Directional-earth-fault protection

Using Low Current Adapter (LCA) when setting is <50mA

Directional earth fault protection is commonly used to protect long outgoing feeders from tripping because of fault on other outgoing lines. Because of changing from overhead lines to cables the capacitive input from outgoing feeders has increased. This makes healthy feeder trip if directional earth fault protection is not used. Restriking fault has also increased because of isolating problem with aging cables.

This application handles the type of directional earth fault that are cos phi measuring, and compares with an old type that are impedance measuring.

Type 1 – cos phi measuring used in impedance or compensated neutral system.

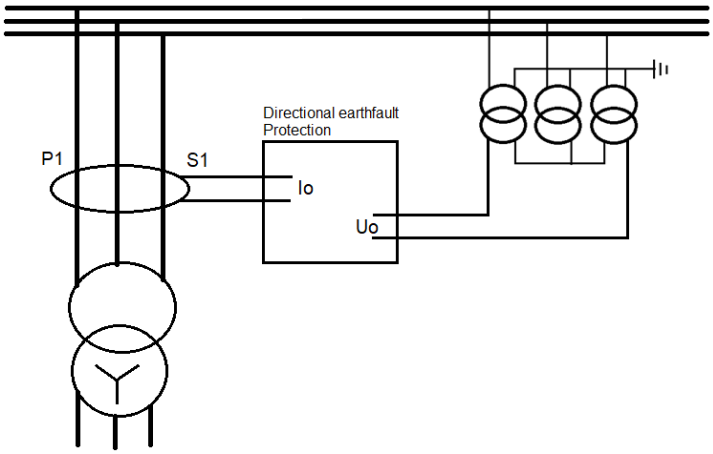
Type 2 – impedance measuring used in impedance or solidly earthed system.

A tripping zone is limited by characteristic angle, sector angle and setting level. Protection relays has different setting possibilities for the characteristic angle and sector angle, see manual for specific relay tested. For Type 1: the trip level is measured from the resistive value and for Type 2: it is measured from the impedance value. This means that if both types have setting 10 mA and fault angle is 45°.

Type 1: will trip at 10 mA/ cos45=10.41 mA (active current) Type 2: will trip at 10 mA (apparent current)

For selectivity reason it is not recommended to mix the two types in the same station and voltage level. It can be different direction reference depending on protection, always check what is the correct direction for trip (see pictures with explanation on next pages). Different characteristic angels can be chosen depending on type of protection. Below are two commonly used characteristic angels described.

Primary connection drawing for CT and VT to protection



The connection for Uo must be twisted when testing because in a real faulty case the direction for Uo is changed 180°, see test connection below.

Testing

Important

Read and comply with the safety instructions in the User's manual.

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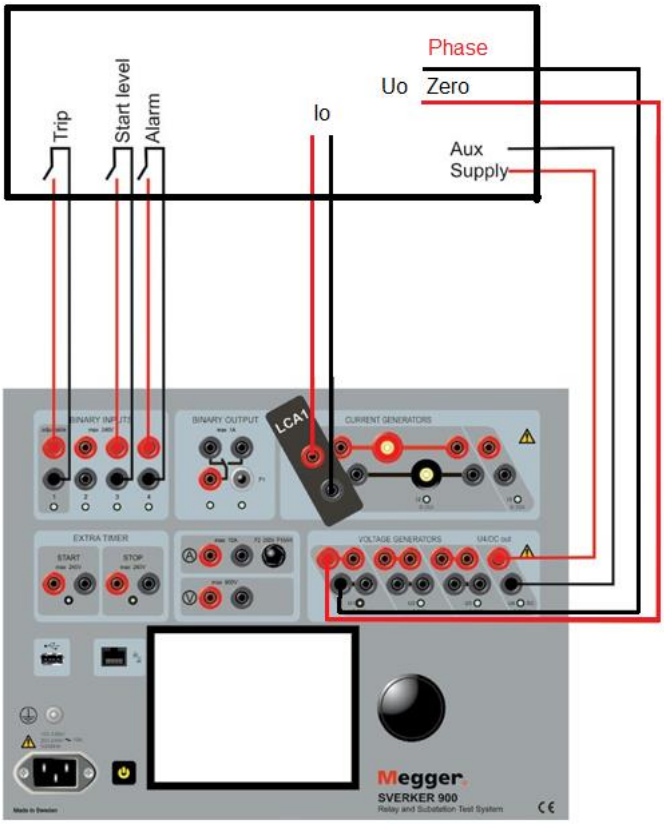
Connect according to picture below, if start output is not available make manual close on BI3 when start diode light up. Selection of BI is only one example.

