

APPLICATION NOTE

Testing of directional overcurrent protection with SVERKER 900

1. When to use Directional OverCurrent

For parallel lines and in power networks with several incoming feeding points directional overcurrent protection is commonly used to get good selectivity.

Disconnecting of parallel lines in a radial power network can be done with two directional and two none directional protections. (see picture)

For the directional protection to operate correctly at close fault, it has to work correctly at very low voltage.



Function of Directional OverCurrent

In order to determine the direction of the error, at least one main voltage is required which is compared to one of the missing phases. If the fault is two or three phased, the protection must be able to remember the voltage just before the fault. The setting of the protection function to detect the error can be made single-phase, two-phase or three-phase. The setting chosen depends on the structure of the network and the setting choices in the monitoring relay. In this application, single-phase and two-phase detection is used, see pictures below.

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 $\theta = 30^{\circ}$

U21



2. Instrument used at testing

To test the protective function amplitude and zone limits, the "main" instrument can be used. For time test of two or three-phase failures, the protection must feel stable state before error and the "Pre-fault, Fault" or "Sequence" instrument must be used.

Below are examples of 1-phase and 2-phase errors. Different characteristic angles of the error can be selected, usually 30, 45 or 60 degrees. See pictures below.



Fault tripping in line zone with angle 30 degree.





line

busbar

zone

zone _{I3}▲ α3

Fault tripping in line zone with angle 45 degree.





Fault tripping in line zone with angle 60 degree.

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Connect according to drawing below.

If start contact is not available use start diode or lower trip delay to minimum. Use existing auxiliary voltage if available. In this example Sepam protection type S84 is used. For other protections all values have to be adjusted to that specific test object.

Main Instrument with Hold function.

Pickup/dropout for protection with one phase fault selection, protection set to 0.7A and characteristic set to 30 degree.

Test1: Set current to 0.65A and angel to 0 degree, voltage over activating level about 20V select BI1 to changing contact dry or wet (if voltage is used) press start and blue hold symbol increase current to trip then press blue hold symbol again and decrease current to dropout.

0.0 °	50.000 Hz	13	I1 0.652 A	0.0 °	50.000 Hz	1 3
			I2			$(\sim \sim $
			I3			
			U1			
240.0 °	50.000 Hz		U2 20.00 V	240.0 °	50.000 Hz	
120.0 °	50.000 Hz		U3 20.00 V	120.0 °	50.000 Hz	
		48 VDC BI				48 VDC BI
		TRIP HOLD 1				TRIP HOLD 2
пме	123.45		OFF+TIME ON+	ТІМЕ	123.45	
	0.0 °	0.0 ° 50.000 Hz 240.0 ° 50.000 Hz 120.0 ° 50.000 Hz	0.0 ° 50.000 Hz 240.0 ° 50.000 Hz 120.0 ° 50.000 Hz HE 12200 C BI TRIP HOLD 1	0.0 ° 50.000 Hz 240.0 ° 50.000 Hz 240.0 ° 50.000 Hz 120.0 ° 50.000 Hz Hz Hz Hz Hz Hz Hz Hz Hz Hz	0.0 ° 50.000 Hz 240.0 ° 50.000 Hz 120.0 °	0.0 ° 50.000 Hz 240.0 ° 50.000 Hz 240.0 ° 50.000 Hz 120.0 ° 50.000 Hz

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Angel zone test for phase I1

Test2: Go out of zone by setting angel to over 30 degree and set current above trip level, press hold again and go into zone by lower angel to trip (about 30 degree) press hold again and continue to twist the knob to go out of zone (about 210 degree). Use knob to change all values.

