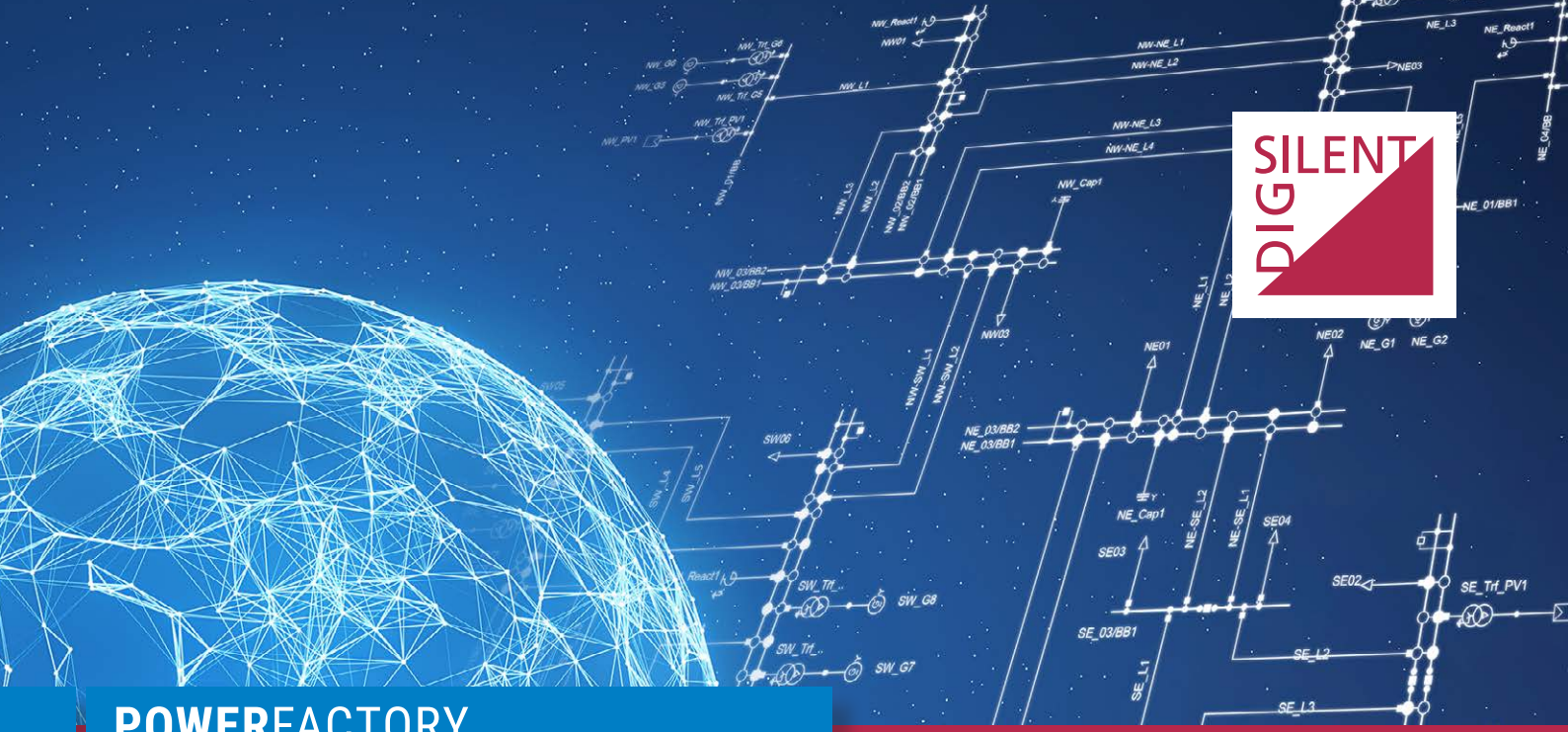

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PowerFactory 2021

Technical Reference

Sprecher SPRECON-E DD

PF2021

POWER SYSTEM SOLUTIONS

MADE IN GERMANY

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1 Model information

Manufacturer Sprecher

Model SPRECON-E DD

Variants This PowerFactory relay model simulates a reduced set of the features present in the Sprecher SPRECON-E DD relay.

2 General description

The Sprecher SPRECON-E DD devices are one-box solutions for protection and control, which allow protection of primary equipment by simultaneously accomplishing control and monitoring functions in electric power systems. The digital distance protectors DD...6 are preferably used as a selective protection for single- and double-fed lines (overhead lines and cables) in the medium-voltage or, respectively, the lower highvoltage level. They are suitable for all system configurations (radial, ring, and meshed systems) and methods of neutral-point connection (earthed with or without limiting resistance, inductive, isolated).
The protection functions available in the devices provide selective short-circuit protection, ground fault protection, voltage and frequency control and overload protection in medium- and high-voltage systems.

The PowerFactory Sprecher SPRECON-E DD relay model simulates a subset of the protective features available in the relay and consists of a main relay model and the following sub relays:

- IL
- IE
- Ineg
- Overload
- CBF
- SCD
- Voltage
- Frequency

The main relay contains the measurement and acquisition elements, the output element which operated the power breaker(s), the distance protection elements, the reclosing element and the sub relays.

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

3 Supported features

3.1 Measurement and acquisition

It represents the interface between the power system and the relay protective elements.

The phase currents flowing in the power system are converted by a block which simulates a 3 phase CT and by a block which models a single phase CT detecting the earth current; the voltages are converted by a block which simulates a 3 phase VT and by a block which simulates an open delta VT. The secondary currents and voltages are then measured in the relay model by six elements which simulate the digital sampling of the relay.

3.1.1 Available elements and input signals

The *Measurement and acquisition* feature consists of the following elements:

- One 3 phase current transformer (”Ct” block).
- One neutral current transformer (”Ct-E/N” block).
- One 3 phase voltage transformer (”Vt” block).
- One open delta voltage transformer (”Open Delta Vt” block).
- One 3 phase measurement element (”Measurement” block).
- One voltage sequence measurement element (”V seq Measurement” block).
- One single phase neutral measurement element (”Neutral measurement” block).
- One 3 phase phase-phase measurement element (”Delta Measurement” block).
- One zero sequence voltage measurement element (”U0 Measurement” block).
- One frequency measurement element (”Meas Freq” block).

