

ELEKTRONIKA

**ECE 35
CABLE EXPERT**

**Operating Manual
For Cable Fault Location Options**

460-000-000

| | |
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| Operating Manual 2 | OM 460-020-001 |
|--------------------|----------------|

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1 INTRODUCTION

1.1 Application Guide for Fault Location

The bridge and TDR HW option of ECE 35 provides quick, comfortable, very accurate and automatic measurements for fault location on telecom cables. This HW option contains the following measuring modules:

Active Bridge

The active bridge provides quick, comfortable, very accurate and automatic measurements. There are two measuring modes to select:

- Sensitive mode providing extremely accurate test results even if the measured fault resistances are very high but high disturbing AC voltages may overload the bridge indicator
- Protected mode providing accurate test result even in the presence of medium level disturbing voltages when the fault resistances are not higher than 3 to 5 MOhm

It is recommended to start the measurement with sensitive mode. When the disturbing voltages overload the indicator a warning appears informing the user that the result can be inaccurate. In that case the measurement should be repeated in protected mode.

Passive Wheatstone-Bridge

The passive bridge is not sensitive for the external disturbing AC voltages but its usage is not as comfortable as that of the active bridge. Measuring methods like Küpfmüller or Three-point methods require two or three consecutive measurements. Measuring error may occur if the level of disturbing DC voltage changes between the measurements.

End to End Synchronic Measuring Method

In the worst case due to high and intermittent disturbing AC and DC voltages neither the active nor the passive bridge can provide satisfactory result.

In that case the best tool is the improved version of Graaf method using the disturbing voltages for the measurement. (No other measuring voltage is added to it).

ECE 35 performs current measurements at the two ends of the tested cable at the same time and calculates the location of fault out of the rate of currents. That means:

The higher is the disturbing voltage the easier to locate a fault !

The only drawback is: two instruments are necessary working in Master-Slave mode. In that mode ECE 35 can communicate with another ECE 35 or with an intelligent Slave device ECFL 30S.

TDR

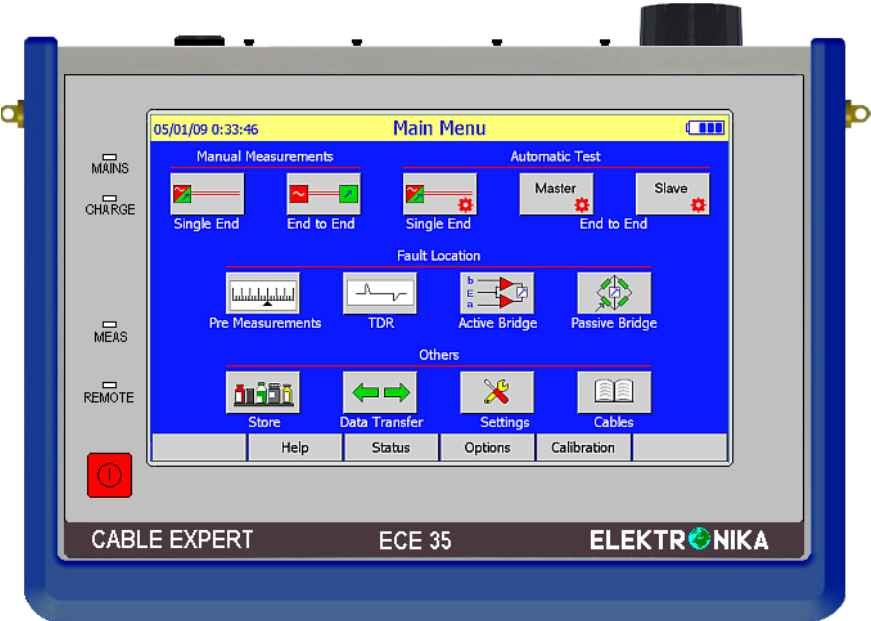
The TDR of ECE 35 has been designed for quick and accurate fault location and qualification of loaded and non loaded telecommunication cables using impulse reflection technique.

The various measuring modes provide accurate location of discontinuities and errors like open circuit, wet section, loose contact etc.

ECE 35 employs optimized pulsing and sampling methods, supported with advanced filtering and signal processing techniques, to reach the maximum measurement range and clean waveform for easier fault interpretation.

4 to 10 ns pulse widths for close-in resolution. Faults as near as 0.5 m from the pedestal can be easily located.

1.2 Keyboard and LEDs



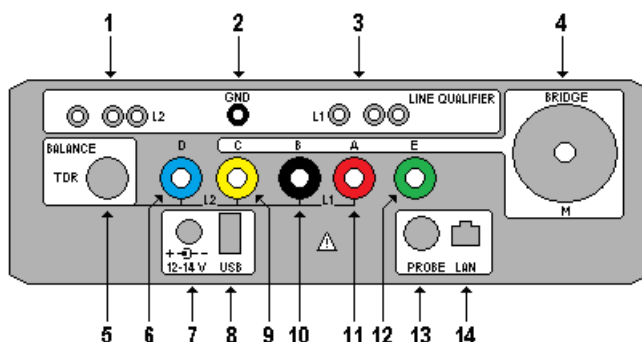
Controls

| | |
|--|---|
| | Switches the ECE 35 on and off. The instrument has an automatic switch-off feature to save battery life: switch-off takes place automatically 10 minutes after the latest keystroke. (see chapter settings for details) |
|--|---|

LEDs

| | | |
|--|--------|--------------------------|
| | MAINS | Mains indicator |
| | CHARGE | Charge indicator |
| | MEAS | Measurement indicator |
| | REMOTE | Remote control indicator |

1.3 Connectors



| | |
|----|--|
| 1 | L 2 connector for line qualification(Tx only) |
| 2 | Ground connector for line qualification |
| 3 | L 1 connector for line qualification |
| 4 | Bridge balance |
| 5 | TDR balance |
| 6 | Socket to connect wire D in bridge modes, and L2 in TDR mode |
| 7 | 2.1/5.5 mm coaxial connector for mains or 12V car adapter |
| 8 | USB connector for connecting an USB stick |
| 9 | Socket to connect wire C in bridge modes, and L2 in TDR mode |
| 10 | Socket to connect wire B in bridge modes, and L1 in TDR mode |
| 11 | Socket to connect wire A in bridge modes, and L1 in TDR mode |
| 12 | Socket to connect to ground in bridge modes |
| 13 | Connector for high impedance probe |
| 14 | Connector for LAN |

1.4 Calibration

ECE 35 is a very stable instrument but, the specified accuracy can be guaranteed only after calibration.

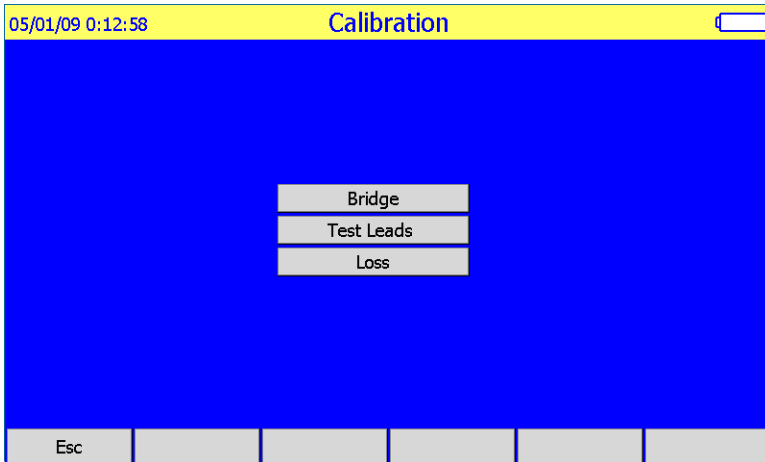
The conditions of the calibration are unchanged until the next calibration.

Start of calibration:

- Press the **Calibration** key of **Main Menu**.

The appearing **Calibration** menu provides:

- Self Calibration of **Bridge**
- Calibration of **Test Leads**



Calibration of Test Leads

In that mode not only the resistance of test leads **A**, **B**, and **E** but also the relay resistances of the input switch field will be measured, stored and during the measurements compensated as well.

During the manufacturing process the actual resistance values were stored but before the measurement of very low resistances or resistance differences a repeated calibration is recommended.

Before calibration join the far end of the three test leads and after:

- Press the **Test Leads**
- Press **Start/Stop**

When the calibration is completed three resistance values are displayed containing the test lead and relay resistances.

These resistances will be taken into consideration at the following measuring modes:

- Resistance 2-wire
- Resistance 2-wire&gnd
- Resistance difference
- Fault location Murray-Method
- Fault location 3 Point-Method
- Fault location Küpfmüller- Methods

Bridge Self Calibration

- Press the **Bridge** key and follow the appearing instructions

Doing so the calibration parameters of active and passive bridges are measured

1.5 Provided Special Actions after Measurements

In case of fault location measurements

In addition to the measured resistance or capacitance values, the cable length (DTS) and the distance to fault (DTF) are also indicated on the result page. These additional parameters can be calculated when:

- Cable type and temperature are known or
- The exact length of the cable is known

When the cable type and temperature are known

The display always shows the cable type and temperature value selected during the last measurement.

To change the cable type

- Press the **Cables** key
- Select a new cable type and press **Enter**
- Press **Esc**

To change the cable temperature

- Press the **Temperature** key,
- Type in the temperature value and press **Enter**

The lengths DTS and DTF are automatically recalculated immediately after the changes.

When the exact length of the cable is known

- Press the **Length** key
- Type in the known length and press **Enter**

Doing so, the fault location and the cable length are calculated only from the measured **Lx / L** value and the entered length value without considering the measured resistances.

For returning to the normal display

- Press the **Length** key
- Press **Esc**

In case of resistance, and capacitance measurements

When the cable type and temperature are known you can calculate the cable length Ω/km or nF/km values

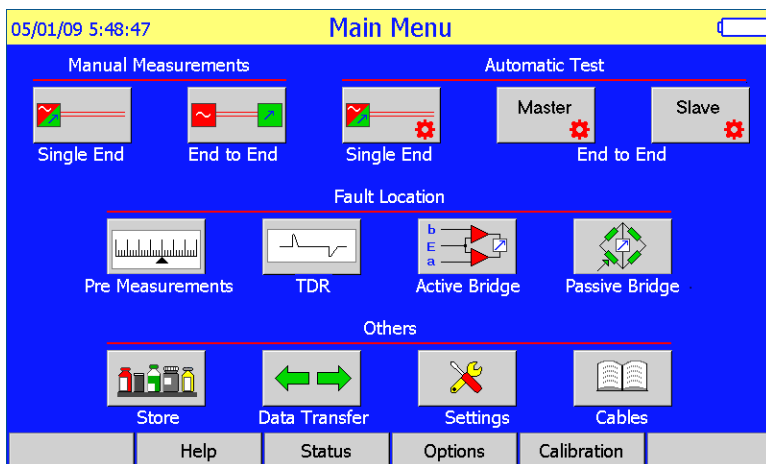
- Press the **Length** key
- Type in the known length and press **Enter**

Doing so, the Ω/km or nF/km appears

For returning to the normal display

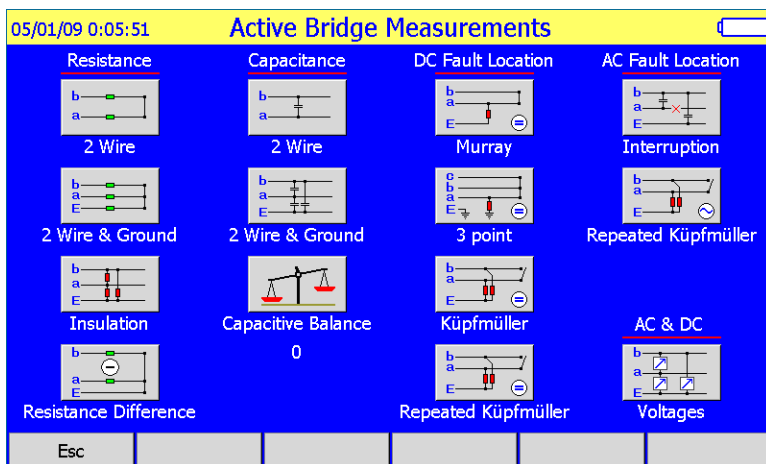
- Press the **Length** key
- Press **Esc**

2 ACTIVE-BRIDGE



Active bridge selection

- Press the **Active Bridge** key of **Main Menu**

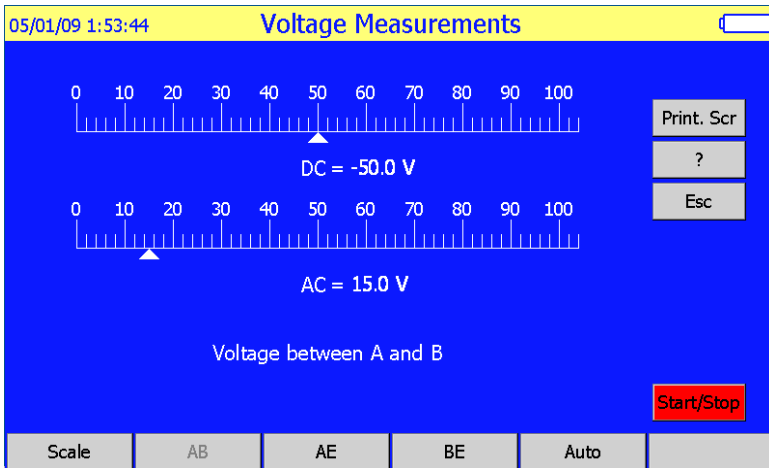


2.1 AC-DC Disturbing Voltage Measurement

ECE 35 has a measuring module with balanced input to measure AC and DC voltages at the same time. Measuring range is 1 to 400 V DC and 1 to 250V AC, input impedance 2 MOhm

Mode selection

- Press the **Voltage** key



Input selection

- Pressing the **AB**, **AE** or **BE** key ECE 35 measures the AC DC voltages continuously between the selected two inputs.
- The measuring range can be changed with the **Scale** key
- Pressing **Auto** ECE 35 performs all the AC-DC voltage measurements after each other
- The measurement can be restarted with key **Start/Stop**

2.2 Resistance Measurements

The active bridge of ECE 35 provides four resistance-measuring modes:

- **2 Wire**
- **2 Wire & Ground**
- **Resistance Difference**
- **Insulation**

Before resistance measurement the instrument measures the disturbing AC-DC voltages. The results are displayed only when the high disturbing voltages may cause the impairment of measurement accuracy.

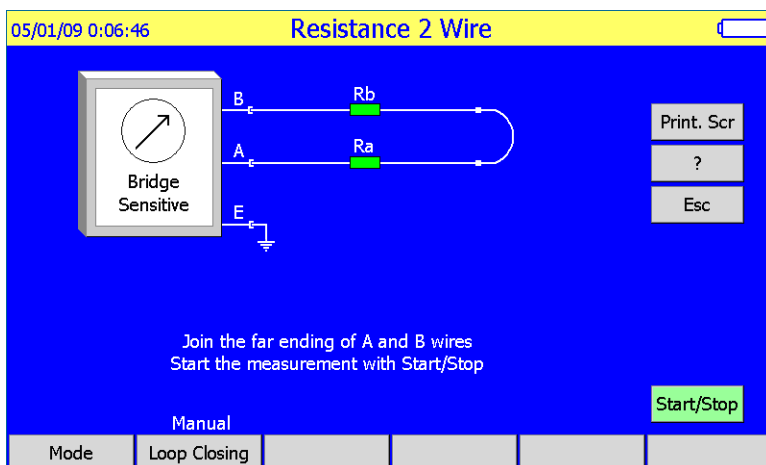
The resistance measurement is automatically performed independently of the results of voltage measurement but in case of high voltage indication a repeated measurement is recommended.

The resistance measurement is performed twice, first without and after with measuring voltage. The double measuring method provides accurate result because the effect of disturbing DC voltage can be compensated.

2.2.1 2 Wire Resistance Measurement

Test Procedure

Press the **Resistance / 2 Wire** key and then the measuring arrangement appears:



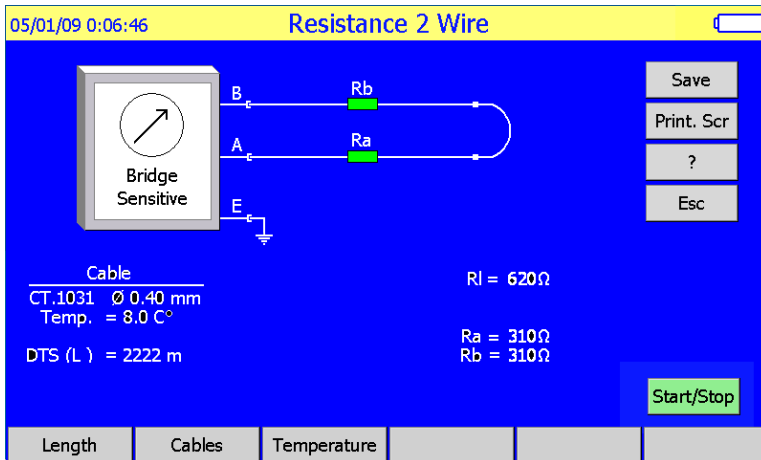
The far ending of the tested pair should be joined manually or by means of the remote controllable loop-closing device **ELC30** or **ECFL30S**.

Two measuring modes are provided: **Sensitive** or **Protected** mode.

It is recommended to start the measurement with sensitive mode. When the disturbing voltages overload the indicator a warning appears informing the user that the result can be inaccurate. In that case the measurement should be repeated in protected mode.

- Select the proper mode with the **Mode** key
- Start the measurement with the **Start/Stop** key

Having the measurement completed the test results appear.



Displayed Test Results

- Loop resistance **RI**, **Ra**, and **Rb** ($RI/2$)

The cable length (**DTS**) calculated from R_s considering the displayed **cable type** and **Temp.** Values.

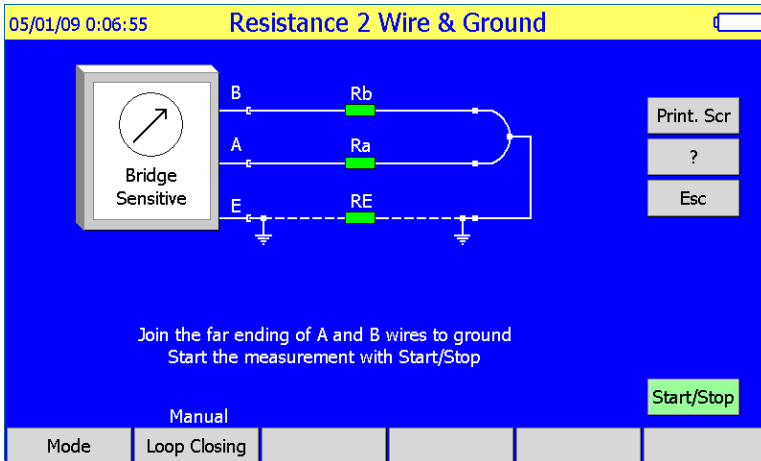
Notice:

In case of short cables the calibration of test leads is recommended.

2.2.2 2-Wire & Ground Resistance Measurement

Test Procedure

Press the **2-Wire & Ground** key and then the measuring arrangement appears:



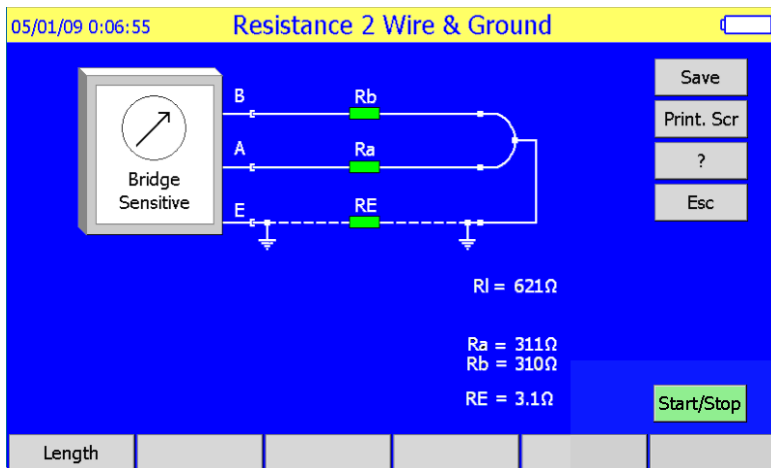
The far ending of the tested pair should be joined manually or by means of the remote controllable loop-closing device **ELC30** or **ECFL 30S**.

Two measuring modes are provided: **Sensitive** or **Protected** mode.

It is recommended to start the measurement with sensitive mode. When the disturbing voltages overload the indicator a warning appears informing the user that the result can be inaccurate. In that case the measurement should be repeated in protected mode.

- Select the proper mode with the **Mode** key
- Start the measurement with the **Start/Stop** key

Having the measurement completed the test results appear.



Displayed Test Results

- **RI** Loop resistance
- **Ra, Rb** Wire resistances
- **RE** Sheath resistance

Notice:

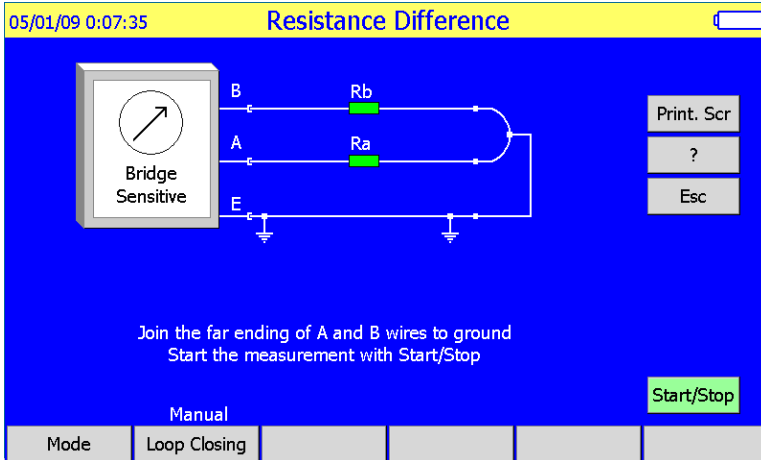
In case of short cables the calibration of test leads is recommended

2.2.3 Resistance Difference Measurement

The difference between the wire resistances of a pair is usually small compared to the wire resistances. ECE 35 has to measure the small difference of high resistances, therefore the calibration of test leads is recommended.

Test Procedure

Press the **Resistance Difference** key and then the measuring arrangement appears.



