SVERKER 900

Measuring cable impedance with SVERKER 900

This is an easy solution to measure the impedance values for cables, the values are used for calculation of compensation factor in distance protection.
The compensation factor is first theoretically calculated and these values can now be compared with the measured values.
Note: This application is only valid for cables because of the risk for overvoltage when measuring overhead lines in case of lightning strikes.

Assuming we have the same impedance in all three phases $Z_{L1} = Z_{L2} = Z_{L3}$ we only need to perform two measurements; Z_{LL} phase to phase loop impedance and Z_{LE} phase to ground loop impedance. The measured Z_{LL} and Z_{LE} values can be presented either as X and R values or Z and phase angle values. The current output terminals of SVERKER 900 can be used to make an easy and fast connection for impedance measurement. Normally one single generator is enough to use. However, if the load is too high because of longer cables the compliance voltage can reach its maximum and turn off the generated current. In this case the serial configuration for Igen can be used.

Note: Igen parallell configuration is not illustrated here because it gives same result as for one current generator up to 10A. The ampere meter measures up to 10A and it has to be used for calculating of impedance.

Calculating compensation factor K used in distance protection:
To get a more accurate value for ZLE and ZLL connection for L2-E, L3-E and   L2-L3, L3-L1 can be measured, then an average value from this can be used to calculate compensation factor.

Calculate the average value for compensation factor:
ZL= ((ZL1+ZL2) + (ZL2+ZL3) + (ZL3+ZL1))/6Ω   ZE= (ZL1E+ZL2E+ZL3E)/3 - ZLΩ
The average value Kz= ZE / ZL

The same calculations can be made for X/R format:
RL= ((RL1+RL2) + (RL2+RL3) + (RL3+RL1))/6Ω   RE= (RL1E+RL2E+RL3E)/3-RLΩ
XL= ((XL1+XL2) + (XL2+XL3) + (XL3+XL1))/6Ω   XE= (XL1E+XL2E+XL3E)/3–XLΩ
The average value Kx= XE/XL and the average value Kr= RE/RL

Note: Compensation factors in Kx and Kr formats are normally used by ABB and Siemens protections.

For information how to set: Configuration, Generatorvalues, Binary Input and Saving tests, see manual.

Below pictures show the connections when individual configuration is used.

Impedance ZLL measured using Igen 1 connection L1-L2
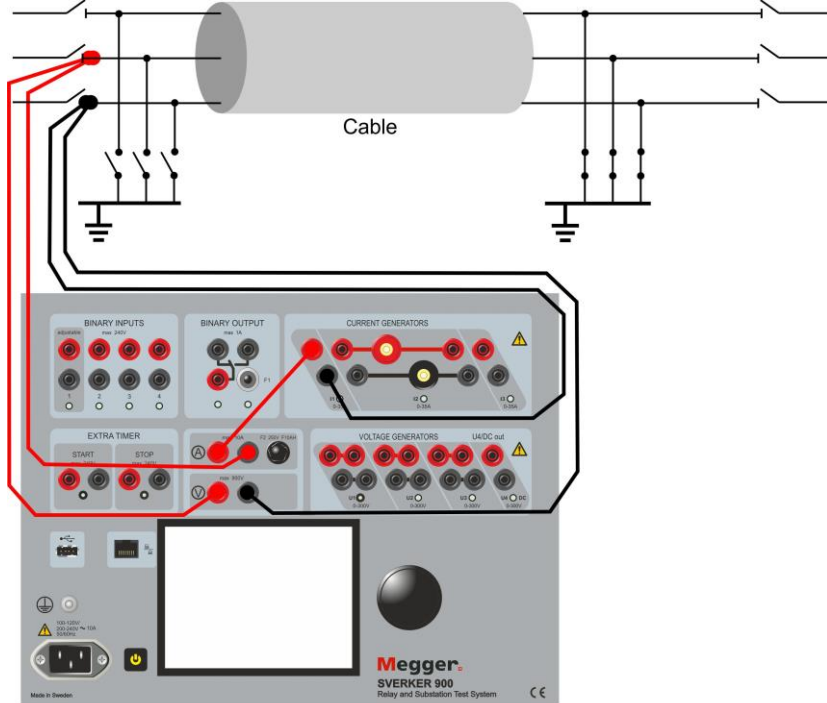
Connection diagram, ZLL: L1-L2 current feeding