The following relay input signals can be used:

- *ExtBlock_L1A;B;C* (one for each phase) blocking the ”IL>” element (”IL” subrelay).
- *ExtBlock_L2A;B;C* (one for each phase) blocking the ”IL>>” element (”IL” subrelay).
- *ExtBlock_L3A;B;C* (one for each phase) blocking the ”IL>>>” element (”IL” subrelay).
- *ExtBlock_L4A;B;C* (one for each phase) blocking the ”IL>>>>” element (”IL” subrelay).
- *ExtBlock_E1* blocking the ”IE>” element (”IE” subrelay).
- *ExtBlock_E2* blocking the ”IE>>” element (”IE” subrelay).
- *ExtBlock_E3* blocking the ”IE>>>” element (”IE” subrelay).
- *ExtBlock_E4* blocking the ”IE>>>>” element (”IE” subrelay).
- *ExtBlock_neg* blocking the ”Ineg” subrelay elements.
- *ExtBlock_overload* blocking the thermal image element (”Overload” subrelay).

- *ExtBlock_CBF* blocking the circuit breaker failure logic (”CBF” subrelay).
- *extblock_A;extblock_B;extblock_C_UM* blocking the ”U>” element (”Voltage” subrelay).
- *extblock_A;extblock_B;extblock_C_UMM* blocking the ”U>>” element (”Voltage” subrelay).
- *extblock_A;extblock_B;extblock_C_Um* blocking the ”U<” element (”Voltage” subrelay).
- *extblock_A;extblock_B;extblock_C_Umm* blocking the ”U<< ” element (”Voltage” subrelay).
- *extblock_UNEM* blocking the ”UNE>” element (”Voltage” subrelay).
- *extblock_UNEMM* blocking the ”UNE>>”element (”Voltage” subrelay).
- *ExtBlock_f1* blocking the ”F1><” element (”Frequency” subrelay).
- *ExtBlock_f2* blocking the ”F2><” element (”Frequency” subrelay).
- *ExtBlock_f3* blocking the ”F3><” element (”Frequency” subrelay).
- *ExtBlock_f4* blocking the ”F4><” element (”Frequency” subrelay).

3.1.2 Functionality

The ”Ct” and the ”Ct-E/N” block represent ideal CTs. Using the CT default configuration the current at the primary side are converted to the secondary side using the CT ratio. The CT saturation and/or its magnetizing characteristic are not considered. Please set the ”Detailed Model” check box in the ”Detailed Data” tab page of the CT dialog and insert the data regarding the CT burden, the CT secondary resistance and the CT excitation parameter if more accurate simulation results are required.

The input current values are sampled by the ”Measurement”, the ”Delta Measurement”, , and the ”Neutral measurement” block at 20 samples/cycle. The values are processed by a DFT filter, operating over a cycle, which then calculates the voltage and current RMS values used by the protective elements.

3.1.3 Data input

The CT secondary rated current (1 or 5 A) value must be set in the ”Measurement”, the ”Delta Measurement”, and the ”Neutral measurement”. The VT secondary rated voltage must be set in the same measurement elements and in the ”Measure Frequency”, in the ”V seq Measurement”, and in the ”U0 Measurement” block.

If no core CT is available please select the 3 phases CT also in the ”Ct-E/N” slot: the earth current will be calculated assuming that an Holmgreen’s connection of the phases is used.

3.2 Distance Protection

The *Distance Protection* part models the polygonal distance shapes with directional characteristic and multiple type starting.

3.2.1 Available elements

- Five 6 loops polygonal distance elements (”Z1Poly”, ”Z2Poly”, ”Z3Poly”, ”Z4Poly”, and ”Z1XPoly” block).
- One starting element (”Starting” block).
- One polarizing element (”Polarizing” block).
- Six timers (”T1”, ”T2”, ”T3”, ”T4”, ”T5”, and ”T6” block).
- One Distance directional element (”Dir-Z” block).

3.2.2 Functionality

The *Distance Protection* part simulate a 4 zones 6 loops distance relay with zone extension and polygonal shape. The distance elements are directional and are activated by a starting element which can be configures to use the following starting types:

- Overcurrent.
- Undervoltage.
- Underimpedance.

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):

Address	Relay Setting	Model block	Model setting	Note
501	Real Part Earth Fact	Polarizing	Re/Rl	
502	Imag.Part Earth Fact	Polarizing	Xe/Xl	
531	System Neutral	Starting	System Grounding (isysstar)	
5000	Distance Detection	Z1Poly	Out of Service (outserv)	
		Z2Poly	Out of Service (outserv)	
		Z3Poly	Out of Service (outserv)	
		Z4Poly	Out of Service (outserv)	
		Z1XPoly	Out of Service (outserv)	
5001	Inclin.Angle Polygon	Z1Poly	Relay Angle (phi)	
		Z2Poly	Relay Angle (phi)	
		Z3Poly	Relay Angle (phi)	
		Z4Poly	Relay Angle (phi)	
		Z1XPoly	Relay Angle (phi)	
5002	Red.AnglePolygonZ1(x)	Z1Poly	+X Angle (beta)	
5100	Zone Z1,t1	Z1Poly	Out of Service (outserv)	
5131	Direction Z1,t1	Z1Poly	Tripping Direction (idir)	
5101	X1s*In/A Reactance	Z1Poly	+X Reach (Xmax)	