I1 0.800 A	29.0 °	50.000 Hz	1 3	I1 0.800 A	208.7 °	50.000 Hz	1 3
I2				I2			$(\wedge \land $
I3				I3			
U1				U1			II.
U2 20.00 V	240.0 °	50.000 Hz		U2 20.00 V	240.0 °	50.000 Hz	
U3 20.00 V	120.0 °	50.000 Hz		U3 20.00 V	120.0 °	50.000 Hz	
			48 VDC BI				48 VDC BI
			TRIP HOLD 3				TRIP HOLD 4
OFF+TIME ON+	ТІМЕ	123.45		OFF+TIME ON+	TIME	123.45	

Voltage low limit test for pick up

Test3: Lower the voltage to about 0.5V and turn the angel back to inside zone press hold and increase voltage to trip

I 1	0.800 A	0.0 °	50.000 Hz	13
I2				[~~\\\\\\\
I 3				
U1				
U2	1.25 V	240.0 °	50.000 Hz	
U3	1.25 V	120.0 °	50.000 Hz	
				48 VDC BI
				TRIP HOLD 5
OFF+1	TIME ON+TI	ME	123,45	

The other two combinations can be tested the same way: I2=ON, U1andU3=ON, I3=ON U1andU2=ON. All changes can be made with keypad if each test is made individually.

Main Hold: Result

1. Pick up value I1# 2. Drop out value I1# 3. First zone limit at about 30 degree# 4. Second zone limit at about 210 degree# 5. Voltage low limit for activating trip.

#	I1: A	٥	U2: V	U3: V
1	0.695	0.0	20.00	20.00
2	0.652	0.0	20.00	20.00
(2/1)	0.938			
3	0.800	29.0	20.00	20.00
4	0.800	208.7	20.00	20.00
(4/3)				
5	0.800	0.0	1.25	1.25

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Trip area at characteristic angle, see fault tripping zones for phase I1.

Pickup/dropout for protection with two phase fault selection, protection set to 0,7A

Test 1: Set I1 current to 0.65A, I2 over trip level and voltage over activating level. Select BI1 to changing contact dry or wet (if voltage is used) press start and blue hold symbol



Make the same test with 11 over trip level and 12 at 0,65A



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Main Hold: Result

1. Pick up value I1: A (I2: A set to fault) # 3. Pick up value I2: A (I1: A set to fault)

2. Drop out value I1: A (I2: A set to fault) # 4. Drop out value I2: A (I1: A set to fault)

#	I1: A	I2: A
1	0.696	0.800
2	0.650	0.800
(2/1)	0.934	
3	0.800	0.696
4	0.800	0.653
(4/3)		0.938

Test2: Voltage low limit for pick up U1 (U2) and U3 start at 1.0V no trip, I1 and I2 in faulty level.



Test3: Angel zone test for phase I1 start_at angle 30° and I2 start at angle 270°



Main Hold:Result

Two phase fault voltage pick up						
PU	U1=1.48V / U2=1.00V / U3=1.48V					
PU	U1=1.00V / U2=1.49V / U3=1.49V					

Main Hold:Result

Pick up	Drop out
l1:29.6°	l1:210.3°
l2:269.6°	l2:89.4°

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Angel zone test for phase I2 start at angle 90° and I3 start at angle 330° # 12: ° 13: ° U1: V U2: V U3: V 1 120.0 1.26 1.26 240.0 1.00 2 240.0 120.0 1.26 1.00 1.26 (2/1)0.794 1.260 3 329.5 2.00 90.3 2.00 2.00 4 276.4 150.8 2.00 2.00 2.00 (4/3)

Result from same test as above with U1(U3) and U2, I2 and I3 in faulty level.

#1: U1andU2 voltage Pu #2: U1andU3 voltage PU

#3: I1 and I3 first zone angle

#4: I1 and I3 second zone angle

Test in Pre fault/Fault Instrument

Time test for one and two phase fault, protection set to 500ms

Pref	ault					One	phase	fault			
I1	0.500 A	0.0 °	50.000 Hz			I 1	1.00 A	0.0 °	50.000 Hz		
12	0.500 A	240.0 °	50.000 Hz		>>	I2	0.500 A	240.0 °	50.000 Hz] / 💦	\gg
13	0.500 A	120.0 °	50.000 Hz	++		13	0.500 A	120.0 °	50.000 Hz] []	
U1	63.50 V	0.0 °	50.000 Hz		> 1	U1	0.00 V	0.0 °	50.000 Hz]\	>
U2	63.50 V	240.0 °	50.000 Hz	0212		U2	63.50 V	240.0 °	50.000 Hz] 💘	
U3	63.50 V	120.0 °	50.000 Hz		<u>ি</u> শ	U3	63.50 V	120.0 °	50.000 Hz		[7"
				48 VDC	BI					48 VDC	BI
Prefault: 1000 ms		STOPPED		Max:	1000 ms	Off Delay: 0	ms	STO	PPED		
<u> </u>				\neg	√_/√+	<u>Ů</u> ∿+^	\checkmark				

