SVERKER 900

Relay and Substation Test System

Application Note

Testing directional-earth-fault

Directional earth fault protection are commonly used to protect long outgoing feeders from tripping because of fault on other outgoing lines. Because of changing from over-head lines to cables the capacitive input from outgoing feeders has increased. This makes healthy feeders trip if directional earth fault protection is not used.

Restriking fault has also increased because of isolating problem with aging cables.

In this application the directional earth fault protection for outgoing feeders (Sepam S84) is used. This protection uses two main types of directional earth fault detection also common for other protection manufacturer.

- Type 1 – cos phi measuring
  Used in impedant or compensated neutral system.
- Type 2 – angle measuring
  Used in impedant 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.

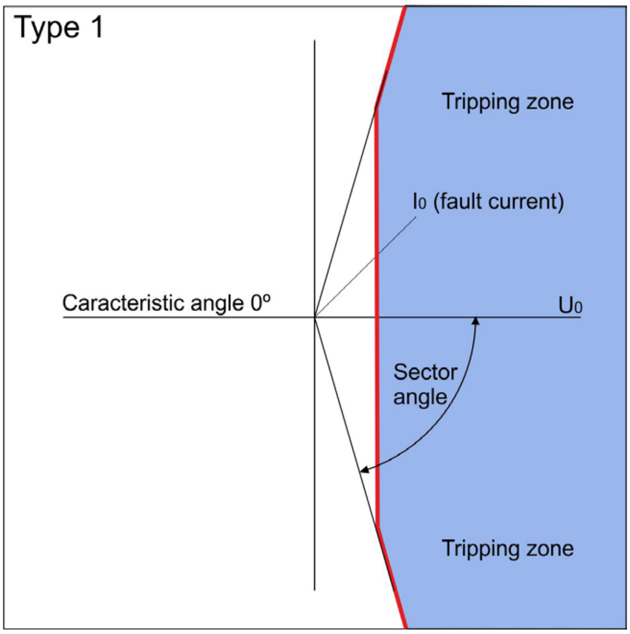
For Type 1 the trip level is measured from the resistive value and for Type 2 it is measured from the impedance value. This means that if both types has setting 1 A and fault angle is 45°.

- Type 1 will trip at 1 A/cos 45 = 1.41 A
- Type 2 will trip at 1 A.

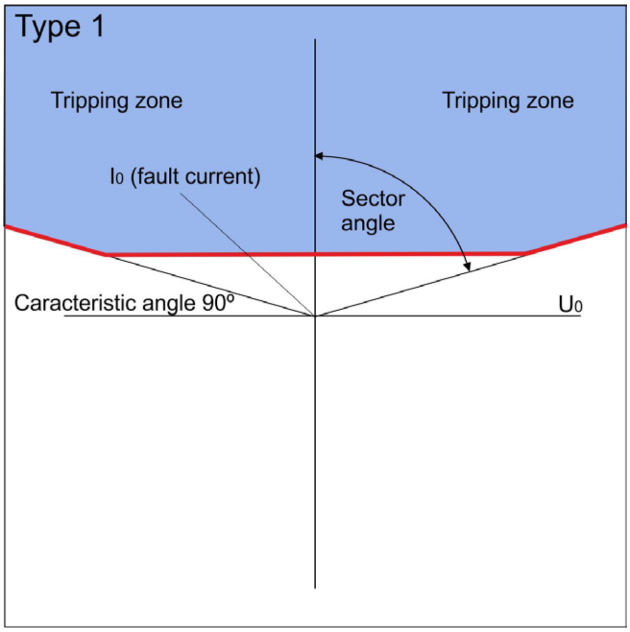
For selectivity reason it is not recommended to mix the two types in the same station and voltage level.

It can be different direction reference depending of protection, always check what is the correct direction for trip (see pictures with explanation on next pages).

Different characteristic angels can be chosen depending of type of protection. Below are two commonly used characteristic angels described.