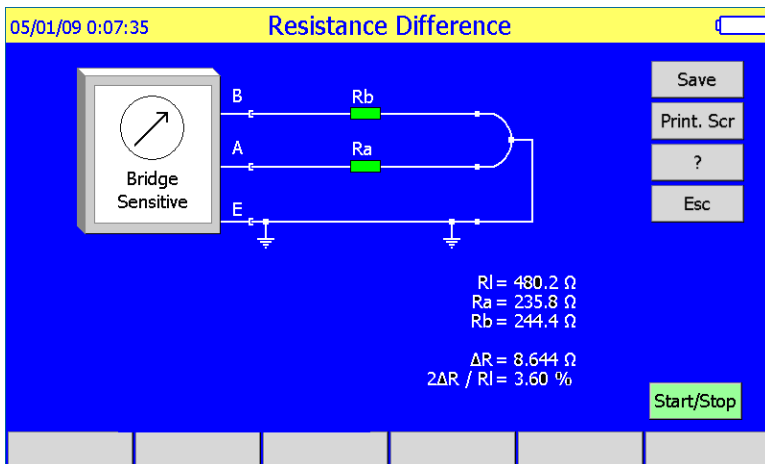
This measurement is implemented as a Murray measurement. The far ending of the tested pair should be joined manually or by means of the remote controllable loop-closing device **ELC30** or **ECFL30S**.

Two measuring modes are provided: **Sensitive** or **Protected** mode.

It is recommended to start the measurement with sensitive mode. When the disturbing voltages overload the indicator a warning appears informing the user that the result can be inaccurate. In that case the measurement should be repeated in protected mode.

- Select the proper mode with the **Mode** key
- Start the measurement with the **Start/Stop** key

Having the measurement completed the test results appear.

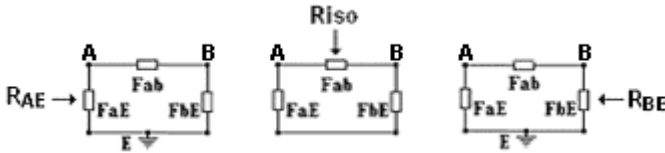


Displayed Test Results

- $R_I = R_a + R_b$ loop resistance
- $\Delta R = R_a - R_b$ resistance difference
- $2 \Delta R / R_I$ (in %)
- R_a and R_b calculated out of R_I and ΔR

2.2.4 Insulation Resistance Measurement

The insulation resistance measurement is performed in the following arrangement:



$R_{iso} = F_{ab} \text{ parallel with } (F_{aE} + F_{bE})$

$R_{AE} = F_{ab} \text{ parallel with } (F_{ab} + F_{bE})$

$R_{BE} = F_{ab} \text{ parallel with } (F_{ab} + F_{aE})$

The physical resistances are marked as: **Fab**, **FaE** and **FbE**

There are two measuring ranges: 5 km and 10 km

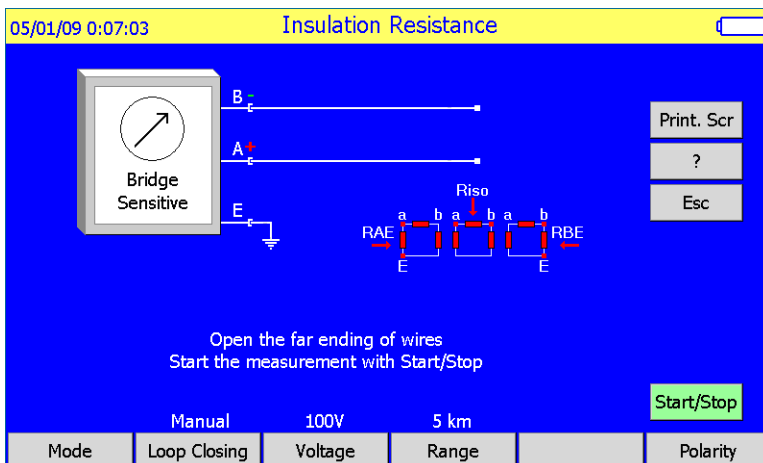
Measuring times:

- ~37 sec for the 5 km range
- ~45 sec for the 10 km range

The relatively long measuring time is necessary because of the capacitance of the measured cable.

Test Procedure

Press the **Insulation** key and the measuring arrangement appears



The far endings of the tested pair should be open.

Two measuring modes are provided: **Sensitive** or **Protected** mode.

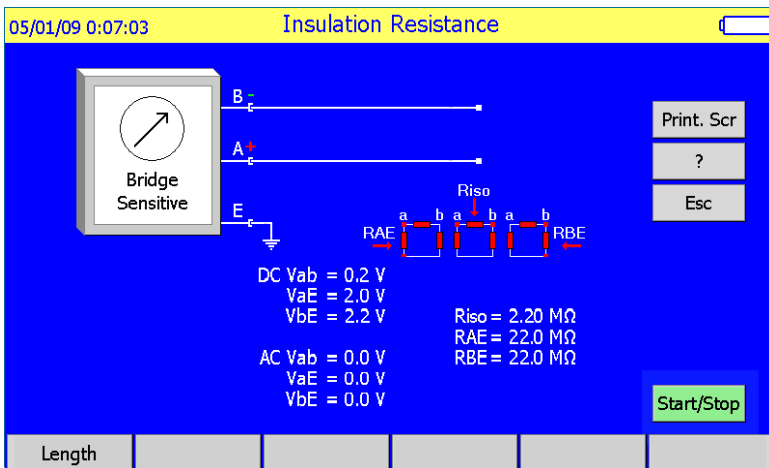
It is recommended to start the measurement with sensitive mode. When the disturbing voltages overload the indicator a warning appears informing the user that the result can be inaccurate. In that case the measurement should be repeated in protected mode.

- Select the proper mode with the **Mode** key
- Select the proper range with the **Range** key
- Select the proper polarity with the **Polarity** key

Two measuring voltages are provided: 100 or 250 V

- Select the required voltage with the **Voltage** key
- Start the measurement with the **Start/Stop** key

Having the measurement completed the test results appear.



Displayed Test Results

- **Riso** resistance between wire **a** and wire **b**
- **RAE** resistance between wire **a** and GND
- **RBE** resistance between wire **b** and GND
- **Vab**, **VaE** and **VbE** AC and DC measured disturbing voltages

Calculation of Ω/km when the cable length is known

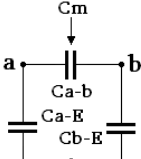
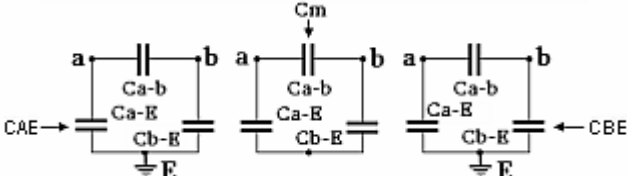
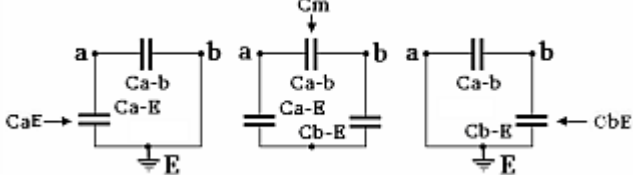
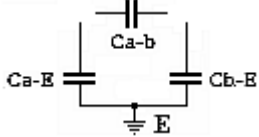
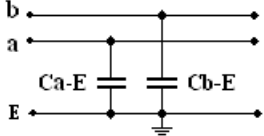
- Press the **Length** key
- Type in the length value and press **Enter**

For returning to the normal display

- Press the **Length** key and press **Esc**

2.3 Capacitance Measurements

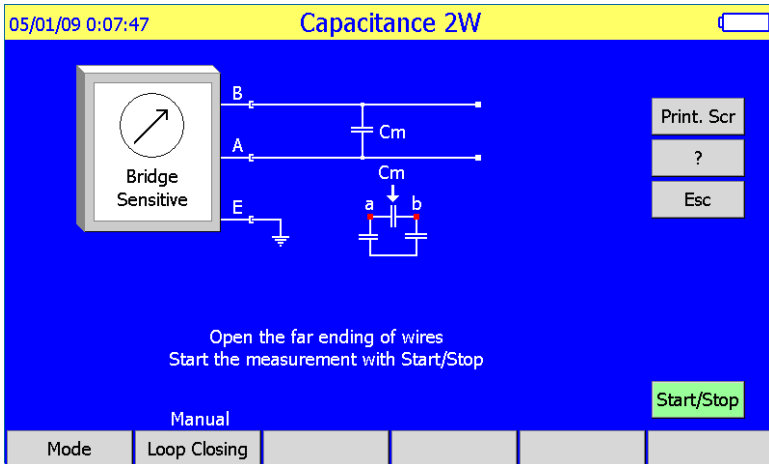
ECE 35 provides five capacitance measuring modes like:

| | |
|--|--|
| <u>2 WIRE</u> |  <p>(Measuring result is marked as: Cm)</p> |
| <u>2 WIRE & GND</u> TWO POLE (Default) |  <p>(Measuring results are marked as: Cm, CAE and CBE)</p> |
| <u>2 WIRE & GND</u> WITH HORTS |  <p>According to norm EN 50289-1-5:2001 (Measuring results are marked as: Cm, CaE and CbE)</p> |
| <u>2 WIRE & GND</u> PHISICAL |  <p>(The results are marked as: Ca-b, Ca-E and Cb-E)</p> |
| <u>CAPACITIVE</u> <u>BALANCE</u> |  <p>(The results are marked as: Ca-E and Cb-E)</p> |

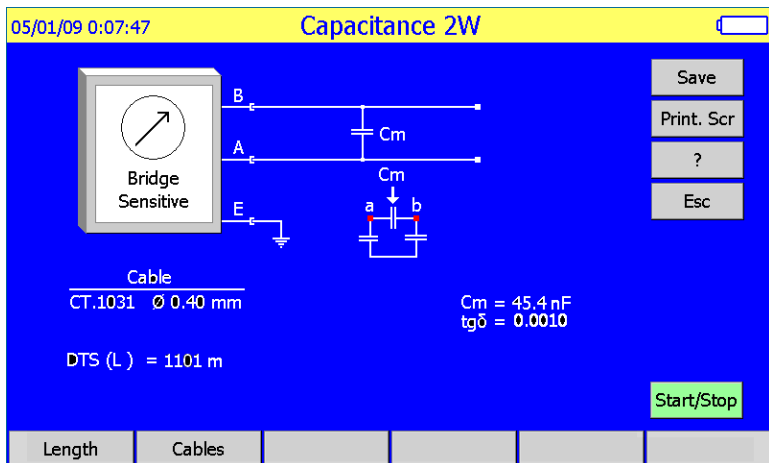
2.3.1 Capacitance 2 Wire Measurement

Test Procedure

- Press the **Capacitance / 2Wire** key
- Start the measurement with the **Start/Stop** key



Having the measurement completed the results appear:



Displayed Test Result

- **Cm** Mutual capacitance
- **tan δ** of mutual capacitance
- **DTS** Cable length (calculated out of cable parameters)

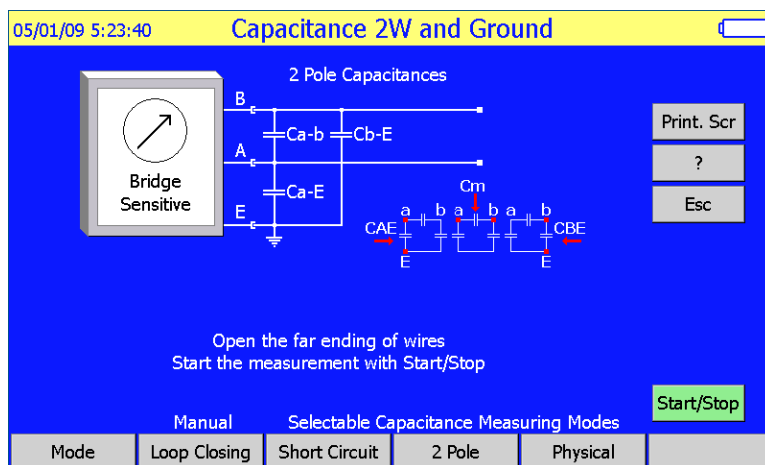
2.3.2 Capacitance 2 Wire & Ground, Measurement

Three measuring modes are provided:

- **Short Circuit**,
- **2 Pole** (Default)
- **Physical**

Test Procedure

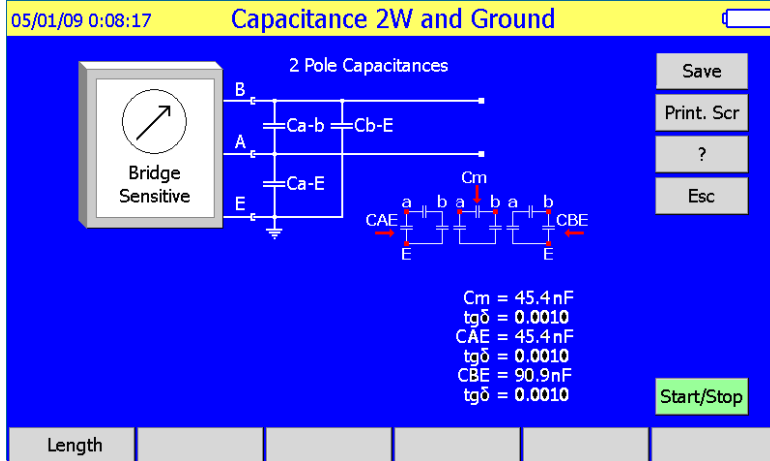
- Press the **Capacitance / 2-Wire & Ground** key
- Select the required measuring mode with the corresponding key.
- Start the measurement with the **Start/Stop** key.



Displayed Test Results

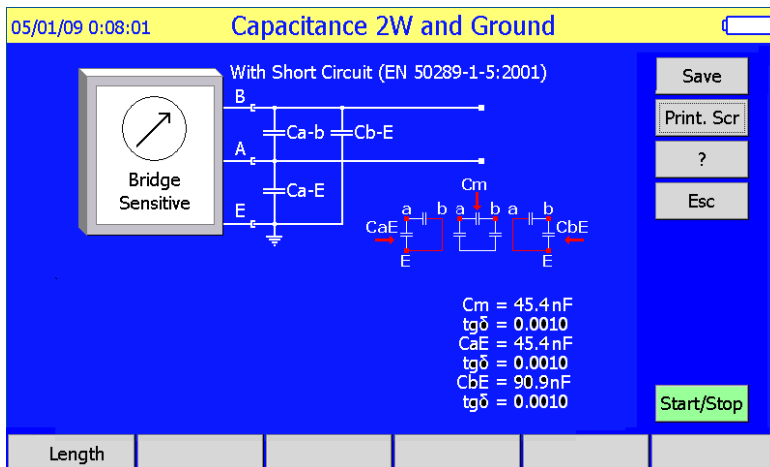
Displayed Test Results in 2 Pole Mode

- **C_m** capacitance and **tan δ** between wire **A** and wire **B**
- **CAE** capacitance and **tan δ** between wire **A** and **GND**
- **CBE** capacitance and **tan δ** between wire **B** and **GND**



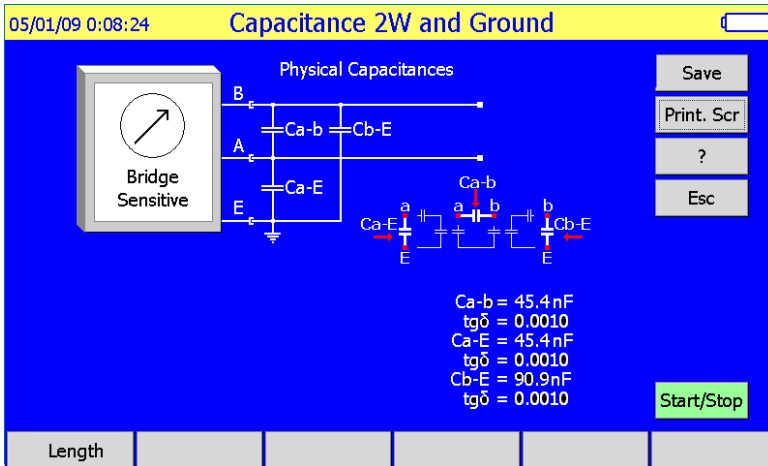
Displayed Test Results according to EN 50289-1-5:2001 norm

- **C_m** capacitance and **tan δ** between wire **A** and wire **B**
- **CaE** capacitance and **tan δ** between wire **A** and **GND**
- **CbE** capacitance and **tan δ** between wire **B** and **GND**



Displayed Test Results in Physical Mode

- **Ca-b** capacitance and **$\tan \delta$** between wire **A** and wire **B**
- **Ca-E** capacitance and **$\tan \delta$** between wire **A** and **GND**
- **Cb-E** capacitance and **$\tan \delta$** between wire **B** and **GND**

Calculation of nF/km when the cable length is known

- Press the **Length** key
- Type in the length value and press **Enter**

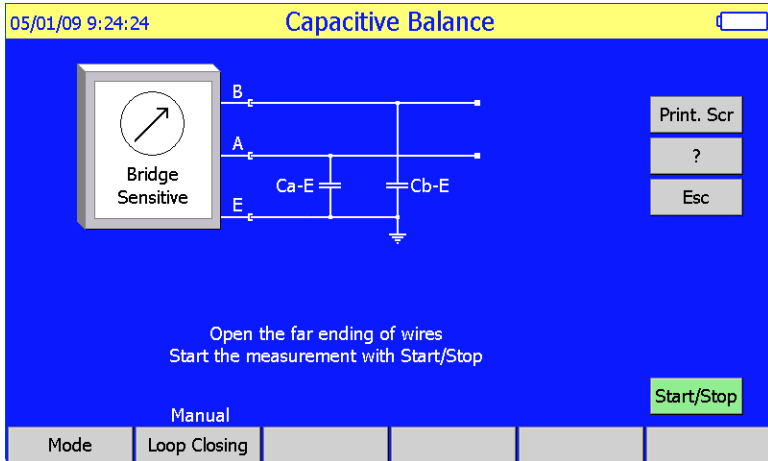
For returning to the normal display

- Press the **Length** key and press **Esc**

2.3.3 Capacitive Balance Measurement

Test Procedure

- Press the **Capacitive Balance** key
Doing so the measuring arrangement appears



Two measuring modes are provided: **Sensitive** or **Protected** mode. It is recommended to start the measurement with sensitive mode. When the disturbing voltages overload the indicator a warning appears informing the user that the result can be inaccurate. In that case the measurement should be repeated in protected mode.

- Select the proper mode with the **Mode** key
- Start the measurement with the **Start/Stop** key

Displayed Test Results

- Ca-E** wire capacitance
- Cb-E** wire capacitance
- $\Delta C = C_{a-E} - C_{b-E}$ capacitance difference
- $\Delta C\% = 2 \Delta C / (C_{a-E} + C_{b-E})$ difference in percents

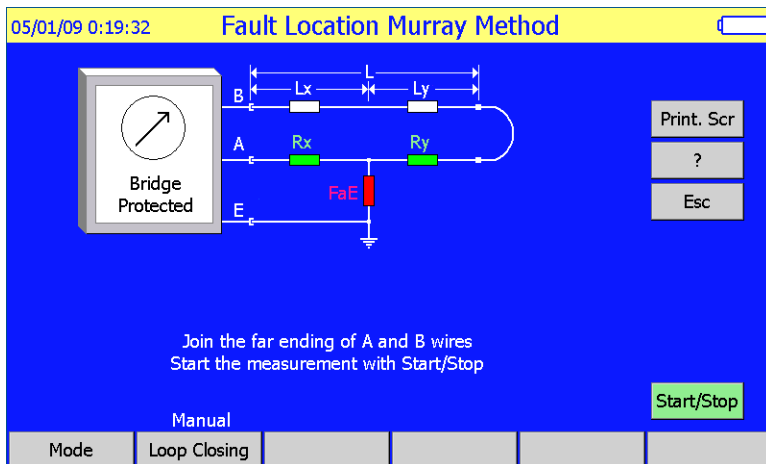
2.4 DC Fault Location

2.4.1 Murray Method

The Murray-method applicable when the two wires of the pair have the same gauge (\varnothing), the same length, are made of the same material and only one of them is leaky. To provide the specified accuracy, the good wire's insulation resistance between wire and ground must be at least 1000 times greater than the faulty wire's insulation resistance between wire and ground. The insulation resistance of the healthy wire must be higher than 10 M Ω even if the fault resistance of the faulty wire is smaller than 10 k Ω . The measurement can be performed if the healthy and faulty wires are taken from different pairs. That method can be applied when all the two wires of the faulty pair are wet but another healthy pair is available. The two pairs must be in the same cable

Test Procedure

- Press the **DC Fault Location / Murray** key
Doing so and then the measuring arrangement appears



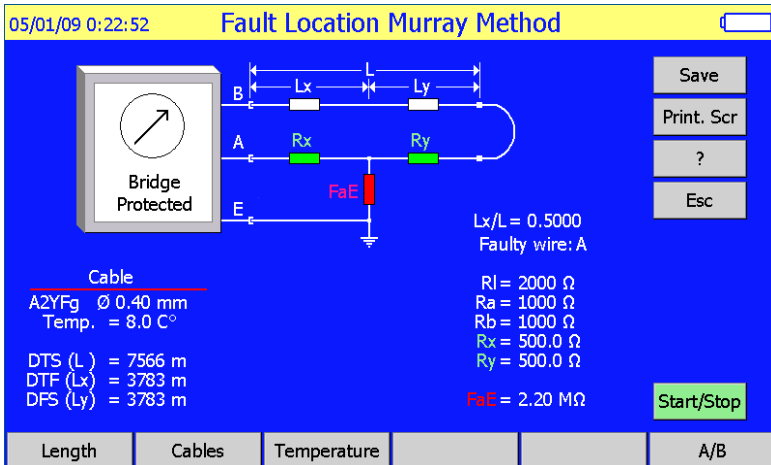
The far ending of the tested pair should be joined manually or by means of the remote controllable loop-closing device ELC30. The faulty wire should be connected to socket A

Two measuring modes are provided: **Sensitive** or **Protected** mode.

It is recommended to start the measurement with sensitive mode. When the disturbing voltages overload the indicator a warning appears informing the user that the result can be inaccurate. In that case the measurement should be repeated in protected mode.