Address	Relay Setting	Model block	Model setting	Note
5102	R1sLL*In/A Resist.	Z1Poly	+R Resistance (Rmax)	
5103	R1sLE*In/A Resist.	Z1Poly	+R Resistance (Ph-E) (REmax)	
5111	t1 Time Zone Z1	T1	Time Setting (Tdelay)	
5231	Direction Z1x,t1x	Z1xPoly	Tripping Direction (idir)	
5201	X1xs*In/A Reactance	Z1xPoly	+X Reach (Xmax)	
5202	R1xsLL*In/A Resist.	Zx1Poly	+R Resistance (Rmax)	
5203	R1xsLE*In/A Resist.	Z1xPoly	+R Resistance (Ph-E) (REmax)	
5211	t1x Time Zone Z1	T1	Time Setting (Tdelay)	
5331	Direction Z2,t2	Z2Poly	Tripping Direction (idir)	
5301	X2s*In/A Reactance	Z2Poly	+X Reach (Xmax)	
5302	R2sLL*In/A Resist.	Z2Poly	+R Resistance (Rmax)	
5303	R2sLE*In/A Resist.	Z2Poly	+R Resistance (Ph-E) (REmax)	
5311	t2 Time Zone Z2	T2	Time Setting (Tdelay)	
5431	Direction Z3,t3	Z3Poly	Tripping Direction (idir)	
5401	X3s*In/A Reactance	Z3Poly	+X Reach (Xmax)	
5402	R3sLL*In/A Resist.	Z3Poly	+R Resistance (Rmax)	
5403	R3sLE*In/A Resist.	Z3Poly	+R Resistance (Ph-E) (REmax)	
5411	t3 Time Zone Z3	T3	Time Setting (Tdelay)	
5531	Direction Z4,t4	Z4Poly	Tripping Direction (idir)	
5501	X4s*In/A Reactance	Z4Poly	+X Reach (Xmax)	
5502	R4sLL*In/A Resist.	Z4Poly	+R Resistance (Rmax)	
5503	R4sLE*In/A Resist.	Z4Poly	+R Resistance (Ph-E) (REmax)	
5511	t4 Time Zone Z4	T4	Time Setting (Tdelay)	
5600	Direct.BackupTime t5	T5	Time Setting (Tdelay)	
5700	Undir. Time Limit t6	T6	Time Setting (Tdelay)	
5800	Dist (U-)I Start	Starting	Undervoltage (iopt_u)	In the ”Basic Data” tab page, ”Type of Starting” frame
5900	Z< Impedance Start	Starting	Underimpedance (iopt_u)	In the ”Basic Data” tab page, ”Type of Starting” frame
5901	Zs*In/A	Starting	Forward Impedance, Ph-Ph (ZfPP)	
		Starting	Forward Impedance, Ph-E (ZfPG)	
5902	Xs*In/A forward	Starting	Forward Reactance (Xfw)	
5903	Xs*In/A reverse	Starting	Backward/Forward Impedance Ratio (ZbwZfw)	Xs*In/A reverse = ZfPP*ZbwZfw
5905	Angle ZLL I.Quadr.	Starting	Load Angle (Beta)	
5906	Angle ZLL II.Quadr.	Starting		Fixed and equal to 110 deg
5907	Angle ZLL III.Quadr.	Starting	Load Angle (Beta)	
5908	Angle ZLL IV.Quadr.	Starting		Fixed and equal to -70 deg
5909	RsmaxLL*In/A Resist	Starting	Forward Resistance,Ph-Ph (RfPP)	
5915	Angle ZLE I.Quadr.	Starting	Load Angle (Beta)	
5916	Angle ZLE II.Quadr.	Starting		Fixed and equal to 110 deg
5917	Angle ZLE III.Quadr.	Starting	Load Angle (Beta)	
5918	Angle ZLE IV.Quadr.	Starting		Fixed and equal to -70 deg
5919	RsmaxLE*In/A Resist.	Starting	Forward Resistance,Ph-E (RfPE)	
5930	Z< Monitoring of:	Starting	Z Operation Mode (iZOpMode)	The *only LE loops* mode is not supported.

3.3 Reclosing

The purpose of the *Reclosing* feature is model, during the RMS and the EMT simulation, up to 5 shot 3-pole auto reclosures of the circuit breaker. It simulates a simplified version of the reclosing feature available in the Sprecher SPRECON-E DD relay.

3.3.1 Available elements

The *Reclosing* feature is modeled by the ”Reclosing” block.

3.3.2 Functionality

The ”Reclosing” block models during a simulation the following features:

- An user settable number of AR.
- Separated dead time for the first AR attempt and for the first reclosing attempt after an earth fault.
- User configurable reclosing/no reclosing logic for each overcurrent element.
- User configurable duration of the circuit breaker close command.
- User configurable reclosing sequence reclaim time.

3.3.3 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):

Address	Relay Setting	Model block	Model setting	Note
9900	Auto-Reclosing AR	Reclosing	Out of Service	In the ”Basic data” tab page
9930	Number of AR Shots	Reclosing	Operations to lockout(oplockout)	
9950	AR Shots Earthfault	Reclosing	Operations to lockout(oplockout)	
9931	IL> AR Start	Reclosing	Logic (ilogic)	In the ”Logic” tab page.
9932	IL>> AR Start	Reclosing	Logic (ilogic)	In the ”Logic” tab page.
9933	IL>>> AR Start	Reclosing	Logic (ilogic)	In the ”Logic” tab page.
9934	IL>>>> AR Start	Reclosing	Logic (ilogic)	In the ”Logic” tab page.
9935	IE> AR Start	Reclosing	Logic (ilogic)	In the ”Logic” tab page.
9936	IE>> AR Start	Reclosing	Logic (ilogic)	In the ”Logic” tab page.
9937	IE>>> AR Start	Reclosing	Logic (ilogic)	In the ”Logic” tab page.
9938	IE>>>> AR Start	Reclosing	Logic (ilogic)	In the ”Logic” tab page.
9940	Ineg> AR Start	Reclosing	Logic (ilogic)	In the ”Logic” tab page.
9941	Ineg>> AR Start	Reclosing	Logic (ilogic)	In the ”Logic” tab page.
9955	1stDeadTimeEarthfault	Reclosing	Reclosing int 1 1Ph-Grnd Faults (recltime11ph)	In the ”Basic data” tab page
9911	First Dead Time(tD)	Reclosing	Reclosing interval 1 (recltime1)	In the ”Basic data” tab page
9912	Dead Time delayed R.	Reclosing	Reclosing interval 1 (recltime1)	In the ”Basic data” tab page
			Reclosing interval 2 (recltime2)	
			Reclosing interval 3 (recltime3)	
			Reclosing interval 4 (recltime4)	
			Reclosing interval 5 (recltime5)	

Address	Relay Setting	Model block	Model setting	Note
9917	tcl Duration CBCLOSE	Reclosing	Closing command duration (closingcomtime)	In the ”Basic data” tab page
9916	tr Reclaim Time AR	Reclosing	Reset Time (resettime)	In the ”Basic data” tab page

3.4 IL subrelay

The *IL* subrelay contains the phase overcurrent protective logic.