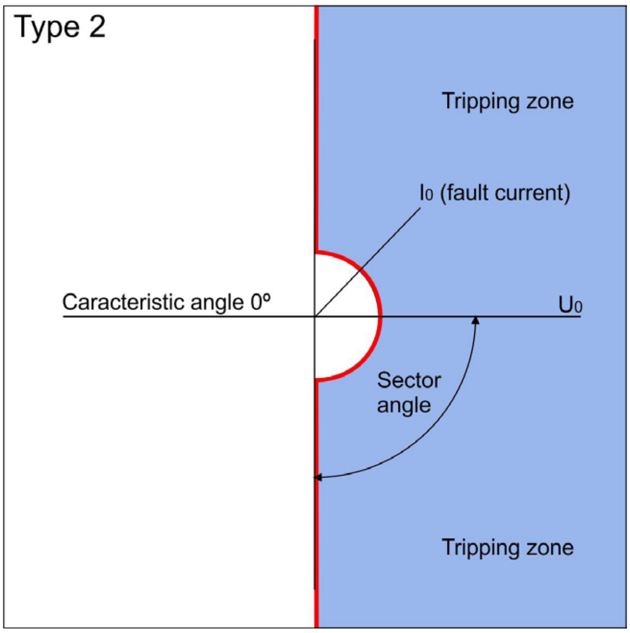


Network connected to ground – cos phi measuring, with 0° as characteristic angle.

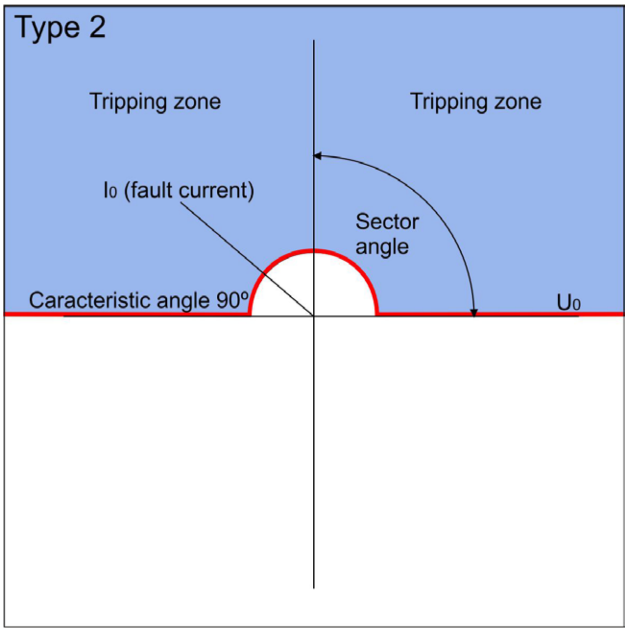


Network floating to ground – cos phi measuring, with 90° as characteristic angle.

Megger.



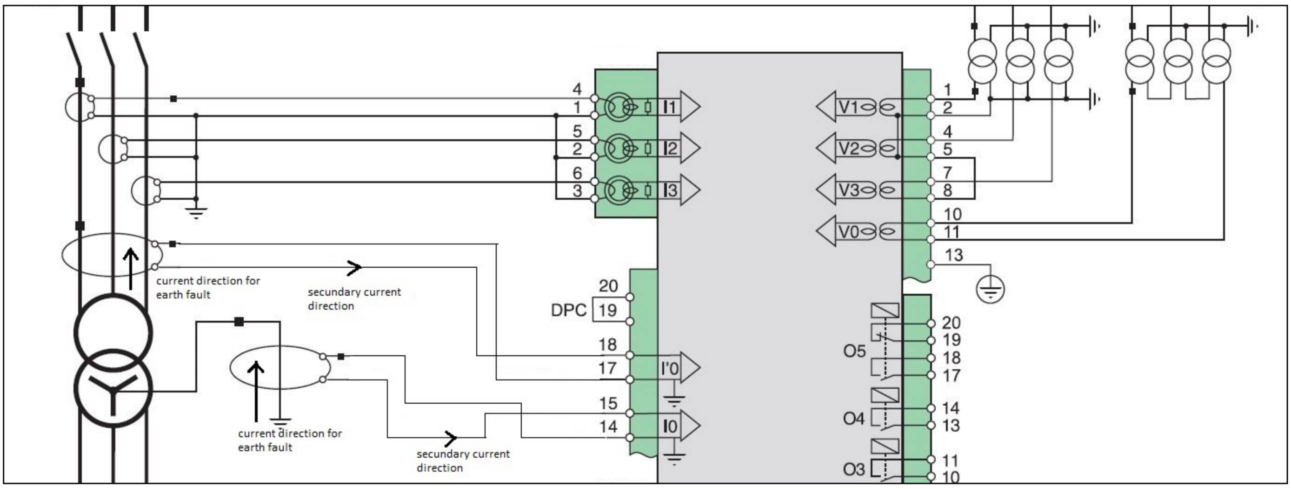
Network connected to ground – angle measuring, with 0° as characteristic angle.



