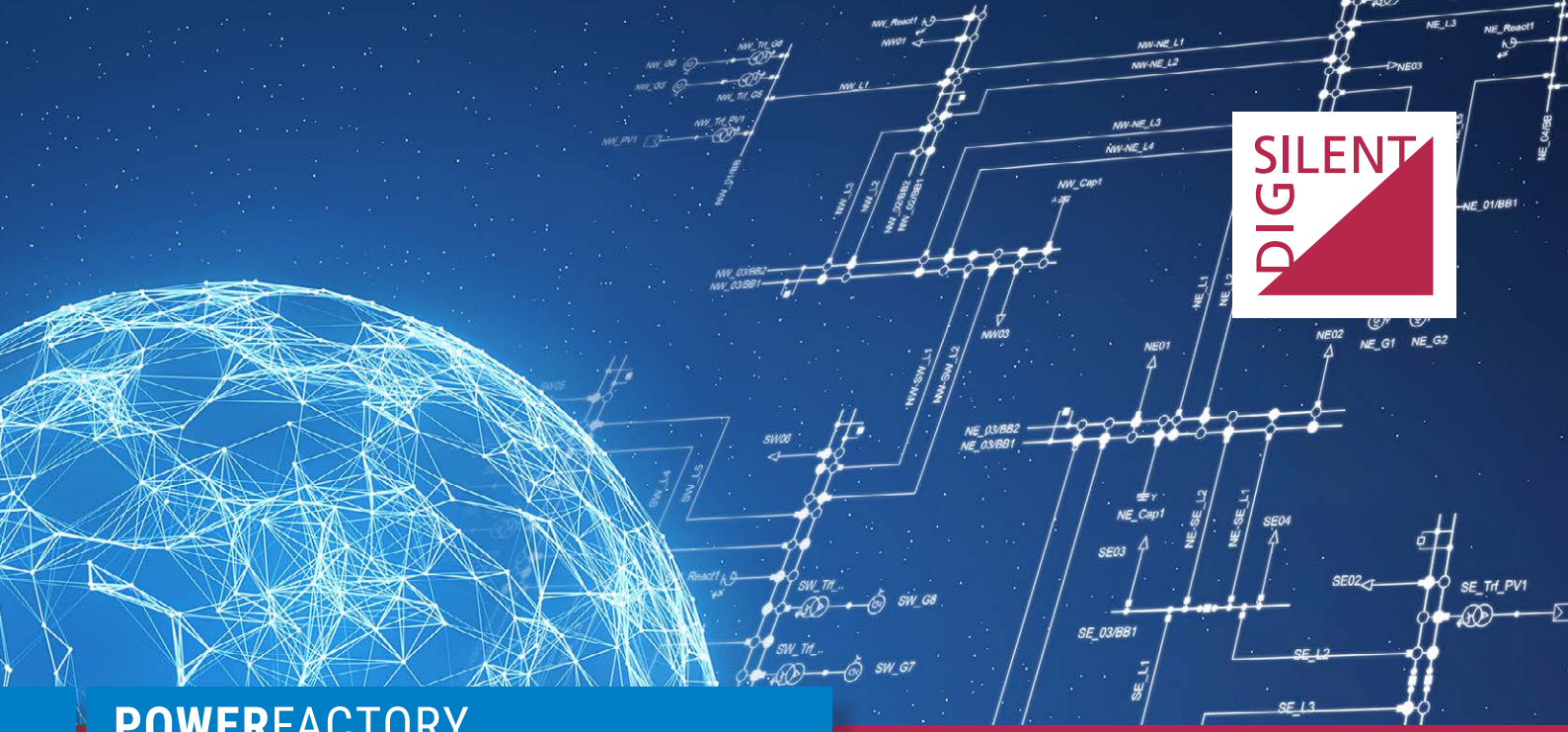

PowerFactory 2021

Technical Reference

Siemens 7SA522

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POWER SYSTEM SOLUTIONS
MADE IN GERMANY

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Contents

1 Model information

Manufacturer Siemens

Model 7SA522

Variants The Siemens 7SA522 PowerFactory relay models can be used to simulate any version of the Siemens 7SA522 relay. However please consider that the models have been implemented with the features available in the V4.60.08 firmware version.

2 General description

The Siemens 7SA522 line distance protection terminal is a protective relay for EHV line distance protection applications. Additional protection functionality includes phase overcurrent, residual current and power swing/out of step functions.

The Siemens 7SA522 PowerFactory relay model consists of a monolithic scheme. Two model versions are available, one for each available rated current; the following model versions are provided:

- 7SA522 1A
- 7SA522 5A

The Siemens 7SA522 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 elements, the distance elements, the directional element for the distance elements, the powers wing detection feature the overcurrent elements and the output logic.

