



POWERFACTORY

PowerFactory 2021

Technical Reference

SEL 351R

PF2021

POWER SYSTEM SOLUTIONS
MADE IN GERMANY

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1 Model information

Manufacturer SEL

Model 351R

Variants The SEL 351R PowerFactory relay model can be used to simulate the different firmware versions of the SEL 351R protective relays. The reference firmware version used to implement the model is SEL-351R-2-R300-V0-Z003003-D20020131. 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 351R relay includes phase, negative-sequence, residual, and neutral overcurrent elements. Each element type has six levels of instantaneous protection (four of these levels with definite-time functions). Each element type has a time-overcurrent element (phase elements include a maximum-phase time-overcurrent element and single-phase time-overcurrent elements). Directional control is provided for each of these overcurrent elements.

The SEL 351R PowerFactory relay model consists of a monolithic scheme.

Only the model version for the relay with 1 A secondary rated current is available and is listed as *SEL 351R-1A*.

The relay model has been implemented trying to simulate the most commonly used protective functions.

The relay model contains the measurement and acquisition units, an accurate model of the directional element, the phase, negative sequence, zero sequence and neutral overcurrent elements, the voltage elements and the frequency elements, the output logic. The overcurrent elements can be set to trigger a reclosing procedure.

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 one three phase current transformer ("Ct" block), one single phase current transformer ("CoreCt" block) and one three phase voltage transformer ("Vt" block).

Five measurement units ("MeasU-I", "Meas Delta", "Measurement seq", "Meas Neutral I" and "Meas Freq" block) are fed by these CTs and this VT.

3.1.1 Available Units

- One three phase current transformers measuring the phase current ("Ct" block).
- One single phase current transformers measuring the neutral current ("CoreCt" block).
- One three phase voltage transformer measuring the phase voltages("Vt" block).
- One three phase measurement element calculating both the current and voltage values ("Measurement" block).
- One three phase measurement element calculating the phase to phase currents and voltages ("Mea Idelta" block).
- One three phase measurement element calculating the current and the voltage sequence vectors ("Measurement seq" block).
- One single phase measurement element calculating the neutral current value ("Meas Neutral I" block).
- One frequency measurement element ("Meas Freq" 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 "Mea Idelta" block calculates the phase-phase current values monitored by the phase-phase voltage elements and the phase-phase current values monitored by the overcurrent elements.

The "Meas Freq" measures the frequency using a selectable voltage; by default the phase a - phase b voltage is used.

3.1.3 Data input

No user input is required.

3.2 Main Relay protective elements

The overcurrent elements, the directional element and the recloser elements are working together to simulate the SEL 351R protection functionalities. The ancillary voltage and frequency elements are also modeled.

3.2.1 Available Units

- Two inverse time directional 3phase overcurrent elements ("51P1" and "51P2" block).
- Four definite time directional 3phase overcurrent elements ("67P1", "67P2", "67P3" and "67P4" block).
- Two instantaneous 3phase overcurrent elements ("50P5" and "50P6" block).
- Four instantaneous directional 3phase phase-phase overcurrent elements ("50PP1", "50PP2", "50PP3" and "50PP4" block).
- Two inverse time directional ground overcurrent elements ("51G1" and "51G2" block).
- Four definite time directional ground overcurrent elements ("67G1", "67G2", "67G3" and "67G4" block).
- Two instantaneous ground overcurrent elements ("50G5" and "50G6" block).
- Two inverse time directional neutral overcurrent elements ("51N1" and "51N2" block).
- Four definite time directional neutral overcurrent elements ("67G1", "67G2", "67G3" and "67G4" block).
- Two instantaneous neutral overcurrent elements ("50G5" and "50G6" block).
- One inverse time directional negative sequence overcurrent element ("51Q" block).
- Four definite time directional negative sequence overcurrent elements ("67Q1", "67Q2", "67Q3" and "67Q4" block).
- Two instantaneous negative sequence overcurrent elements ("50Q5" and "50Q6" block).
- One definite time phase-phase overvoltage elements ("59PP" block).
- One definite time phase-phase undervoltage elements ("27PP" block).
- One definite time positive sequence overvoltage element ("59V1" block).
- One definite time negative sequence overvoltage element ("59Q" block).
- Two definite time residual overvoltage elements ("59N1" and "59N2" block).
- Two definite time phase-ground overvoltage elements ("59P1" and "59P2" block).
- Two definite time phase-ground undervoltage elements ("27P1" and "27P2" block).
- Six over/under frequency elements ("81D1", "81D2", "81D3", "81D4", "81D5" and "81D6" block).
- One directional element ("Sel Dir" block).
- Two reclosing elements ("Phase reclogic" and "Ground reclogic" block)

3.2.2 Functionality

Directional element The directional element simulate in detail the SEL 351R negative sequence, ground and phase direction detection logic. The direction of the overcurrent elements must be set in the directional element dialog, four directional *levels* can be set. The ground directional priority feature is supported.

