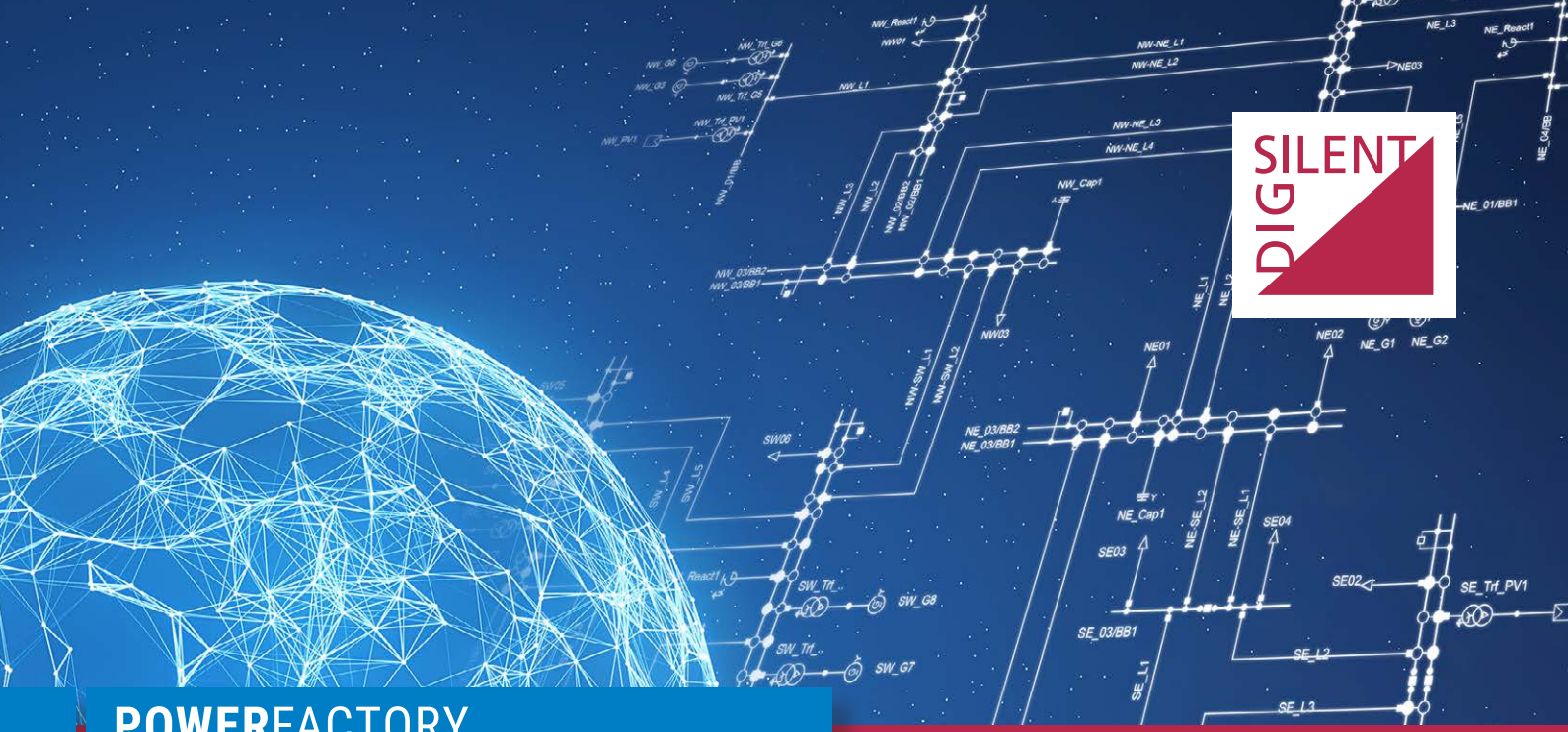

POWERFACTORY

PowerFactory 2021

Technical Reference

Siemens 7SA513

PF2021

POWER SYSTEM SOLUTIONS

MADE IN GERMANY

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Contents

1 Model information

Manufacturer Siemens

Model 7SA513

Variants The Siemens 7SA513 PowerFactory relay models can be used to simulate any version of the Siemens 7SA513 relay. However please consider that the models have been implemented with the features available in the V3.2/V3.3 firmware version.

