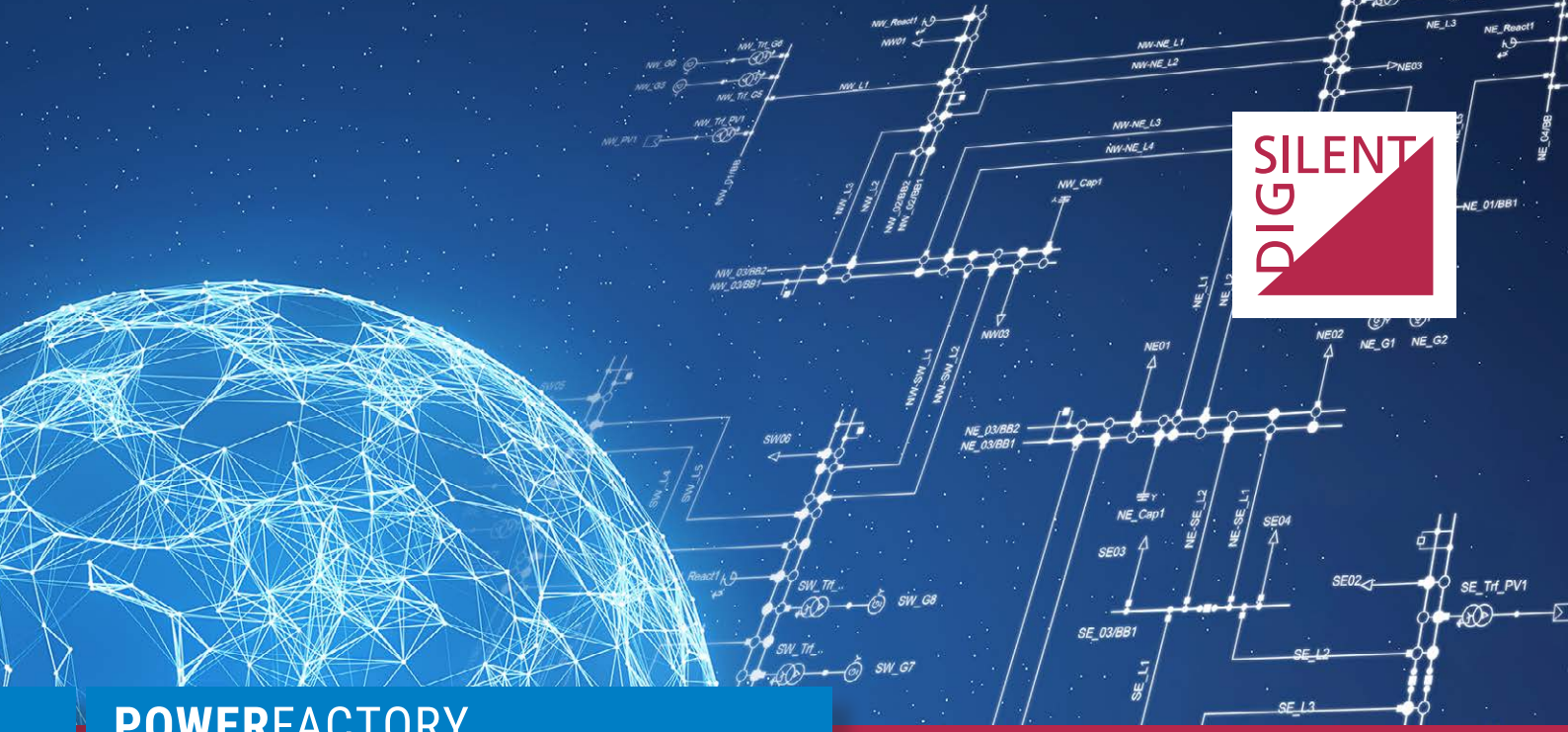

POWERFACTORY

PowerFactory 2021

Technical Reference

SEL 321

PF2021

POWER SYSTEM SOLUTIONS

MADE IN GERMANY

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1 Model information

Manufacturer SEL

Model 321

Variants The SEL 321 PowerFactory relay models can be used to simulate the different firmware versions of the SEL 321 protective relays. The reference firmware version used to implement the model is SEL 321-5-R854 990415 and SEL 321-5-R454 990415. 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 321 relay protects, controls, and monitors EHV, HV, and subtransmission lines. The relay contains all protective elements and control logic to protect any overhead transmission line.