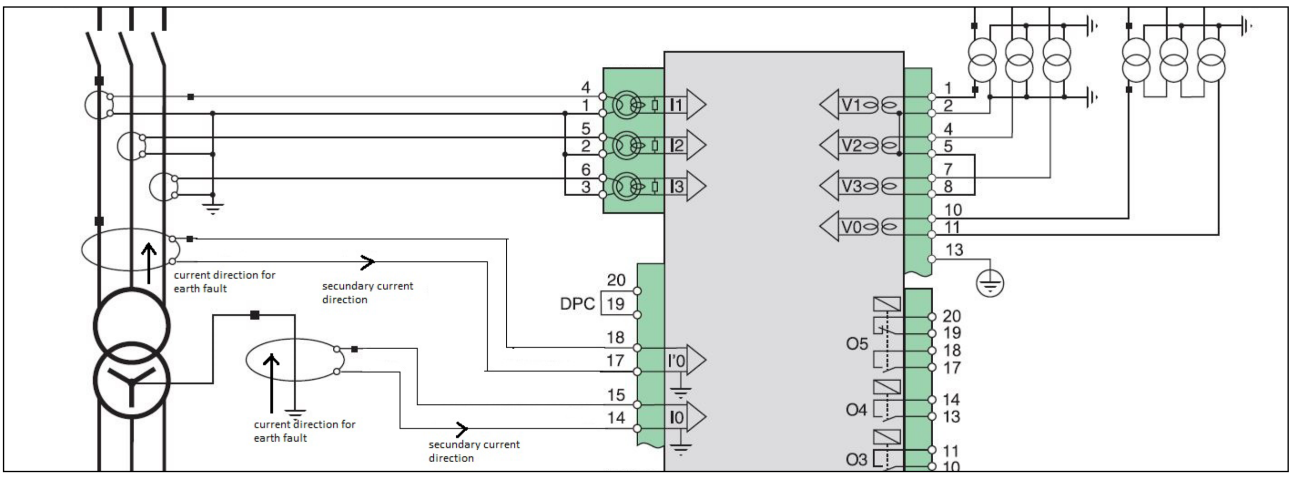
Network floating to ground – angle measuring, with 90° as characteristic angle.

Connecting

Example of connection drawings for CT and VT to protection



Connection 1: The normal load reference are marked with a black square, but the connection are made according to earth fault current flooting at fault. This makes 0 angle between current and voltage.



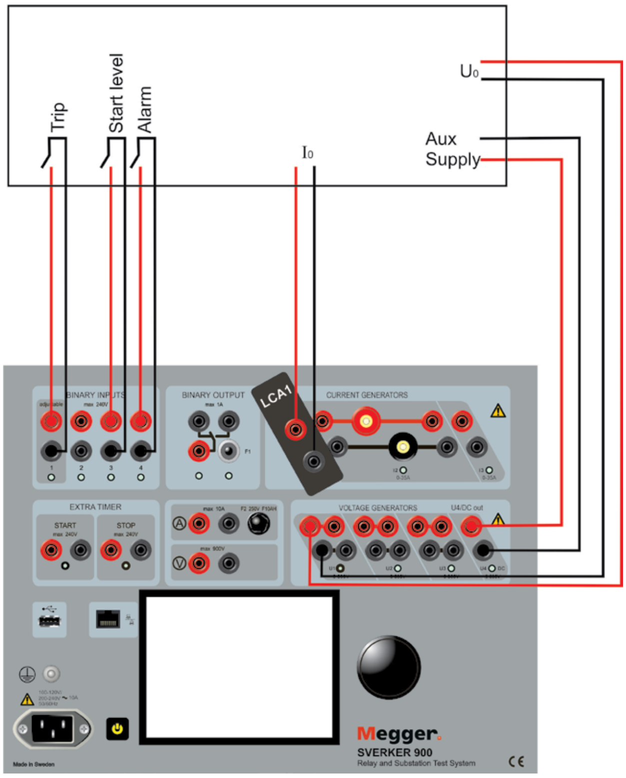
Connection 2: The normal load reference are marked with a black square, but the connection are not changed according to earth fault current flooting at fault. This makes 180° angle between current and voltage.