2 General description

The Siemens 7SA513 line distance protection terminal is a protective relay for EHV line distance protection applications. Additional protection functionality includes phase overcurrent, residual current and out of step functions.

The Siemens 7SA513 PowerFactory relay model consists of a monolithic scheme. Four model versions are available. Two model versions can be used to simulate the Siemens 7SA513 relays with special features to protect EHV series compensated lines and two versions can be used to simulate the relays for normal EHV lines. In each set of models a model for each available rated current is present. The following model versions are available

- 7SA513 1A
- 7SA513 5A
- 7SA513 SC 1A (version for series compensated line)
- 7SA513 SC 5A (version for series compensated line)

The Siemens 7SA513 PowerFactory relay models have been implemented to simulate the most commonly used protective functions.

The main relay contains the measurement and acquisition units, the starting element, the polarizing element(s), the distance elements, the directional element for the distance elements, the overcurrent elements and the output logic.

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

3 Features supported

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).
Two measurement units (”Measure” and ”Delta Measure” block) are fed by this CT and this VT.

An additional three phase/single phase current transformer (”Ct-Mutual” block) measures the zero sequence current contribution coming from a nearby line and feeds a separate measuring unit (”MeasI0mut” block).

One relay input signal (’yExt”) is present and can be used to implement a Permissive Underreach Transfer Trip logic (”PUTT”).

3.1.1 Available Units and Input Signals

- One three phase current transformer (”Ct” block).
- One three phase voltage transformer (”Vt” block).
- One three phase/single phase current transformer (”Ct-Mutual” block).
- One three phase measurement block calculating both the phase and voltage angle and magnitude (”Measurement” block).
- One three phase measurement block calculating the phase to phase. currents and the phase to phase voltages (”Delta Measure” block).
- One single phase measurement block calculating the mutual zero sequence current (”MeasI0mut” block).
- One relay input signal (”’yExt” signal).

3.1.2 Functionality

The input signals are sampled at 80 samples/cycle; for each signal the average values are calculated using groups of 4 samples. The average values are processed by a DFT filter operating over a cycle which then calculates the voltage and current values used by the protective elements.

The ”Delta Measure” block calculates the current and voltage ph-ph values used by the phase loop distance elements.

3.1.3 Data input

The nominal current and the nominal voltage values MUST be entered in all the measurement blocks.

3.2 Main Relay protective elements

The starting element, the polarizing element, the directional element, the reclosing feature and the distance elements work together to simulate the Siemens 7SA513 distance functionalities. The distance elements can be controlled by the reclosing feature. Additionally some ancillary overcurrent elements are also available.

3.2.1 Available Units

- One starting element implementing the fault detection logic (”Starting” block)
- One directional element (”Dir-Z” block).
- One polarizing element (”Polarizing” block).
- One polarizing block acting as delay (”ZPol15” block, only in the models for no compensated lines).
- Four distance trip zones processing both the phase and the ground loop impedances(”Z1”, ”Z2”, ”Z3” and ”Z1b” block)
- Four timers associated with the distance trip zones (”ZT1”, ”ZT2”, ”ZT3” and ”ZT1b” block)
- Two additional timers driven by the starting element (”ZT4” and ”T5” block)
- One inverse time phase overcurrent element (”I>” block)
- One define time phase overcurrent element (”I>>” block)
- One inverse time earth current element (”IE>” block)
- One define time earth current element (”IE>>” block)
- One reclosing element (”Reclosing” block)

3.2.2 Functionality

Starting element The Siemens 7SA513 relay model starting element simulates the relay fault detection function and can be set to use one of the following criteria:

- Overcurrent fault detection (*Overcurrent I>>* option)
- Voltage controlled fault detection (*Underimpedance U/I* option)
- Impedance fault detection (*Impedance Z* option)
- Underimpedance U/I/ϕ

Separate settings are available for the earth fault detection (*Earth Fault detection* tab page). Loop determination rules can be set with different settings for *Earthed Networks* and for *Non-Earthed Networks*.