The SEL 321 PowerFactory relay models consist of a main model and a subrelay hosting the out of step logic.

The following model versions are available:

- SEL 321-1A
- SEL 321-5A

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 element for the distance elements, the mho and the polygonal distance elements, a set of timers, the overcurrent elements, the undervoltage and overvoltage elements, 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 voltage and the current are measured by one three phase current transformer (”Ct” block) and one three phase voltage transformer (”Vt” block).

Three measurement units (”M-I/U”, ”M-Iab/Ibc/Ica” and ”Meas RMS seq” block) are fed by this CT and this VT.

3.1.1 Available Units

- One three phase current transformers measuring the phase current (”Ct” block).
- One three phase voltage transformer measuring the phase voltages(”Vt” block).
- One three phase measurement element calculating both the current and voltage values (”M-I/U” block).
- One three phase measurement element calculating the phase to phase currents (”M-Iab/Ibc/Ica” block).
- One three phase measurement element calculating the current and the voltage sequence vectors (”Meas RMS seq” block).

3.1.2 Functionality

The input current and voltage values are sampled at 20 samples/cycle. The 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 ”M-Iab/Ibc/Ica” block calculates the phase-phase current 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 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 321 distance functionalities. The ancillary overcurrent elements and the voltage protective elements are also modeled.

3.2.1 Available Units

- Four phase starting elements (”50PP1”, ”50PP2”, ”50PP3” and ”50PP4” block).
- Four ground starting elements (”50G1/50L1”, ”50G2/50L2”, ”50G3/50L3” and ”50G4/50L4” block)
- Two polarizing elements (”Polarizing” and ”Polarizing 2-3-4” block).
- One load encroachment element (”Load Encroachment” block).
- One directional element (”Sel Dir” block).
- Four mho distance elements for the phase loops (”Z1P”, ”Z2P”, ”Z3P” and ”Z4P” block).
- Three timers associated to the phase mho elements (”Z2PD”, ”Z3PD” and ”Z4PD” block).
- Four mho distance elements for the ground loops (”Z1MG” , ”Z2MG”, ”Z3MG” and ”Z4MG” block).
- Four polygonal distance elements for the ground loops (”Ph-Q1” , ”Ph-Q2”, ”Ph-Q3” and ”Ph-Q4” block).
- Three timers associated to the ground polygonal and mho elements (”Z2GD”, ”Z3GD” and ”Z4GD” block).
- One inverse time directional phase overcurrent element (”51P” block).
- One inverse time directional ground overcurrent element (”51N” block).
- Four definite time directional ground overcurrent element (”50/67N1”, ”50/67N2”, ”50/67N3” and ”50/67N4” block).
- One inverse time directional negative sequence overcurrent element (”51Q” block).
- Four definite time directional negative sequence overcurrent element (”50/67Q1”, ”50/67Q2”, ”50/67Q3” and ”50/67Q4” block).
- One definite time phase-phase overvoltage element (”59L” block).
- One definite time positive sequence overvoltage element (”59B” block).
- One definite time phase-phase undervoltage element (”27L” block).
- One definite time residual overvoltage element (”59N” block).

3.2.2 Functionality

Overcurrent starting elements Separated set of overcurrent starting elements are available for the phase-phase and for the phase-ground loops. An overcurrent starting element is available for each distance zone. The phase-ground loop starting elements have both a ground and a phase current threshold.

Directional elements The directional element simulate in detail the SEL 321 negative sequence direction detection logic. The direction of the four distance elements and of the overcurrent elements must be set in the directional element dialog. For each inverse time overcurrent element the full set of available direction logics is present:

51P

- M2P (direction controlled by the Zone 2 phase distance element)
- N

51N

- 32QF
- 32QR
- Z2G (direction controlled by the Zone 2 ground distance elements)
- N

51Q

- 32QF
- 32QR
- M2P (direction controlled by the Zone 2 phase distance element)
- Z2G (direction controlled by the Zone 2 ground distance elements)
- N

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” block) and for the other zones (”Polarizing 2-3-4” block).

Mho elements Separated sets 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. The phase mho elements can be blocked by the load encroachment element when the system impedance is in the load encroachment zone.