- Select the proper mode with the **Mode** key
- Start the measurement with the **Start/Stop** key

Having the measurement completed the following results appear:



Displayed Test Results

- **Lx/L** relative distance of fault compared to the cable length
- **RI** loop resistance
- **Ra** wire resistance
- **Rb** wire resistance
- **Rx** wire resistance between the instrument and fault
- **Ry** resistance between fault **RI** and cable end
- **FaE** fault resistance
- **DTS (L)** calculated out of the cable parameters and RI
- **DTF (Lx)** calculated out of the cable parameters, RI and Lx/L
- **DFS (Ly)** calculated out of the cable parameters, RI and Lx/L

When the cable length is known

- Press the **Length** key
- Type in the length value and press **Enter**

For returning to the normal display

- Press the **Length** key and press **Esc**

2.4.2 3 Point Method

The purpose of the test is to find the location of the insulation fault. This test is applicable when the two wires of the pair have different gauges and only one of them is leaky. The ratio of the good wire insulation to the leaky wire insulation must be at least 1000.

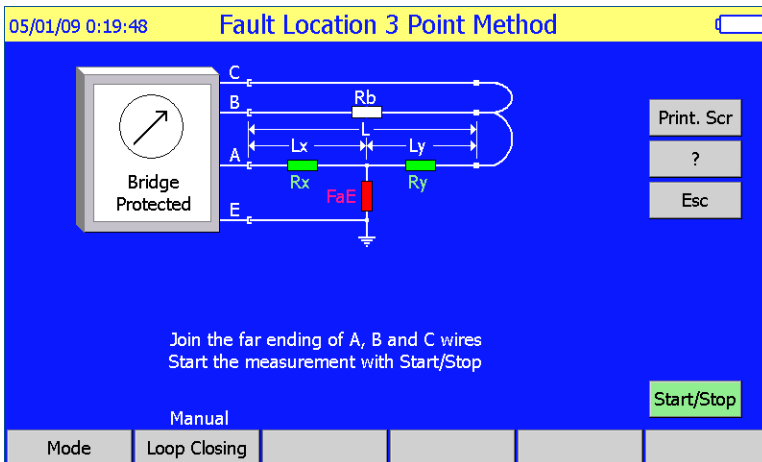
For that measurement, a third auxiliary wire is required (Wire C)

The resistance of auxiliary wire has no effect on the measurement.

During the test the far endings of the tested pair and the auxiliary wire should be interconnected manually or by means of the remote controllable Loop-Closing Device ELC30.or ECFL30S

Test Procedure

- Press the **DC Fault Location / 3 Point** key and then the measuring arrangement appears

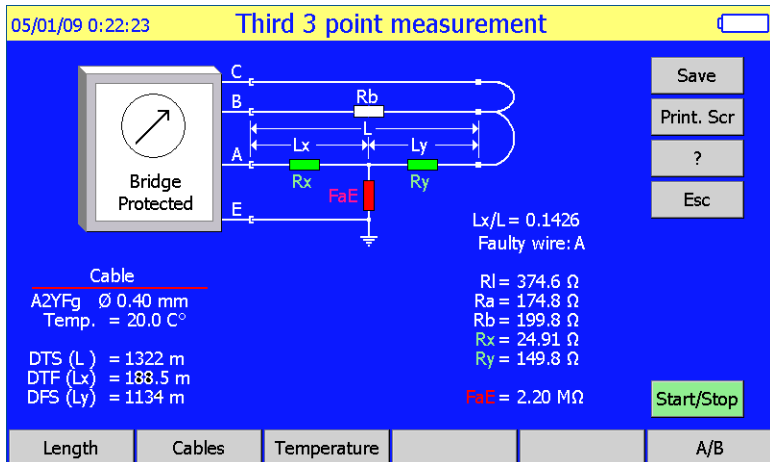


Two measuring modes are provided: **Sensitive** or **Protected** mode.

It is recommended to start the measurement with sensitive mode. When the disturbing voltages overload the indicator a warning appears informing the user that the result can be inaccurate. In that case the measurement should be repeated in protected mode.

- Select the proper mode with the **Mode** key
- The measurement can be started with the **Start/Stop** key

Having the measurement completed the following display appear:



Displayed Test Results

- **Lx/L** relative distance of fault compared to the cable length
- **RI** loop resistance
- **Ra** wire resistance
- **Rb** wire resistance
- **Rx** wire resistance between the instrument and fault
- **Ry** resistance between fault **RI** and cable end
- **FaE** fault resistance
- **DTS (L)** calculated out of the cable parameters and RI
- **DTF (Lx)** calculated out of the cable parameters, RI and L_x/L
- **DFS (Ly)** calculated out of the cable parameters, RI and L_x/L

When the cable length is known

- Press the **Length** key
- Type in the length value and press **Enter**

For returning to the normal display

- Press the **Length** key and press **Esc**

2.4.3 Küpfmüller Method

The Küpfmüller-method is applicable when the two wires of the pair have the same gauge (\emptyset), the same length, are made of the same material and both of them are leaky. An accurate result can be obtained when the two Küpfmüller conditions are fulfilled:

$$FaE + FbE > 100 \times RI$$

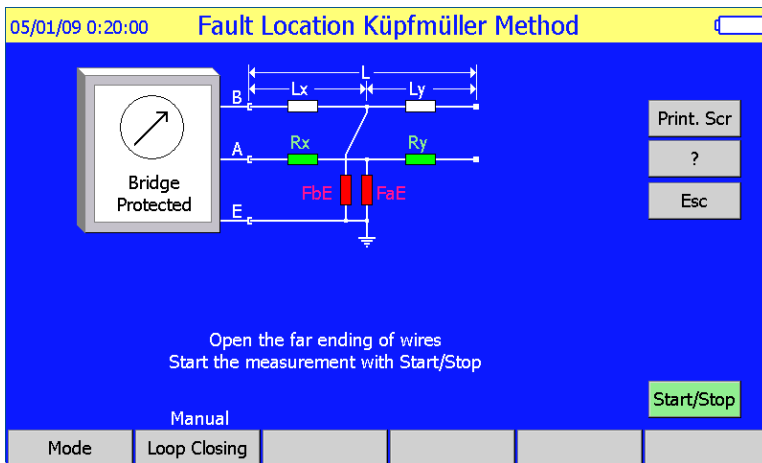
$$0,5 > FaE / FbE > 2$$

Thanks to the high accuracy of the active bridge acceptable accuracy can be reached when the tested line is free of disturbing voltages and the following condition is fulfilled:

$$0,9 > FaE / FbE > 1,1$$

Test Procedure

- Press the **DC Fault Location / Küpfmüller** key and then the measuring arrangement appears:



The Küpfmüller method requires two part measurements.

- First measurement with open loop
- Second one with closed loop

The far endings of the tested pair can be open and joined manually or by means of the remote controllable loop-closing device ELC30.or ECFL30S Having the far endings of the tested pair opened

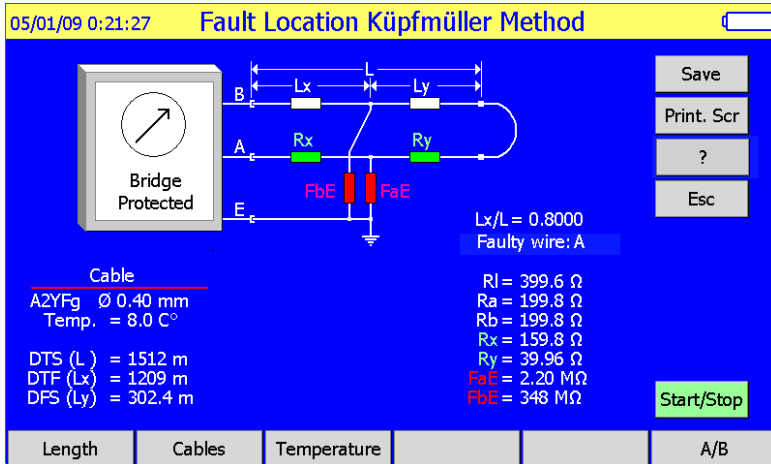
- Start the first** measurement with the **Start/Stop** key

Having the far endings of the tested pair shorted

- Start the second** measurement with the **Start/Stop** key

If the remote control function is switched on and the Loop-Closing Device is connected, the instrument automatically performs the second Küpfmüller measurement.

When the second measurement completed the following results appear:



Displayed Test Results

- **Lx/L** relative distance of fault compared to the cable length
- **RI** loop resistance
- **Ra** wire resistance
- **Rb** wire resistance
- **Rx** wire resistance between the instrument and fault
- **Ry** resistance between fault **RI** and cable end
- **FaE** and **FbE** fault resistances
- **DTS (L)** calculated out of the cable parameters and RI
- **DTF (Lx)** calculated out of the cable parameters, RI and Lx/L
- **DFS (Ly)** calculated out of the cable parameters, RI and Lx/L

When the cable length is known

- Press the **Length** key
- Type in the length value and press **Enter**

For returning to the normal display

- Press the **Length** key and press **Esc**

2.4.4 Repeated Küpfmüller method

That method is a sequence of repeated Küpfmüller measurements. It is applicable when both wires of a pair is faulty. That method is very useful in case of intensely changing fault resistances, DC voltages or electrolytic voltages.

That method requires 16 part measurements alternating:

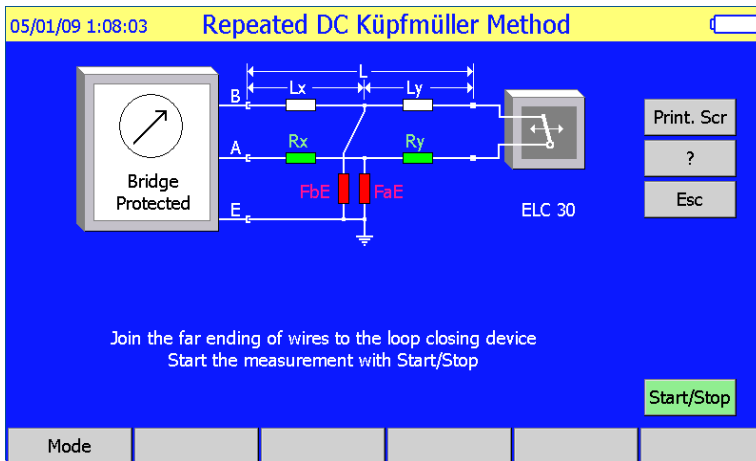
- 8 measurements with open loop (L)
- 8 measurements with closed loop (K)

After all partial measurements have been completed, the ECE 35 performs an automatic evaluation. In the course of this evaluation, the first two measurements and the unreal L_x / L values (for example, the negative values or values that deviate greatly from the average value) are not taken into account in the calculation. With the exception of the first two measurements, all 14 L_x / L results will be displayed and the partial measurements not taken into account will be marked with asterisks. During the calculation, all L and K results are considered twice. This is shown by the $n:n$ and $n: n + 1$ labels above the result columns. The mean value MW and the number of considered L_x / L values are also displayed.

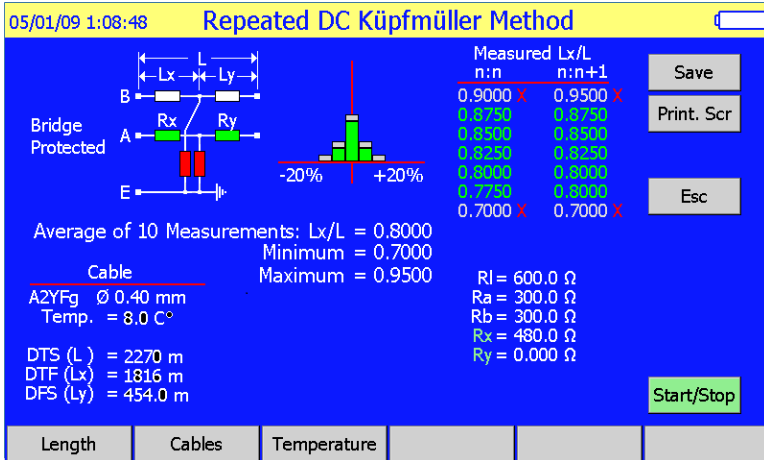
The far endings of the tested pair should be connected to ELC30 or ECFL30S remote controllable loop closing devices.

Test Procedure

- Press the **DC Fault Location / Repeated Küpfmüller** key and then the measuring arrangement appears:



- The measurement can be started with the **Start/Stop** key
- Having the test sequence completed the result display appears:



The result display contains:

- 14 measured **Lx/L** values (the unlikely ones are marked with X)
- The **average** and **number** of Lx/L values
- The **minimum** and **maximum** of Lx/L value
- Histogram** showing the distribution of Lx/L values
- RI** loop resistance
- Ra** resistance of wire A (RI/2)
- Rb** resistance of wire B (RI/2)
- Rx** wire resistance between the instrument and fault
- Ry** resistance between the fault and cable end
- DTS (L)** calculated out of the cable parameters and RI
- DTF (Lx)** calculated out of the cable parameters, RI and Lx/L
- DFS (Ly)** calculated out of the cable parameters, RI and Lx/L

When the cable length is known

- Press the **Length** key
- Type in the length value and press **Enter**

For returning to the normal display

- Press the **Length** key and press **Esc**

Evaluation by means of Histogram

In case of high disturbing voltages the L_x/L values calculated out of the results of part measurements may show remarkable dispersion and the user can't be sure that automatic average calculation produces really proper value.

Therefore a **HISTOGRAMM** is provided showing the dispersion of calculated part results.

The histogram presents the L_x/L values along the horizontal axis.

- The width of bars is 7% of average value
- The height of bars shows the prevalence of L_x/L values
- The bars used for the average calculation are green
- The unused bars are grey

At the evaluation of histogram the user should consider:

- The histogram of a **perfect measurement** is a green bar showing that the results of all part measurements were within a $\pm 3.5\%$ range around the average.
- The histogram of a **sufficient measurement** is absolutely symmetrical but some results are in the neighboring bars around the average.
- The histogram of a **doubtful measurement** is generally unsymmetrical and the dispersion is irregular. In that case the measurement should be repeated with another wire combination.

When the level of disturbing voltage is too high the whole histogram and the test results can be **unacceptable**. In this case try to repeat the test in protected mode or with the passive bridge of ECE 35.

Notice:

Two measuring modes are provided: **Sensitive** or **Protected** mode.

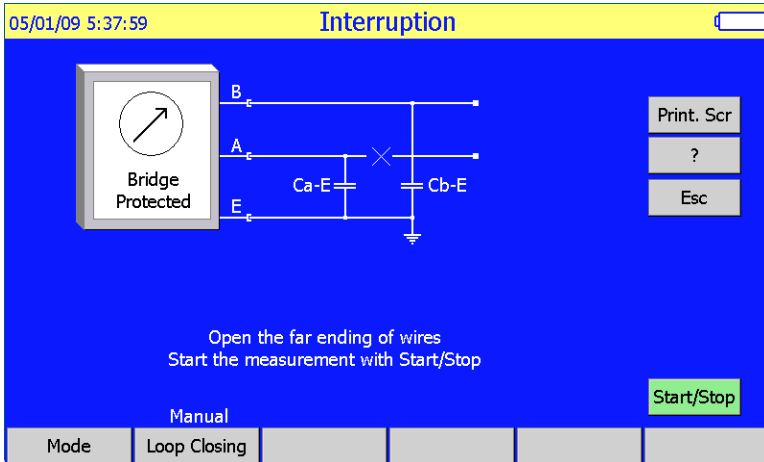
It is recommended to start the measurement with sensitive mode. When the disturbing voltages overload the indicator a warning appears informing the user that the result can be inaccurate. In that case the measurement should be repeated in protected mode. The proper mode can be selected with the **Mode** key

2.5 AC Fault Location

2.5.1 Interruption Measurement

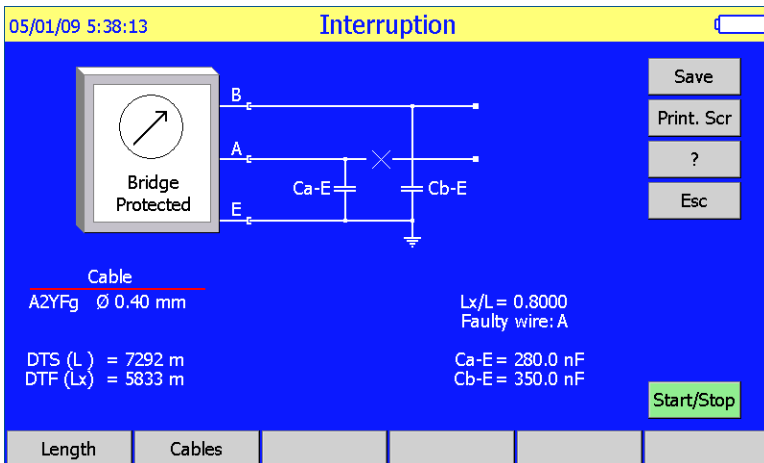
Test Procedure

- Press the **AC Fault Location / Interruption** key and then the measuring arrangement appears



The far endings of the pair should be open.

- Start the measurement pressing the **Start/Stop** key



Displayed Test Results

- **Lx/L** relative distance of fault compared to the cable length
- **Ca-E** wire capacitance between the instrument and fault
- **Cb-E** ground capacitance of wire b

To save the test result press the **Save** key

Calculation of DTF when the cable parameters are known

When the cable type is known the length (DTS) and the distance to fault (DTF) can be calculated out of the measured capacitances.

- To enter or change the cable type press the **Cables** key select a cable type and press **Esc**

Calculation of DTF when the cable length is known

The **DTF** can be calculated from the Lx/L value when the length is known

To enter the length of the cable press the **Length** key, type in the length value and press **Enter**

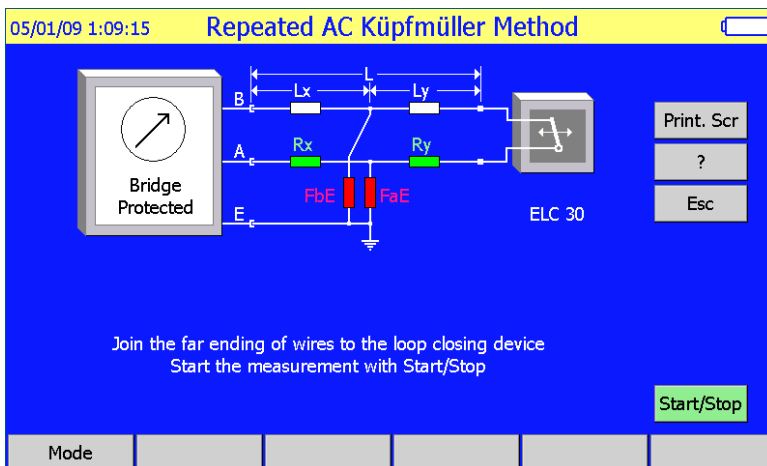
2.5.2 Repeated AC Küpfmüller method

The process of the measurement is similar to DC method.

The only difference is: the measuring voltage is 11 Hz AC instead of DC.

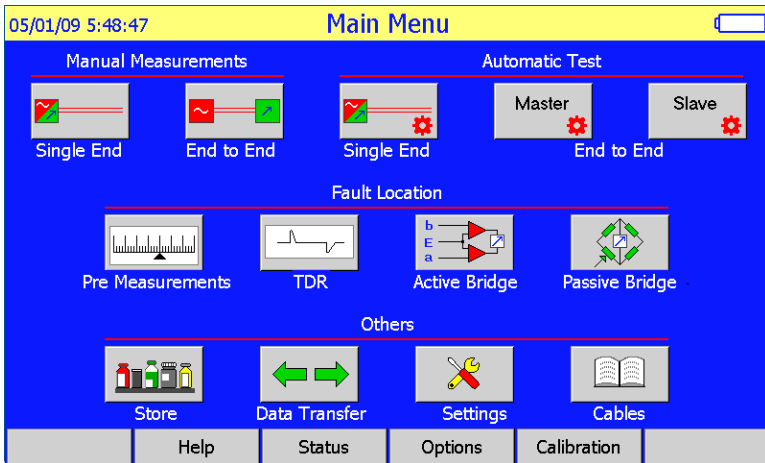
The AC method provides accurate test result in case of changing electrolytic voltages

- Press the **AC Fault Location / Repeated Küpfmüller** key and then the measuring arrangement appears:



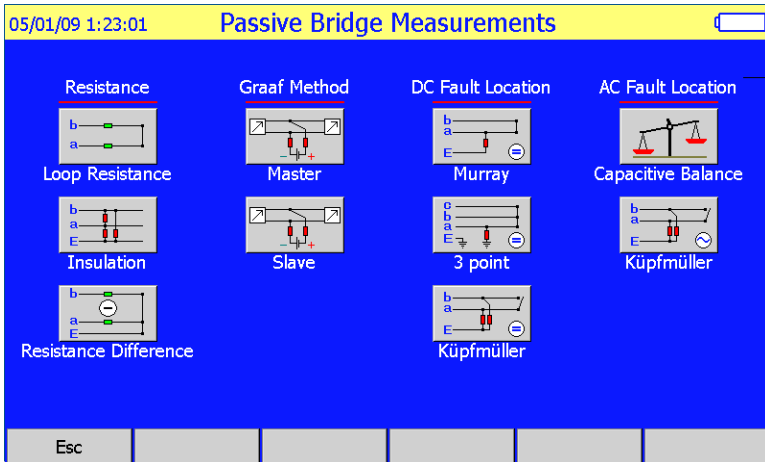
- Start the first measurement pressing the **Start/Stop** key

3 PASSIVE BRIDGE (Option)



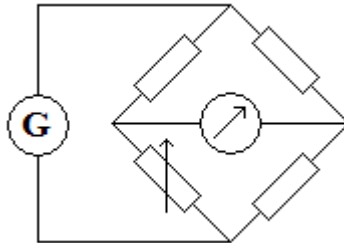
Active bridge selection

- Press the **Passive Bridge** key of **Main Menu**



3.1 Principles of Operation

In **Passive Bridge** mode ECE 35 applies the classic Wheatstone bridge arrangement consisting of fix and variable resistors, generator and null-indicator.



- The generator produces 100 V DC or 100 Vp, 11 Hz AC
- The null-indicator contains a 11 Hz low pass filter
- The variable resistor is a high precision potentiometer (Helipot)

The passive bridge of ECE 35 can be manually balanced by means of the Helipot (Like it is usual at the conventional bridges), but the reading of potentiometer resistance is electronic)

That solution combines the good features of conventional bridges with the comfort of micro processor controlled circuits.