Directional element The directional element is based on the polarizing voltages calculated by the polarizing block(s) and on the phase currents. The 3 phase loops and the 3 ground loops are evaluated separately.

The directional element uses the positive-sequence voltage for the respective fault loops.

Polarizing elements The polarizing element calculates the voltage vectors used by the distance elements and directional element, taking account of the zero sequence current and of the *Earth Factor*. The operating current vectors are calculated using the mutual current contribution and the *Mutual Earth Factor*.

EHV normal line model version Two polarizing blocks are available: ”Polarizing” calculates the actual positive sequence voltage, ”ZPol15”works as a circular buffer storing the positive sequence voltage calculated during the last 400 ms and returning the positive sequence voltage calculated 400 ms before as output. In any case ”Polarizing” is configured to calculate the polarizing voltage using a voltage memory which stores the voltage values sampled during the last 400 ms when the input voltage drops below 4% Un. The two positive sequence voltages returned by ”Polarizing” and by ”ZPol15” are combined by the ”Poladder” block: the output polarizing voltage is the sum of 85% of the actual positive sequence voltage and of 15% of the positive voltage calculated 400 ms before.

EHV series compensated line model version One polarizing block is present: ”Polarizing” calculates the actual positive sequence voltage acting as a circular buffer, storing the positive sequence voltage calculated during the last 400 ms and returning the positive sequence voltage calculated 400 ms before as output. This is done to improve the stability of the fault direction detection after the fault.

Distance trip zones The polygonal distance elements monitor both the phase and the ground loops; each loop is evaluated separately. All distance elements are directional and the direction can be set for each distance element. Independent timers are available for each distance element.

The ”Z1b” block can be used to implement an acceleration trip zone (the ”Reclosing” block should be set to enable the ”Z1b” element only during the first trip operation)

Reclosing element The reclosing element can be set to trigger a variable number of reclosing attempts. Different dead times during the first reclosing attempt can be set depending upon the type of fault (single phase-earth fault or other types of fault). Different dead times can be set for the first reclosing attempt and for the following attempts.

Overcurrent elements Some ancillary overcurrent elements have been implemented in the model to simulate the two phase overcurrent elements and the two earth overcurrent elements. The fuse failure feature is modeled using a three phase undervoltage element (”Fuse failure voltage threshold” block): the time defined ground overcurrent element and the phase overcurrent elements can be blocked when any phase voltage is smaller then a given threshold.

The phase inverse time element (”I>” block) supports the following inverse characteristics:

- extremely inverse
- inverse
- very inverse
- Definite

The earth fault inverse time element (”High resistence IE>” block) supports the following inverse characteristics:

- extremely inverse
- inverse
- very inverse

All the inverse time element trip characteristic equations comply with the IEC 60255-3 standards.

Additional timers The ”ZT4” and the ”T5” timer can be used to trigger a delayed backup trip. These are started after a fault has been detected by the starting element.The trip logic implemented by ”ZT4” is controlled by the directional element: the fault must be detected in the direction defined by the *Tripping Direction* parameter of the ”Dir-Z” block to trigger the trip after the time specified inside ”Zt4” has expired. The trip logic implemented by ”T5” is non directional.