The "Loss of potential" logic is also supported.

Overcurrent The inverse time elements ("51P1", "51P2", "51N1", "51N2", "51G1", "51G2" 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
- C5 - IEC Short Time Inverse
- U1 - U.S. Moderately Inverse
- U2 - U.S. Inverse
- U3 - U.S. Very Inverse
- U4 - U.S. Extremely Inverse
- U5 - U.S. Short Time Inverse
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- 102
- 103
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- 107
- 111
- 112
- 113
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- 165

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

The overcurrent element direction is controlled by the directional element ("SelDir" block). Please notice that the following directional control logic has been used in the model:

- *Level 1 direction:* inverse time elements, phase single phase elements, "67P1", "67G1", "67N1", "67Q1", "50PP1".
- *Level 2 direction:* "67P2", "67G2", "67N2", "67Q2", "50PP2".
- *Level 3 direction:* "67P3", "67G3", "67N3", "67Q3", "50PP3".
- *Level 4 direction:* "67P4", "67G4", "67N4", "67Q4", "50PP4".

Reclosing feature Two recloser elements are available:

- the *Phase reclogic* element is controlling the phase inverse and definite time elements ("51P1", "51P2", "50/67P1", "50/67P2", "50/67P3", "50/67P4", "50P5" and "50P6" block).
- the *Ground reclogic* element is controlling the ground and the neutral inverse and definite time elements ("51G1", "51G2", "50/67G1", "50/67G2", "50/67G3", "50/67G4", "50G5", "50G6", "51G1", "51G2", "50/67N1", "50/67N2", "50/67N3", "50/67N4", "50N5" and "50N6" block).

Different *Open Interval times* can be inserted for each reclosing attempt. The reclosing logic can be defined in the "Logic" tab page. Different logics are present for each inverse time element and for the whole set of definite time elements.

The *Sequnec Coordination* feature is also available.

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):

Directional element ("Sel Dir") :

Address	Relay Setting	Model block	Model setting	Note
	3PVOLT	Sel Dir	True 3-Phase voltage connected 3PVOLT (s3PVOLT)	In the "Basic settings" tab page
	ORDER	Sel Dir	Ground directional element priority(ORDER)	In the "Basic settings" tab page
	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

3 Supported features

Address	Relay Setting	Model block	Model setting	Note
	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
	50P32P	Sel Dir	Phase directional element 3-phase pickup 50P32P (s50P32P)	In the "Phase" tab page
	50LP	Sel Dir	Load Detection phase pickup 50LP (s50LP)	In the "Ground" tab page
	E32IV	Sel Dir	Ground directional element enabling flag E32IV (E32IV)	In the "Ground" tab page

Overcurrent :

Address	Relay Setting	Model block	Model setting	Note
	E51P	51P1	Out of Service (outserv)	
		51P2	Out of Service (outserv)	
	51P1P	51P1	Current Setting (Ipsetr)	
	51P1C	51P1	Characteristic(pcharac)	
	51P1TD	51P1	Time Dial (Tpset)	
	51P1CT	51P1	Time Adder (cTadder)	
	51P1MR	51P1	Min. Response Time (cminresptime)	
	51P2P	51P2	Current Setting (Ipsetr)	
	51P2C	51P2	Characteristic(pcharac)	
	51P2TD	51P2	Time Dial (Tpset)	
	51P2CT	51P2	Time Adder (cTadder)	
	51P2MR	51P2	Min. Response Time (cminresptime)	
	E51G	51G1	Out of Service (outserv)	
		51G2	Out of Service (outserv)	
	51G1P	51G1	Current Setting (Ipsetr)	
	51G1C	51G1	Characteristic(pcharac)	
	51G1TD	51G1	Time Dial (Tpset)	
	51G1CT	51G1	Time Adder (cTadder)	
	51G1MR	51G1	Min. Response Time (cminresptime)	
	51G2P	51G2	Current Setting (Ipsetr)	
	51G2C	51G2	Characteristic(pcharac)	
	51G2TD	51G2	Time Dial (Tpset)	
	51G2CT	51G2	Time Adder (cTadder)	
	51G2MR	51G2	Min. Response Time (cminresptime)	
	E51N	51N1	Out of Service (outserv)	
		51N2	Out of Service (outserv)	
	51N1P	51N1	Current Setting (Ipsetr)	
	51N1C	51N1	Characteristic(pcharac)	
	51N1TD	51N1	Time Dial (Tpset)	
	51N1CT	51N1	Time Adder (cTadder)	
	51N1MR	51N1	Min. Response Time (cminresptime)	
	51N2P	51N2	Current Setting (Ipsetr)	
	51N2C	51N2	Characteristic(pcharac)	
	51N2TD	51N2	Time Dial (Tpset)	