- The passive bridge measures accurately even in the presence of disturbing longitudinal AC voltages.
- The electronic „reading“ of potentiometer provides quick and accurate calculation of fault location (L_x/L)

Applications

DC Fault Location

- Fault location with Murray-Method
- Fault location with 3 Point-Method
- Fault location with Küpfmüller- Method
- Resistance difference measurement

AC Fault Location

- Fault location with Küpfmüller- Method
- Capacitance balance measurement

ECE 35 applies the generator and the null-indicator also for resistance measurements like

- Loop resistance measurement
- Insulation resistance measurement

3.2 Resistance Measurements

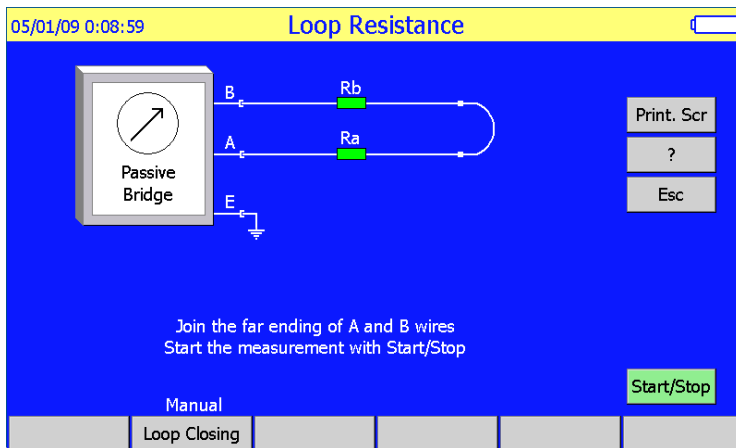
3.2.1 Loop Resistance Measurement

The purpose of that measurement is to measure the loop resistance.

ECE 35 measures the loop resistance accurately even in the presence of disturbing longitudinal AC voltages on the line.

Test Procedure

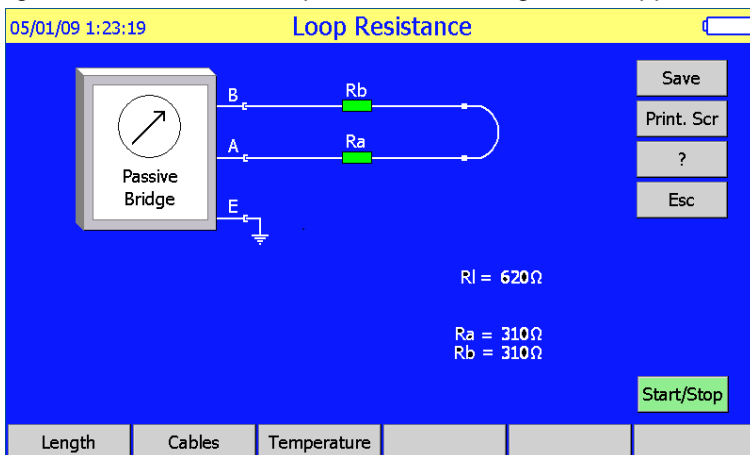
- Press the **Loop Resistance** key and then the measuring arrangement appears.



The far endings of the tested pair should be joined manually or by means of the remote controllable loop-closing device ELC30 or ECFL 30S

- The measurement can be started with the **Start/Stop** key

Having the measurement completed the following results appears:



Displayed Test Results

- Loop resistance **RI**, **Ra**, and **Rb** (Ra and Rb is calculated as $RI/2$)
- **DTS (L)** calculated out of the cable parameters and RI

To change the cable temperature

- Press the **Temperature** key,
- Type in the temperature value and press **Enter**.

Calculation of Ω/km when the cable length is known

- Press the **Length** key
- Type in the length value and press **Enter**

For returning to the normal display

- Press the **Length** key and press **Esc**

Notice:

In case of short cables the calibration of test leads is recommended.

3.2.2 Insulation Resistance Measurement

The purpose of that measurement is to measure the insulation resistance. **ECE 35** measures the insulation resistance accurately even in the presence of disturbing longitudinal AC voltages on the line.

There are two measuring ranges: up to 300 M Ω and up to 10 G Ω

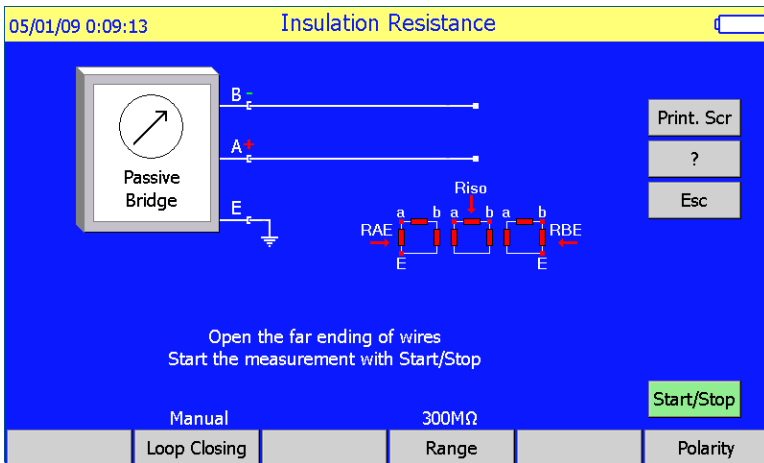
Measuring times:

- ~ 80 sec for the 300 M Ω range
- ~ 100 sec for the 10 G Ω range

The relatively long measuring time is necessary because of the capacitance of the measured cable.

Test Procedure

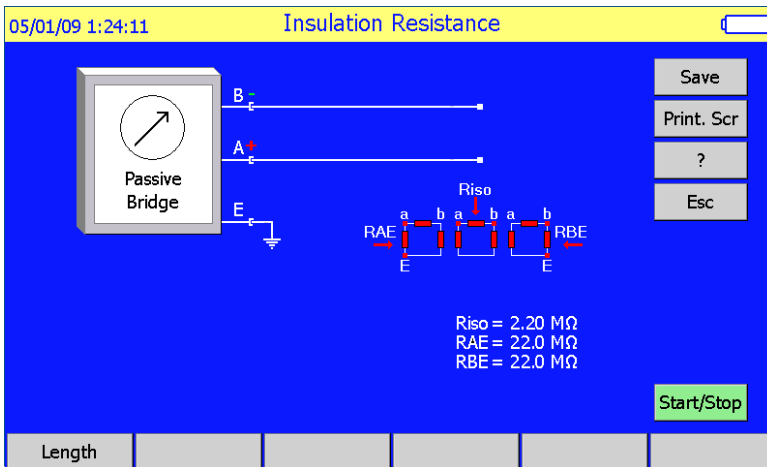
- Press the **Insulation** key and then the measuring arrangement appears



The far endings of the tested pair should be open.

- Select the required measuring range with the **Range** key
- Select the proper polarity with the **Polarity** key
- Start the measurement with the **Start/Stop** key

Having the measurement completed the following results appears



Displayed Test Results

- **Riso** resistance between wire **A** and wire **B**
- **RaE** resistance between wire **A** and GND
- **RbE** resistance between wire **B** and GND

Calculation of Ω/km when the cable length is known

- Press the **Length** key
- Type in the length value and press **Enter**

For returning to the normal display

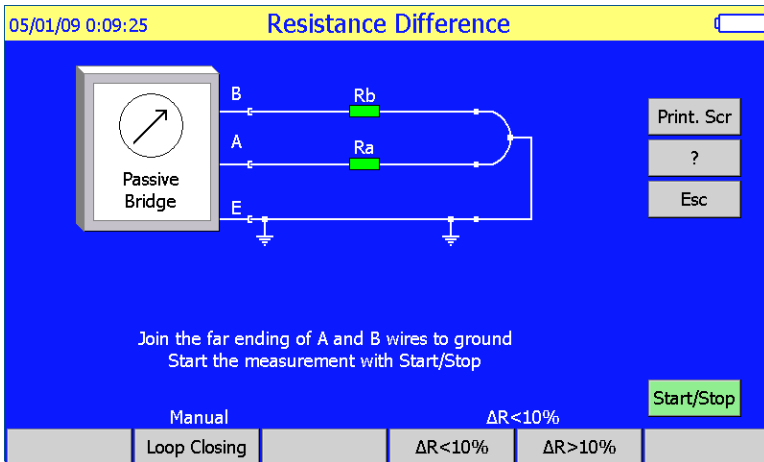
- Press the **Length** key and press **Enter**

3.2.3 Resistance Difference Measurement

The purpose of that measurement is to measure the resistance difference between wire **a**, and wire **b**. ECE 35 measures the resistance difference accurately even in the presence of disturbing longitudinal AC voltages on the line.

Test Procedure

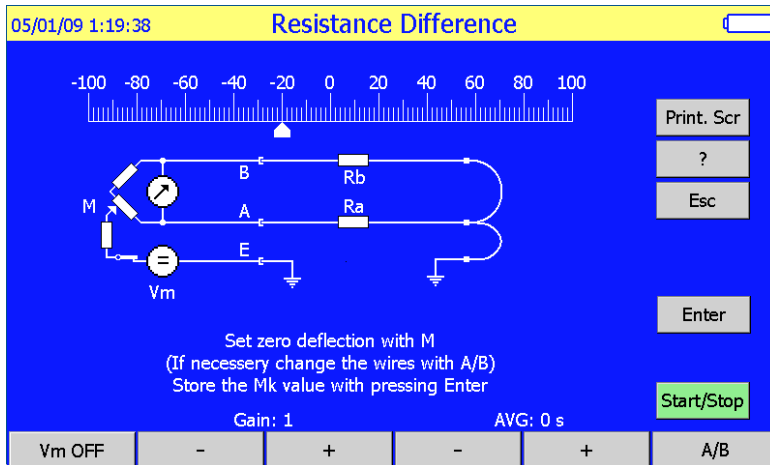
Press the **Resistance Difference** key and the measuring arrangement appears.



The far endings of the tested pair should be joined to the ground manually or by means of the remote controllable loop-closing device ELC30 or ECFL 30S.

- Select the required measuring range with pressing the $\Delta R < 10\%$ or $\Delta R > 10\%$ key
- Start the measurement with the **Start / Stop** key

Having the measurement started the following display appears after a few seconds and the bridge is ready for balancing



Bridge Balancing

- Select the minimum gain with the **Gain-** key
- Switch the measuring voltage off with the **Vm OFF** key and keep it pressed until the pointer reaches a stable position.

While the key is pressed ECE 35 measures the disturbing DC voltage. After releasing the key, ECE 35 performs a null-correction compensating the effect of disturbing voltage. The null point remains in the middle.

- Set the pointer to the 0 point with the M balancing potentiometer
- Increase the gain gradually with the **Gain+** key and repeat the first two points until reaching the perfect balance.

The balance is perfect when the gain is 4 or 5 and the pointer stands on the 0 point with pressed and released **Vm OFF** key as well.

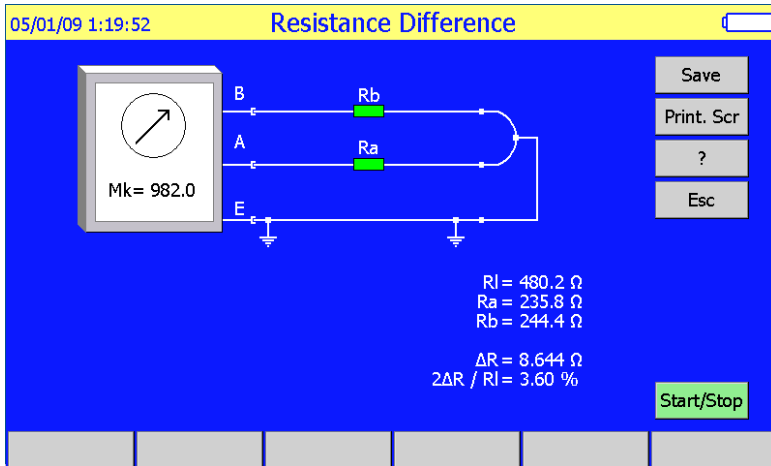
The indicator performs numerous measurements per second. The pointer shows the result of the last measurement. When the line is too noisy the pointer is waving around a middle point and the reading is difficult.

The waving of pointer can be reduced by average calculation.

Five averaging times are provided: 0, 0.5, 1, 2 or 4 sec. (Zero means: no averaging)

- The averaging time can be changed with **AVG-** and **AVG+** keys

When the balancing is completed press **Enter** and the results appear



Displayed Test Results

- **Mk** value
- **RI = $R_a + R_b$** loop resistance
- **R_a and R_b** (R_a and R_b is calculated as $RI/2$)
- **$\Delta R = R_a - R_b$** resistance difference
- **$2 \Delta R / RI$** resistance difference in percents

Notice

The result is calculated from the measured **RI** and **Mk** values.

The difference between the wire resistances of a pair is usually small compared to the wire resistances. ECE 35 has to measure the small difference of high resistances, therefore the calibration of test leads is recommended.

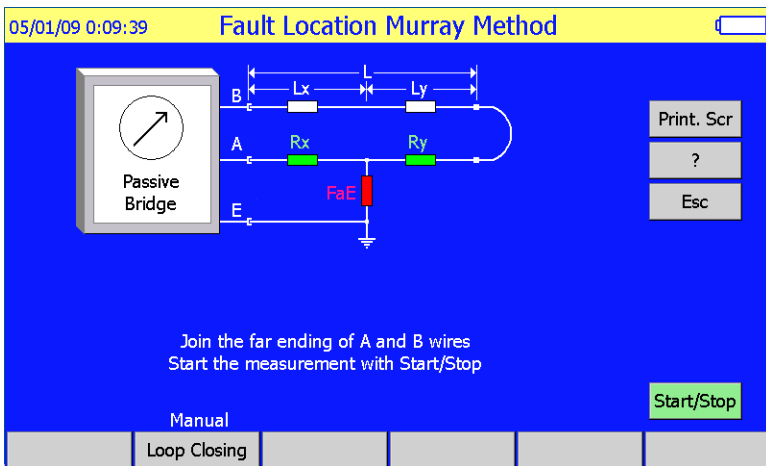
3.3 DC Fault Location

3.3.1 Murray Method

The Murray-method applicable when the two wires of the pair have the same gauge (\varnothing), the same length, are made of the same material and only one of them is leaky. To provide the specified accuracy, the good wire's insulation resistance between wire and ground must be at least 1000 times greater than the faulty wire's insulation resistance between wire and ground. The passive bridge of ECE 35 measures accurately even in the presence of disturbing longitudinal AC voltages on the line.

Test Procedure

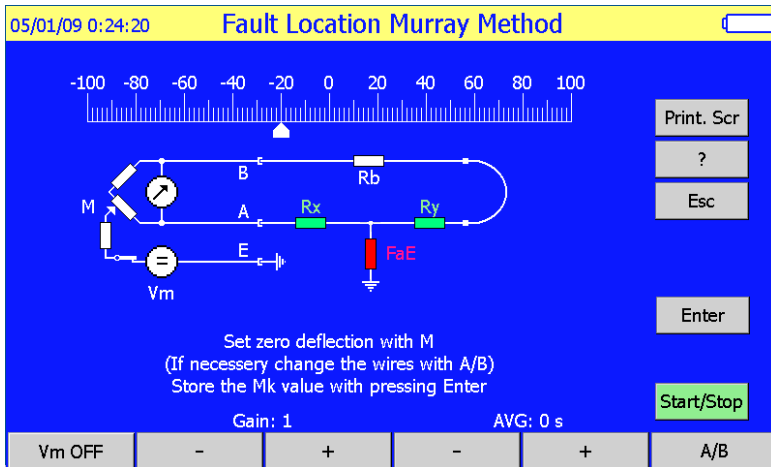
- Press the **DC Fault Location / Murray** key and then the measuring arrangement appears



The far ending of the tested pair should be joined manually or by means of the remote controllable loop-closing device ELC30 or ECFL 30S

- Start the measurement with the **Start / Stop** key

Having the measurement started the following display appears after a few seconds and the bridge is ready for balancing.



Bridge Balancing

- Select the minimum gain with the **Gain-** key
- Switch the measuring voltage off with the **Vm OFF** key and keep it pressed until the pointer reaches a stable position.

While the key is pressed ECE 35 measures the disturbing DC voltage. After releasing the key, ECE 35 performs a null-correction compensating the effect of disturbing voltage. The null point remains in the middle.

- Set the pointer to the 0 point with the M balancing potentiometer
- Increase the gain gradually with the **Gain+** key and repeat the first two points until reaching the perfect balance.

The balance is perfect when the gain is 4 or 5 and the pointer stands on the 0 point with pressed and released **Vm OFF** key as well.

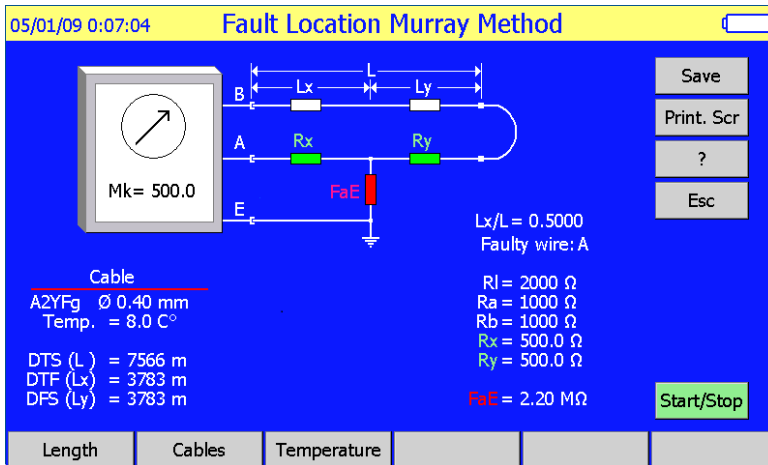
The indicator performs numerous measurements per second. The pointer shows the result of the last measurement. When the line is too noisy the pointer is waving around a middle point and the reading is difficult.

The waving of pointer can be reduced by average calculation.

Five averaging times are provided: 0, 0.5, 1, 2 or 4 sec. (Zero means: no averaging)

- The averaging time can be changed with **AVG-** and **AVG+** keys

When the balancing is completed press **Enter** and the results appear:



Displayed Test Results

- **MK** value
- **Lx/L** relative distance of fault compared to the cable length
- **RI** loop resistance
- **Ra** wire resistance
- **Rb** wire resistance
- **Rx** wire resistance between the instrument and fault
- **Ry** resistance between fault **RI** and cable end
- **FaE** fault resistance
- **DTS (L)** calculated out of the cable parameters and RI
- **DTF (Lx)** calculated out of the cable parameters, RI and Lx/L
- **DFS (Ly)** calculated out of the cable parameters, RI and Lx/L

When the cable length is known

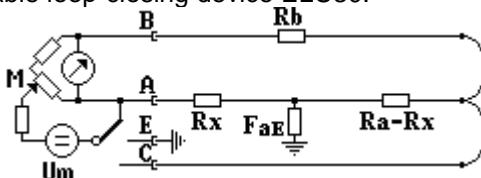
- Press the **Length** key
- Type in the length value and press **Enter**

For returning to the normal display

- Press the **Length** key and press **Esc**

3.3.2 3 Point Method

The purpose of the test is to find the location of the wire-to-ground insulation fault. This test is applicable when the two wires of the pair have different gauges and only one of them is leaky. The ratio of the good wire insulation to the leaky wire insulation must be at least 1000. The passive bridge of ECE 35 measures accurately even in the presence of disturbing longitudinal AC voltages on the line. For that measurement a third, auxiliary wire is required between ECE 35 and the far end. The resistance of auxiliary **wire C** has no effect on the accuracy. The far endings of the tested pair should be joined to the wire **C** manually or by means of the remote controllable loop-closing device ELC30.



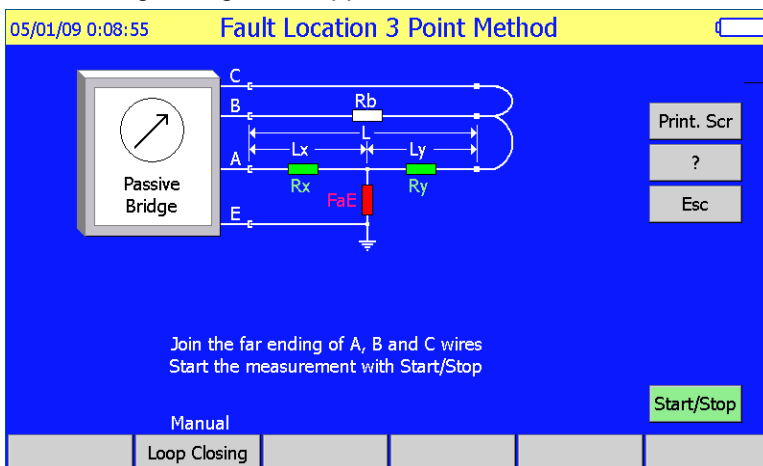
The 3 Point method requires three part-measurements:

1. The generator U_m is connected to wire A. The result is **Mk1** (Practically always 0)
2. The generator U_m is connected to the ground. The result is **Mk2**
3. The generator U_m is connected to wire **C**. The result is **Mk3**

The L_x/L value is calculated out of **Mk1**, **Mk2** and **Mk3**

Test Procedure

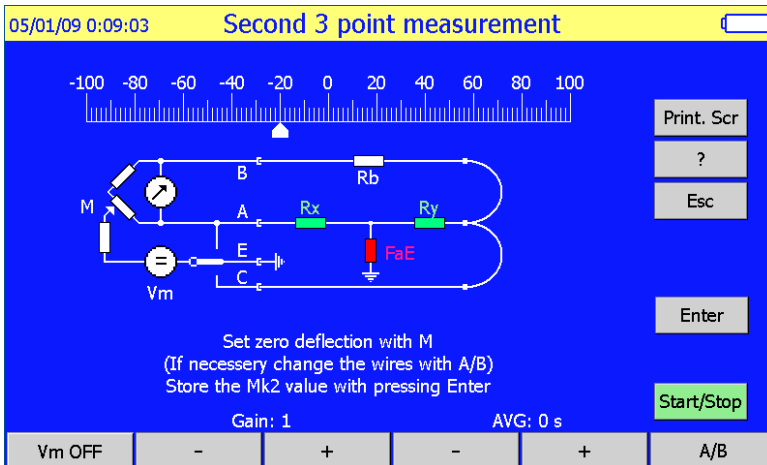
- Press the **DC Fault Location / 3 Point** key and then the measuring arrangement appears



- Start the measurement with the **Start / Stop** key

Having the **Start / Stop** key pressed ECE 35 automatically performs the first measurement without balancing and stores the MK1 value.