3.4.1 Available Units

- One inverse time phase overcurrent element (”IL>” block).
- Three time defined phase overcurrent element (”IL>>”, ”IL>>>”, and ”IL>>>>” block).
- Height logic elements (”IL> ILx Phase Start”, ”IL>> ILx Phase Start”, ”IL>>> ILx Phase Start”, ”IL>>>> ILx Phase Start”, ”Blockage IL>”, ”Blockage IL>>”, ”Blockage IL>>>”, and ”Blockage IL>>>>” block).
- Eight block combining the signals (”Or1”, ”Or2”, ”Or3”, ”Or4”, ”Opt1”, ”Opt2”, ”Opt3”, and ”Or4” block).

3.4.2 Functionality

The phase starting logic of each phase overcurrent element can be set to be triggered only if the current in at least 2 phases is greater than 2/3 of the maximum phase current.

Each phase overcurrent element can be configured to ignore an external block input signal.

The inverse time elements support the definite time characteristic and the following inverse time trip characteristics:

- Inverse
- Very Inverse
- Extremely Inverse
- Longtime inverse

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

3.4.3 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):

Address	Relay Setting	Model block	Model setting	Note
207	SYSTEMSTAR	Starting	System Grounding (isysstar)	”Basic data” tab page
1100	IL> Start	IL>	Out of Service (outserv)	
1101	IL> Definite Time	IL>	Current Setting (Ipset)	
1102	IL> Inverse Time	IL>	Current Setting (Ipset)	
1111	tIL> Time	IL>	Time Dial (Tpset)	
1112	tL> Time Factor	IL>	Time Dial (Tpset)	
1113	tIL> max Time Delay	IL>	Max. Time (udeftmax)	
1132	IL> Timer Module	IL>	Characteristic (pcharac)	
1134	ILx> Phase Start	IL> ILx Phase Start	Greater2_3_Imax (Greater2_3_Imax)	In the ”DIP Settings” tab page

Address	Relay Setting	Model block	Model setting	Note
1198	Blockage IL>	Blockage IL>	blockage_ILM (blockage_ILM)	In the ”DIP Settings” tab page
1200	IL>> Start	IL>>	Out of Service (outserv)	
1201	IL>>	IL>>	Pickup Current (Ipset)	
1211	tIL>> Time	IL>>	Time Setting (Tset)	
1234	ILx>> Phase Start	IL>> ILx Phase Start	Greater2_3_Imax (Greater2_3_Imax)	In the ”DIP Settings” tab page
1298	Blockage IL>>	Blockage IL>>	blockage_ILMM (blockage_ILMM)	In the ”DIP Settings” tab page
1300	IL>>> Start	IL>>>	Out of Service (outserv)	
1301	IL>>>	IL>>>	Pickup Current (Ipset)	
1334	ILx>>> Phase Start	IL>>> ILx Phase Start	Greater2_3_Imax (Greater2_3_Imax)	In the ”DIP Settings” tab page
1398	Blockage IL>>>	Blockage IL>>>	blockage_ILMMM (blockage_ILMMM)	In the ”DIP Settings” tab page
1400	IL>>>> Start	IL>>>>	Out of Service (outserv)	
1401	IL>>>>	IL>>>>	Pickup Current (Ipset)	
1434	ILx>>>> Phase Start	IL>>>> ILx Phase Start	Greater2_3_Imax (Greater2_3_Imax)	In the ”DIP Settings” tab page
1498	Blockage IL>>>>	Blockage IL>>>>	blockage_ILMMMM (blockage_ILMMMM)	In the ”DIP Settings” tab page

3.5 IE subrelay

The *IE* subrelay contains the earth overcurrent protective logic.

3.5.1 Available Units

- One inverse time earth overcurrent element (”IE>” block).
- Three time defined Earth overcurrent element (”IE>>”, ”IL>>>”, and ”IE>>>>” block).
- Eight logic elements (”Value for IE>”, ”Value for IE>>”, ”Value for IE>>>”, ”Value for IE>>>>”, ”Blockage IE>”, ”Blockage IE>>”, ”Blockage IE>>>”, and ”Blockage IE>>>>” block).
- Four block combining the signals (”Or1”, ”Or2”, ”Or3”, and ”Or4” block).

3.5.2 Functionality

The earth current monitored by the overcurrent elements can be

- The current measured by the neutral CT.
- The current calculated adding together the phase currents.

The IE> stage pickup value can be increased in dependence of the amount of the sum of those phase currents that have exceeded the pickup value IL>.
If all three phase currents are greater than IL>, the following applies:

$IE' >= IE > +ks(IL1 + IL2 + IL3 - 3IL >)$

If only two phase currents are greater than IL>, biasing is reduced:

$IE' >= IE > +ks(ILX + ILY - 2IL >)$

If only one phase current pickup is exceeded, the following remains:

$IE' >= IE > +ks(ILX - IL >)$

with
$IE' >$: $biasedpickupvalueoftheearthfaultcurrentstage$
$IE >$: $setpickupvalueoftheDTearthcurrentstageIE >$ ”$2101IE > DefiniteTime$”
ks : $settingofbiasingfactor$”$2107BiasingFactor$”
$IL1, IL2, IL3, ILX, ILY$: $r.m.s.valueofphasecurrents, x, y = [1, 2, 3]$
$IL >$: $Settingofphasecurrentstarting$”$1101IL > DefiniteTime$”

Each earth overcurrent element can be configured to start only if the ”IL>” phase overcurrent element has started.
To model the *Earth Current Differential Protection (unbiased)*, the relay model can be configured to add together the phase current and the current measured by the neutral CT.
Each earth overcurrent element can be configured to ignore an external block input signal.