Testing

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

In this example the directional earth fault protection for outgoing feeders (Sepam S84) is used.

1] Connect according to picture below.



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.

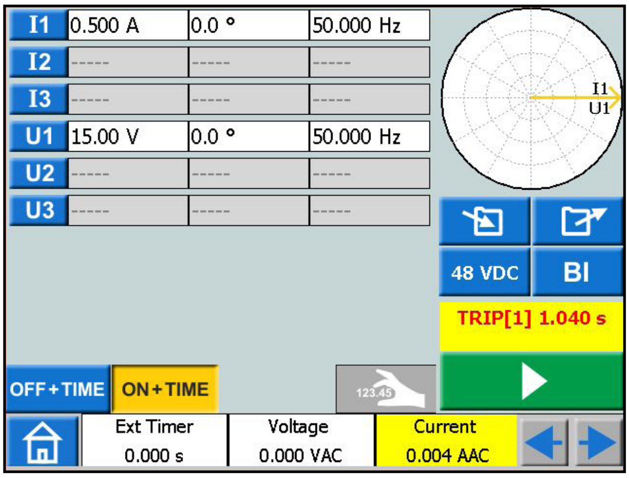
Settings

Settings for connection 1 and 2 (see above).

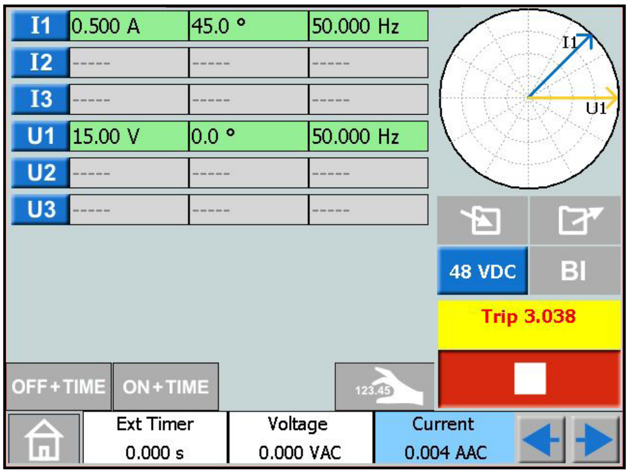
- Protection primary values:
  I = 1.5 A
  Uo = 10% Unp
  Time = 1 s
- Characteristic angle = 0°
  Sector degree for type 1 = 86
  Sector degree for type 2 = 90°
- Ratio for zero current input = 470/1
  Set SVERKER 900 to 0.5 A. Out from LCA 1 will be 4 mA.
  Protection calculates it to primary current
  470 x 0.004 = 1.88 A

Tripping behavior for Type 1 with connection 1 between protection and sensors

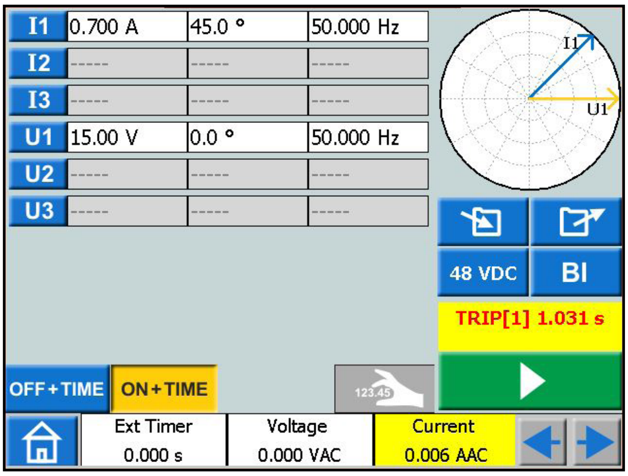
Tripping zone is in quadrant 1 and 4.