3 Supported features

Address	Relay Setting	Model block	Model setting	Note
	51N2CT	51N2	Time Adder (cTadder)	
	51N2MR	51N2	Min. Response Time (cminresptime)	
	E51Q	51Q	Out of Service (outserv)	
	51QP	51Q	Current Setting (Ipsetr)	
	51QC	51Q	Characteristic(pcharac)	
	51QTD	51Q	Time Dial (Tpset)	
	E50P	67P1	Out of Service (outserv)	
		67P2	Out of Service (outserv)	
		67P3	Out of Service (outserv)	
		67P4	Out of Service (outserv)	
		50P5	Out of Service (outserv)	
		50P6	Out of Service (outserv)	
	50P1P	67P1	Pickup Current (Ipsetr)	
	50P2P	67P2	Pickup Current (Ipsetr)	
	50P3P	67P3	Pickup Current (Ipsetr)	
	50P4P	67P4	Pickup Current (Ipsetr)	
	50P5P	50P5	Pickup Current (Ipsetr)	
	50P6P	50P6	Pickup Current (Ipsetr)	
	67P1D	67P1	Time Setting (cTset)	
	67P2D	67P2	Time Setting (cTset)	
	67P3D	67P3	Time Setting (cTset)	
	67P4D	67P4	Time Setting (cTset)	
	E50N	67N1	Out of Service (outserv)	
		67N2	Out of Service (outserv)	
		67N3	Out of Service (outserv)	
		67N4	Out of Service (outserv)	
		50N5	Out of Service (outserv)	
		50N6	Out of Service (outserv)	
	50N1P	67N1	Pickup Current (Ipsetr)	
	50N2P	67N2	Pickup Current (Ipsetr)	
	50N3P	67N3	Pickup Current (Ipsetr)	
	50N4P	67N4	Pickup Current (Ipsetr)	
	50N5P	50N5	Pickup Current (Ipsetr)	
	50N6P	50N6	Pickup Current (Ipsetr)	
	67N1D	67N1	Time Setting (cTset)	
	67N2D	67N2	Time Setting (cTset)	
	67N3D	67N3	Time Setting (cTset)	
	67N4D	67N4	Time Setting (cTset)	
	E50G	67G1	Out of Service (outserv)	
		67G2	Out of Service (outserv)	
		67G3	Out of Service (outserv)	
		67G4	Out of Service (outserv)	
		50G5	Out of Service (outserv)	
		50G6	Out of Service (outserv)	
	50G1P	67G1	Pickup Current (Ipsetr)	
	50G2P	67G2	Pickup Current (Ipsetr)	
	50G3P	67G3	Pickup Current (Ipsetr)	
	50G4P	67G4	Pickup Current (Ipsetr)	
	50G5P	50G5	Pickup Current (Ipsetr)	
	50G6P	50G6	Pickup Current (Ipsetr)	
	67G1D	67G1	Time Setting (cTset)	
	67G2D	67G2	Time Setting (cTset)	
	67G3D	67G3	Time Setting (cTset)	
	67G4D	67G4	Time Setting (cTset)	
	E50Q	67Q1	Out of Service (outserv)	

3 Supported features

Address	Relay Setting	Model block	Model setting	Note
		67Q2	Out of Service (outserv)	
		67Q3	Out of Service (outserv)	
		67Q4	Out of Service (outserv)	
		50Q5	Out of Service (outserv)	
		50Q6	Out of Service (outserv)	
	50Q1P	67Q1	Pickup Current (Ipsetr)	
	50Q2P	67Q2	Pickup Current (Ipsetr)	
	50Q3P	67Q3	Pickup Current (Ipsetr)	
	50Q4P	67Q4	Pickup Current (Ipsetr)	
	50Q5P	50Q5	Pickup Current (Ipsetr)	
	50Q6P	50Q6	Pickup Current (Ipsetr)	
	67Q1D	67Q1	Time Setting (cTset)	
	67Q2D	67Q2	Time Setting (cTset)	
	67Q3D	67Q3	Time Setting (cTset)	
	67Q4D	67Q4	Time Setting (cTset)	