When the first measurement is completed the bridge is ready for balancing and the following display appears:



Bridge Balancing

- Select the minimum gain with the **Gain-** key
- Switch the measuring voltage off with the **Vm OFF** key and keep it pressed until the pointer reaches a stable position.

While the key is pressed ECE 35 measures the disturbing DC voltage. After releasing the key, ECE 35 performs a null-correction compensating the effect of disturbing voltage. The null point remains in the middle.

- Set the pointer to the 0 point with the M balancing potentiometer
- Increase the gain gradually with the **Gain+** key and repeat the first two points until reaching the perfect balance.

The balance is perfect when the gain is 4 or 5 and the pointer stands on the 0 point with pressed and released **Vm OFF** key as well.

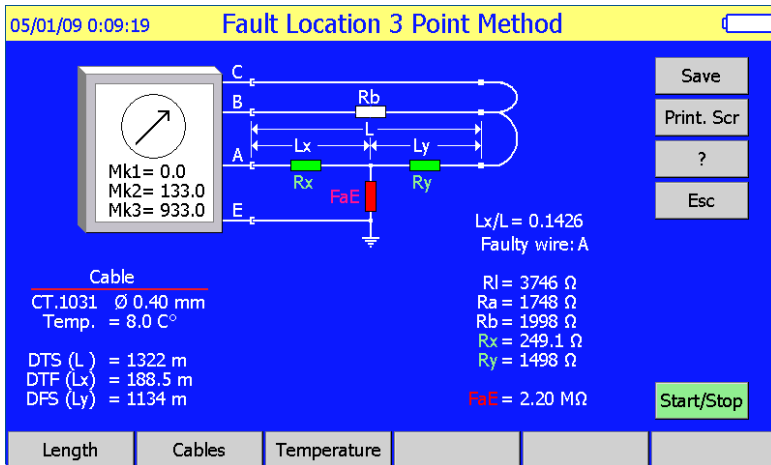
The indicator performs numerous measurements per second. The pointer shows the result of the last measurement. When the line is too noisy the pointer is waving around a middle point and the reading is difficult.

The waving of pointer can be reduced by average calculation.

Five averaging times are provided: 0, 0.5, 1, 2 or 4 sec. (Zero means: no averaging)

- The averaging time can be changed with **AVG-** and **AVG+** keys
- When the balancing is completed press **Enter** to store the result (MK2) and to call the picture of the third measurement.

Balance the bridge again and press **Enter** to store the result (**MK3**) and then the result display appears



Displayed Test Results

- **MK1, MK2 and MK3** values
- **Lx/L** relative distance of fault compared to the cable length
- **RI** loop resistance
- **Ra** wire resistance
- **Rb** wire resistance
- **Rx** wire resistance between the instrument and fault
- **Ry** resistance between fault **RI** and cable end
- **FaE** fault resistance
- **DTS (L)** calculated out of the cable parameters and RI
- **DTF (Lx)** calculated out of the cable parameters, RI and Lx/L
- **DFS (Ly)** calculated out of the cable parameters, RI and Lx/L

When the cable length is known

- Press the **Length** key
- Type in the length value and press **Enter**

For returning to the normal display

- Press the **Length** key and press **Esc**

3.3.3 Küpfmüller Method

The Küpfmüller-method applicable when the two wires of the pair have the same gauge (\varnothing), the same length, are made of the same material and both of them are leaky. An accurate result can be obtained when the two Küpfmüller conditions are fulfilled:

$$FaE + FbE > 100 \times RI$$

$$0,5 > FaE / FbE > 2$$

The passive bridge of ECE 35 measures accurately even in the presence of disturbing longitudinal AC voltages on the line.

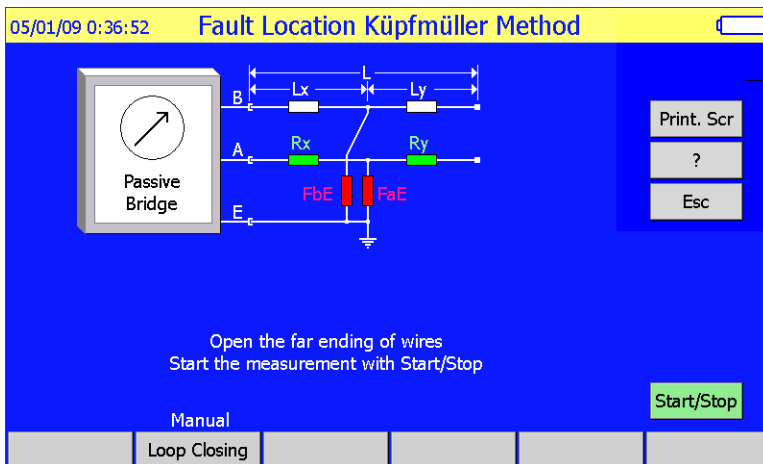
The Küpfmüller method requires two part-measurements

- 1: Performed with **open** loop. The result is **ML**
- 2: Performed with **closed** loop. The result is **MK**

The Lx/L value is calculated out of ML and MK

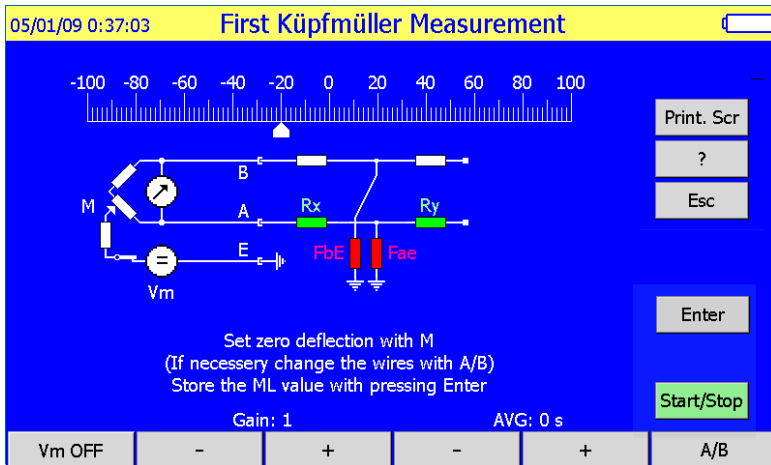
Test Procedure

- Press the **DC Fault Location / Küpfmüller** key and then the measuring arrangement appears



- Start the first measurement pressing the **Start / Stop** key

Having the measurement started the following display appears after a few seconds and the bridge is ready for balancing:



Bridge Balancing

- Select the minimum gain with the **Gain-** key
- Switch the measuring voltage off with the **Vm OFF** key and keep it pressed until the pointer reaches a stable position.

While the key is pressed ECE 35 measures the disturbing DC voltage. After releasing the key, ECE 35 performs a null-correction compensating the effect of disturbing voltage. The null point remains in the middle.

- Set the pointer to the 0 point with the M balancing potentiometer
- Increase the gain gradually with the **Gain+** key and repeat the first two points until reaching the perfect balance.

The balance is perfect when the gain is 4 or 5 and the pointer stands on the 0 point with pressed and released **Vm OFF** key as well.

The indicator performs numerous measurements per second. The pointer shows the result of the last measurement. When the line is too noisy the pointer is waving around a middle point and the reading is difficult.

The waving of pointer can be reduced by average calculation.

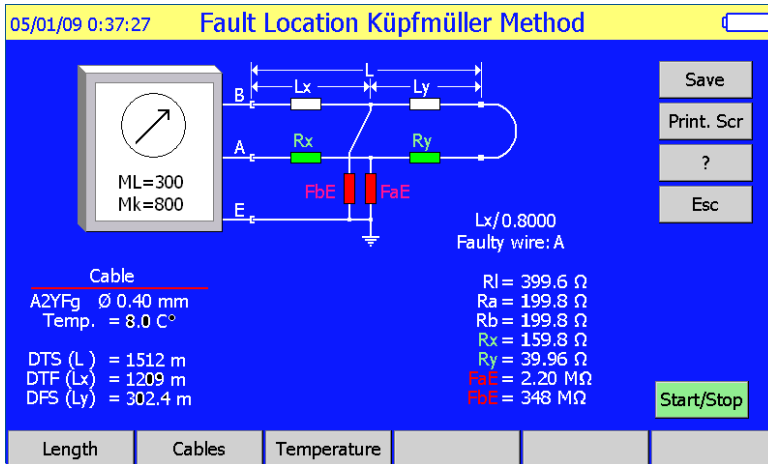
Five averaging times are provided: 0, 0.5, 1, 2 or 4 sec. (Zero means: no averaging)

- The averaging time can be changed with **AVG-** and **AVG+** keys
- When the balancing is completed press **Enter** to store the result (ML).

Before the second measurement the loop should be closed. Close it manually or by means of the remote controllable loop-closing device ELC30 or ECFL 30S.

In case of manual control start the second measurement pressing the **Start / Stop** key and the bridge is ready for the second balancing:

- Balance the bridge again and press **Enter** to store the result (MK) and then the result display appears.



Displayed Test Results

- ML** and **MK** values
- Lx/L** relative distance of fault compared to the cable length
- RI** loop resistance
- Ra** wire resistance
- Rb** wire resistance
- Rx** wire resistance between the instrument and fault
- Ry** resistance between fault **RI** and cable end
- FaE** and **FbE** fault resistances
- DTS (L)** calculated out of the cable parameters and RI
- DTF (Lx)** calculated out of the cable parameters, RI and Lx/L
- DFS (Ly)** calculated out of the cable parameters, RI and Lx/L

When the cable length is known

- Press the **Length** key
- Type in the length value and press **Enter**

For returning to the normal display

- Press the **Length** key and press **Esc**

3.3.4 End to End Synchronous Graaf Measurement

The purpose of that measurement is fault location when due to high and intermittent disturbing voltages neither the active nor the passive bridge can provide satisfactory result.

In that case ECE 35 provides the improved version of Graaf method using the disturbing voltages itself for the measurement. (No other measuring voltage is added).

At that measuring mode two instruments are connected to the ends of the tested pair in MASTER-SLAVE arrangement. The two instruments perform current measurement at the same time and communicate over the tested pair. The Master calculates the location of fault out of the rate of currents. That means:

- The higher is the disturbing voltage the easier to locate a fault!
- That method can be used only in the presence of disturbing voltages between the A and B wires

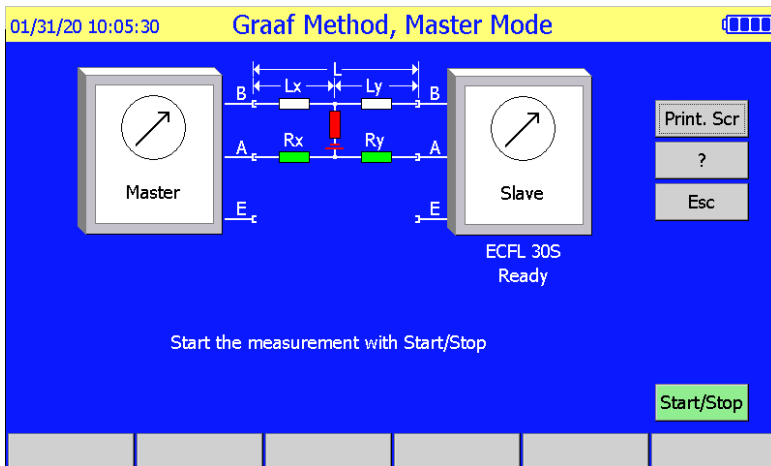
ECE 35 can be programmed as MASTER and SLAVE as well.

Mode selection is in the **Passive Bridge** menu.

For SLAVE function a simplified version is available (ECFL 30S)

Test Procedure

Press the **Graaf Method / Master** key then the measuring arrangement appears.

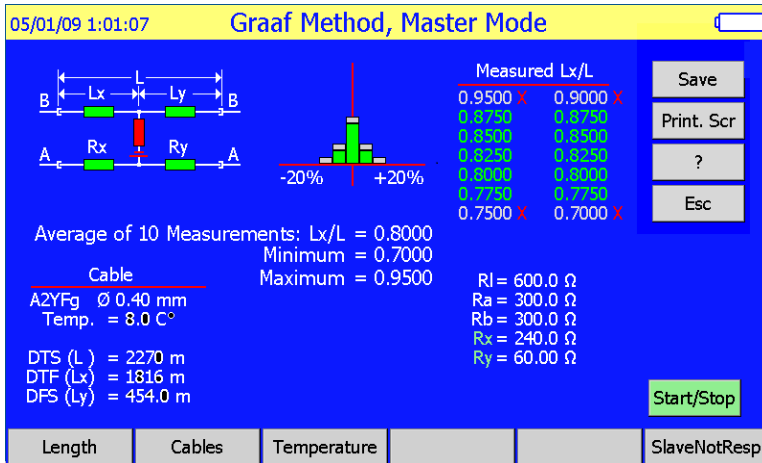


- The measurement can be started with the **Start / Stop** key

ECE 35 performs 16 consecutive synchronous measurements at both sides. The duration of that automatic test sequence is 90 sec.

When the 16 part measurements are ready ECE 35 evaluates the results. In the course of evaluation the results of the first two measurements and Lx/L values unlikely differing from the average are omitted.

Having the test sequence completed the result display appears:



The result display contains:

- 14 measured **Lx/L** values (the unlikely ones are marked with **X**)
- The **average** and **number** of Lx/L values
- The **minimum** and **maximum** of Lx/L value
- **Histogram** showing the distribution of Lx/L values
- **RI** loop resistance
- **Ra** resistance of wire A (RI/2)
- **Rb** resistance of wire B (RI/2)
- **Rx** wire resistance between the instrument and fault
- **Ry** resistance between the fault and cable end
- **DTS (L)** calculated out of the cable parameters and RI
- **DTF (Lx)** calculated out of the cable parameters, RI and Lx/L
- **DFS (Ly)** calculated out of the cable parameters, RI and Lx/L

When the cable length is known

- Press the **Length** key
- Type in the length value and press **Enter**

For returning to the normal display

- Press the **Length** key and press **Esc**

Evaluation by means of Histogram

In case of low disturbing voltages the L_x/L values calculated out of the results of part measurements may show remarkable dispersion and the user can't be sure that automatic average calculation produces really proper value.

Therefore a **HISTOGRAMM** is provided showing the dispersion of calculated part results.

The histogram presents the L_x/L values along the horizontal axis.

- The width of bars is 7% of average value
- The height of bars shows the prevalence of L_x/L values
- The bars used for the average calculation are green
- The unused bars are grey

At the evaluation of histogram the user should consider:

- The histogram of a **perfect measurement** is a green bar showing that the results of all part measurements were within a $\pm 3.5\%$ range around the average.
- The histogram of a **sufficient measurement** is absolutely symmetrical but some results are in the neighboring bars around the average.
- The histogram of a **doubtful measurement** is generally unsymmetrical and the dispersion is irregular. In that case the measurement should be repeated with another wire combination.
- When the level of disturbing voltage is too low the whole histogram and the test results can be **unacceptable**. In this case try to repeat the test with the passive bridge of ECE 35.

Note:

That method can be used only when the DC loop current exceeds 10 μA

3.4 AC Fault Location

3.4.1 AC Küpfmüller Method

The Küpfmüller-method applicable when the two wires of the pair have the same gauge (\emptyset), the same length, are made of the same material and booth of them are leaky. An accurate result can be obtained when the two Küpfmüller conditions are fulfilled:

$$FaE + FbE > 100 \times RI$$

$$0,5 > FaE / FbE > 2$$

The passive bridge of ECE 35 measures accurately even in the presence of disturbing longitudinal AC voltages on the line.

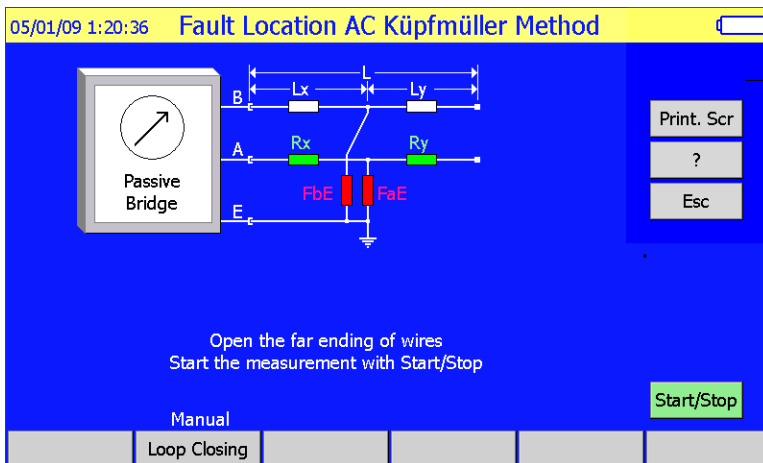
The Küpfmüller method requires two part-measurements

- 1: Performed with **open** loop. The result is **ML**
- 2: Performed with **closed** loop. The result is **MK**

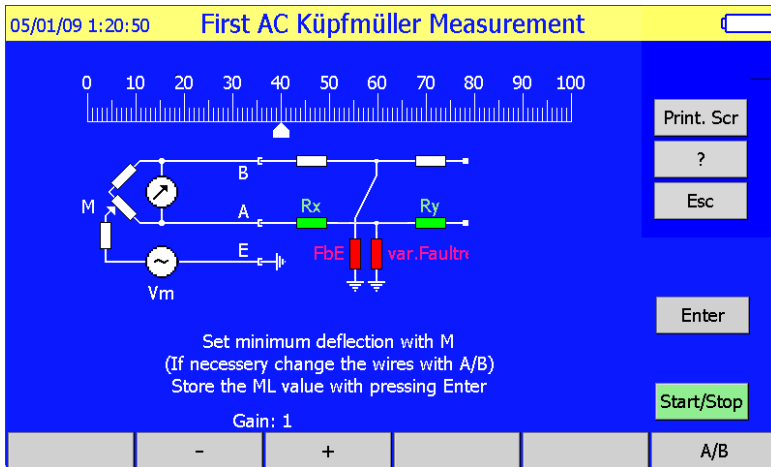
The Lx/L value is calculated out of ML and MK

Test Procedure

- Select the **AC Fault Location / Küpfmüller** key and then the measuring arrangement appears



Start the first measurement pressing the **Start / Stop** key and after a few seconds the bridge is ready for balancing:



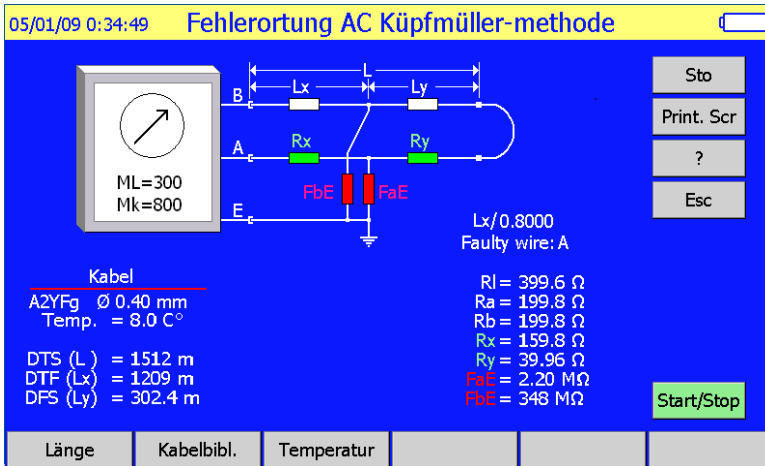
Bridge Balancing

- Select the minimum gain with the **Gain-** key.
- Set the pointer to the **minimum** point of the scale with the M balancing potentiometer
- Increase the gain gradually with the **Gain+** key and repeat the first three points until reaching the perfect balance.
The balance is perfect when the gain is 5 and the pointer stands on the minimum
- When the balancing is completed press **Enter** to store the result (ML).

Before the second measurement the loop should be closed. Close it manually or by means of the remote controllable loop-closing device ELC30 or ECFL 30S

In case of manual control start the second measurement pressing the **Start / Stop** key and the bridge is ready for the second balancing:

- Balance the bridge again and press **Enter** to store the result (MK) and to call the result display.



Displayed Test Results

- **ML** and **MK** values
- **Lx/L** relative distance of fault compared to the cable length
- **RI** loop resistance
- **Ra** wire resistance
- **Rb** wire resistance
- **Rx** wire resistance between the instrument and fault
- **Ry** resistance between fault **RI** and cable end
- **FaE** and **FbE** fault resistances
- **DTS (L)** calculated out of the cable parameters and RI
- **DTF (Lx)** calculated out of the cable parameters, RI and Lx/L
- **DFS (Ly)** calculated out of the cable parameters, RI and Lx/L

When the cable length is known

- Press the **Length** key
- Type in the length value and press **Enter**

For returning to the normal display

- Press the Length key and press **Esc**

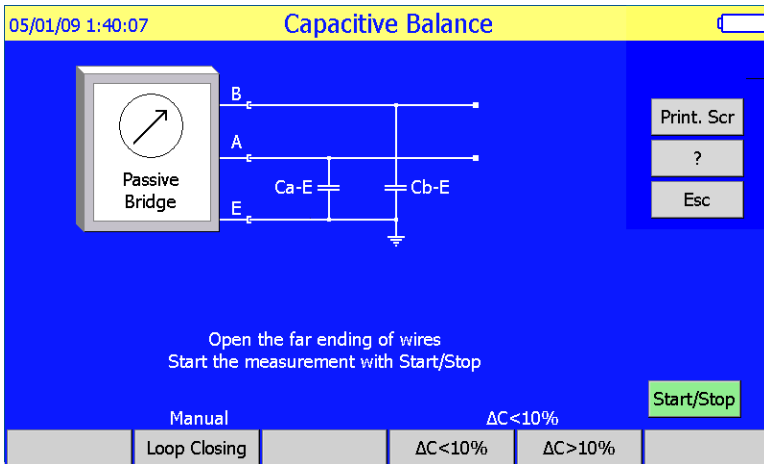
3.4.2 Capacitive Balance Measurement

The purpose of that measurement is to measure the balance between the ground capacitances C_{a-E} and C_{b-E} .

The passive bridge of ECE 35 measures accurately even in the presence of disturbing longitudinal AC voltages on the line.