Protection trips for 0.5 A and 0°.



Protection does not trip for 0.5 A and 45°.



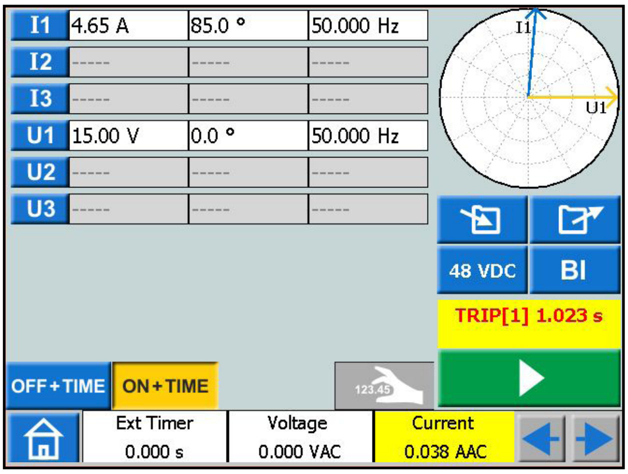
Protection trips for 0.7 A and 45°.

For Type 1 the protection needs more apparent current to reach the setting level of active current.

To test the sector ±86° a much higher current then setting level is needed.

1] For angle set to 85° the protection needs 0.038 A to trip (see ampere meter in VAM). The protection sees it as 470 x 0.038 = 17.86 A. This is how much bigger the fault current has to be compared to set level 1.5 A for the protection to trip at 85°.

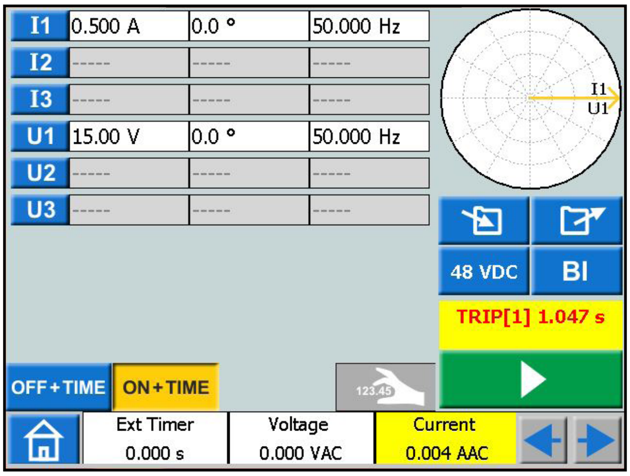
2] The tripping zone can be checked by changing the angle from 0-360°. Press the angle for current and turn the knob..



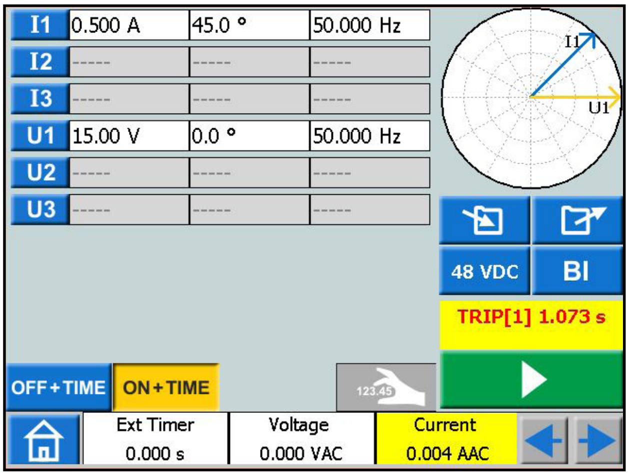
Test values including hold values are saved individually in a test file. See "Test file management" in the User's manual.

Tripping behaviour for Type 2 with connection 1 between protection and sensors

Tripping zone is in quadrant 1 and 4.