Test Connection



As explained above the voltage in a real fault case twist 180degree. The U1gen red must therefore be connected to zero side of protection and U1gen black to phase side.

The LCA 1 has a ratio of 1/100 but it variates a little depending on the load.

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LCA1

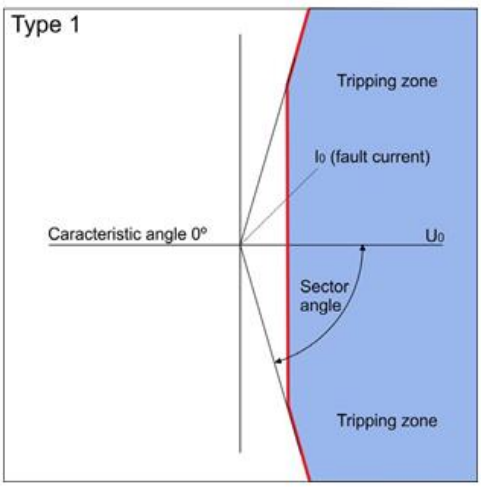
The ratio between the input and output currents is somewhat depending on the load, e.g. a 0.5 Ω load and 1 A current generation gives an output of 9 mA.

Example: Test 1 below 1,09A out from I1gen gives 10,3mA out from LCA 1.

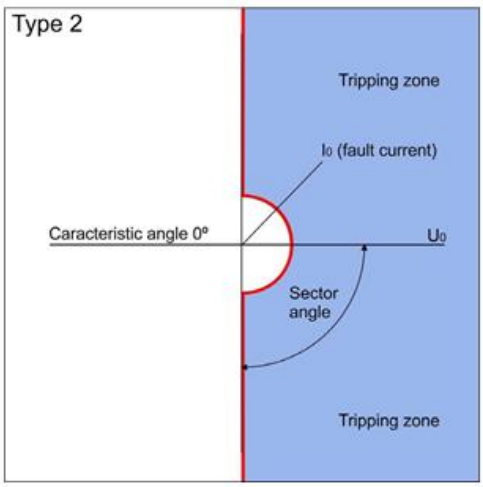
Example of tripping zones depending of type

Network connected to ground with 0° as characteristic angle

Cos phi measuring



Impedance measuring



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Protection settings and pick up values for Type 1

Current Io= 10mA Voltage Uo= 10% Unp Time t= 1s

Characteristic angle = 0° Sector angle = 80°

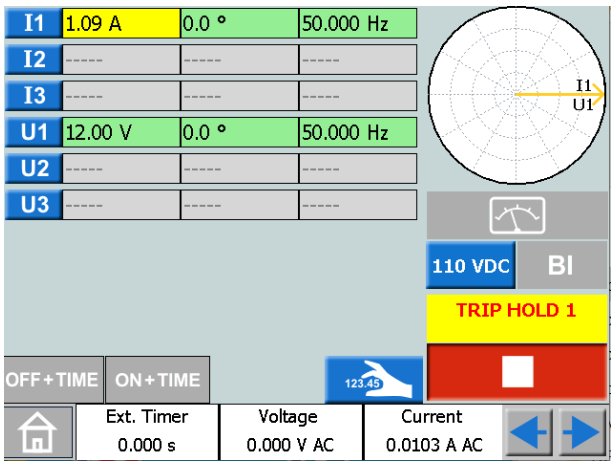
Tested in **"Main"** instrument with **"Hold"** function activated. BI set to react on dry contact closing.

Below pictures demonstrate how the Io value increases with increasing value of angle.

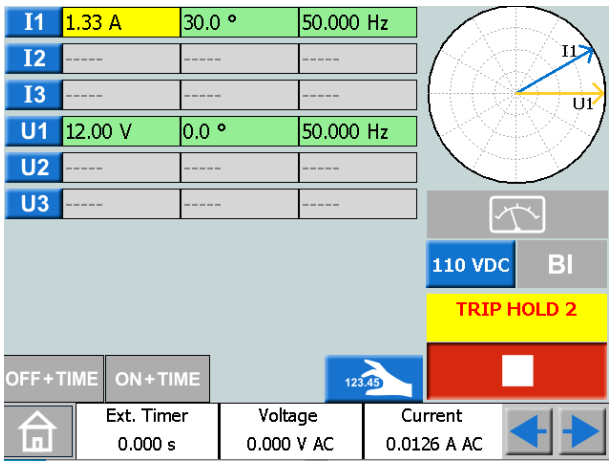
The current is the total of active value and reactive value, the protection activates when the active value reaches 10mA see characteristic for Type 1 above.