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.

Overcurrent The inverse time elements (”51P”, ”51N” and ”51Q” block) are supporting 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
- U1 - U.S. Moderately Inverse
- U2 - U.S. Inverse
- U3 - U.S. Very Inverse
- U4 - U.S. Extremly Inverse

The inverse time element trip characteristic equations comply with the IEC and ANSI standard equations.

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
	50PP1	50PP1	Current I>> (Ip2)	
	50PP2	50PP2	Current I>> (Ip2)	
	50PP3	50PP3	Current I>> (Ip2)	
	50PP4	50PP4	Current I>> (Ip2)	
	50L1	50G1/50L1	Current I>> (Ip2)	
	50L2	50G2/50L2	Current I>> (Ip2)	
	50L3	50G3/50L3	Current I>> (Ip2)	
	50L4	50G4/50L4	Current I>> (Ip2)	
	50G1	50G1/50L1	Current, 3*I0 (Ie)	
	50G2	50G2/50L2	Current, 3*I0 (Ie)	
	50G3	50G3/50L3	Current, 3*I0 (Ie)	
	50G4	50G4/50L4	Current, 3*I0 (Ie)	

Polarizing element :

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

Address	Relay Setting	Model block	Model setting	Note
	k0M	Polarizing 2-3-4	k0 (k0)	
	k0A	Polarizing 2-3-4	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)	
	Z1P	Z1P	Replica Impedance (Zm)	
	Z2P	Z2P	Replica Impedance (Zm)	
	Z3P	Z3P	Replica Impedance (Zm)	
	Z4P	Z4P	Replica Impedance (Zm)	
	GMHOZ	Z1MG	Out of Service (outserv)	
		Z2MG	Out of Service (outserv)	
		Z3MG	Out of Service (outserv)	
		Z4MG	Out of Service (outserv)	
	Z1MG	Z1MG	Replica Impedance (Zm)	
	Z2MG	Z2MG	Replica Impedance (Zm)	
	Z3MG	Z3MG	Replica Impedance (Zm)	
	Z4MG	Z4MG	Replica Impedance (Zm)	
	Positive-Seq.Line Impedance Angle	Z1P	Relay angle (phi)	
		Z2P	Relay angle (phi)	
		Z3P	Relay angle (phi)	
		Z4P	Relay angle (phi)	
	Zero-Seq.Line Impedance Angle	Z1MG	Relay angle (phi)	
		Z2MG	Relay angle (phi)	
		Z3MG	Relay angle (phi)	
		Z4MG	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)	
	XG1	Ph-Q1	+X Reach (Xmax)	
	XG2	Ph-Q2	+X Reach (Xmax)	
	XG3	Ph-Q3	+X Reach (Xmax)	
	XG4	Ph-Q4	+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)	
	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)	

Timers :

Address	Relay Setting	Model block	Model setting	Note
	Z2PD	Z2PD	Time Setting (Tcdelay)	
	Z3PD	Z3PD	Time Setting (Tcdelay)	
	Z4PD	Z4PD	Time Setting (Tcdelay)	
	Z2GD	Z2GD	Time Setting (Tcdelay)	
	Z3GD	Z3GD	Time Setting (Tcdelay)	
	Z4GD	Z4GD	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
	DIR1	Sel Dir	Level 1 direction (DIR1)	In the ”Basic settings" tab page
	DIR2	Sel Dir	Level 2 direction (DIR1)	In the ”Basic settings" tab page
	DIR3	Sel Dir	Level 3 direction (DIR1)	In the ”Basic settings" tab page
	DIR4	Sel Dir	Level 4 direction (DIR1)	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
	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

Overcurrent :

Address	Relay Setting	Model block	Model setting	Note
	E51P	51P	Out of Service (outserv)	
	51PP	51P	Current Setting (Ipsetr)	
	51PC	51P	Characteristic(pcharac)	
	51PTD	51P	Time Dial (Tpset)	
	51PTC	Sel Dir	Phase(51P) Torque Control (s51PTC)	
	E51N	51N	Out of Service (outserv)	
	51NP	51N	Current Setting (Ipsetr)	
	51NC	51N	Characteristic(pcharac)	
	51NTD	51N	Time Dial (Tpset)	
	51NTC	Sel Dir	Residual(51N) Torque Control (s51PTC)	
	E51Q	51Q	Out of Service (outserv)	
	51QP	51Q	Current Setting (Ipsetr)	