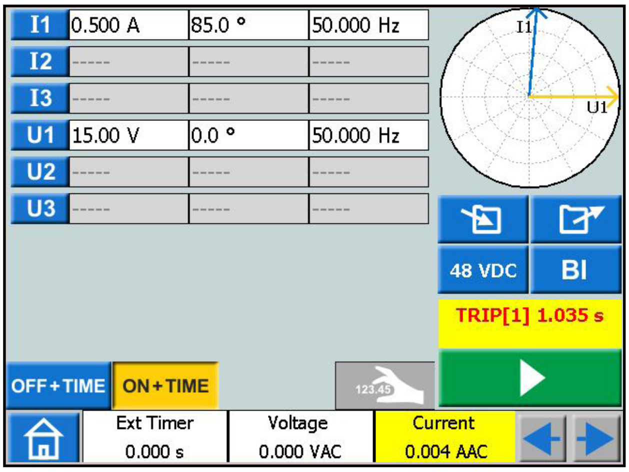


Protection trips for 0.5 A and 0°.



Protection trips for 0.5 A and 45°.

For Type 2 the protection trips for the same value of apparent current between ±90°.

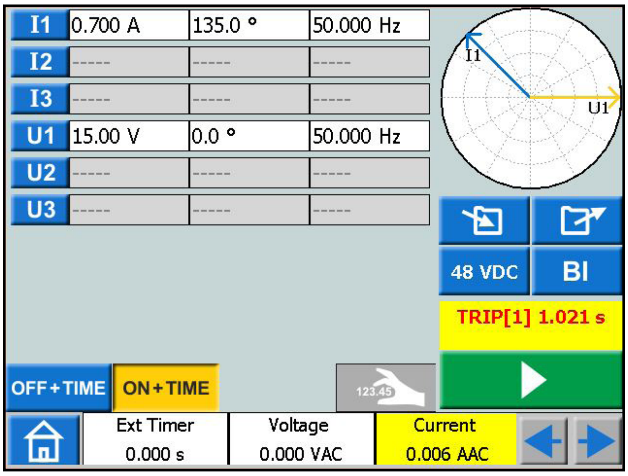


For the angle 85° the value of current is the same for trip, check the zone as above.
Test values including hold values are saved individually in a test file. See "Test file management" in the User's manual.

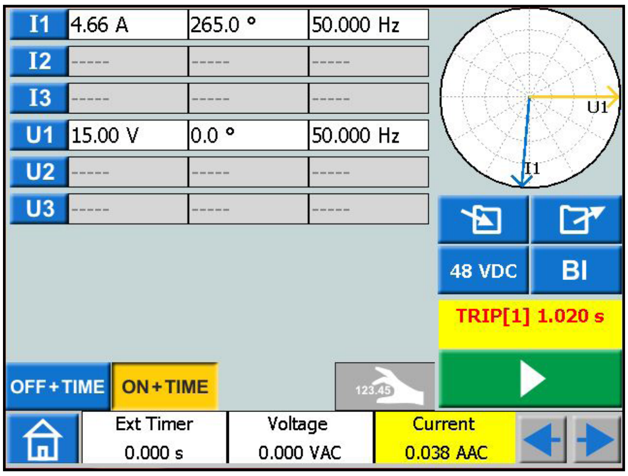
Example for testing with connection 2

The different in Type 1 and Type 2 is the same but with 180° phase shift between current and voltage, see below.
The angle 135° corresponds to 45° above and 265° to 85°.
Tripping zone is in quadrant 2 and 3.

Type 1

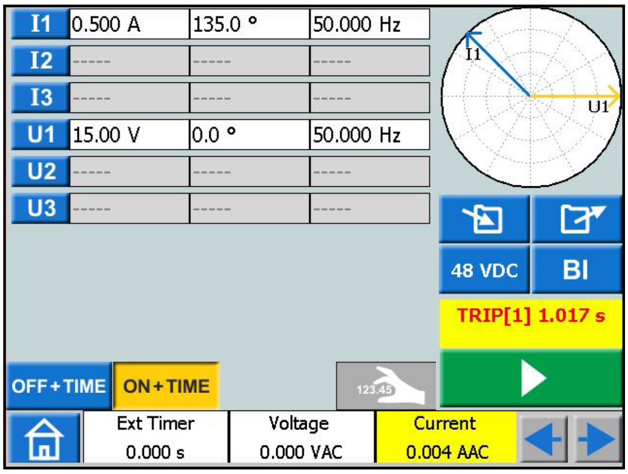


Connection with 180° phase shift tripping in quadrant 2.