The inverse time elements support the definite time characteristic and the following inverse time trip characteristics:

- Inverse
- Very Inverse
- Extremely Inverse
- Longtime inverse

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

3.5.3 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):

Address	Relay Setting	Model block	Model setting	Note
2100	IE> Start	IE>	Out of Service (outserv)	
2101	IE> Definite Time	IE>	Current Setting (Ipset)	
2102	IE> Inverse Time	IE>	Current Setting (Ipset)	
2103	IE> Definit.Time sens	IE>	Current Setting (Ipset)	
2105	IE> Definit.Time sens	IE>	Current Setting (Ipset)	
2106	IE> Inv. Time sens.	IE>	Current Setting (Ipset)	
2107	Biasing Factor	Earth Current Biasing	Ks (Ks)	In the ”Logic” tab page
2108	IE> Inv. Time sens.	IE>	Current Setting (Ipset)	
2111	tIE> Time	IE>	Time Dial (Tpset)	
2112	tE> Time Factor	IE>	Time Dial (Tpset)	
2113	tIE> max Time Delay	IE>	Time Dial (Tpset)	
2131	IE> Direction	IE>	Tripping Direction (idir)	
2132	IE> Timer Module	IE>	Characteristic (pcharac)	
2133	Value for IE>	Value for IE>	I0meas (I0meas)	
2137	IE> Start	Blockage IE> - IE> Start	ILStart (ILStart)	In the ”DIP Settings” tab page
2198	Blockage IE>	Blockage IE> - IE> Start	Extblock (extblock)	In the ”DIP Settings” tab page
2200	IE>> Start	IE>>	Out of Service (outserv)	
2201	IE>>	IE>>	Pickup Current (Ipset)	
2203	IE>> sensitive	IE>>	Pickup Current (Ipset)	
2205	IE>> sensitive	IE>>	Pickup Current (Ipset)	
2211	tIE>> Time	IE>>	Time Setting (Tset)	
2231	IE>> Direction	IE>>	Tripping Direction (idir)	
2233	Value for IE>>	Value for IE>>	I0meas (I0meas)	
2237	IE>> Start	Blockage IE>> - IE>> Start	ILStart (ILStart)	In the ”DIP Settings” tab page
2298	Blockage IE>>	Blockage IE>> - IE>> Start	Extblock (extblock)	In the ”DIP Settings” tab page
2300	IE>>> Start	IE>>>	Out of Service (outserv)	
2301	IE>>>	IE>>>	Pickup Current (Ipset)	
2303	IE>>> sensitive	IE>>>	Pickup Current (Ipset)	
2305	IE>>> sensitive	IE>>>	Pickup Current (Ipset)	
2311	tIE>>> Time	IE>>>	Time Setting (Tset)	
2331	IE>>> Direction	IE>>>	Tripping Direction (idir)	
2333	Value for IE>>>	Value for IE>>>	I0meas (I0meas)	
2337	IE>>> Start	Blockage IE>>> - IE>>> Start	ILStart (ILStart)	In the ”DIP Settings” tab page
2398	Blockage IE>>>	Blockage IE>>> - IE>>> Start	Extblock (extblock)	In the ”DIP Settings” tab page
2400	IE>>>> Start	IE>>>>	Out of Service (outserv)	

Address	Relay Setting	Model block	Model setting	Note
2401	IE>>>>	IE>>>>	Pickup Current (Ipset)	
2403	IE>>>> sensitive	IE>>>>	Pickup Current (Ipset)	
2405	IE>>>> sensitive	IE>>>>	Pickup Current (Ipset)	
2411	tIE>>>> Time	IE>>>>	Time Setting (Tset)	
2431	IE>>>> Direction	IE>>>>	Tripping Direction (idir)	
2433	Value for IE>>>>	Value for IE>>>	I0meas (I0meas)	
2437	IE>>>> Start	Blockage IE>>>> - IE>>>> Start	ILStart (ILStart)	In the ”DIP Settings” tab page
2498	Blockage IE>>>>	Blockage IE>>>> - IE>>>> Start	Extblock (extblock)	In the ”DIP Settings” tab page

3.6 Ineg subrelay

The *Ineg* subrelay contains the negative sequence protective logic.

3.6.1 Available Units

- One inverse time negative sequence overcurrent element (”Ineg>” block).
- One time defined negative sequence overcurrent element (”Ineg>>” block).
- One configuration interface element (”Blockage Ineg” block).
- One logic elements (”const”block).
- One output logic element (”Output Logic” block).

3.6.2 Functionality

The *Ineg* subrelay models a inverse time negative sequence overcurrent element and a definite time negative sequence overcurrent element. Each element can be blocked by an unique relay input signal and for each element the user can decide if the input block signal is active. In the ”Blockage Ineg” block the *BlockageInegM* dip switch allows to ignore the input block signal for the ”Ineg>” element and the *BlockageInegMM* dip switch inhibits the blocking for the ”Ineg>>” element.

The inverse time element supports the definite time characteristic and the following inverse time trip characteristics:

- Inverse
- Very Inverse
- Extremely Inverse
- Longtime inverse

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

3.6.3 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):

Address	Relay Setting	Model block	Model setting	Note
3100	Ineg> Start	Ineg>	Out of Service (outserv)	
3198	Blockage Ineg>	Blockage Ineg	Blockage_InegM (Blockage_InegM)	In the ”DIP Settings” tab page
3132	Ineg> Timer Module	Ineg>	Characteristic (pcharac)	
3101	Ineg> Definite Time	Ineg>	Current Setting (Ipset)	
3102	Ineg> Inverse Time	Ineg>	Current Setting (Ipset)	
3111	tIneg> Time	Ineg>	Time Dial (Tpset)	
3112	tIneg> Time Factor	Ineg>	Time Dial (Tpset)	
3113	tIneg> max Time Delay	Ineg>	Max. Time (udeftmax)	
3200	Ineg>> Start	Ineg>>	Out of Service (outserv)	
3298	Blockage Ineg>>	Blockage Ineg	Blockage_InegMM (Blockage_InegMM)	In the ”DIP Settings” tab page
3201	Ineg>>	Ineg>>	Pickup Current (Ipset)	
3211	tIneg>> Time	Ineg>>	Time Setting (Tset)	

3.7 Overload subrelay

The *Overload* subrelay contains the thermal image protective logic.

3.7.1 Available Units

- One thermal image element with selectable cooling logic (”Overload” block).
- Two thermal warning threshold elements (”Thermal Warning 1”, and ”Thermal Warning 2” block).
- One maximum allowed current threshold element (”ILMax” block).
- Three logic elements (”const”, and ”Imax Logic” block).
- One output logic element (”Output Logic” block).