Test Procedure

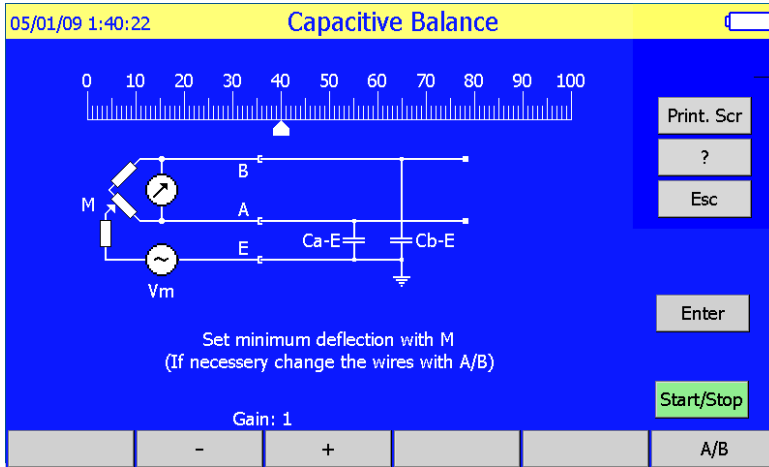
- Press the **AC Fault Location / Capacitive Balance** key and the measuring arrangement appears:



The far endings of the tested pair should be open

- Select the required measuring range with pressing the **$\Delta C < 10\%$ (F4)** or **$\Delta C > 10\%$ (F5)** key
- Start the measurement with the **Start / Stop** key

Having the measurement started the following display appears after a few seconds and the bridge is ready for balancing

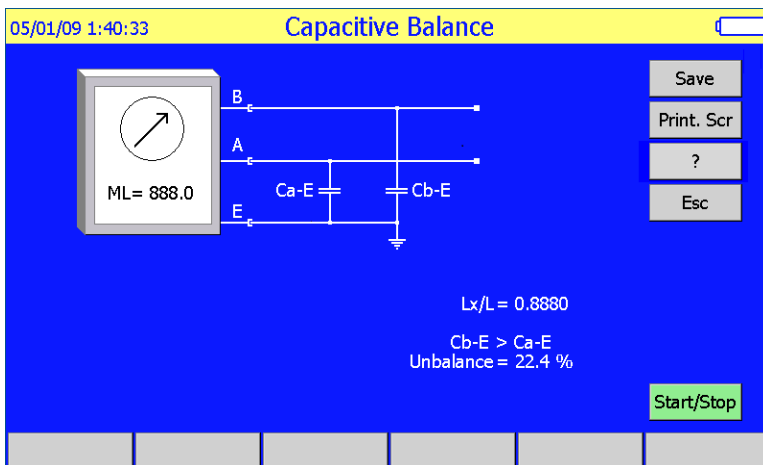


Bridge Balancing

- Select the minimum gain with the **Gain-** key.
- Set the pointer to the **minimum** point of the scale with the M balancing potentiometer.
- Increase the gain gradually with the **Gain+** key and repeat the first three points until reaching the perfect balance.

The balance is perfect when the gain is 5 and the pointer stands on the minimum

- When the balancing is completed press **Enter** to store the result (ML) and to call the result display.



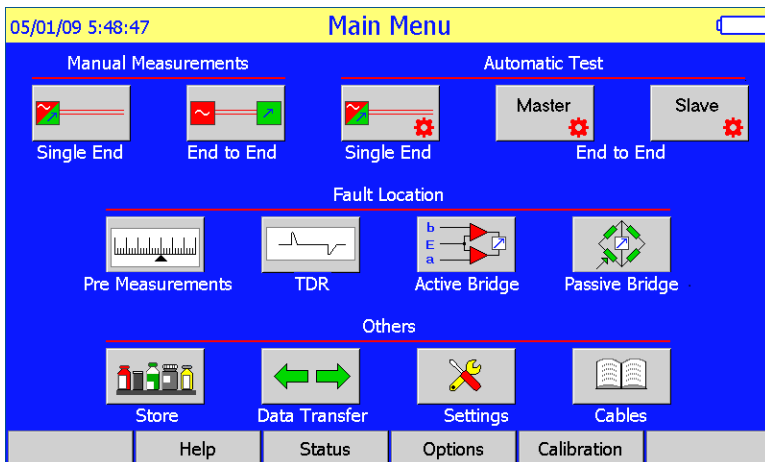
Displayed Test Results

- ML value
- Lx/L rate
- Unbalance %

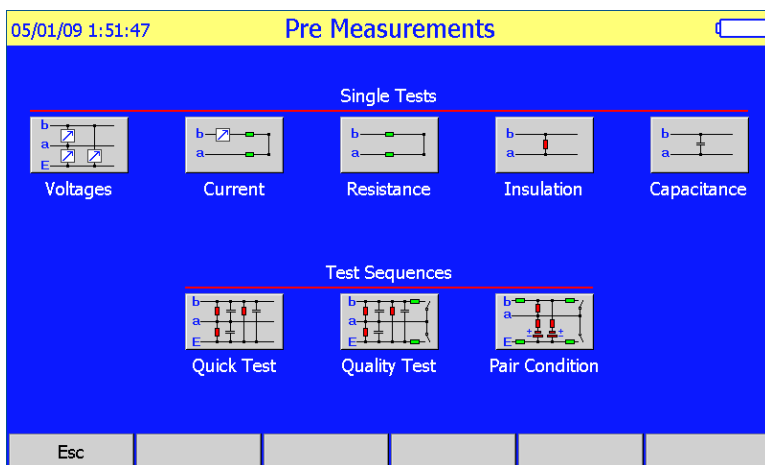
Notice

The result is calculated out of the measured ML value

4 PRE MEASUREMENTS



- Press the **Pre Measurements** key of **Main Menu** and then the concerning menu appears



The pre measurements are included into two groups:

- Single test
- Test sequences

4.1 Single Tests

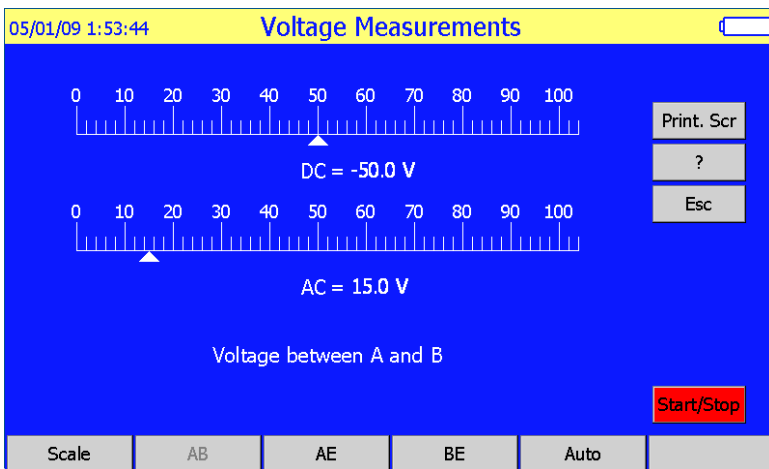
4.1.1 AC DC Voltage Measurement

The purpose of that measurement is to get quick information about the disturbing DC-AC voltages between the wires of the tested pair.

Test Procedure

- Open the far endings of a and b wires
- Press the **Voltages** key

ECE 35 starts the measurements automatically and repeatedly continue it until the next **Start/Stop** key stroke.



The sensitivity can be changed with the **Scale** key

Input Selection

- Pressing the **AB**, **AE** or **BE** key ECE 35 continuously measures the AC DC voltages between the two selected inputs.
- Pressing the **Auto** key ECE 35 performs all AC-DC voltage measurements consecutively one after the other.

Displayed Test Results

- DC-AC voltages in graphic form
- DC-AC voltages in digital form

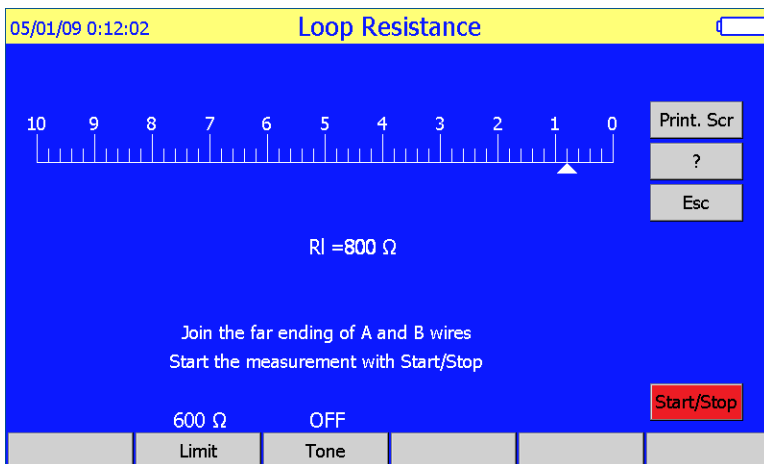
4.1.2 Loop Resistance Measurement

The purpose of that measurement is to get quick information about the loop resistance of numerous pairs. For the sake of quick measurement the compensation of disturbing DC voltages is disabled.

Test Procedure

- Join the far endings of a and b wires
- Press the **Resistance** key

ECE 35 starts the measurements automatically and repeatedly continues it until the next **Start/Stop** key stroke.



Pair identification

Purpose of that service is to find the pair of wires that has a strap or is shorted (perhaps at its far end). If the resistance measured between the wires is smaller than the preset limit, then you will hear a buzzing sound

- To set the resistance limit below which the buzzer is working press the **Limit** key and type in the wanted limit

The buzzer can be switched on/off with the **Tone** key

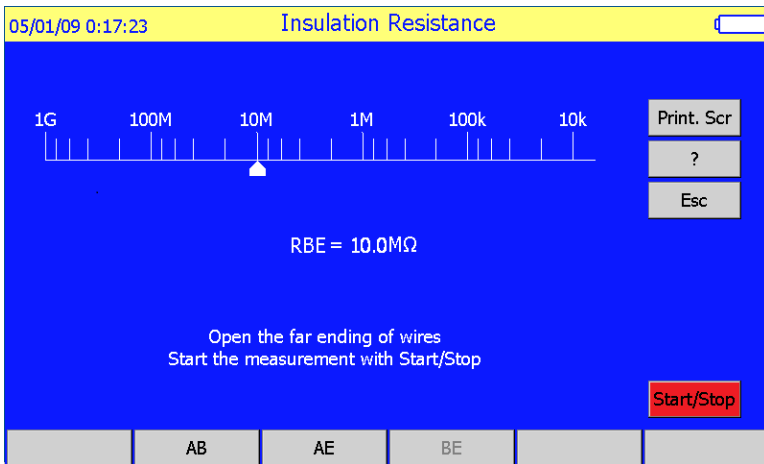
4.1.3 Insulation Resistance Measurement

Purpose of the test is to measure the insulation resistance between the a and b wires. ECE 35 in this mode provides fast measurement of disturbing voltage free pairs. Measuring range: 10 k Ω to 300 M Ω

Test Procedure

- Open the far endings of a and b wires
- Press the **Insulation** key

ECE 35 starts the measurements automatically and repeatedly continues it until the next **Start/Stop** key stroke.



Input Selection

- Pressing the **AB**, **AE** or **BE** key ECE 35 continuously measures the resistance between the two selected inputs.

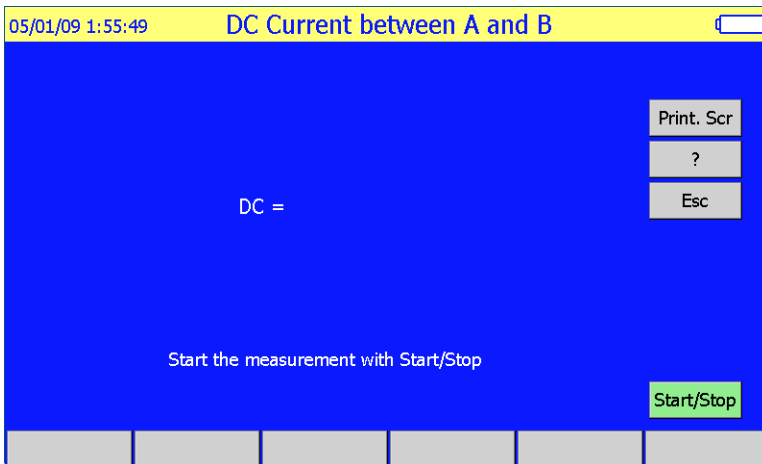
4.1.4 DC Current Measurement

Purpose of the test is to measure the DC loop current. Internal resistance: 1 Ohm, measuring range: 0.1 A.

Test Procedure

- Close the far endings of A and B wires.
- Press the **Current** key

ECE 35 starts the measurements automatically and repeatedly continues it until the next **Start/Stop** key stroke.



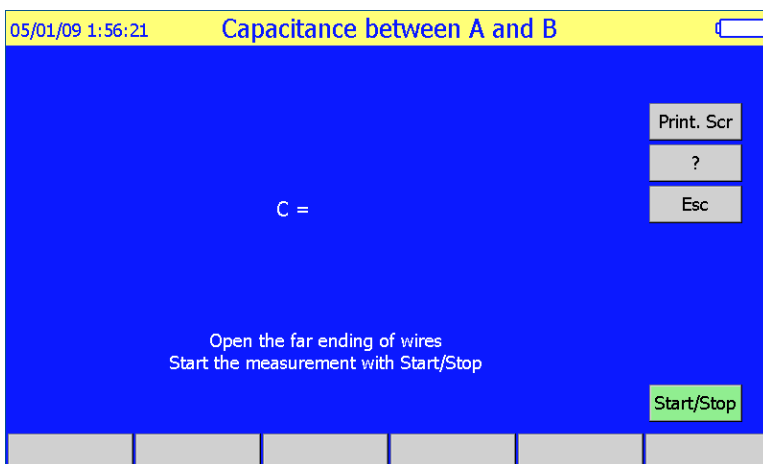
4.1.5 Capacitance Measurement

ECE 35 in this mode provides fast measurement of capacitance between a and b wires. Measuring range: 10 nF to 2 μ F

Test Procedure

- Open the far endings of a and b wires
- Press the **Capacitance** key

ECE 35 starts the measurements automatically and repeatedly continue it until the next **Start/Stop** key stroke.



4.2 Test Sequences

4.2.1 Automatic Quick Test

The purpose of the automatic quick test is to get rough estimate about the features of an unknown pair of wires. Measuring time is: ~50 sec.

The list of measurements:

AC, DC voltages:

- Between wire **A** and wire **B**
- Between wire **A** and **E** (GND)
- Between wire **B** and **E** (GND)

Insulation resistance (Maximum 300 M Ω)

- Between wire **A** and wire **B**
- Between wire **A** and **E** (GND)
- Between wire **B** and **E** (GND)

Capacitances (Measured according to Rec EN 50289-1-5:2001)

- Between wire **A** and wire **B**
- Between wire **A** and **E** (GND), b connected to ground
- Between wire **B** and **E** (GND), a connected to ground

Capacitive unbalance

- Between CaE and CbE

Test Procedure

- Open the far endings of a and b wires manually or by means of the remote controllable loop-closing device ELC30
- Press the **Quick Test** key and the following display appears:

05/01/09 1:56:51 **Automatic Quick Test**

| | AB | aE (AE) | bE (BE) |
|-----|----|---------|---------|
| DC | | | |
| AC | | | |
| Iso | | | |
| C | | | |

Print. Scr
?
Esc

Capacitive Balance
CaE/CbE Balance

Open the far ending of wires
Start the measurement with Start/Stop

Manual **Start/Stop**

Loop Closing

- Start the measurement with the **Start/Stop** key

4.2.2 Automatic Quality Test

The purpose of the automatic quality test is to get accurate results about the features of an known good pair of wires. Measuring time is: ~100 sec.

The list of measurements:

Insulation resistance (Maximum 1000 MΩ)

- Between wire **A** and wire **B**
- Between wire **A** and **E** (GND)
- Between wire **B** and **E** (GND)

Capacitance

- Between wire **A** and wire **B**
- Between wire **A** and **E** (GND), b connected to ground
- Between wire **B** and **E** (GND), a connected to ground

Capacitive unbalance

- Between CaE and CbE

Loop resistance

Resistance difference

Test Procedure

- Connect the remote controllable loop-closing device ELC30 to the far end of the tested pair.
- Press the **Quality Test** key and the following display appears:

05/01/09 1:57:09 **Automatic Quality Test**

Insulation & Capacitance

| | | |
|----|---------|---------|
| AB | aE (AE) | bE (BE) |
| | | |

Capacitive Balance

| | |
|---------|---------|
| CaE/CbE | Balance |
| | |

Resistance Difference

| | | | | |
|----|----|----|----|----------|
| RI | Ra | Rb | ΔR | 2ΔR / RI |
| | | | | |

Open the far ending of wires
Start the measurement with Start/Stop

Manual

Loop Closing

Print. Scr
?
Esc
Start/Stop

- Start the measurement with the **Start/Stop** key
- The test results can be saved by pressing the **Save** key

4.2.3 Survey of Pair Condition

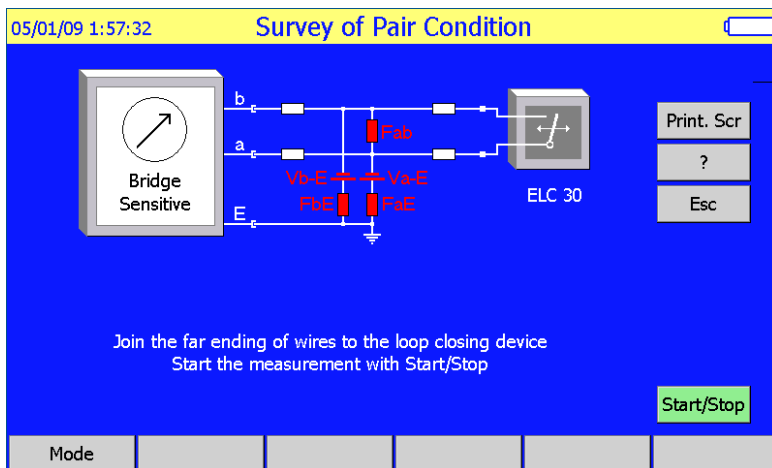
The Survey of Pair Condition is extremely useful test sequence to find the best fault location method.

The test sequence consists of the following measurements:

- **DC** and **AC** disturbing voltage measurement
- Mutual capacitance **Cm**
- Physical capacitance between wires and GND **Ca-E** and **Cb-E**
- Loop resistance **RI**
- Resistance of wires A and B, **Ra** and **Rb**
- Resistance between wire A and wire B **Riso**
- Fault resistances **FaE** and **FbE**
- Voltage sources cascaded with FaE and FbE, **Va-E** and **Vb-E**
- The fault resistances and source voltages are measured twice to see the intensity of fluctuation

Test Procedure

- To perform Loop Condition survey program the remote controllable loop closing device ELC30 is definitely necessary!
- Press the **Pair Condition** key an the corresponding display appears



Three measurement methods are available: Sensitive, Protected, or Auto

- Select the desired method with the **Mode** key

AUTO mode means:

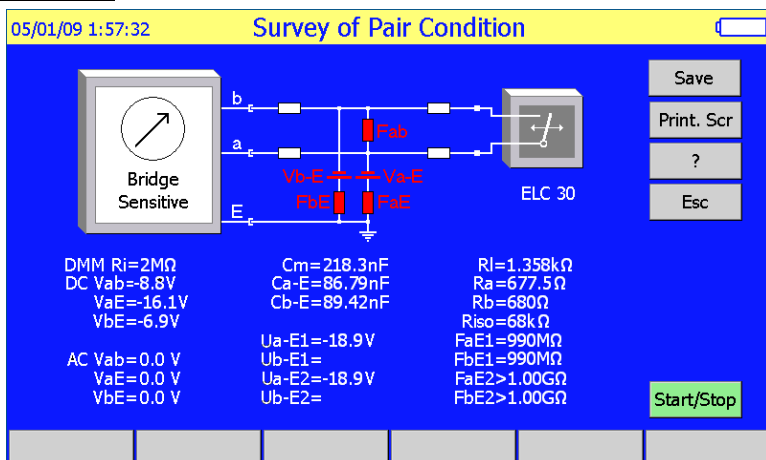
ECE 35 begins the measurement in **Sensitive**-mode. If the input amplifier becomes overloaded the process is repeated in **Protected**-mode.

By means of Loop Condition Survey the technicians can get useful information about the condition of the tested pairs.

1. As a first step the shunt resistances **FaE1** and **FbE1** are measured.

A cascaded DC source is displayed if the shunt resistor interconnects the tested wire with an active neighbor wire and therefore a disturbing voltage of >5V appears. (5V is negligible beside the 100V measuring voltage of ECE 35). These results inform the technician about the magnitude of shunt resistors and disturbing DC voltages.

2. Indication of disturbing **DC** and **AC** voltages over 1V. (The indicated DC voltage can be lower than the disturbing voltage if the shunt resistance is not much smaller than the input resistance of DMM)
3. The measurement of physical capacitances (**Ca-E** and **Cb-E**) provides information about the break or high unbalance of wires.
4. Measurement of fault resistances and the voltages of disturbing DC sources. These measurements are performed twice to see the intensity of fluctuation. The fluctuation can be intensive if the shunt resistance or the disturbing voltage is strongly intermittent. In that case the obtained results can be false.
5. Loop resistance measurement
6. Checking the rate between the insulation and loop resistances. If the rate is less than 100 the **Fab!** warning appears.

Test Results

5 TDR MEASUREMENTS

ECE 35 in Time Domain Reflectometer (TDR) mode utilizes the radar principle. A measuring pulse is transmitted down a cable. When that pulse reaches the end of the cable or a fault along the cable, a certain part or all the pulse energy is reflected back to the instrument.

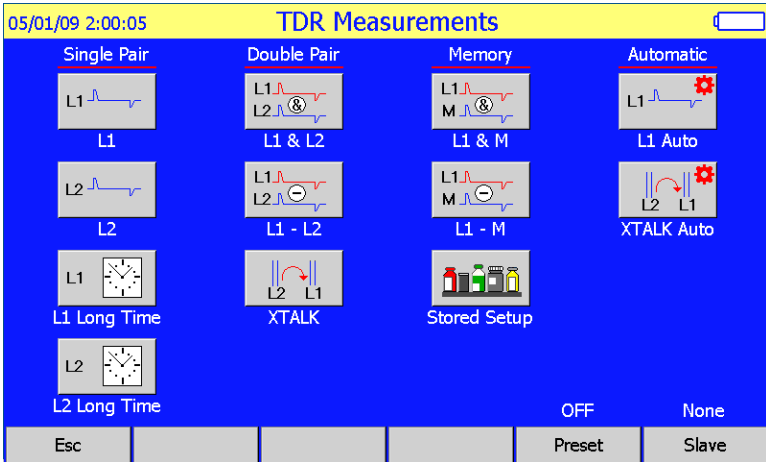
ECE 35 measures the time taken by the pulse to travel down the cable, see the problem, and reflect back. Then converts this time to distance and displays the information as a waveform. The displayed waveform shows all impedance discontinuities along the cable.