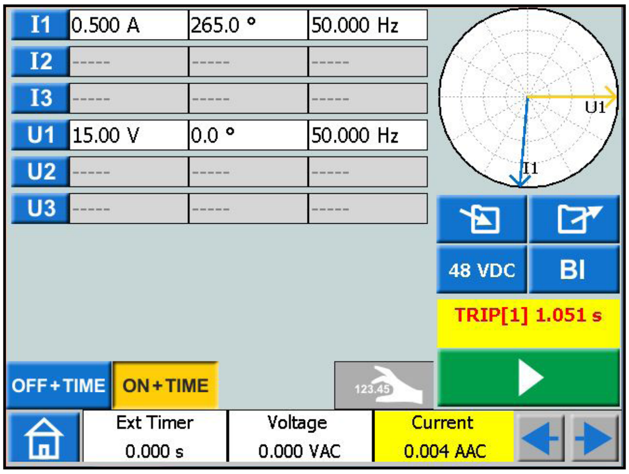


Connection with 180° phase shift tripping in quadrant 3.

Type 2



Connection with 180° phase shift tripping in quadrant 2. The current level is the same for trip between 90-270°.



Connection with 180° phase shift tripping in quadrant 3. The current level is the same for trip between 90-270°.

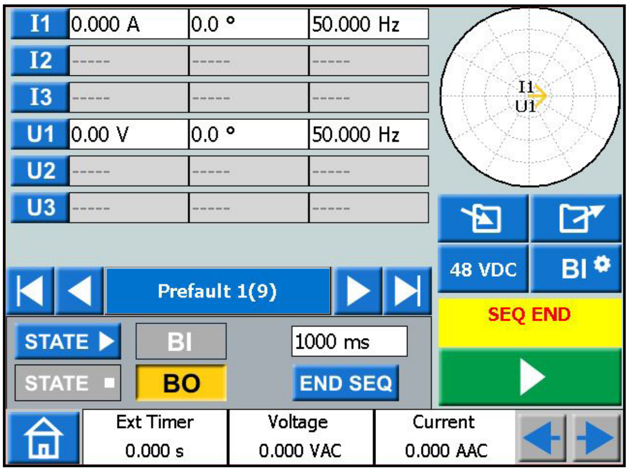
Restriking fault

Modern protection also has the possibility to detect short faults down to 1-2 ms that comes back repeatedly. Some protection measures the amount of "spikes" but for Sepam S84 used here there is a memory time set between the "spikes . Each "spike" keeps the protection activated until it finally trips.

Testing of restriking fault

The same current setting as in point 1 above but without LCA1 the current will then be 10 times higher the voltage is set to 50 V, configuration are made in nine states including prefault. The protection time memory is set to 400 ms and the total time is still 1 s. The sequence consists of nine states.

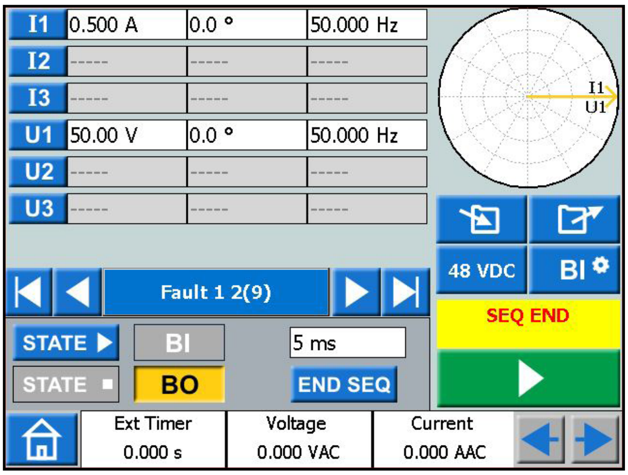
STATE 1



Prefault 1 s without current and voltage.