Seven different functional areas can be defined in the scheme:

- Measurement acquisition
- Impedance calculation
- Fault detection and directional logic
- Impedance protection
- Power swing detection feature
- Overcurrent ancillary elements
- 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) is measuring the zero sequence current contribution coming from a close line and is feeding 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 values (”Measure” 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 calculates then the voltage and current values used by the protective elements.

The ”Delta Measure” block is calculating 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, the load encroachment element and the distance elements work together to simulate the Siemens 7SA522 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).
- Three polarizing elements(”Pol_Z1”, ”Pol_Z1b-Z2-Z5” and ”ZPol15” block).
- One load encroachment element (”Load Area” block)
- Six polygonal distance trip zones processing both the phase and the ground loop impedances(”Z1”, ”Z2”, ”Z3”, ”Z4”, ”Z5” and ”Z1b” block)
- Six timers associated with the polygonal distance trip zones (”ZT1”, ”ZT2”, ”ZT3”, ”ZT4”, ”ZT5” and ”ZT1b” block)
- Six mho trip zones processing both the phase and the ground loop impedances(”Z1Mho”, ”Z2Mho”, ”Z3Mho”, ”Z4Mho”, ”Z5Mho” and ”Z1bMho” block)
- Six timers associated with the mho trip zones (”ZT1m”, ”ZT2m”, ”ZT3m”, ”ZT4m”, ”ZT5m” and ”ZT1bm” block)
- One power swing detection element (”Power Swing” block using the ”Z5 Mho” , ”Z5- Mho”, ”PPOL mho”, ”PPOL- mho” and ”PPOL Poly” ancillary blocks)
- One inverse time phase overcurrent element (”I>” block)
- One time defined phase overcurrent element (”I>>” block)
- One inverse time ground current element (”H-Resist-IE>” block)
- One time defined ground current element (”IE>>” block)
- One reclosing element (”Reclosing” block)

3.2.2 Functionality

Starting element The Siemens 7SA522 relay model starting element simulates the relay fault detection function.

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. If a single phase-ground fault has been detected by the *Starting element* the directional element uses as operating current the currents calculated by the *Polarizing elements* adding to the phase currents the earth impedance compensation and the mutual compensation. 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 is calculating the voltage vectors used by the distance elements and directional element taking care of the zero sequence current and of the *Earth Factor*. The operating current vectors are calculated including the mutual current contribution and the *Mutual Earth Factor*.

Three polarizing blocks are available:

- *"Pol_Z1"* is calculating the actual positive sequence voltage which is sent to the 1^{st} zone distance elements ("Z1" and "'Z1mho" block)
- *"Pol_Z1b-Z2-Z5"* is calculating the actual positive sequence voltage which is sent to the 2^{nd}, 3^{rd},4^{th} and 5^{th} zone distance elements ("Z1b", "'Z1bmho", "Z2", "'Z2mho", "Z3", "'Z3mho", "Z4", "'Z4mho", "Z5" and "'Z5mho" block)
- *"ZPol15"* is working as a circular buffer storing the positive sequence voltage calculated during the last 200 ms and returning as output the positive voltage calculated 200 ms before.

Please consider that "Pol_Z1" and "Pol_Z1b-Z2-Z5" are configured to calculate the polarizing voltage using a voltage memory which stored the voltage values sampled during the last 200 ms when the input voltage drops below 4% Un. These two positive sequence voltages returned by "Pol_Z1" and by "ZPol15" are put together 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 200 ms before. It's done to improve the stability of the fault direction detection after the fault.

The polarizing blocks support both the earth factor decouple representation and the polar representation. The mutual earth factor value is unique for any polarizing block.

Distance trip zones The polygonal and the mho 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" and the " 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-grnd fault or other types of fault). Different dead times can be set for the first reclosing attempt and for the following attempts.

Power swing detection feature This feature has the purpose to block the polygonal distance elements when a power swing condition has been detected. The power swing detection area can be defined by four mho elements or by two polygonal elements. The mho elements are:

- *Z5 Mho*
- *Z5- Mho*
- *PPOL mho*
- *PPOL- mho*

The polygonal elements are:

- *PPOL Poly*
- *Z5* (5^{th} polygonal zone)

Its principle of operation is based on the measurement of the time it takes a power swing transient impedance to pass through the impedance area between the outer and the inner characteristics. Power swings are identified by transition times longer than the dz/dt timer setting together with trajectory monotony and continuity. The main power swing settings are located inside the "Power Swing" block: it's possible to define which polygonal zones must be blocked, the passing through time and the maximum time the zones are blocked.