3.7.2 Functionality

The *Overload* subrelay implements a thermal replica with ”memory”, i.e. taking the preload into account in accordance with IEC 60255-8 or EN 60255-8. The r.m.s. values of the highest phase current or of the measured earth fault current are used. It is possible to insert a current threshold which permits limitation up to which current the replica is to be filled.

The overload trip logic is inhibited by the *extblock* input signal.

3.7.3 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):

Address	Relay Setting	Model block	Model setting	Note
4100	Overload Protection	Overload protection	Out of Service (outserv)	
4137	O.loadProt. Current	O.loadProt. Current	MeasuredEarthCurrent (MeasuredEarthCurrent)	In the ”DIP Settings” tab page. Set the dip *on* to use the measured earth current
4101	k Pickup Factor	Overload protection	Current Setting (Ipset)	
4102	tau therm.Timeconst.	Overload protection	Time Dial (Tpset)	
4111	OLoadProt. up to Imax	OLoadProt. up to Imax	Pickup Current (Ipset)	
4131	Therm. Warn.Level 1	Therm. Warn.Level 1	Out of Service (outserv)	
4108	Therm. Warn.Level 1	Therm. Warn.Level 1	Pickup Current (Ipset)	
4132	Therm. Warn.Level 2	Therm. Warn.Level 2	Out of Service (outserv)	
4109	Therm. Warn.Level 2	Therm. Warn.Level 2	Pickup Current (Ipset)	
4196	Blockage therm. TRIP	Blockage therm. TRIP	BlockageThermTRIP (BlockageThermTRIP)	In the ”DIP Settings” tab page.

3.8 CBF subrelay

The *CBF* subrelay implements a simplified version of the circuit breaker failure logic.

3.8.1 Available Units and input signals

The *CBF* subrelay contains the following elements:

- One minimum current definite time threshold element (”IminCBF” block).
- One timer (”tCBF intern” block).
- One configuration interface element (”Blockage CBF” block).
- One output logic element (”Output Logic” block).

The following input signals are used

- *wtrip*: the trip input signals which is *on* when at least one protective element of the Sprecher SPRECON-E DD relay model is tripped.
- *Iabs_A;Iabs_B;Iabs_C*: the phase currents measured by the relay model.
- *extblock*: a relay input signal which can be used to inhibit the *CBF* logic.

3.8.2 Functionality

The *CBF* sub relay activates an output signal and operates the associated breaker when both the following conditions are verified:

- The trip input signal remains *on* for a time greater than ”tCBF intern ” (usually equal to the breaker operating time+ a safety margin).
- At least one phase of a 3 phase currents system remains always greater than ”IminCBF” after that the trip signal became *on*.

The operation logic is inhibited by the *extblock* input signal. The signal can be ignored setting equal to *off* the *Blockage_CBF* dip switch in the ”Blockage CBF” block.

3.8.3 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):

Address	Relay Setting	Model block	Model setting	Note
9300	CB Fail.Protect. CBF	IminCBF	Out of Service (outserv)	
9398	Blockage CBF	Blockage CBF	Blockage_ CBF	In the ”DIP Settings” tab page
9308	IminCBF	IminCBF	Pickup Current (Ipset)	
9311	tCBF intern	tCBF intern	Time Setting (Tdelay)	

3.9 SCD subrelay

The *SCD* subrelay implements the phase and the ground directional logic.

3.9.1 Available Units and input signals

The *SCD* subrelay contains the following elements:

- One 3 phase directional element (”SCD” block).
- One single phase earth directional element (”ESCD”).
- Two configuration interface element (”Blockage SCD”, and ”Value for ESCD” block).
- One output logic element (”Output Logic” block).
- One logic element (”Const” block).

3.9.2 Functionality

The *SCD* subrelay phase directional element compares the angle between each phase current vector and the relevant opposite (at 90° in a symmetric system) phase-phase voltage vector. If the angle is smaller then 90° the forward direction is declared. A minimum phase voltage activation threshold can be configured by the user. A 2 seconds voltage buffer is automatically activated when the phase-phase voltage drops below 4 % of the rated voltage. The phase directional element can be set to consider or not an external input blocking signal (in the ”Blockage SCD” block).
The earth directional element declares the forward direction if the angle between the zero sequence current and the zero sequence voltage rotated by the *Max Torque Angle* is smaller then 90°. A minimum earth voltage activation threshold can be configured by the user. The earth directional element can be set to consider or not an external input blocking signal.

3.9.3 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):

Address	Relay Setting	Model block	Model setting	Note
1900	Short Circ.Direction	SCD	Out of Service (outserv)	
1998	Blockage SCD	Blockage SCD	Blockage_SCD (Blockage_SCD)	
1905	Charact.Angle SCD	SCD	Max. Torque Angle (mtau)	
1908	Umem if ULL <	SCD	Polarizing Voltage (upolu)	In the ”Voltage Polarizing” tab page
1911	Validity Umem	SCD	Memory Time (tmem)	In the ”Voltage Polarizing” tab page of the SCD.TypDir dialog
2900	Earth SC Direction	ESCD	Out of Service (outserv)	
2998	Blockage ESCD	Blockage SCD	Blockage_ESCD (Blockage_ESCD)	
2905	Charact.Angle ESCD	ESCD	Max. Torque Angle (mtau)	
2933	Value for IE ESCD	Value for ESCD	IE_ESCD_Measured (IE_ESCD_Measured)	In the ”DIP Settings” tab page

Address	Relay Setting	Model block	Model setting	Note
2935	Value for UNE ESCD	Value for ESCD	UNE_ESCD_Measured (UNE_ESCD_Measured)	In the ”DIP Settings” tab page
2902	UNEmin ESCD	ESCD	Polarizing Voltage (upolu)	In the ”Voltage Polarizing” tab page

3.10 Voltage subrelay

The *Voltage* subrelay implements the phase and the zero sequence overvoltage and undervoltage protection logic.