3.2.3 Data input

The relationships between the relay settings and the model parameters can be found in the following tables (the relay model parameter names are listed between brackets):

Starting element :

Address	Relay Setting	Model block	Model setting	Note
7813	DIST. F. DET.	Starting	Type of starting (atype)	”Basic data” tab page
1102	SYSTEMSTAR	Starting	System Grounding (isysstar)	”Basic data” tab page
1501	PROG. U/I/phi	Starting	Prog. U/I (iProgUI)	”Underimpedance/Overcurrent” tab page
1503	PROG. ZA	Starting	Prog. ZA (iProgZA)	”Impedance” tab page
1602	Ie>	Starting	Ie> (Ieg)	”Earth Fault Detection” tab page
1603	Ie>>	Starting	Ie>> (Iegg)	”Earth Fault Detection” tab page
1610	Iph>>	Starting	Iph>> (Iphggd)	”Impedance” tab page
1611	Iph>	Starting	Iph> (Iphg)	”Impedance” tab page
1612	Uphe (I>>)	Starting	Uphe(I>>) (UpheIgg)	”Underimpedance/Overcurrent” tab page
1613	Uphe (I>)	Starting	Uphe(I>) (UpheIg)	”Underimpedance/Overcurrent” tab page
1614	Uphph (I>>)	Starting	Uphph(I>>) (UphphIgg)	”Underimpedance/Overcurrent” tab page
1615	Uphph (I>)	Starting	Uphph(I>) (UphphIg)	”Underimpedance/Overcurrent” tab page
1616	Iϕ>	Starting	Iphi> (Iphig)	”Underimpedance/Overcurrent” tab page
1617	Uphe (Iϕ>)	Starting	Uphe (Iphi>) (UpheIgphi)	”Underimpedance/Overcurrent” tab page
1618	Uphph(Iϕ>)	Starting	Uphph (Iphi>) (UphphIgphi)	”Underimpedance/Overcurrent” tab page
1619	ϕ >	Starting	phi> (phig)	”Underimpedance/Overcurrent” tab page
1620	ϕ <	Starting	phi> (phis)	”Underimpedance/Overcurrent” tab page
1621	Iph>	Starting	Minimum Iph> (Iphmin)	”Impedance” tab page
1622	X + A	Starting	Reactance Forward (XpA)	”Impedance” tab page

Address	Relay Setting	Model block	Model setting	Note
1623	X - A	Starting	Reactance Forward (XmA)	”Impedance” tab page
1624	RA1	Starting	Resistance RA1, Ph-Ph (RA1)	”Impedance” tab page
1625	RA2	Starting	Resistance RA2, Ph-Ph (RA2)	”Impedance” tab page
1626	RA1E	Starting	Resistance RA1E, Ph-E (RA1E	”Impedance” tab page
1627	RA2E	Starting	Resistance RA2E, Ph-E (RA2E)	”Impedance” tab page
1628	ANGLE PHIA	Starting	Angle PHIA, Ph-Ph (PHIA)	”Impedance” tab page
1629	ANG. PHIAE	Starting	Angle PHIA, Ph-E (PHIAE)	”Impedance” tab page
1630	Iph>>	Starting	Iph>>(Iphggd)	”Impedance” tab page
1701	Ue>	Starting	Ue> grd. (Ue)	”Earth Fault Detection” tab page
1703	PH PHE FLTS PHASE-PHASEONLY	Starting	Ph-Ph-Earth Faults (iPhPhE)	”Fault loop Settings” tab page
1705	1PH FAULTS PHASE-EARTHS	Starting	Single Phase Detection (i1PhFLT)	”Fault loop Settings” tab page
1707	E/F DETECT	Starting	Earth Fault detection (iEarthdet)	”Earth Fault Detection” tab page
1802	Ue>	Starting	Ue> ungrd. (Ueiso)	”Earth Fault Detection” tab page
1803	PHASE PRE	Starting	Phase Preference for Ph-Ph-E Faults(iPHPRE)	”Fault loop Settings” tab page

Directional element :

No user input is required.