The result includes points taken in quadrant 1 and 4

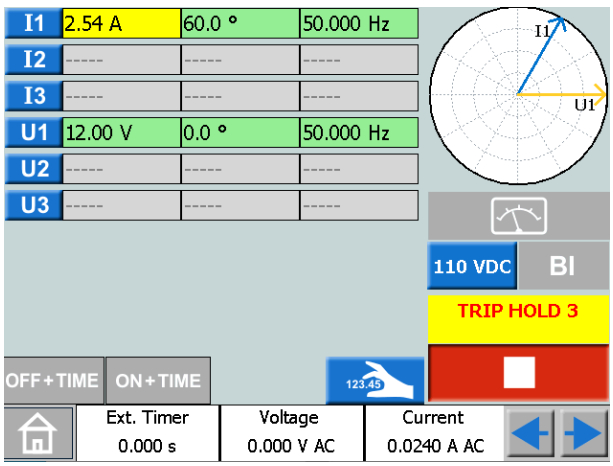
Test 1



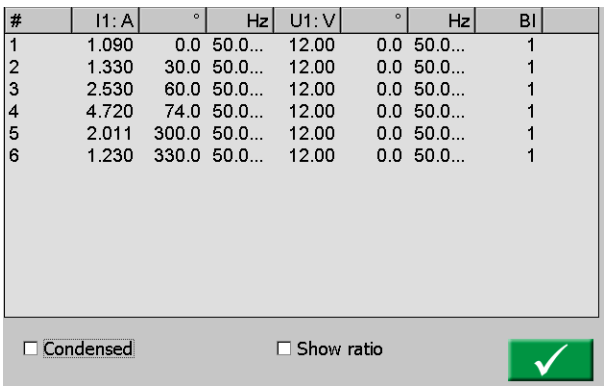
Test 2



Test 3



Result



#	I1: A	°	Hz	U1: V	°	Hz	BI
1	1.090	0.0	50.0...	12.00	0.0	50.0...	1
2	1.330	30.0	50.0...	12.00	0.0	50.0...	1
3	2.530	60.0	50.0...	12.00	0.0	50.0...	1
4	4.720	74.0	50.0...	12.00	0.0	50.0...	1
5	2.011	300.0	50.0...	12.00	0.0	50.0...	1
6	1.230	330.0	50.0...	12.00	0.0	50.0...	1

Condensed Show ratio

Unmark condensed and show ratio

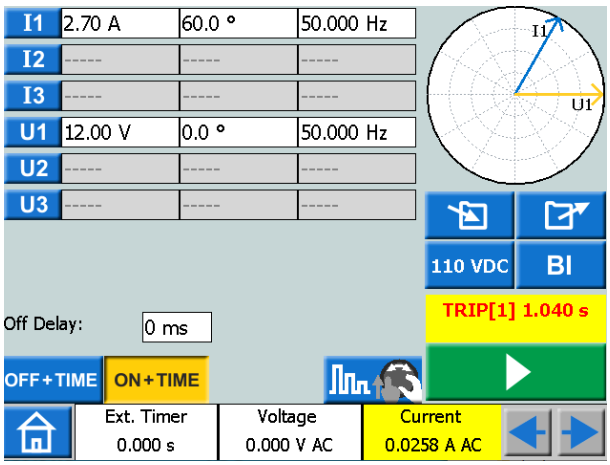
Protection with the same setting value as above but with Type 2 selected

In this case the test result will always be 10mA in zone 1 and 4 the angel will not have any impact on the result. The Io value will be stable on 10mA for all values of different angels. The activating current is the total of active value and reactive value.

Trip time taken for Type 1 t=1s at angel 60°

Tested in **“Main”** instrument with **“ON +Time”** function activated. BI set to react on dry contact closing.

Type 1



Activating current set to 25,8mA

Restriking fault

Modern protection also has the possibility to detect short flash over faults down to 1-2 ms that comes back repeatedly. Also called Intermittent earth fault, some protection measures the number of "spikes" but for this test, the relay has a memory time set between the "spikes”. Each "spike" keeps the protection activated until it finally trips.