			Res	ult one	phase			
50.000 Hz			I1	1.00 A	0.0 °	50.000 Hz		
50.000 Hz] / 🔨 📐	$\gg 1$	I2	0.500 A	240.0 °	50.000 Hz]/~	\sim
50.000 Hz			I3	0.500 A	120.0 °	50.000 Hz] [[]	\rightarrow $\stackrel{I1}{\rightarrow}$
50.000 Hz		>>1	U1	0.00 V	0.0 °	50.000 Hz		<u>*</u> >>/
50.000 Hz		>	U2	63.50 V	240.0 °	50.000 Hz] 义	\sim
50.000 Hz		িস	U3	63.50 V	120.0 °	50.000 Hz		িস
	48 VDC	BI					48 VDC	BI
Max: 1000 ms Off Delay: 0 ms STOP		PPED	Max:	1000 ms	Off Delay:	ms	TRIP[1]	0.507 s
\checkmark			\land	$\sqrt{}$	Ū <mark>∿+⁄</mark>	$\overline{\mathbf{V}}$		
	50.000 Hz 50.000 Hz 50.000 Hz 50.000 Hz 50.000 Hz 50.000 Hz 50.000 Hz	50.000 Hz 50.000 Hz 50.000 Hz 50.000 Hz 50.000 Hz 50.000 Hz 50.000 Hz 48 VDC 50 ms ✓	50.000 Hz 50.000 Hz	\$50.000 Hz 11 \$50.000 Hz 13 \$50.000 Hz 14 \$50.000 Hz 12 \$50.000 Hz 13 \$50.000 Hz 14 \$50.000 Hz 14 <td< th=""><th>\$50.000 Hz 1 1.00 Å \$50.000 Hz 1 1.00 V \$50.000 Hz 1.00 V 1.00 V</th><th>\$50.000 Hz \$0.0° \$50.000 Hz \$1 \$50.000 Hz \$240.0° \$50.000 Hz \$35.0 V \$50.000 Hz \$35.0 V \$50.000 Hz \$120.0° \$50.000 Hz \$100 ms \$50.000 Hz \$100 ms \$50.000 Hz \$100 ms \$50.000 Hz \$100 ms \$50.000 ms</th><th>\$50.000 Hz \$0.0 ° \$50.000 Hz \$50.000 Hz \$11 1.00 A 0.0 ° \$50.000 Hz \$50.000 Hz \$31 0.500 A \$240.0 ° \$50.000 Hz \$50.000 Hz \$30.000 Hz \$30.000 A \$240.0 ° \$50.000 Hz \$50.000 Hz \$30.000 Hz \$30.000 A \$240.0 ° \$50.000 Hz \$50.000 Hz \$30.000 Hz \$30.000 Hz \$30.000 Hz \$30.000 Hz \$50.000 Hz \$10 0.0 ° \$50.000 Hz \$30.000 Hz \$30.000 Hz \$50.000 Hz \$12 0.0 ° \$50.000 Hz \$30.000 Hz \$30.000 Hz \$50.000 Hz \$12 0.0 ° \$50.000 Hz \$30.000 Hz \$30.000 Hz \$50.000 Hz \$12 0.0 ° \$50.000 Hz \$30.000 Hz \$30.000 Hz \$50.000 Hz \$12 0.0 ° \$50.000 Hz \$30.000 Hz \$30.000 Hz \$50.000 Hz \$12 0.0 ° \$50.000 Hz \$50.000 Hz \$50.000 Hz \$50.000 Hz \$10 00 ms \$0 ff Delay: 0 ms \$50.000 Hz \$50.000 Hz \$50.000 Hz \$50.000 Hz \$50.000 Hz \$50.000 Hz \$50.000 Hz \$50.000 Hz \$50.000 Hz <</th><th>S0.000 Hz Image: Constraint of the second secon</th></td<>	\$50.000 Hz 1 1.00 Å \$50.000 Hz 1 1.00 V \$50.000 Hz 1.00 V 1.00 V	\$50.000 Hz \$0.0° \$50.000 Hz \$1 \$50.000 Hz \$240.0° \$50.000 Hz \$35.0 V \$50.000 Hz \$35.0 V \$50.000 Hz \$120.0° \$50.000 Hz \$100 ms \$50.000 Hz \$100 ms \$50.000 Hz \$100 ms \$50.000 Hz \$100 ms \$50.000 ms	\$50.000 Hz \$0.0 ° \$50.000 Hz \$50.000 Hz \$11 1.00 A 0.0 ° \$50.000 Hz \$50.000 Hz \$31 0.500 A \$240.0 ° \$50.000 Hz \$50.000 Hz \$30.000 Hz \$30.000 A \$240.0 ° \$50.000 Hz \$50.000 Hz \$30.000 Hz \$30.000 A \$240.0 ° \$50.000 Hz \$50.000 Hz \$30.000 Hz \$30.000 Hz \$30.000 Hz \$30.000 Hz \$50.000 Hz \$10 0.0 ° \$50.000 Hz \$30.000 Hz \$30.000 Hz \$50.000 Hz \$12 0.0 ° \$50.000 Hz \$30.000 Hz \$30.000 Hz \$50.000 Hz \$12 0.0 ° \$50.000 Hz \$30.000 Hz \$30.000 Hz \$50.000 Hz \$12 0.0 ° \$50.000 Hz \$30.000 Hz \$30.000 Hz \$50.000 Hz \$12 0.0 ° \$50.000 Hz \$30.000 Hz \$30.000 Hz \$50.000 Hz \$12 0.0 ° \$50.000 Hz \$50.000 Hz \$50.000 Hz \$50.000 Hz \$10 00 ms \$0 ff Delay: 0 ms \$50.000 Hz \$50.000 Hz \$50.000 Hz \$50.000 Hz \$50.000 Hz \$50.000 Hz \$50.000 Hz \$50.000 Hz \$50.000 Hz <	S0.000 Hz Image: Constraint of the second secon