Polarizing element :

Address	Relay Setting	Model block	Model setting	Note
1117	RE/RL	Polarizing	Re / Rl (ReRl)	
		ZPol15	Re / Rl (ReRl)	EHV normal line model version
1118	XE/XL	Polarizing	Xe / Xl (XeXl)	
		ZPol15	Xe / Xl (XeXl)	EHV normal line model version
1119	RM/RL	Polarizing	Rm / Rl (RmRl)	
		ZPol15	Rm / Rl (RmRl)	EHV normal line model version
1120	XM/XL	Polarizing	Xm / Xl (XmXl)	
		ZPol15	Xm / Xl (XmXl)	EHV normal line model version

Distance trip zones :

Address	Relay Setting	Model block	Model setting	Note
1301	R1	Z1	+R Resistance (Rmax)	
1302	X1	Z1	+X Reach (Xmax)	
1303	R1E	Z1	+R Resistance PH-E (REMax)	
1304	DIREC. Z1	Z1	Tripping direction (idir)	
1305	T1 1PHASE	ZT1	Time Setting (Tdelay)	
1306	T1 >1PHASE	ZT1	Time Setting (Tdelay)	
1311	R2	Z2	+R Resistance (Rmax)	
1312	X2	Z2	+X Reach (Xmax)	
1313	R2E	Z2	+R Resistance PH-E (REMax)	
1314	DIREC. Z2	Z2	Tripping direction (idir)	
1315	T2 1PHASE	ZT2	Time Setting (Tdelay)	
1316	T2 >1PHASE	ZT2	Time Setting (Tdelay)	
1321	R3	Z3	+R Resistance (Rmax)	

Address	Relay Setting	Model block	Model setting	Note
1322	X3	Z3	+X Reach (Xmax)	
1323	R3E	Z3	+R Resistance PH-E (REMax)	
1324	DIREC. Z3	Z3	Tripping direction (idir)	
1325	T3	ZT3	Time Setting (Tdelay)	
1401	R1B	Z1b	+R Resistance (Rmax)	
1402	X1B	Z1b	+X Reach (Xmax)	
1403	R1BE	Z1b	+R Resistance PH-E (REMax)	
1404	DIREC. Z1B	Z1b	Tripping direction (idir)	
1405	T1B 1PHASE	ZT1b	Time Setting (Tdelay)	
1406	T1B >1PHASE	ZT1b	Time Setting (Tdelay)	

Reclosing :

Address	Relay Setting	Model block	Model setting	Note
1201	DIST.PROT.	Z1,Z2,Z3,Z1b	Out of Service(outserv)	
1216	RAR->Z1B	Reclosing	”Z1b” row, ”Trip1”	in this cell in the ”Logic” tab page select the ”Reclosing” item to make Z1b effective before RAR
1221	BLK. AR Z1B	Reclosing	”Z1b” row, ”Trip1”	in this cell in the ”Logic” tab page select the ”Lockout” item to block the autoreclose for faults inside Z1b
3405	T-RECLAIM	Reclosing	Reset Time (resettime)	
3425	RAR T - 3POL	Reclosing	Reclosing Interval 1 (recltime1)	
3426	RAR T - 1POL	Reclosing	Reclosing int 1 1Ph-Grnd faults (recltime11ph)	
3443	DAR no. 1PH	Reclosing	Operations to lockout (oplockout)	Set model parameter = relay setting + 2
3444	DAR no. 3PH	Reclosing		
3447	DAR T3POL2	Reclosing	Reclosing Interval 2 (recltime2)	
3448	DAR T3POL3	Reclosing	Reclosing Interval 3 (recltime3)	

Overcurrent :