3.10.1 Available Units and input signals

The *Voltage* subrelay contains the following elements:

- Two definite time phase overvoltage elements (”U>”, and ”U>>” block).
- Two definite time phase undervoltage elements (”U<”, and ”U<< ” block).
- Two definite time zero sequence overvoltage elements (”UNE<”, and ”UNE>>” block).
- Six configuration interface element which allow to set the input quantities(”Value for U> - U> Mode”, ”Value for U>> - U>> Mode”, ”Value for U< - U< Mode”, ”Value for U<< - U<< Mode”, ”Value for UNE> - UNE> Mode”, and ”Value for UNE>> - UNE>> Mode” block).
- Six configuration interface element enabling/disabling the blocking input(”Blockage U>”, ”Blockage U>>”, ”Blockage U<”, ”Blockage U<< ”, ”Blockage UNE>”, and ”Blockage UNE>>” block).
- Four configuration interface element which allow to set the trip mode(”U> Trip Mode”, ”U>> Trip Mode”, ”U< Trip Mode”, and ”U<< Trip Mode” block).
- One output logic element (”Output Logic” block).
- One logic element (”Const” block).

3.10.2 Functionality

The *Voltage* subrelay models two 3phase overvoltage elements, two 3phase undervoltage elements and two zero sequence overvoltage elements. Each phase voltage element can be set to use:

- the phase-phase voltages
- the phase-ground voltages.

Each voltage element can be configured to ignore an external block input signal.

3.10.3 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):

Address	Relay Setting	Model block	Model setting	Note
14100	U> Stage	U>	Out of Service (outserv)	
14198	Blockage U>	Blockage U>	blockage_UM (blockage_UM)	In the ”DIP Settings” tab page, when the dip is *on* the element can be blocked by the external element

Address	Relay Setting	Model block	Model setting	Note
14140	Value for U>	Value for U> - U> Mode	Use_1stharmonic (Use_1stharmonic)	In the "DIP Settings" tab page, when the dip is *on* only the voltage 1^{st} harmonic is used
14131	U> Mode	Value for U> - U> Mode	Use_Phase_Phase_Voltage (Use_Phase_Phase_Voltage)	In the "DIP Settings" tab page, when the dip is *on* the phase-Phase voltage is used otherwise the phase-ground voltage is used
14101	U>	U>	Input Setting (Ipset)	
14111	tU> Time	U>	Time Dial (Tpset)	
14200	U>> Stage	U>>	Out of Service (outserv)	
14298	Blockage U>>	Blockage U>>	blockage_UMM (blockage_UMM)	In the "DIP Settings" tab page, when the dip is *on* the element can be blocked by the external element
14240	Value for U>>	Value for U>> - U>> Mode	Use_1stharmonic (Use_1stharmonic)	In the "DIP Settings" tab page, when the dip is *on* only the voltage 1^{st} harmonic is used
14231	U>> Mode	Value for U>> - U>> Mode	Use_Phase_Phase_Voltage (Use_Phase_Phase_Voltage)	In the "DIP Settings" tab page, when the dip is *on* the phase-Phase voltage is used otherwise the phase-ground voltage is used
14201	U>>	U>>	Input Setting (Ipset)	
14211	tU>> Time	U>>	Time Dial (Tpset)	
15100	U< Stage	U<	Out of Service (outserv)	
15198	Blockage U<	Blockage U<	blockage_Um (blockage_Um)	In the "DIP Settings" tab page, when the dip is *on* the element can be blocked by the external element
15140	Value for U<	Value for U< - U< Mode	Use_1stharmonic (Use_1stharmonic)	In the "DIP Settings" tab page, when the dip is *on* only the voltage 1^{st} harmonic is used
15131	U< Mode	Value for U< - U< Mode	Use_Phase_Phase_Voltage (Use_Phase_Phase_Voltage)	In the "DIP Settings" tab page, when the dip is *on* the phase-Phase voltage is used otherwise the phase-ground voltage is used
15101	U<	U<	Input Setting (Ipset)	
15111	tU< Time	U<	Time Dial (Tpset)	
15200	U<< Stage	U<<	Out of Service (outserv)	
15298	Blockage U<<	Blockage U<<	blockage_Umm (blockage_Umm)	In the "DIP Settings" tab page, when the dip is *on* the element can be blocked by the external element
15240	Value for U<<	Value for U<< - U< Mode	Use_1stharmonic (Use_1stharmonic)	In the "DIP Settings" tab page, when the dip is *on* only the voltage 1^{st} harmonic is used
15231	U<< Mode	Value for U<< - U<< Mode	Use_Phase_Phase_Voltage (Use_Phase_Phase_Voltage)	In the "DIP Settings" tab page, when the dip is *on* the phase-Phase voltage is used otherwise the phase-ground voltage is used

Address	Relay Setting	Model block	Model setting	Note
15201	U<<	U<<	Input Setting (Ipset)	
15211	tU<< Time	U<<	Time Dial (Tpset)	
14300	UNE> Stage	UNE>	Out of Service (outserv)	
14398	Blockage UNE>	Blockage UNE>	blockage_UNEM (blockage_UNEM)	In the ”DIP Settings” tab page, when the dip is *on* the element can be blocked by the external element
14340	Value for UNE>	Value for UNE> - UNE> Mode	Use_1stharmonic (Use_1stharmonic)	In the ”DIP Settings” tab page, when the dip is *on* only the voltage 1^{st} harmonic is used
14335	UNE> Mode	Value for UNE> - UNE> Mode	Use_Measured (Use_Measured)	In the ”DIP Settings” tab page, when the dip is *on* the neutral voltage measured by the open delta Vt voltage is used
14301	UNE>	UNE>	Input Setting (Ipset)	
14311	tUNE> Time	UNE>	Time Dial (Tpset)	
14400	UNE>> Stage	UNE>>	Out of Service (outserv)	
14498	Blockage UNE>>	Blockage UNE>>	blockage_UNEMM (blockage_UNEMM)	In the ”DIP Settings” tab page, when the dip is *on* the element can be blocked by the external element
14440	Value for UNE>>	Value for UNE>> - UNE>> Mode	Use_1stharmonic (Use_1stharmonic)	In the ”DIP Settings” tab page, when the dip is *on* only the voltage 1^{st} harmonic is used
14435	UNE>> Mode	Value for UNE>> - UNE>> Mode	Use_Measured (Use_Measured)	In the ”DIP Settings” tab page, when the dip is *on* the neutral voltage measured by the open delta Vt voltage is used
14401	UNE>>	UNE>>	Input Setting (Ipset)	
14411	tUNE>> Time	UNE>>	Time Dial (Tpset)	

3.11 Frequency subrelay

The *Frequency* subrelay implements the overfrequency and the underfrequency protection logic.