STATE 2

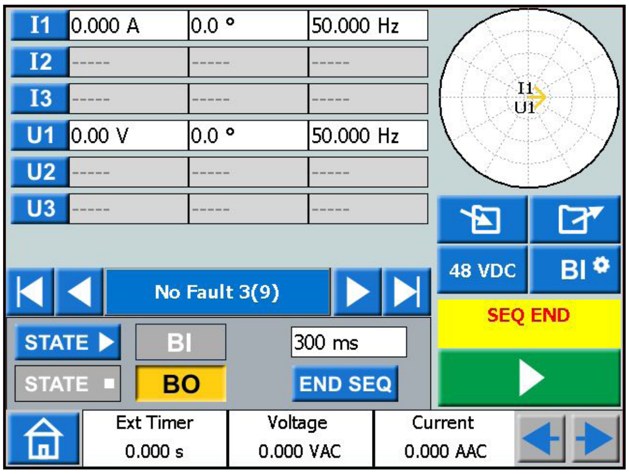
First fault set time to 5 ms (lowest possible setting) for simulating intermittent earth fault (short spikes). The short but much higher spike activates the protection and starts the memory time.
State: 4, 6, and 8 has the same setting.



First fault

STATE 3

Is a no fault state for 300 ms and during that time the protection time memory is activated.
State: 5 and 7 has the same setting.



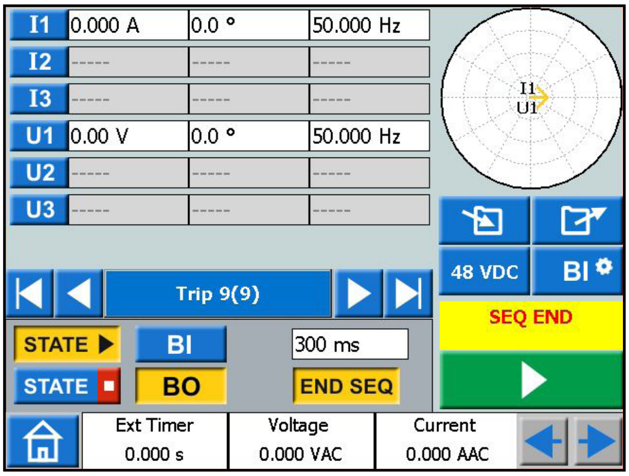
No Fault

After 300 ms a new 5 ms fault is generated and the protection will continue to be activated.

This is repeated two more times until the total tripping time of 1 s is reached, (se report below).

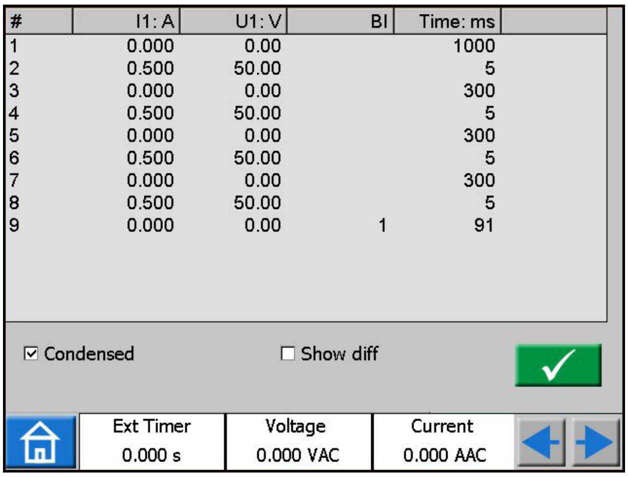
STATE 9

Is the trip and end state, here BI is set to be activated on closing signal.



Trip

Report



#	I1: A	U1: V	BI	Time: ms
1	0.000	0.00		1000
2	0.500	50.00		5
3	0.000	0.00		300
4	0.500	50.00		5
5	0.000	0.00		300
6	0.500	50.00		5
7	0.000	0.00		300
8	0.500	50.00		5
9	0.000	0.00	1	91

In the report all times are displayed, prefault 1000 ms, four "spikes" 5 ms and three "No fault times" 300 ms , the final time is the trip time left up to one second, the total trip time not including prefault time is:
5+300+5+300+5+300+5+ 91 = 1011 ms.

Note *For best time result, deactivate zero-crossing.*

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