Address	Relay Setting	Model block	Model setting	Note
2601	EMERG. O C ON	Iph>	Out of Service (outserv)	
		I>>	Out of Service (outserv)	
2602	I>>	I>>	Pickup Current (Ipsetr)	
2603	T-I>>	I>>	Time Setting (Tset)	
2611	CHARACT.PH	Iph>	Characteristic (pcharac)	
2612	I>	Iph>	Current Setting (Ipsetr)	Threshold for the definite time charact.
2613	T-I>	Iph>	Time Dial (Tpset)	Time delay for the definite time charact.
2614	Ip	Iph>	Current Setting (Ipsetr)	Threshold for the IDMT charact.
2615	T-Ip	Iph>	Time Dial (pTset)	Time dial for the IDMT charact.
2631	EMER. O/C E	IE>	Out of Service (outserv)	
		IE>>	Out of Service (outserv)	
2632	IE>>	IE>>	Pickup Current (Ipsetr)	
2633	T-IE>>	IE>>	Time Setting (Tset)	
2641	CHARACT. E	IE>	Characteristic (pcharac)	
2642	IE>	IE>	Pickup Current (Ipsetr)	
2643	T-IE>	IE>	Time Setting (Tset)	
2907	UMEAS U<	Fuse failure voltage threshold	Pickup Voltage (Uset)	

Additional timers :

Address	Relay Setting	Model block	Model setting	Note
1202	DIR. FD&T4	Dir-Z	Tripping direction (idir)	
1203	T4	ZT4	Time Setting (Tdelay)	
1204	T5	T5	Time Setting (Tdelay)	

3.3 Output logic

The output logic is the interface between the relay and the power system. A set of relay output signals can be used to simulate the control logics.

3.3.1 Available Units and Output Signals

The trip logic is implemented by the ”Logic” block located in the main relay. The ”Closing Logic” block controlled by the reclosing feature (”Reclosing” block) has the purpose of generating a closing command for the power breaker when a reclosing attempt is triggered.

Twelve relay output signals are available:

- *forward* The directional block forward signal (*on* when a forward fault has been detected).
- *reverse* The directional block reverse signal (*on* when a reverse fault has been detected).
- *yZ1b* The extension distance zone starting signal.
- *yZ3* The third distance zone starting signal.
- *yZ2* The second distance zone starting signal.
- *yZ1* The first distance zone starting signal.
- *yTZ1b* The extension distance zone tripping signal.
- *yTZ3* The third distance zone tripping signal.
- *yTZ2* The second distance zone tripping signal.
- *yTZ1* The first distance zone tripping signal.
- *yout* The ”Logic” block output signal.
- *yClose* The ”Closing Logic” block output signal.

3.3.2 Functionality

The ”Logic” block located in the main relay operates the breaker.
The relay output signal which is used to operate the breaker is ”yout”.

Moreover it implements the Permissive Underreach Transfer Trip logic (”PUTT”).
For this purpose the ”yExt” relay input signal is used in accordance with the following logic:

A PUTT condition is declared and the breaker is operated when

- The PUTT logic is active (”PUTT” parameter).
- The PUTT input signal (*yExt*) is on.
- The relay has started (the *Starting* element picked up).

3.3.3 Data input

Please disable the ”Logic” block in the main relay to disable the relay model’s ability to open the power circuit.

To enable the PUTT logic set the ”PUTT ” parameter in the ”Logic” tab page of the ”Logic” block dialog equal to TRIP. This is disabled (NOTRIP) by default.

4 Features not supported

The following features are not supported:

- Overreach zone Z1L.
- Power swing detection.
- Out of step trip.
- Synchronism and voltage check.
- Fault location.
- User definable logic functions.
- Permissive Overreach Transfer Trip and other teleprotection scheme (POTT scheme, directional comparison, unblocking etc.).
- High current switch onto fault protection.
- Week infeed protection.
- Overvoltage protection.
- Circuit breaker failure protection.
- Distance zone Z1, Z1b and Z2 delays , multiphase faults (address 1305, 1315, 1405).
- High resistance earth fault protection directional characteristic (address block 31 and 32).

5 References

[1] Siemens, AKTIENGESELLSCHAFT, Dept EV S SUP 21, D-13623 Berlin. *Numerical Distance Protection Relay for EHV Systems 7SA513 V3.2/V3.3 Order n. C53000-G1176-C103-6, 2001*, 1995.