Protection setting for restriking fault

Current Io= 10mA Voltage Uo= 10% Unp Time t= 1s Delay memory= 400ms

Testing of restriking fault

Tested in **“Sequence”** instrument, the test current is set to 0,1A 10 times setting current. To simulate the high current generated at intermittent earth fault. The zero voltage is set to 12 V, configuration is made in nine states including prefault. The protection time memory is set to 400ms and the total time is still 1 s.

In this test the LCA is not needed for accuracy as the fault current is higher than 50mA.

Uo connection twisted I1gen black connected to phase side and I1gen red connected to zero side

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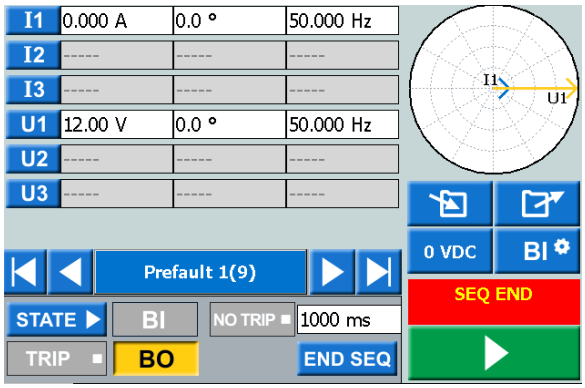
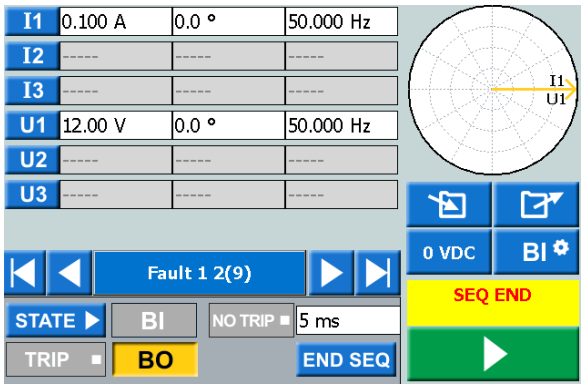
Make three states, state1 **“Prefault”** state2 **“Fault 1”** and state3 **“Memory 1”** see below. Set BI1 to react on dry contact closing. First fault set time to 5ms (lowest possible setting) for simulating intermittent earth fault (short spikes). The short but much higher spike value compared to setting 10mA activates the protection and starts the memory time. State: 2, 4, 6 and 8 has the same setting, state 3, 5, 7 and 9 has the same setting. Copy state 2 into state 4, 6, 8 with name fault 2, fault 3, fault 4 and state 3 into 5, 7, 9 with name memory 2, memory 3, memory 4. In last state for the sequence set **“END SEQ”** For more information about copy states see manual chapter 4.6 Sequencer instrument

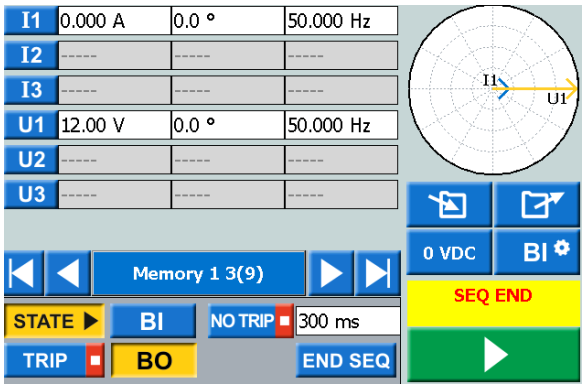
Prefault



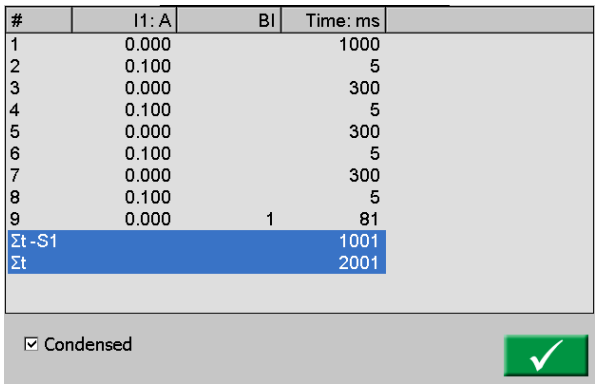
Fault 1



Memory 1



Result



#	I1: A	BI	Time: ms
1	0.000		1000
2	0.100		5
3	0.000		300
4	0.100		5
5	0.000		300
6	0.100		5
7	0.000		300
8	0.100		5
9	0.000	1	81
Σt -S1			1001
Σt			2001

Condensed