The amplitude of any reflection is determined by the degree of the impedance change.

Distance to fault is displayed on the screen after the cursor is positioned to the start of the reflected fault pulse

Mode Selection

- Press the **TDR** key of **Main Menu** and the TDR menu appears
The required measuring modes can be selected here.



For the comfort of user an automatic test parameter preset function is provided. In case the preset function is switched on with the **Preset** key the test Pulse and Gain are automatically preset with the range selection.

In case of TDR testing of cables containing bridged taps it is often difficult to decide that a reflection comes from the tap or from the end of the cable. A remote controlled slave unit (ELC 30 or ECFL 30S) connected to the far end can make the connecting point “visible” by pulsing (short / open)

The slave type can be selected by pressing the **Slave** key

5.1 Manual Measuring Modes

Test of a single pair

- L1** Transmission and reception of the test pulses over L1
This is the most frequently used basic mode of operation.
- L2** The same as the L1 mode above but L2 is used instead of L1

Long time measurement

L1 LONG TIME

L1 mode measurements are repeatedly done for a long time. All the obtained waveforms are displayed together and so the intermittent faults are to be seen.

L2 LONG TIME

The same as L1 LONG TIME but L2 is used instead of L1

Location of cross talk points

XTALK One of the pairs is connected to the L1 sockets and the other one to the L2 sockets. The measuring pulse is transmitted via L2 and the reflected pulses are received via L1. This mode is typically used for locating splits and resplits.

Comparison between two pairs

L1&L2 this mode is the combination of the L1 and L2 modes. Two waveforms are simultaneously displayed.

L1- L2 In this mode, the difference between two waveforms is displayed. The typical use of this mode is to find close in faults, because the balance between two cables may be better than between one cable and the internal balance control.

Comparison with memory

A waveform stored in memory can be used for comparison of the cable conditions before and after a critical period, or a repair job.

L1 & MEMORY

In this mode, two waveforms are simultaneously displayed.

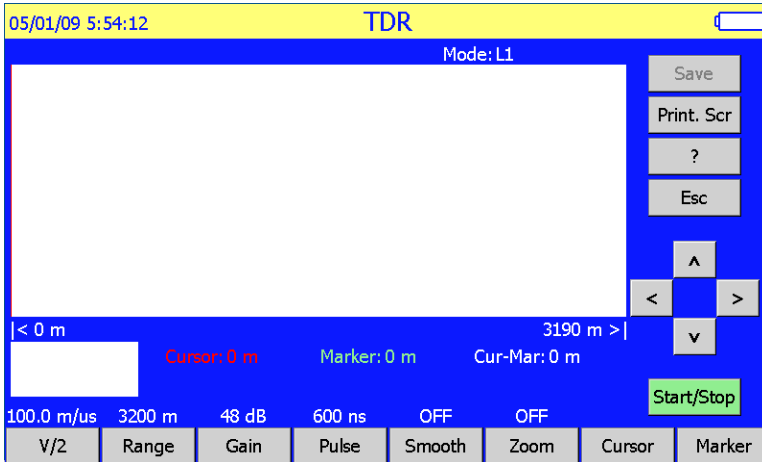
L1 - MEMORY

In this mode, the difference between two waveforms is displayed

.

5.1.1 Settings before Start

- Enter the required manual measuring mode of **TDR** menu
- In case of mode **L1** selection the following display appears



For the proper evaluation of the obtained waveform we have to know

- the propagation velocity of the tested cable

For the proper initial settings of test parameters we have to know

- the approximate length of the tested cable

The propagation velocity of different cable types can be taken from the cable library of ECE 35.

Range selection

- Press the **Range** key
- Select the measuring range that definitely covers the cable length with the $\uparrow\downarrow$ keys

Cable Type selection

The actually valid cable type can be seen on the upper field of display. Parameters belonging to that type will be used for the subsequent measurements. To change the cable type:

- Press the **V/2** key

| 05/01/09 2:01:54 | | Half Propagation Velocity V/2 | | | |
|----------------------------|--------|-------------------------------|------|-------------------------------|---------|
| Actual Value: 100.0 m/us | | | | Print. Scr | |
| Acceptable: 45 to 149 m/us | | | | ? | |
| | | | | Esc | |
| | | | | Calculation by known distance | |
| | Cables | | Edit | Cursor | Cur-Mar |

- Call the cable library by pressing the **Cables** key

| 05/01/09 1:11:12 | | Cable Library | | | |
|----------------------------|--|---------------|--|------------|--|
| Applied Cable | | | | Print. Scr | |
| Standard cables | | | | ? | |
| A2YFg Ø 0.40 mm | | | | Esc | |
| Cable temperature: 20.0 C° | | | | | |
| Cable Types | | | | | |
| Standard | | | | | |
| User Defined | | | | | |
| | | Temperature | | | |

- Enter the new type
- Press **Apply**
- Press **Esc**

5.1.2 Single Pair Measurements

Having mode, range and cable-type set the measurement can be started by pressing the **Start/Stop** key.

The measurement is running repeatedly until a following **Start/Stop** key-stroke.

- The last obtained waveform is displayed in all measuring modes except **L1 LONG TIME** mode. To save battery life, the measurement is automatically stopped after one minute elapsed time.
- In **L1 LONG TIME** mode all the obtained waveforms are displayed together showing the intermittent faults. In this mode there is no time out.

Balance Adjustment

Adjust the rotary **BALANCE** control to minimize the transmit pulse at the start of waveform. (In **XTALK** mode, the balance control is not effective.)

Gain Adjustment

Because of the attenuation of the cable under test, the amplitude of the reflected pulse will decrease as the distance to the reflection location increases. To obtain suitable reflected pulse amplitude, the gain should be set as follows:

- Press the **Gain** key
- Select the required gain with the $\uparrow\downarrow$ keys

The gain can be adjusted between 0 and 90 dB in 6 dB steps

Setting Transmit Pulse Width (optional)

In case of high cable attenuation, a better reading may sometimes be obtained by using a wider pulse. Therefore, if required, the pulse width can be changed as follows:

- Press the **Pulse** key
- Select the required width by the $\uparrow\downarrow$ keys

5.1.3 Waveform Evaluation

The waveform can be evaluated by means of Cursor and Marker
They can be placed to any selected point of the waveform.

The cursor is displayed as a vertical red line

To place the cursor:

- Press the cursor key
- Touch where you want to place it
- Change the position with the <> keys (fine setting)

The marker is displayed as a vertical green line

To place the marker

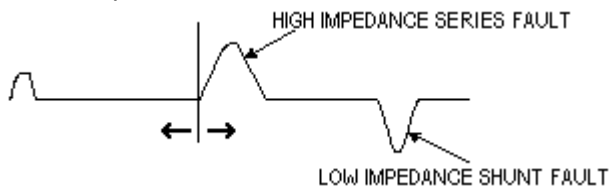
- Press the Marker key
- Touch where you want to place it
- Change the position with the <> keys (fine adjustment)

The displayed values are:

- The position of marker,
- The position of cursor,
- The distance between marker and cursor

Reading the Distance to Fault

After the measurement process is terminated, move the cursor to the start point of the reflected pulse.



The displayed value of the cursor shows the distance to fault. Remember to deduct the length of the test leads.

Reading the Distance between any two points

- Move the Cursor to the point from which the distance is to be measured (e.g. reflection from a known point or from the change of the cable type)
- Move the Marker to the point to which the distance measurement is to be carried out.

The distance between these points is directly shown on the display.

Waveform Expansion (Zoom)

The waveform can be shown in more detail around the **Cursor** line by using the **Zoom** facility. The amount of horizontal expansion can be selected as follows:

- Move the cursor to the point around which you want to expand the waveform
- Press the **Zoom** key and
- Select the required zoom value with the $\uparrow\downarrow$ keys

On the down left corner of the display there is a “Zoom info” showing information about the non visible part of trace if the Zoom is on

The Smoothing Function

Because of the attenuation losses, the reflection from a fault long way down the cable may be much smaller than a regular reflection from a nearby discontinuity. The amplitude display of near reflections can be reduced by the smoothing function as follows:

- Press the **Smooth** key
- Select the required reduction with the $\uparrow\downarrow$ keys

5.1.4 Location of Cross Talk Points

The measurement

In **XTALK** mode one of the pairs is connected to the L1 sockets, and the other one to the L2 sockets. The measuring pulse is transmitted on L2 socket the reflected pulses are received on L1. This mode is typically used for locating splits and resplits. The steps of measurement are similar for the L1 mode. (The **Balance** control is not operational in this mode.)

5.1.5 Comparison of Two Pairs

The comparison is used to identify the differences between a known good cable and a faulty one. There are two methods of comparison:

- L1 & L2 mode
- L1 - L2 mode

Comparison in the L1 & L2 mode

In the L1 & L2 mode, two waveforms are simultaneously displayed, one for L1 and the other for L2

The steps of measurement are similar to the L1 and L2 modes.

For the evaluation of the two waveforms the **Cursor**, **Marker** and **Zoom** facilities are available. Using the ↑ and ↓ keys, the L2 waveform can be vertically shifted.

Comparison in the L1 - L2 mode

In this mode, the difference between the L1 and the L2 waveform is displayed. Using this method, the reflections caused by the common features of the two cables can be separated from reflections caused by cable faults. The steps of measurement and the waveform evaluation are the same as the **L1 & L2** mode.

5.1.6 Comparison to Stored Result

Waveforms stored in memory can be used for comparison of the cable conditions before and after a critical period, or before and after a repair job. **The stored waveform and the recently obtained waveform can only be compared if the main parameters are the same.** As the main parameters are stored together with the waveform, the actual measurement must be performed with the stored settings (V/2, Range, Pulse, Gain). Accordingly, in this mode, the controls of the above mentioned parameters are not operational.

There are two methods of comparison:

Comparison in L1 & M mode

In this mode, the stored and the actually obtained waveforms are displayed together (the stored is brown the actually obtained is blue)

Measurement steps:

- Enter the **L1 & M** option of **TDR** menu
- Press the **Stored Results** key.
- Select the memory location containing the stored waveform to be used for comparison and press **Enter**.
- Start the measurement by pressing the **Start/Stop** key.
- For evaluation, the **Cursor Marker** and **Zoom** facilities can be used as in the single pair investigation.

The vertical position of stored Waveform can be shifted with the $\uparrow \downarrow$ keys.

Comparison in L1 - M mode

In this mode, the difference between the obtained and the stored Waveform is displayed. Measurement steps:

- Enter the **L1 - M** option of **TDR** menu. The list of stored waveforms is now displayed.
- Select the memory location containing the stored waveform to be used for comparison and press **Enter**.
- Start the measurement by pressing the **Start/Stop** key.

For evaluation, the **Cursor Marker** and **Zoom** facilities can be used as in the single pair investigation.

5.2 Automatic Measuring Modes

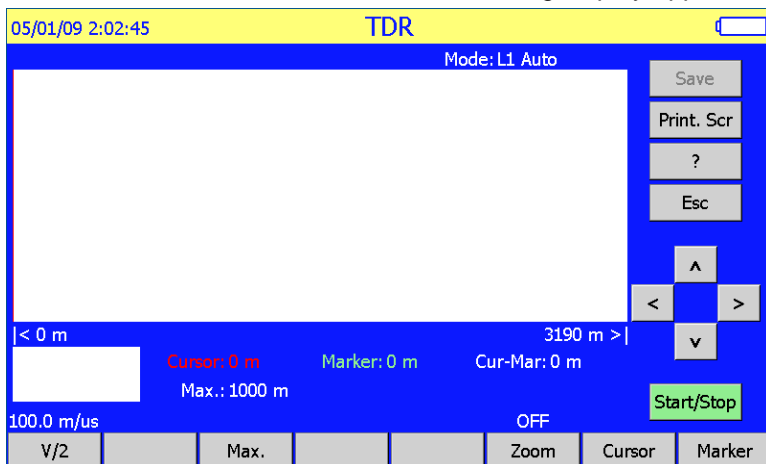
In auto configuration TDR mode ECE 35 can detect one or more reflected pulses and preset the best setup for each pulse separately

Auto configuration mode can be selected booth for single and double pair measurement

5.2.1 Start the Measurement

- Enter the required auto measuring mode of **TDR** menu

In case of mode **L1 Auto** selection the following display appears

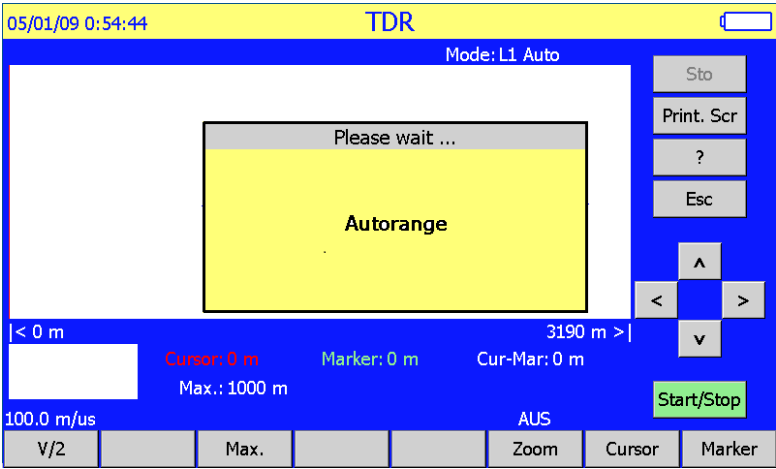


Before starting the measurement

- Press the **Max.** key
- Enter the expected maximum length of the tested cable

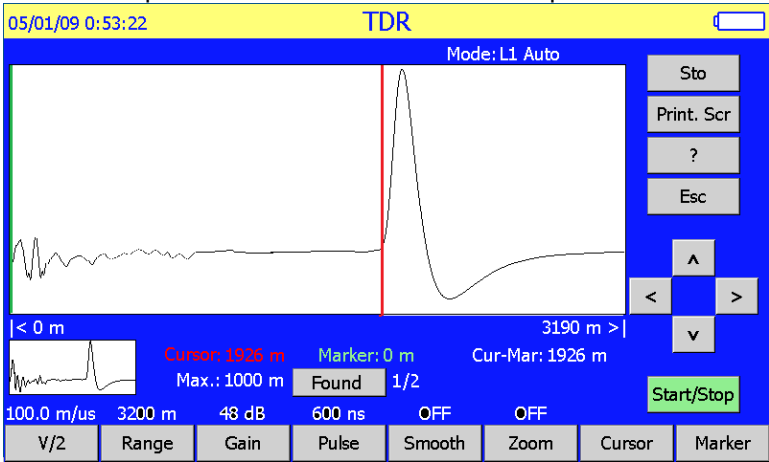
The measurement can be started with the **Start/Stop** key

The detection process may take several seconds depending on the features of the tested line.



5.2.2 Test Results

When the detection process completed the result display appears showing the first reflected pulse and the number of detected pulses.



- Press the Found key
- The further reflected pulses can be selected with the $\uparrow\downarrow$ keys

The Alteration of Test Setup

If necessary the obtained waveform can be improved by the alteration of the automatically preset Range, Gain and Pulse values.

5.3 TDR application guide

General Hints

Reflections can be classified to fall into two groups:

- Regular reflections
- Reflections from faults (irregular reflections)

Regular reflections

Even faultless pairs may produce reflections caused by inherent discontinuities such as joints or cable type changes.

Reflections from faults

A faulty pair produces regular reflections and, in addition, reflections from the fault. Because of the attenuation losses, the reflection from a fault long way down the cable may be much smaller than a regular reflection from a nearby discontinuity.

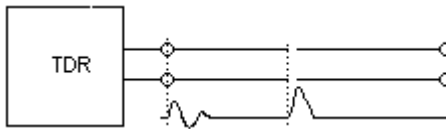
A suitable method to distinguish regular and irregular reflections is to compare the faulty cable with a good one. By using the **L1 & M** method, the regular reflections caused by the common features of the two pairs can be separated from reflections caused by faults.

- In telephone cables there are several pairs of conductors. The physical length of the pairs depends on their position in the cable, the length increasing with the distance of the layer from the center. Consequently, the physical length of pairs can be longer than the cable length, and the propagation velocity (V) may be different for different layers. Therefore, in case of comparative tests, the two pairs compared should be in the same layer.
- If there is more than one fault, the first one may reflect so much from the pulse energy that the subsequent fault may not be seen. Therefore, having located and eliminated the first fault, the cable section following the fault should be tested again.

5.3.1 Typical Waveforms

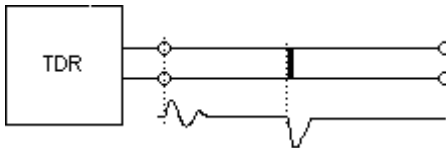
Open circuit (series faults)

The reflection is a positive (upward going) pulse.
No reflected pulse from the far end.



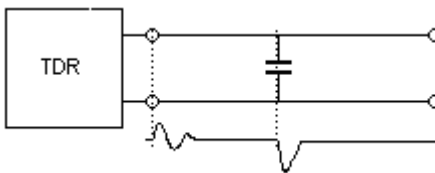
Short circuit (shunt fault)

The reflection is a negative (downward going) pulse.
No reflected pulse from the far end.



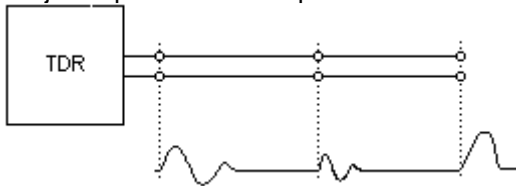
Capacitance network

The reflection is negative (downward going pulse).



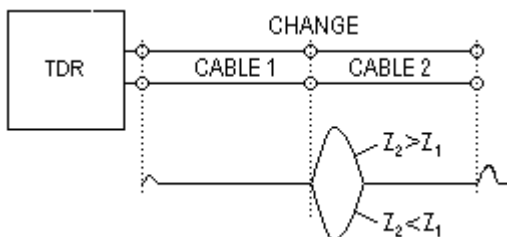
Joints (splices)

The joints produce 'S' shaped reflections.



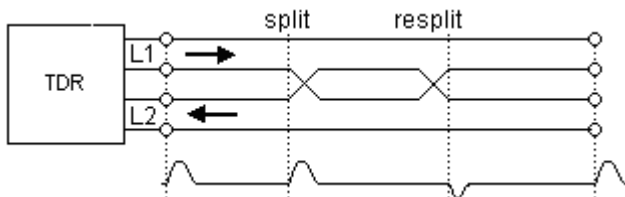
Change of cable type (mismatch)

The amplitudes of the reflected pulses are determined by the degree of impedance changes.



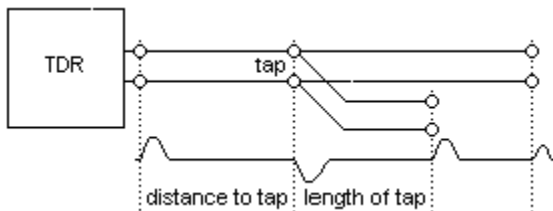
Splits and resplits

Splits and resplits produce cross talk.



Taps (tee joints)

A tap produces two pulses, one at the beginning and the other at the end of the tap.



The troubleshooting may be difficult if the tested pair is tapped at many points. In this case, the test should be progressively done with moving from tap to tap.

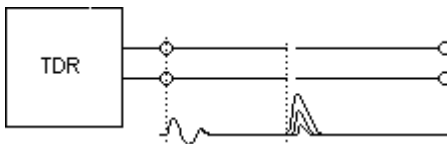
Open sheath

If the metallic sheath of the cable is broken, the position of the break can be located by connecting the test leads to the shield and to as many conductors as possible.



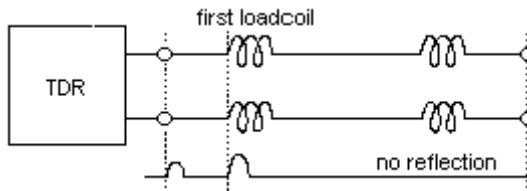
Loose contacts

The loose contacts can be detected in Long Time modes. In these modes measurements are repeatedly done for a long time. All the obtained waveforms are displayed together and so the intermittent faults are to be seen.



Load coils

Load coils produce positive (upward going) reflections. Generally, TDR's can not 'see' beyond the first loading coil. For fault location beyond the loading coil, the TDR should be connected to another point following the coil.



5.3.2 Automatic velocity constant calculation

The unknown propagation velocity constant can be determined in the following cases:

- The length of the cable is known
- The distance to a known point is available (e.g. join box, change of cable-type etc.)
- A sample of the same cable is available with a known length
- The distance between two points is known.

When the cable length or the distance to a known point is available

- Connect the cable to the **L1** terminals and obtain a waveform
- Stop the measurement with the **Start/Stop** key
- Place the cursor to the start point of the pulse reflected from the known point.
- Press the **V/2** key
- Press the **Cursor** key
- Type in the known distance
- Pressing the **Enter** key, the proper value will be set automatically

When the distance between two points is known

- Connect the cable to the **L1** sockets and obtain a waveform
- Stop the measurement with the **Start/Stop** key
- Place the cursor to the starting point of the pulse reflected from the first known point, and set the marker by pressing **Enter**
- Place the cursor to the starting point of the pulse reflected from the second known point
- Press the **V/2** key
- Press the **Cur-Mar** key
- Type in the known distance between the two points.
- By pressing the **Enter** key, the proper value will be set automatically.