Overcurrent elements Some ancillary overcurrent elements have been implemented in the model to simulate the two phase overcurrent elements and the two ground 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:

- ANSI Definite inverse
- ANSI Inverse
- ANSI Extremely Inverse
- ANSI Long Time Inverse
- ANSI Moderately Inverse
- ANSI Short Inverse
- ANSI Very Inverse
- Definite Time
- IEC Extremely Inverse
- IEC Very Inverse
- IEC Normal Inverse
- IEC Long Inverse

The earth fault inverse time element (”H-Resist-IE>” block) supports the following inverse characteristics:

- ANSI Definite inverse
- ANSI Inverse
- ANSI Extremely Inverse
- ANSI Long Time Inverse
- ANSI Moderately Inverse
- ANSI Short Inverse
- ANSI Very Inverse
- Definite Time
- IEC Extremely Inverse
- IEC Very Inverse
- IEC Normal Inverse
- IEC Long Inverse
- Logarithmic Inverse

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

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
207	SYSTEMSTAR	Starting	System Grounding (isysstar)	”Basic data” tab page
1202	Minimum Iph>	Starting	Minimum Iph> (Icphgg)	”Impedance” tab page
1203	3I0> Threshold	Starting	Ie> (Ieg)	”Earth Fault Detection” tab page
1204	3U0> Threshold	Starting	Ue> grd. (Ueg)	”Earth Fault Detection” tab page
1205	3U0> COMP/ISOL.	Starting	Ue> ungrd. (Uegiso)	”Earth Fault Detection” tab page
1207A	3I0>/ Iphmax	Starting	Stabilization Slope (Estabfac)	”Earth Fault Detection” tab page
1209A	E/F recognition	Starting	Earth Fault detection (iEarthdet)	”Earth Fault Detection” tab page
1220	PHASE PREF.2phe	Starting	Phase Preference for Ph-Ph-E Faults(iPHPRE)	”Fault loop Settings” tab page
1221A	2Ph-E faults	Starting	Ph-Ph-Earth Faults (iPhPhE)	”Fault loop Settings” tab page

Directional element :

No user input is required.

Polarizing element :

Address	Relay Setting	Model block	Model setting	Note
1105	Line Angle	Pol_Z1	Line angle (lineangle)	Set "Show as complex number" (complexrepr)
		Pol_Z1b-Z2-Z5	Line angle (lineangle)	Set "Show as complex number" (complexrepr)
		ZPol15	Line angle (lineangle)	Set "Show as complex number" (complexrepr)
1116	RE/RL	Pol_Z1	Re / Rl (ReRl)	
1117	XE/XL	Pol_Z1	Xe / Xl (XeXl)	
1118	RE/RL	Pol_Z1b-Z2-Z5	Re / Rl (ReRl)	
		ZPol15	Re / Rl (ReRl)	
1119	XE/XL	Pol_Z1b-Z2-Z5	Xe / Xl (XeXl)	
		ZPol15	Xe / Xl (XeXl)	
1120	K0 (Z1)	Pol_Z1	k0 (k0)	Set "Show as complex number" (complexrepr)
1121	Angle K0(Z1)	Pol_Z1	Angle (phik0)	Set "Show as complex number" (complexrepr)
1122	K0 (> Z1)	Pol_Z1b-Z2-Z5	k0 (k0)	Set "Show as complex number" (complexrepr)
		ZPol15	k0 (k0)	Set "Show as complex number" (complexrepr)
1123	Angle K0(> Z1)	Pol_Z1b-Z2-Z5	Angle (phik0)	Set "Show as complex number" (complexrepr)
		ZPol15	Angle (phik0)	Set "Show as complex number" (complexrepr)
1126	RM/RL	Pol_Z1	Rm / Rl (RmRl)	
		Pol_Z1b-Z2-Z5	Rm / Rl (RmRl)	
		ZPol15	Rm / Rl (RmRl)	
1127	XM/XL	Pol_Z1	Xm / Xl (XmXl)	
		Pol_Z1b-Z2-Z5	Xm / Xl (XmXl)	
		ZPol15	Xm / Xl (XmXl)	

Load encroachment :

Address	Relay Setting	Model block	Model setting	Note
1241	R load (ϕ-E)	Load Area	R load (Ph-E) (Rloadphe)	
1242	φ load (ϕ-E)	Load Area	R load (Ph-E) (philoadphe)	
1243	R load (ϕ-ϕ)	Load Area	R load (Ph-Ph) (Rloadphph)	
1244	φ load (ϕ-ϕ)	Load Area	R load (Ph-Ph) (philoadphph)	