Result two phase

\wedge					
Max:	1000 ms	TRIP[1]	0.503 s		
				48 VDC	BI
U3	63.50 V	120.0 °	50.000 Hz	1	
U2	63.50 V	240.0 °	50.000 Hz	0212	>
U1	63.50 V	0.0 °	50.000 Hz		×>
I3	0.500 A	120.0 °	50.000 Hz		
I2	1.00 A	240.0 °	50.000 Hz	$\langle \cdot \rangle_{\mathbf{k}}$	5/2/)
I1	1.00 A	0.0 °	50.000 Hz	- 	



Test in Sequence Instrument

Check of zone and time test, zone borders are checked with 2degree above and below limit. The zone for phase I1and I2 at setting 30deegre.

Pre fault				Fault insic	le zone			
I1 0.500 A	0.0 °	50.000 Hz	103 - C	I1 1.00 A	28.0 °	50.000 Hz	U3	
12 0.500 A	240.0 °	50.000 Hz		12 1.00 A	268.0 °	50.000 Hz]/~	11
I3 0.500 A	120.0 °	50.000 Hz		I3 0.500 A	120.0 °	50.000 Hz		
U1 63.50 V	0.0 °	50.000 Hz		U1 63.50 V	0.0 °	50.000 Hz		> 1
U2 63.50 V	240.0 °	50.000 Hz		U2 63.50 V	240.0 °	50.000 Hz		12
U3 63.50 V	120.0 °	50.000 Hz	1	U3 63.50 V	120.0 °	50.000 Hz		িশ
	Prefault 1(5)				F1 in Z 2(5)		0 VDC	BI¥
							SEQ	END
STATE ►	BI	1000 ms			BI	1000 ms		
STATE =	BO	END SEQ		STATE -	BO	END SEQ		