3.11.1 Available Units and input signals

The *Frequency* subrelay contains the following elements:

- Four over/under frequency elements (”f1><”, ”f2><”, ”f3><”, and ”f4><” block).
- One undervoltage element (”ULLmin for fx><” block).
- Four configuration interface element which allow to enable/disable the blocking input(”Blockage f1><”, ”Blockage f2><”, ”Blockage f3><”, and ”Blockage f4><” block).
- One output logic element (”Output Logic” block).
- One logic element (”Const” block).

3.11.2 Functionality

The *Frequency* subrelay models contains 4 over/under frequency define time delay elements. Each frontage element can be configured to ignore an external block input signal. The frequency elements are blocked when any phase-phase voltage is smaller than a user configurable threshold (16008 ULLmin for fx><).Each frequency element can be set to

3.11.3 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):

Address	Relay Setting	Model block	Model setting	Note
16100	f1>< Start	f1><	Out of Service (outserv)	
16198	Blockage f1><	Blockage f1><	blockage_f1Mm (blockage_f1Mm)	In the ”DIP Settings” tab page, when the dip is *on* the element can be blocked by the external element
16130	TRIP at tf1><	Output Logic	tf1Mm_Trip (tf1Mm_Trip)	In the ”DIP Settings” tab page, when the dip is *on* the ”f1><” element trip triggers the relay trip
16101	f1><	f1><	Frequency (Fset)	
16111	tf1>< Time	f1><	Time Delay (Tdel)	
16200	f2>< Start	f2><	Out of Service (outserv)	
16298	Blockage f2><	Blockage f2><	blockage_f2Mm (blockage_f2Mm)	In the ”DIP Settings” tab page, when the dip is *on* the element can be blocked by the external element
16230	TRIP at tf2><	Output Logic	tf2Mm_Trip (tf2Mm_Trip)	In the ”DIP Settings” tab page, when the dip is *on* the ”f2><” element trip triggers the relay trip

Address	Relay Setting	Model block	Model setting	Note
16201	f2><	f2><	Frequency (Fset)	
16211	tf2>< Time	f2><	Time Delay (Tdel)	
16300	f3>< Start	f3><	Out of Service (outserv)	
16398	Blockage f3><	Blockage f3><	blockage_f3Mm (blockage_f3Mm)	In the ”DIP Settings” tab page, when the dip is *on* the element can be blocked by the external element
16330	TRIP at tf3><	Output Logic	tf3Mm_Trip (tf3Mm_Trip)	In the ”DIP Settings” tab page, when the dip is *on* the ”f3><” element trip triggers the relay trip
16301	f3><	f3><	Frequency (Fset)	
16311	tf3>< Time	f3><	Time Delay (Tdel)	
16400	f4>< Start	f4><	Out of Service (outserv)	
16498	Blockage f4><	Blockage f4><	blockage_f4Mm (blockage_f4Mm)	In the ”DIP Settings” tab page, when the dip is *on* the element can be blocked by the external element
16430	TRIP at tf4><	Output Logic	tf4Mm_Trip (tf4Mm_Trip)	In the ”DIP Settings” tab page, when the dip is *on* the ”f4><” element trip triggers the relay trip
16401	f4><	f4><	Frequency (Fset)	
16411	tf4>< Time	f4><	Time Delay (Tdel)	
16001	No. of periods for f	Measure Frequency	Frequency Measurement Time (Tfe)	In the main relay
16008	ULLmin for fx><	ULLmin for fx><	Voltage (Uset)	

3.12 Output logic

It represents the output stage of the relay; it is the interface between the relay and the power breaker.

3.12.1 Available elements and relay output signals

The trip logic is implemented by the ”Output Logic” block. 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.

The relay trip output signals are:

- yout
- Z1TRIP
- Z2TRIP
- Z3TRIP
- Z4TRIP
- Z5TRIP
- Z6TRIP
- START
- yout1
- yout2

”yout” is the trip signal operating the breaker. The other output signals are associated by the default logic available in the relay model to the different zone trip output. A different user logic can be inserted in the ”Logic” tab page of the ”Output Logic” block. The relay closing command output signal is ”yout1”. ”yout2” is the ouput signal activated when the breaker failure condition has been detected.

3.12.2 Functionality

The ”Output Logic” block collects the trip signals coming from the overcurrent protective elements and, when any protective element trips, operates the power breaker and the ”yout” relay output contact.
The trip logic is user configurable and can be set in the ”Logic” tab page.
The additional output signal ”yAlarm”, as default logic, is triggered by the starting of any frequency element.

The ”Closing Logic” block is controlled by the closing signal coming from the ”Reclosing” block and, when a reclosing attempt is initiated, triggers the closing command for the power breaker and operates the ”yout1” relay output contact .

3.12.3 Data input

To disable the relay model ability to open the power circuit breaker simply disable the ”Output Logic” block.

To disable the relay model ability to close the power circuit breaker simply disable the ”Closing Logic” block.

4 Features not supported

The following features are not supported:

- Wattmetric Earth-Fault Direction Decision, Compensated System.
- Wattmetric Earth-Fault Direction Decision, Isolated System.
- Switch-On Protection (SOP).
- Inrush Restraint (harmonic restraint.
- Current annunciations (2x IL> an, 1x IE> an).
- Power Protection.
- Reactive Power – Undervoltage Protection.
- Synchrocheck and Synchrocheck AR.
- Emergency Overcurrent-Time Protection.
- Fault Location (FL).
- Switch-On Protection (SOP/SOTF).
- Trip Circuit Supervision.
- Capture of external earth-fault directions.
- Permissive Overreach Protection (POP).
- Reverse Interlock Function and H2 Logic.
- Teleprotection (TP).
- CB TRIP by external signal.
- Phase-sequence reversal / direction.
- User configurable *Reset Ratio*.

5 References

[1] Sprecher Automation Deutschland GmbH, Moellendorffstr. 47 10367 Berlin Germany. *SPRECON-E-P DD6 PROTECTION AND CONTROL DEVICES DISTANCE PROTECTION User manual for the protection part Structure version 5601 94.2.903.15en from software version 1.01 2012-10-10 Issue E*, 2012.