Voltage :

Address	Relay Setting	Model block	Model setting	Note
	EVOLT	59N1	Out of Service (outserv)	
		59N2	Out of Service (outserv)	
		59Q	Out of Service (outserv)	
		59V1	Out of Service (outserv)	
		27PP	Out of Service (outserv)	
		59PP	Out of Service (outserv)	
		27P1	Out of Service (outserv)	
		27P2	Out of Service (outserv)	
		59P1	Out of Service (outserv)	
		59P2	Out of Service (outserv)	
	59N1	59N1	Pickup Voltage (Usetr)	
	59N2	59N2	Pickup Voltage (Usetr)	
	59Q	59Q	Pickup Voltage (Usetr)	
	59V1	59V1	Pickup Voltage (Usetr)	
	27PP	27PP	Pickup Voltage (Usetr)	
	59PP	59PP	Pickup Voltage (Usetr)	
	27P1	27P1	Pickup Voltage (Usetr)	
	27P2	27P2	Pickup Voltage (Usetr)	
	59P1	59P1	Pickup Voltage (Usetr)	
	59P2	59P2	Pickup Voltage (Usetr)	

Frequency :

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)	
	81D1	81D1	Frequency (Fset)	
	81D1	81D1	Time Delay (cTdel)	
	81D2	81D2	Frequency (Fset)	
	81D2	81D2	Time Delay (cTdel)	

3 Supported features

Address	Relay Setting	Model block	Model setting	Note
	81D3	81D3	Frequency (Fset)	
	81D3	81D3	Time Delay (cTdel)	
	81D4	81D4	Frequency (Fset)	
	81D4	81D4	Time Delay (cTdel)	
	81D5	81D5	Frequency (Fset)	
	81D5	81D5	Time Delay (cTdel)	
	81D6	81D6	Frequency (Fset)	
	81D6	81D6	Time Delay (cTdel)	

Reclosing feature :

Address	Relay Setting	Model block	Model setting	Note
	E79	Phase reclogic	Out of Service (outserv)	
		Ground reclogic	Out of Service (outserv)	
	OPLKPH	Phase reclogic	Operations to lockout (oplockout)	
	OPLKGR	Ground reclogic	Operations to lockout (oplockout)	
	79OI1	Phase reclogic	Reclosing interval 1 (crecltime1)	
		Ground reclogic	Reclosing interval 1 (crecltime1)	
	79OI2	Phase reclogic	Reclosing interval 2 (crecltime2)	
		Ground reclogic	Reclosing interval 2 (crecltime2)	
	79OI3	Phase reclogic	Reclosing interval 3 (crecltime3)	
		Ground reclogic	Reclosing interval 3 (crecltime3)	
	79OI4	Phase reclogic	Reclosing interval 4 (crecltime4)	
		Ground reclogic	Reclosing interval 4 (crecltime4)	
	79RSD	Phase reclogic	Reset Time (cresetime)	
	79SEQ	Phase reclogic	Sequence Coordination (seqaccessory)	

3.3 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.

3.3.1 Available Units and Signals

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

3.3.2 Functionality

The "Logic" block operates the power breaker when a trip command has been issued by any protective element. The "Closing logic" block closes the power breaker when one of the recloser block triggers a reclosing attempt. The block output signal used to operate the breaker is "OUT1". By default the output logic sets other trip signals equal to the no trip value ("NOTRIP" macro) . The behavior of the output signals, the trip logic and any special logic implemented in the relay by a SELOGIC control equation can be configured in the "Logic" tab page of the "Logic" block dialog.

3.3.3 Data input

Please disable the "Logic" block to disable the relay model ability to open the power circuit. The reclosing process can be disabled putting out of service the "Closing logic" block.

4 Features not supported

The following features are not supported:

- Inverse characteristics electromechanical reset.
- Frequency phase undervoltage block.
- Switch onto fault.
- POTT Trip Scheme.
- Additional DCUB Trip Scheme.
- DCB Trip Scheme.
- Power Elements.
- Voltage Sag/Swell/Interrupt.
- Load encroachment.

5 References

- [1] SCHWEITZER ENGINEERING LABORATORIES, 2350 NE HOPKINS COURT PULLMAN, WA USA 99163-5603. *SEL-351R RECLOSER CONTROL INSTRUCTION MANUAL 20020215*, February 2002.