)	Select ”All zones Blocking Configuration” or ”Z1 & Z2 Blocking Configuration” or ”Z2=> Blocking Configuration”
	OOSB3	Out Of Step	Blocking Configuration (iblockconf)	Select ”All zones Blocking Configuration” or ”Z2=> Blocking Configuration”
	OOSB4	Out Of Step	Blocking Configuration (iblockconf)	Select ”All zones Blocking Configuration” or ”Z2=> Blocking Configuration”
	OSBD	Out Of Step	tP1 (TtP1)	In the ”Timer” tab page
	OSTD	OS Time Delay	Time Setting (Tcdelay)	
	X1T6	Zone 6	+X Reach (Xmax)	
	X1B6	Zone 6	-X Reach (Xmin)	
	R1R6	Zone 6	+R Resistance (Rmax)	
	R1L6	Zone 6	-R Resistance (Rmin)	
	X1T7	Zone 7	+X Reach (Xmax)	
	X1B7	Zone 7	-X Reach (Xmin)	
	R1R7	Zone 7	+R Resistance (Rmax)	

Address	Relay Setting	Model block	Model setting	Note
	R1L7	Zone 7	-R Resistance (Rmin)	
	50ABC	I supervision	Pickup Current (Ipsetr)	
	50QUBP	I2 supervision	Pickup Current (Ipsetr)	
	UBD	I2 supervision	Time Setting (cTset)	
	OOSPSC	Out Of Step	OOS, No. of Crossings (iooscrossnum)	

3.8 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.

3.8.1 Available Units and Signals

The trip logic is implemented by the ”Output Logic” block. Sixteen relay output signals are available (”OUT1”, ”OUT2”, ”OUT3” . . . ”OUT16”)

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

The following output signals are available:

- Relaydiff_phase
- Relaydiff_ground
- Relaydiff_negseq

3.8.2 Functionality

The ”Output 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 behavior of the other output signals and the trip logic can be configured in the ”Logic” tab page of the ”Output Logic” block dialog.

The output signal have been conceived to transfer the values of the currents used by the differential feature to an another instance of the SEL 411L relay model. The following signals must be used (i.e. to feed the *External relay 1* signals):

- *Relaydiff_phase* with *External_Relay_1_phase*
- *Relaydiff_ground* with *External_Relay_1_ground*
- *Relaydiff_negseq* with *External_Relay_1_negseq*

3.8.3 Data input

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

4 Features not supported

4.1 Main Relay

The following features are not supported:

- Differential Secure Mode.
- Permissive Overreaching scheme.
- Directional Comparison Unblocking scheme.
- Directional Comparison Blocking scheme.
- Zone 1 extension.
- Remote End Just Opened.
- Switch Onto Fault scheme.
- Positive Sequence Remote Bus Overvoltage element (”59PR” element).
- Polarization ”Non-Homogeneous Correction Angle”.
- Single Pole trip.
- Stub Protection.
- Pole Discordance.
- Breaker Failure.
- Series Compensation.
- Overcurrent element instantaneous not directional pickup.
- Pole Open detection.
- Synchronism check.
- Reclosing feature.

4.2 Out of Step Subrelay

- Negative sequence current unblock.

5 References

[1] Schweitzer Engineering Laboratories, 2350 NE Hopkins Court Pullman, WA USA 99163-5603. *SEL-411L Advanced Line Differential Protection, Automation, and Control System*, 2010.

[2] Schweitzer Engineering Laboratories, 2350 NE Hopkins Court Pullman, WA USA 99163-5603. *SEL-411L Data Sheet Line Current Differential Protection Automation and Control System Date Code 20110628*, 2011.

[3] Schweitzer Engineering Laboratories, 2350 NE Hopkins Court Pullman, WA USA 99163-5603. *SEL-411L Relay Protection and Automation System Instruction Manual 20120228*, 2011.

[4] Schweitzer Engineering Laboratories, 2350 NE Hopkins Court Pullman, WA USA 99163-5603. *SEL-411L Relay Protection and Automation System Instruction Manual Reference Manual 20120228*, 2011.