Impedance ZLE measured using Igen 1 connection L1-E
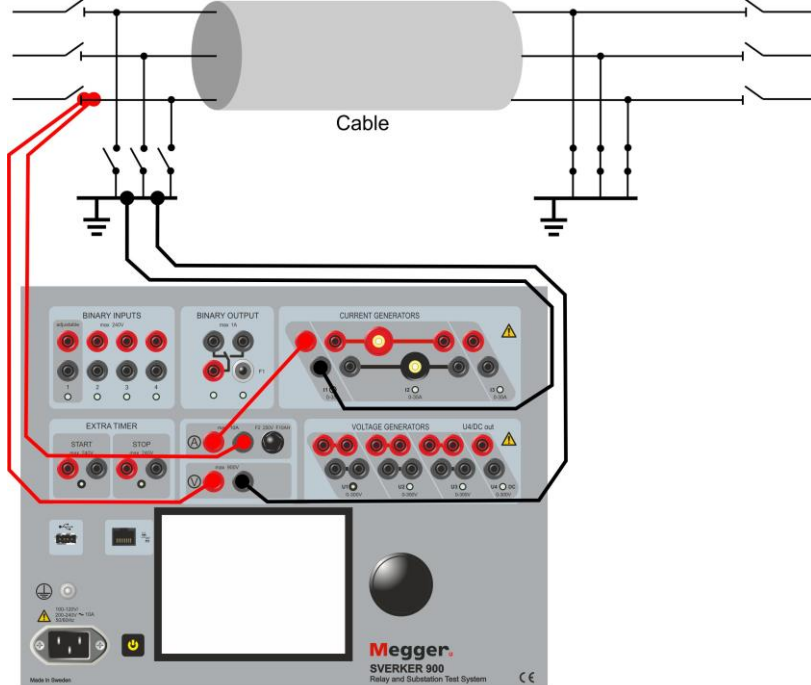
Connection diagram, ZLE: L1-E current feeding

Note: The Voltmeter leads must be connected directly to the current leads on the cable side, to avoid voltage drop over the current leads, valid for all connections.

Values from test made with different loads at 50Hz.
Load 1: Generating with Igen1, maximum current for internal ammeter 10A

I1	10.0 A	0.0 °	50.000 Hz
I2	------	------	------
I3	------	------	------
U⊚⊚	------	------	------

0 VDC   BI
STOPPED

OFF+TIME   ON+TIME   123.45   ▶

Ext Timer   0.000 s   Voltage 20.32 VAC   Current 9.89 AAC   ◀ ▶

I1	10.0 A	0.0 °	50.000 Hz
I2	------	------	------
I3	------	------	------
U⊚⊚	------	------	------

0 VDC   BI
STOPPED

OFF+TIME   ON+TIME   123.45   ▶

Ext Timer   0.000 s   R 1.69 Ohm   Z 2.05 Ohm   X 1.2 Ohm   Ø 34.9 °   ◀ ▶

Voltage and Current meter are set to "Hold On Stop" after values has stabilized, turn off generating and the values will be memorized and can be saved, valid for all tests.

Load 2: Generating with Igen1, compliance voltage has been reached.

I1	2.40 A	0.0 °	50.000 Hz
I2	------	------	------
I3	------	------	------
U1	------	------	------
U2	------	------	------
U3	------	------	------

0 VDC   BI

OFF+TIME   ON+TIME   123.45   ▶

Ext Timer   0.000 s   Voltage 48.26 VAC   Current 2.392 AAC   ◀ ▶

I1	2.40 A	0.0 °	50.000 Hz
I2	------	------	------
I3	------	------	------
U1	------	------	------
U2	------	------	------
U3	------	------	------

0 VDC   BI

OFF+TIME   ON+TIME   123.45   ▶

Ext Timer   0.000 s   R 4.2 Ohm   Z 20.2 Ohm   X 19.7 Ohm   Ø 78.1 °   ◀ ▶

Load 3: Generating with Igen1, compliance voltage has been reached.

I1	0.407 A	0.0 °	50.000 Hz
I2	------	------	------
I3	------	------	------
U1	------	------	------
U2	------	------	------
U3	------	------	------
U4	------	------	------

0 VDC   BI

OFF+TIME   ON+TIME   123.45   ▶

Ext Timer   0.000 s   Voltage 49.87 VAC   Current 0.406 AAC   ◀ ▶

I1	0.407 A	0.0 °	50.000 Hz
I2	------	------	------
I3	------	------	------
U1	------	------	------
U2	------	------	------
U3	------	------	------
U4	------	------	------