Distance trip zones :

Address	Relay Setting	Model block	Model setting	Note
1211	Distance Angle	Z1, Z1b, Z2, Z3, Z4, Z5	Relay Angle (phi)	
		Z1mho, Z1bmho, Z2mho, Z3mho, Z4mho, Z5mho	Relay Angle (phi)	
1301	Op. mode Z1	Z1	Tripping direction (idir)	
1302	R(Z1) $\phi - \phi$	Z1	+R Resistance (Rmax)	
1303	X(Z1)	Z1	+X Reach (Xmax)	

Address	Relay Setting	Model block	Model setting	Note
1304	RE(Z1) $\phi - E$	Z1	+R Resistance (PH-E) (REmax)	
1306	T1-1phase	ZT1	Time Setting (Tdelay)	
1307	T1-multi-phase	ZT1	Time Setting (Tdelay)	
1311	Op. mode Z2	Z2	Tripping direction (idir)	
1312	R(Z2) $\phi - \phi$	Z2	+R Resistance (Rmax)	
1313	X(Z2)	Z2	+X Reach (Xmax)	
1314	RE(Z2) $\phi - E$	Z2	+R Resistance (PH-E) (REmax)	
1316	T2-1phase	ZT2	Time Setting (Tdelay)	
1317	T2-multi-phase	ZT2	Time Setting (Tdelay)	
1321	Op. mode Z3	Z3	Tripping direction (idir)	
1322	R(Z3) $\phi - \phi$	Z3	+R Resistance (Rmax)	
1323	X(Z3)	Z3	+X Reach (Xmax)	
1324	RE(Z3) $\phi - E$	Z3	+R Resistance (PH-E) (REmax)	
1326	T3-1phase	ZT3	Time Setting (Tdelay)	
1327	T3-multi-phase	ZT3	Time Setting (Tdelay)	
1331	Op. mode Z4	Z4	Tripping direction (idir)	
1332	R(Z4) $\phi - \phi$	Z4	+R Resistance (Rmax)	
1333	X(Z4)	Z4	+X Reach (Xmax)	
1334	RE(Z4) $\phi - E$	Z4	+R Resistance (PH-E) (REmax)	
1336	T4-1phase	ZT4	Time Setting (Tdelay)	
1337	T4-multi-phase	ZT4	Time Setting (Tdelay)	
1341	Op. mode Z5	Z5	Tripping direction (idir)	
1342	R(Z5) $\phi - \phi$	Z5	+R Resistance (Rmax)	
1343	X(Z5)	Z5	+X Reach (Xmax)	
1344	RE(Z5) $\phi - E$	Z5	+R Resistance (PH-E) (REmax)	
1346	T5-1phase	ZT5	Time Setting (Tdelay)	
1347	T5-multi-phase	ZT5	Time Setting (Tdelay)	
1351	Op. mode Z1b	Z1b	Tripping direction (idir)	
1352	R(Z1b) $\phi - \phi$	Z1b	+R Resistance (Rmax)	
1353	X(Z1b)	Z1b	+X Reach (Xmax)	
1354	RE(Z1b) $\phi - E$	Z1b	+R Resistance (PH-E) (REmax)	
1356	T1b-1phase	ZT1b	Time Setting (Tdelay)	
1357	T1b-multi-phase	ZT1b	Time Setting (Tdelay)	
1401	Op. mode Z1	Z1mho	Tripping direction (idir)	
1402	ZR(Z1)	Z1mho	Replica Impedance (Zm)	
1411	Op. mode Z2	Z2mho	Tripping direction (idir)	
1412	ZR(Z2)	Z2mho	Replica Impedance (Zm)	
1421	Op. mode Z3	Z3mho	Tripping direction (idir)	
1422	ZR(Z3)	Z3mho	Replica Impedance (Zm)	
1431	Op. mode Z4	Z4mho	Tripping direction (idir)	
1432	ZR(Z4)	Z4mho	Replica Impedance (Zm)	
1441	Op. mode Z5	Z5mho	Tripping direction (idir)	
1442	ZR(Z5)	Z5mho	Replica Impedance (Zm)	
1451	Op. mode Z1b	Z1bmho	Tripping direction (idir)	
1452	ZR(Z1b)	Z1bmho	Replica Impedance (Zm)	

Reclosing :