Address	Relay Setting	Model block	Model setting	Note
	51QC	51Q	Characteristic(pcharac)	
	51QTD	51Q	Time Dial (Tpset)	
	51QTC	Sel Dir	Negative Sequence(51Q) Torque Control (s51PTC)	
	E50N	50/67N1	Out of Service (outserv)	
		50/67N2	Out of Service (outserv)	
		50/67N3	Out of Service (outserv)	
		50/67N4	Out of Service (outserv)	
	50N1	50/67N1	Pickup Current (Ipsetr)	
	50N2	50/67N2	Pickup Current (Ipsetr)	
	50N3	50/67N3	Pickup Current (Ipsetr)	
	50N4	50/67N4	Pickup Current (Ipsetr)	
	E50Q	50/67Q1	Out of Service (outserv)	
		50/67Q2	Out of Service (outserv)	
		50/67Q3	Out of Service (outserv)	
		50/67Q4	Out of Service (outserv)	
	50Q1	50/67Q1	Pickup Current (Ipsetr)	
	50Q2	50/67Q2	Pickup Current (Ipsetr)	
	50Q3	50/67Q3	Pickup Current (Ipsetr)	
	50Q4	50/67Q4	Pickup Current (Ipsetr)	
	67NL1D	50/67N1	Time Setting (cTset)	
	67NL2D	50/67N2	Time Setting (cTset)	
	67NL3D	50/67N3	Time Setting (cTset)	
	67NL4D	50/67N4	Time Setting (cTset)	
	67QL1D	50/67Q1	Time Setting (cTset)	
	67QL2D	50/67Q2	Time Setting (cTset)	
	67QL3D	50/67Q3	Time Setting (cTset)	
	67QL4D	50/67Q4	Time Setting (cTset)	

Voltage :

Address	Relay Setting	Model block	Model setting	Note
	EVOLT	59L	Out of Service (outserv)	
		59B	Out of Service (outserv)	
		27L	Out of Service (outserv)	
		59N	Out of Service (outserv)	
	59N	59N	Pickup Voltage (Usetr)	
	27L	27L	Pickup Voltage (Usetr)	
	59L	59L	Pickup Voltage (Usetr)	
	59PB	59PB	Pickup Voltage (Usetr)	
	59PBD	59PBD	Time Delay (cTdel)	

3.3 Out of Step subrelay

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

3.3.1 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).

3.3.2 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”).

3.3.3 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)	
	X1T5	Zone 5	+X Reach (Xmax)	
	X1B5	Zone 5	-X Reach (Xmin)	
	R1R5	Zone 5	+R Resistance (Rmax)	
	R1L5	Zone 5	-R Resistance (Rmin)	
	X1T6	Zone 6	+X Reach (Xmax)	
	X1B6	Zone 6	-X Reach (Xmin)	
	R1R6	Zone 6	+R Resistance (Rmax)	

Address	Relay Setting	Model block	Model setting	Note
	R1L6 50ABC	Zone 6 I supervision	-R Resistance (Rmin) Pickup Current (Ipsetr)	

3.4 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.

3.4.1 Available Units and Signals

The trip logic is implemented by the "Logic" block. Twenty two relay output signals are available (”OUT1”, ”OUT2”, ”OUT3” . . . ”OUT22”)

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

3.4.2 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.

3.4.3 Data input

Please disable the ”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:

- Permissive Overreaching scheme.
- Directional Comparison Unblocking scheme.
- Directional Comparison Blocking scheme.
- Zone 1 extension.
- Remote End Just Opened.
- Switch Onto Fault.
- Positive Sequence Remote Bus Overvoltage element (”59PR” element).
- Polarization ”Non-Homogeneous Correction Angle”.
- Single Pole trip.
- Stub Protection.
- Pole Discordance.

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-321-5 PHASE AND GROUND DISTANCE RELAY DIRECTIONAL OVERCURRENT RELAY FAULT LOCATOR INSTRUCTION MANUAL*, February 2001.

[2] SCHWEITZER ENGINEERING LABORATORIES, 2350 NE HOPKINS COURT PULLMAN, WA USA 99163-5603. *SEL-321 Data Sheet*, February 2001.