0 VDC   BI

OFF+TIME   ON+TIME   123.45   ▶

Ext Timer   0.000 s   R 64.0 Ohm   Z 122.8 Ohm   X 104.8 Ohm   Ø 58.6 °   ◀ ▶

In test "Load 2" we have reached compliance voltage 50V at 2,4A this level of current is enough to get god values. In test "Load 3" compliance voltage has been reached at 0,407A here serial configuration should be used. (see below)
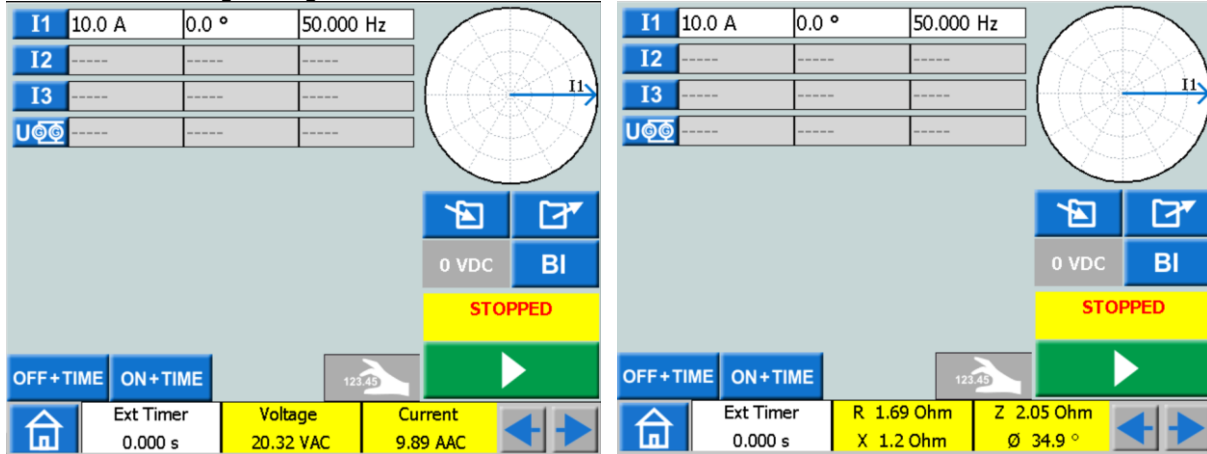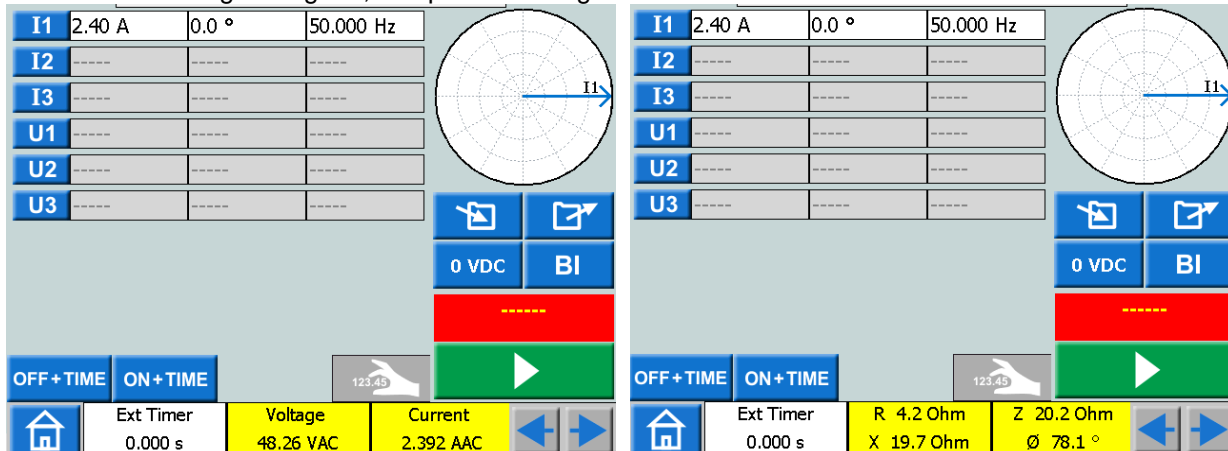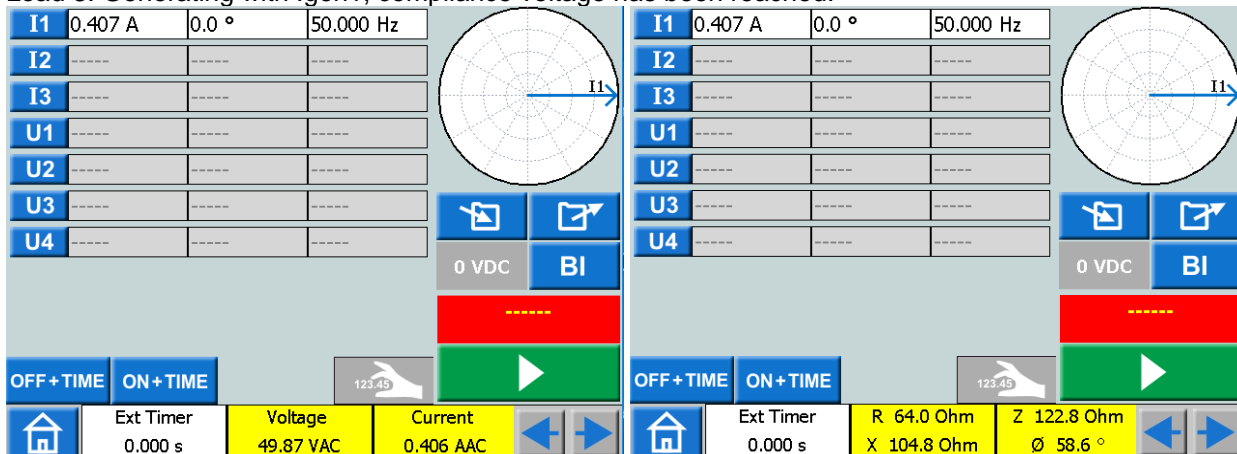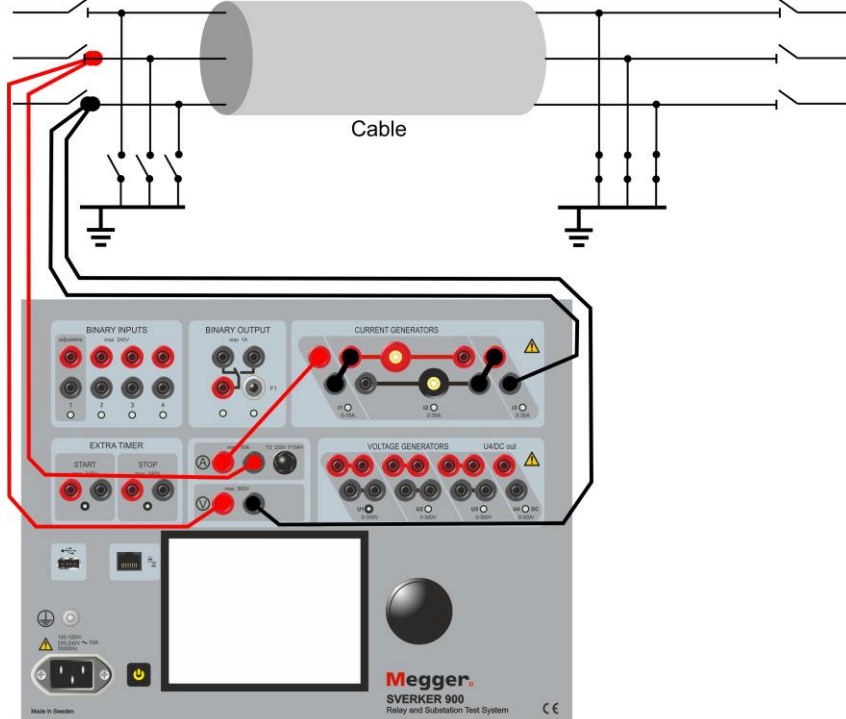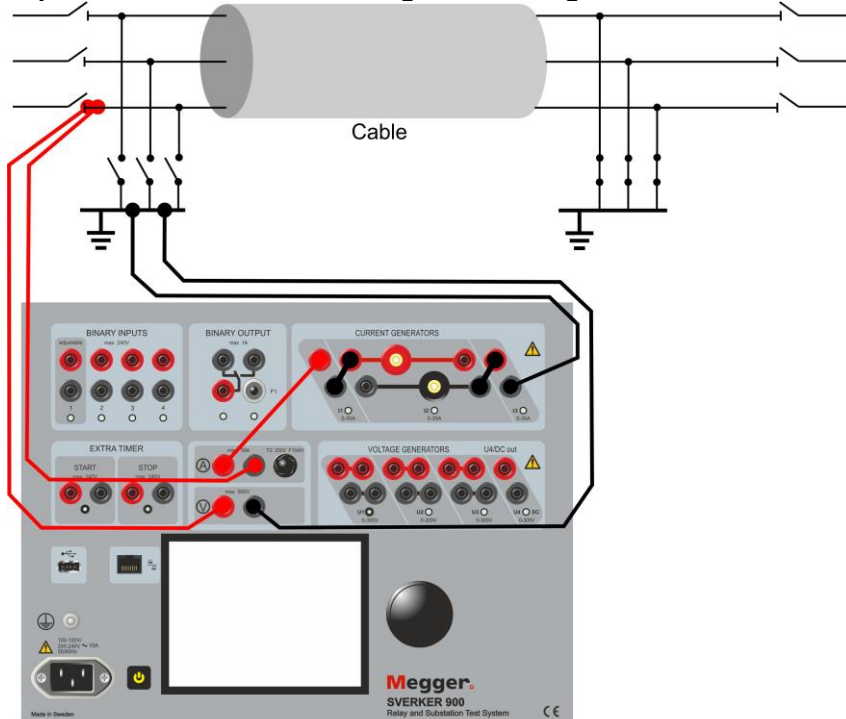
Below pictures show the connections when serial configuration is used.