Address	Relay Setting	Model block	Model setting	Note
3401	AUTO RECLOSE	Reclosing	Out of Service(outserv)	
3403	T-RECLAIM	Reclosing	Reset Time (resettime)	
3456	1.AR Tdead1Trip	Reclosing	Reclosing int 1 1Ph-Grnd faults (recltime11ph)	
3457	1.AR Tdead3Trip	Reclosing	Reclosing Interval 1 (recltime1)	

Address	Relay Setting	Model block	Model setting	Note
133	Auto Reclose	Reclosing	Operations to lockout (oplockout)	Set model parameter = relay setting + 2
3468	2.AR Tdead3Trip	Reclosing	Reclosing Interval 2 (recltime2)	
3479	3.AR Tdead3Trip	Reclosing	Reclosing Interval 3 (recltime3)	
3490	4.AR Tdead3Trip	Reclosing	Reclosing Interval 4 (recltime4)	
		Reclosing	”Z1b” row, ”Trip1”	in this cell in the ”Logic” tab page select the ”Reclosing” item to make Z1b effective before 1.AR
		Reclosing	”Z1b” row, ”Trip1”	in this cell in the ”Logic” tab page select the ”Lockout” item to block the autoreclose for faults inside Z1b

Power swing detection feature :

Address	Relay Setting	Model block	Model setting	Note
2002	P/S Op. mode	Power Swing	Blocking Configuration (iblockconf)	In the ”Basic Data - ”InternalPolygon Settings”
2007	Trip DELAY P/S	Power Swing	tH (tH)	In the ”Timers” tab page

No user input is required in the *PPOL mho*, *PPOL- mho*,*Z5-Mho*and *PPOL poly* block.

Overcurrent :

Address	Relay Setting	Model block	Model setting	Note
2601	EMERG. O C ON	I>	Out of Service (outserv)	
		I>>	Out of Service (outserv)	
		IE>	Out of Service (outserv)	
		IE>>	Out of Service (outserv)	
2610	Iph>>	I>>	Pickup Current (Ipsetr)	
2611	T Iph>>	I>>	Time Setting (Tset)	
2660	IEC Curve	Iph>	Characteristic (pcharac)	Enabled/disabled at addr. 126
2661	ANSI Curve	Iph>	Characteristic (pcharac)	Enabled/disabled at addr. 126
2640	Ip>	I>	Current Setting (Ipsetr)	
2642	T Ip Time Dial	I>	Time Dial (pTset)	Time dial for the IDMT charact.
2643	Time Dial TD Ip	I>	Time Dial (Tpset)	Time delay for the definite time charact.
2612	3I0>> PICKUP	IE>>	Pickup Current (Ipsetr)	
2613	T 3I0>>	IE>>	Time Setting (Tset)	
2650	3I0p>	IE>	Current Setting (Ipsetr)	
2652	T 3I0p Time Dial	IE>	Time Dial (pTset)	Time dial for the IDMT charact.
2653	Time Dial TD 3I0p	IE>	Time Dial (Tpset)	Time delay for the definite time charact.

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.

twenty two relay output signals are available:

- *yTZ1bm(1)* The extension mho distance zone tripping signal.
- *yTZ5m(1)* The fifth mho distance zone tripping signal.
- *yTZ4m(1)* The fourth mho distance zone tripping signal.
- *yTZ3m(1)* The third mho distance zone tripping signal.
- *yTZ2m(1)* The second mho distance zone tripping signal.
- *yTZ1m(1)* The first mho distance zone tripping signal.
- *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 polygonal distance zone starting signal.
- *yZ5* The fifth polygonal distance zone starting signal.
- *yZ4* The fourth polygonal distance zone starting signal.
- *yZ3* The third polygonal distance zone starting signal.
- *yZ2* The second polygonal distance zone starting signal.
- *yZ1* The first polygonal distance zone starting signal.
- *yTZ1b* The extension polygonal distance zone tripping signal.
- *yTZ5* The fifth polygonal distance zone tripping signal.
- *yTZ4* The fourth polygonal distance zone tripping signal.
- *yTZ3* The third polygonal distance zone tripping signal.
- *yTZ2* The second polygonal distance zone tripping signal.
- *yTZ1* The first polygonal 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 is operating 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 1^{st} extension distance zone (*Z1b*) has started.

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.
- 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 and undervoltage protection.
- Circuit breaker failure protection.
- Distance zone Z1, Z1b and Z2 delays, multiphase faults.
- High resistance earth fault protection directional characteristic.
- Frequency protection elements.
- Monitoring functions.

5 References

[1] Siemens, AKTIENGESELLSCHAFT, Dept EV S SUP 21, D-13623 Berlin. *SIPROTEC Distance Protection 7SA522 V4.6 Manual C53000-G1176-C155-4, 2004*, 2004.