Impedance ZLL measured using serial configuration connection L1-L2

Connection diagram, ZLL: L1-L2 current feeding

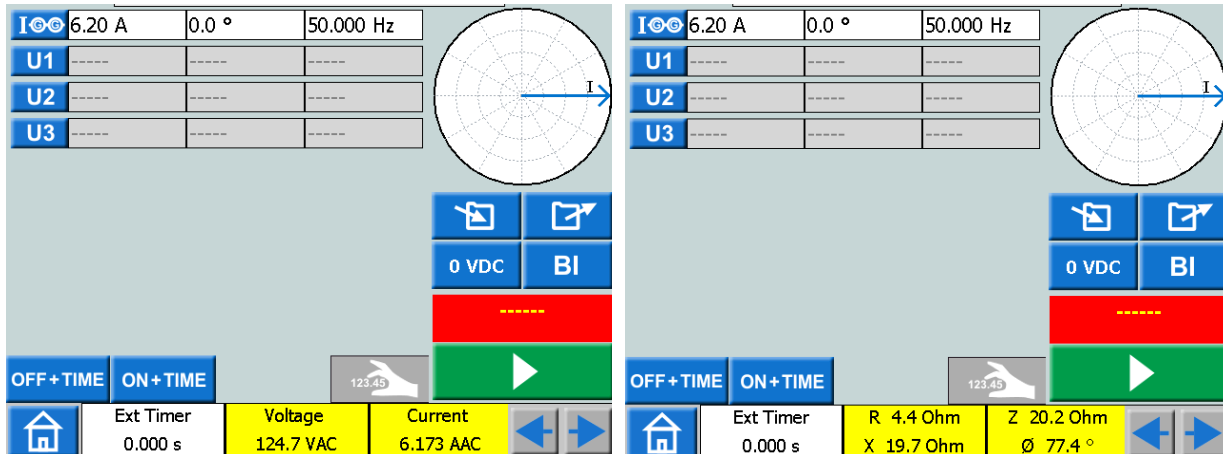**Impedance ZLE measured using serial configuration connection L1-E**

Connection diagram, ZLE: L1-E current feeding

Values from test made with different loads at 50Hz
As the maximum ampere level for Load 1 can be reached using single Igen connection, tests with serial connection are made only with Load 2 and 3.

Load 2: Generating with Igen in serial, maximum power has been reached.

I 6.20 A	0.0 °	50.000 Hz
U1 ------	------	------
U2 ------	------	------
U3 ------	------	------

0 VDC   BI

OFF+TIME	ON+TIME	
Ext Timer	Voltage	Current
0.000 s	124.7 VAC	6.173 AAC

I 6.20 A	0.0 °	50.000 Hz
U1 ------	------	------
U2 ------	------	------
U3 ------	------	------

0 VDC   BI

OFF+TIME	ON+TIME	
Ext Timer	R 4.4 Ohm	Z 20.2 Ohm
0.000 s	X 19.7 Ohm	Ø 77.4 °

Load 3: Generating with Igen in serial, compliance voltage has been reached

I 1.22 A	0.0 °	50.000 Hz
U1 ------	------	------
U2 ------	------	------
U3 ------	------	------
U4 ------	------	------

0 VDC   BI

OFF+TIME	ON+TIME	
Ext Timer	Voltage	Current
0.000 s	149.7 VAC	1.215 AAC

I 1.22 A	0.0 °	50.000 Hz
U1 ------	------	------
U2 ------	------	------
U3 ------	------	------
U4 ------	------	------

0 VDC   BI

OFF+TIME	ON+TIME	
Ext Timer	R 64.4 Ohm	Z 123.2 Ohm
0.000 s	X 105.1 Ohm	Ø 58.5 °