6 CABLE PARAMETER MANAGEMENT

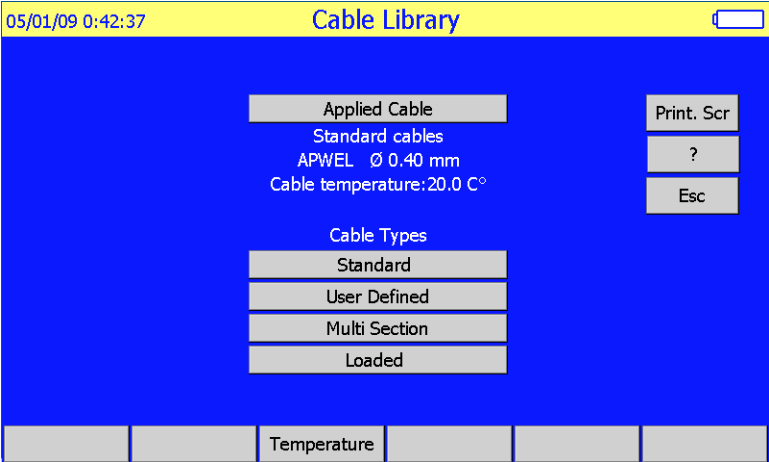
6.1 Introduction

The cables are included in four groups:

- Standard Cables
- User Defined Cables
- Multi Section Cable
- Loaded Cable

The cable parameters can be reached:

- from the **Main Menu** entering the **Cables** option or
- from the result pages pressing the **Cables** key



The conductor diameter and the name of actually active cable type is displayed. This cable type will be applied for the subsequent measurements.

To see the parameters of the actually active cable type

- Press the **Applied Cable** key

To change the cable temperature:

- Press the **Applied Cable** key
- Press the **Cable Temperature** key
- Type in the new value and press **Enter**

6.2 Standard Cables

Press the **Cable Library /Standard** key and then the list of standard cables appear. The actually active cable type is marked with green.

| 05/01/09 0:43:52 | | Standard cables | |
|------------------|---------------|---------------------|------------|
| Cable Name | Diameter [mm] | Cable Type | |
| A2YFg | 0.35 | VollPEgefüllt | Print. Scr |
| A2Y | 0.35 | VollPE | ? |
| A2YFg | 0.40 | VollPEgefüllt | Esc |
| A2Y | 0.40 | VollPE | |
| APWEL | 0.40 | PapierLagen | |
| APML | 0.40 | PapierLagen | |
| APWEB | 0.40 | PapierBündel | |
| A2Y | 0.50 | ZellPE | |
| A02YSF | 0.50 | FoamSkinPEgefüllt | |
| A2YT | 0.60 | FollPETragseilkabel | Apply |
| View | | Next | Previous |

To replace the actually active cable type with another one:

- Press the key of the required cable type
- Press **Enter**

This cable type will be applied for the subsequent measurements.

To see the parameters of a cable type

- Press the key of the required cable type
- Press **View**

| 05/01/09 0:44:21 | | Cable Data | |
|------------------------|-----------------------|------------|------------|
| Cable temperature | 20.0 C° | | Print. Scr |
| Cable Name | APWEL | | ? |
| Cable Type | PapierLagen | | Esc |
| V/2 | 112.0 m/us | | |
| Wire material | Cu | | |
| Wire diameter | 0.40 mm | | |
| Wire resistance (Rl/2) | 138.01 Ω/km @ 20.0 C° | | |
| Mutual capacitance | 40.0 nF | | |
| Wire to gnd capac | 48.0 nF | | |

6.3 User Defined Cables

To change the actual cable type to a user defined cable:

- Press the **Cable Library / User defined** key

05/01/09 0:54:16 User Defined Cables

| Cable Name | Diameter [mm] | Cable Type | |
|------------|---------------|--------------|------------|
| User 1 | 0.60 | FullPEfilled | Print. Scr |
| User 2 | 0.40 | FullPE | ? |
| User 3 | 0.80 | PaperLayers | Esc |

Apply

NewEditDeleteEmptyNextPrevious

- Press the required name and press **Apply**
Pressing **Apply** this cable will be actually active cable type for the subsequent loop resistance or fault location measurements.

To modify the cable parameters:

- Press the required name and press **Edit**

05/01/09 0:44:21 Cable Data

| | | |
|------------------------|----------------------|------------|
| Cable temperature | 20.0 C° | Print. Scr |
| Cable Name | User 3 | ? |
| Cable Type | PaperLayers | Esc |
| V/2 | 106.5 m/us | |
| Wire material | Cu | |
| Wire diameter | 0.80 mm | |
| Wire resistance (Rl/2) | 33.01 Ω/km @ 20.0 C° | |
| Mutual capacitance | 40.0 nF | |
| Wire to gnd capac | 48.0 nF | |

CableSave

- Press the required parameter
- Do the modifications and press **Save**

Defining a New Cable Type

ECE 35 provides a very simple process to create new cable types.

The existing **Standard** and **User defined** cables can be modified and stored under new user given names.

The steps of defining process:

- Press the **Cable Library** / **User defined** key
- Press the **New** key and the parameters of actually active cable appear
- Press the **Cable** key

The screenshot shows a software interface titled "Cable Library" with a yellow header bar. The main area has a blue background. In the center, there is a box labeled "Applied Cable" containing the text: "Standard cables", "A2YFg Ø 0.40 mm", and "Cable temperature: 20.0 C°". To the right of this box are three stacked buttons: "Print. Scr", "?", and "Esc". Below the "Applied Cable" box is a section labeled "Cable Types" with two stacked buttons: "Standard" and "User Defined". At the bottom of the screen, there is a row of six buttons; the third button from the left is labeled "Temperature".

- Select a cable type similar to the cable you want to apply
- Press **Apply**
- Press **Esc**
- Do the modifications and press **Save**

6.4 Multi Section Cables (Option)

(Applicable if the SW-460-660-000 option is active)

Multi section cable means that the line contains different cable types.

Mode selection

- Press **Cable Library / Multi Section** key

Doing so, the data of actually active multi section cable will appear.

Note: In case of first use an empty form appears.

05/01/09 1:17:40

Multi Section Cable

S1

S2

S3

S4

S5

...

S10

Section

Length

Cable Type

| | | | | | |
|-----|--------|------|---------|----|------------|
| S 1 | 1000 m | A2Y | 0.50 mm | Cu | 90.01 Ω/km |
| S 2 | 500 m | A2YT | 0.60 mm | Cu | 61.51 Ω/km |
| S 3 | 2000 m | A02Y | 0.90 mm | Cu | 27.51 Ω/km |

Print. Scr

?

Esc

Apply

New

Insert

Length

Cable

Delete

Empty

Definition the sections of a multi section cable

There are four possibilities:

- to create a new section
- to insert a new section between the existing ones
- to delete an existing one
- to delete all of the existing sections and define new ones

When the definition of all sections is ready:

- Press **Apply**

Pressing **Apply** this cable will be the actually active cable type for the subsequent fault location measurements

To create a new section

- Press the **New** key
- Enter the length of new section

05/01/09 1:24:32 Section 1

Length: 1000 m
Acceptable : 1-15000

1 2 3 4 5 6 7 8 9 0

Enter new length

Esc Clear Back Enter

Having the length defined the data of the new section will appear below the existing ones. The cable type can be defined now.

- Press the **Cable** key.

05/01/09 1:11:12 Cable Library

Applied Cable
Standard cables
A2YFg Ø 0.40 mm
Cable temperature: 20.0 C°

Print, Scr
?
Esc

Cable Types
Standard
User Defined

Temperature

- Select the required cable type and press **Apply**
- To return to the multi section page press **Esc**

To insert a section between the existing ones

- Press the name of section over which you want to insert another one.
- Press the **Length** key and enter the length of the inserted section
- Press the **Cable** key and select the cable type of inserted section

When the definition of newly inserted section is completed all the sections located below the selected one will be shifted down.

To delete an existing cable section

- Press the name of section to be deleted
- Press the **Delete** key

When a section is deleted all the sections located below the deleted one will be shifted up.

To delete all the existing cable sections

- Press the **Empty** key

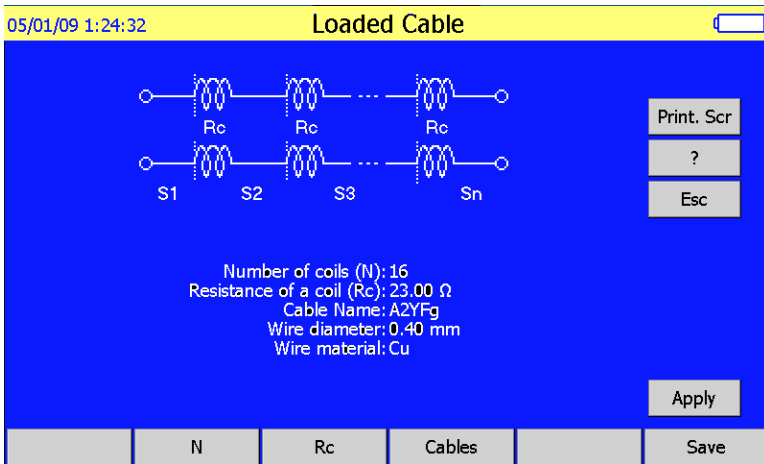
Doing so all the sections will be deleted

6.5 Loaded Cables (Option)

(Applicable if the SW-460-650-000 option is active)

Loaded cable means: the line contains Pupin coils

Enter **Cable Library /Loaded** option of the menu and the following display appears showing the parameters of the last measured loaded cable:



To define a new loaded cable:

- press the **N** key
- type in the number of coils
- press **Enter**
- press the **RC** key
- type in the resistance of coils
- press **Enter**
- press the **Cables** key
- select the cable type
- press **Enter**
- When the edition is completed press **Apply**

Pressing **Apply** this cable will be actually active cable type applied for the subsequent loop resistance or fault location measurements

7 SPECIFICATIONS

7.1 Active Bridge

Disturbing Voltage

Measuring range

DC voltage.....up to 400 V

AC voltageup to 250 V rms

Accuracy $\pm 3\% \pm 1 \text{ V}$

Frequency range.....15 to 300 Hz

Input resistance 2 M Ω

Test results AC, DC voltage between:
wire A and B, wire A and GND, wire B and GND

Loop Resistance

Measuring range..... 1 Ω to 10 k Ω

Accuracy $\pm 0.3\% \pm 0.1 \text{ } \Omega$

Resistance Difference

Loop resistance range 10 to 5000 Ω

Accuracy $\pm 0.2\%$ of loop resistance $\pm 0.2 \text{ } \Omega$

Lx/L- value resolution 1/1000

Test results Lx/L, RI, Ra, Rb, $\Delta R\Omega$, $\Delta R\%$

Insulation Resistance

Measuring range..... 10 k Ω to 300 M Ω

Measuring voltage 100/250 V

Measuring time (Depends on cable length)

For 5 km range ~70 sec

For 10 km range ~100 sec

DC disturbing voltage compensation..... Enabled

Test results Resistance between: wire A and wire B
wire A and GND
wire B and GND
AC, DC voltages: A-B, A-E, B-E

Accuracy

100 M Ω to 300 M Ω 5 %

Capacitance

Measuring range 1 nF to 2 μF

Accuracy $\pm 2\% \pm 0.2 \text{ nF}$

Measuring voltage 11 Hz, 100 Vp

Test results Capacitance between: wire A and wire B
wire A and GND
wire B and GND

Capacitive Balance

| | |
|---------------------------------------|---|
| <u>Measuring range</u> | 1 nF to 2 μ F |
| <u>Accuracy of Lx/L value</u> | $\pm 0.2\%$ |
| <u>Resolution of Lx/L-value</u> | 1/1000 |
| <u>Measuring voltage</u> | 11 Hz, 100 Vp |
| <u>Test results</u> | Capacitance between wire A and GND Capacitance between wire B and GND Lx/L, ΔC , $\Delta C\%$ |

DC Fault Location with Murray, Küpfmüller and 3 Point Methods

| | |
|---|--|
| <u>Loop resistance range</u> | 1 Ω to 10 k Ω |
| <u>Fault resistance range</u> | up to 100 M Ω |
| <u>Accuracy of Lx/L value</u> (R I = 2k Ω , Lx/L=0,1 to 1) | |
| Fault resistance < 1 M Ω | $\pm 0.2\%$ |
| Fault resistance 1 M Ω to 5 M Ω | $\pm 0.3\%$ |
| Fault resistance 5 M Ω to 25 M Ω | $\pm 0.5\%$ |
| Fault resistance 25 M Ω to 100 M Ω | $\pm 2.0\%$ |
| <u>Resolution of Lx/L-value</u> | 1/1000 |
| <u>Measuring voltage</u> | 100 V |
| <u>DC disturbing voltage compensation</u> | Enabled |
| <u>Test results</u> | |
| Murray and 3 Point | Lx/L, Rx, 2Rx, RI, Ra, Rb, FaE or FbE |
| Küpfmüller | Lx/L, Rx, 2Rx, RI, Ra, Rb, FaE and FbE |

DC-AC Fault Location with REPEATED KÜPFMÜLLER Method

| | |
|---|---------------------------|
| <u>Loop resistance range</u> | 1 Ω to 2k Ω |
| <u>Fault resistance range</u> | up to 5 M Ω |
| <u>Accuracy of Lx/L value</u> (R I = 2k Ω , Lx/L=0,1 to 1) | |
| Fault resistance < 1 M Ω | $\pm 1\%$ |
| Fault resistance 1 M Ω to 5 M Ω | $\pm 2\%$ |
| <u>Resolution of Lx/L-value</u> | 1/1000 |
| <u>Measuring voltage</u> | DC or 11 Hz AC, 100 Vp |
| <u>Test results</u> | Lx/L, RI |

AC Fault Location Interruption

| | |
|------------------------------|---|
| <u>Measuring range</u> | up to 20 km (Depends on cable type) |
| <u>Accuracy</u> | $\pm 2\% \pm 0.2$ nF |
| <u>Test results e</u> | Lx/L, Ca-E, Cb-E, ΔC , $\Delta C\%$ |

7.2 Passive Bridge

Loop Resistance

| | |
|------------------------------|--------------|
| <u>Measuring range</u> | 1Ω to 10 kΩ |
| <u>Measuring time</u> | ~ 15 sec |
| <u>Accuracy</u> | ±0.3% ±0.3 Ω |

Insulation Resistance

| | |
|--|---|
| <u>Measuring range</u> | 10 kΩ to 300 MΩ 10 kΩ to 10 GΩ |
| <u>Measuring voltage</u> | 100 V |
| <u>Measuring time</u> | |
| For 300 MΩ Range | ~80 sec |
| For 10000 MΩ Range | ~100 sec |
| DC disturbing voltage compensation | Enabled |
| <u>Test results</u> | Resistance between: wire A and wire B wire A and GND wire B and GND AC, DC voltages: A-B, A-E, B-E |
| <u>Accuracy</u> | |
| 10 kΩ to 50 MΩ | 5% ±1kΩ |
| 50 MΩ to 100 MΩ | 10 % |
| 100 MΩ to 5 000 MΩ | 20 % |
| 5 000 MΩ to 10 000 MΩ | 30 % |

Resistance Difference

| | |
|--------------------------------------|---------------------------------|
| <u>Loop resistance range</u> | 1 to 5000 Ω |
| <u>Accuracy</u> | ±0.2% of loop resistance ±0.2 Ω |
| <u>Resolution of Lx/L (Mk)-value</u> | |
| In range ΔR <10% | 1/10000 |
| In range ΔR >10% | 1/1000 |
| <u>Test results</u> | Mk, RI, Ra, Rb, ΔRΩ, ΔR% |

Fault Location Graaf Method

| | |
|---|---------------|
| Loop resistance range | 10 Ω to 10 kΩ |
| DC current range | 10μA to 0.1A |
| Accuracy of current measurement | ±0.3% ±2μA |
| Accuracy of Lx/L value (current >0.1mA) | ±3% |
| Accuracy of Lx/L value (current >1mA) | ±0.3% |

DC Fault Location with Murray, Küpfmüller and 3 Point Methods

| | |
|---|---|
| <u>Loop resistance range</u> | 1 Ω to 10 k Ω |
| <u>Fault resistance range</u> | up to 100 M Ω |
| <u>Accuracy of Lx/L value</u> (R I = 2k Ω , Lx/L=0,1 to 1) | |
| Fault resistance < 1 M Ω | $\pm 0.2\%$ |
| Fault resistance 1 M Ω to 5 M Ω | $\pm 0.3\%$ |
| Fault resistance 5 M Ω to 25 M Ω | $\pm 0.5\%$ |
| Fault resistance 25 M Ω to 100 M Ω | $\pm 2.0\%$ |
| <u>Resolution of M value</u> | 1/1000 |
| <u>Measuring voltage</u> | 100 V |
| <u>Test results</u> | |
| Murray..... | Mk, Lx/L, Rx, 2Rx, RI, Ra, Rb, FaE or FbE |
| Küpfmüller | ML, Mk, Lx/L, Rx, 2Rx, RI, Ra, Rb, FaE and FbE |
| 3 Point..... | Mk1, Mk2, Mk3, Lx/L, Rx, RI, Ra, Rb, FaE or FbE |

AC Fault Location with Küpfmüller Method

| | |
|---|---|
| <u>Loop resistance range</u> | 1 Ω to 10 k Ω |
| <u>Fault resistance range</u> | up to 25 M Ω |
| <u>Accuracy of Lx/L value</u> (R I = 2k Ω , Lx/L=0,1 to 1) | |
| Fault resistance < 1 M Ω | $\pm 0.3\%$ |
| Fault resistance 1 M Ω to 5 M Ω | $\pm 0.5\%$ |
| Fault resistance 5 M Ω to 25 M Ω | $\pm 1.0\%$ |
| <u>Resolution of M value</u> | 1/1000 |
| <u>Measuring voltage</u> | 11 Hz, 100 Vp |
| <u>Test results</u> | ML, Mk, Lx/L, Rx, RI, Ra, Rb, FaE and FbE |

AC Fault Location Capacitive Balance

| | |
|-------------------------------------|-----------------------|
| <u>Measuring range</u> | 10 nF to 2 μ F |
| <u>Accuracy of Lx/L value</u> | $\pm 0.2\%$ |
| <u>Resolution of Lx/L value</u> | |
| In range Lx/L=0.9 to 1.1 | 1/10000 |
| In range Lx/L<0.9 or Lx/L>1.1 | 1/1000 |
| <u>Measuring voltage</u> | 11 Hz, 100 Vp |
| <u>Test results</u> | ML, Lx/L, Ca-E/Cb-E % |

7.3 Pre Measurements

Disturbing Voltages

| | |
|-------------------------------|--|
| <u>Measuring range</u> | |
| DC voltage | up to 400 V |
| AC voltage | up to 250 V eff |
| <u>Measuring mode</u> | Repeated measurements |
| <u>Accuracy</u> | $\pm 3\% \pm 1 \text{ V}$ |
| <u>Frequency range</u> | 15 to 300 Hz |
| <u>Input resistance</u> | 2 M Ω |
| <u>Test results</u> | AC, DC voltage wire A and wire B wire A and GND wire B and GND |

Loop Resistance

| | |
|---|--------------------------------------|
| <u>Measuring range</u> | 1 Ω to 10 k Ω |
| <u>Measuring mode</u> | Repeated measurements |
| <u>DC disturbing voltage compensation</u> | Disabled |
| <u>Accuracy (without disturbing voltages)</u> | |
| In % of test result | $\pm 0.5\% \pm 0.2\%$ |
| <u>Test results</u> | Resistance between wire A and wire B |

Insulation Resistance

| | |
|---|--|
| <u>Measuring range</u> | 10 k Ω to 1 G Ω |
| <u>Measuring mode</u> | Repeated measurements |
| <u>DC disturbing voltage compensation</u> | Disabled |
| <u>Measuring time</u> | ~ 3 sec |
| <u>Measuring voltage</u> | 100 V |
| <u>Accuracy (without disturbing voltages)</u> | |
| Up to 300 M Ω | 20 % |
| <u>Test results</u> | Resistance between wire A and wire B wire A and GND wire B and GND |

Capacitance

| | |
|--------------------------------|--------------------------------|
| <u>Measuring range</u> | 10 nF to 2 μF |
| <u>Accuracy</u> | $\pm 3\% \pm 0.3 \text{ nF}$ |
| <u>Measuring voltage</u> | 11 Hz, 100 V _p |
| <u>Test results</u> | Capacity between wires A and B |

DC Current

| | |
|------------------------------|-----------------------------|
| <u>Measuring range</u> | 10 μA to 0.1A |
| <u>Accuracy</u> | $\pm 3\% \pm 2 \mu\text{A}$ |

Automatic Quick Test

Disturbing voltage

Measuring range..... up to 400 V DC, 250 V AC
Test results AC, DC voltage between: wire a and wire b
wire a and GND, wire b and GND
Accuracy..... normal

Insulation resistance

Measuring range..... 10 kΩ to 300 MΩ
Measuring voltage 100 V
Measuring time ~47 sec
DC disturbing voltage compensation..... Enabled
Test results Resistance between: wire A and wire B
wire A and GND
wire B and GND

Accuracy

100 MΩ to 300 MΩ 20 %
50 MΩ to 100 MΩ 10 %
10 kΩ to 50 MΩ 5 % ±1kΩ

Capacitance

Measuring range..... 10 nF to 2 μF
Measuring voltage 11 Hz, 100 Vp
Test results Capacitance between: wire A and wire B
wire A and GND, wire B joined to GND
wire B and GND, wire A joined to GND
Accuracy ±2%, ±200pF

Capacitive Balance

Measuring voltage 11 Hz, 100 Vp
Test results $C_a > C_b$ or $C_b > C_a$, L_x/L , unbalance %
Resolution..... 1/1000

Automatic Quality Test

Insulation resistance

| | |
|---|---------------------------------------|
| Measuring range..... | 10kΩ to 10 GΩ |
| Measuring voltage | 100 V |
| Measuring time | ~100 sec |
| DC disturbing voltage compensation..... | Enabled |
| Test results | Resistance between: wire A and wire B |
| | wire A and GND |
| | wire B and GND |

Accuracy

| | |
|-----------------------------|---------|
| 10 kΩ to 50 MΩ | 5% ±1kΩ |
| 50 MΩ to 100 MΩ | 10 % |
| 100 MΩ to 5 000 MΩ | 20 % |
| 5 000 MΩ to 10 000 MΩ | 30 % |

Capacitance

| | |
|-------------------------|--|
| Measuring range | 10 nF to 2 μ F |
| Measuring voltage | 11 Hz, 100 Vp |
| Test results | Capacitance between: wire A and wire B wire A and GND, wire B joined to GND wire B and GND, wire A joined to GND |
| Accuracy | $\pm 2\%$, ± 200 pF |

Capacitive Balance

| | |
|-------------------------|-----------------------------------|
| Measuring voltage | 11 Hz, 100 Vp |
| Test results | Ca>Cb or Cb>Ca, Lx/L, unbalance % |
| Resolution..... | 1/1000 |

Loop resistance

| | |
|----------------------|--------------|
| Measuring range..... | 1Ω to 10kΩ |
| Accuracy | ±0.3% ±0.1 Ω |

Resistance difference

| | |
|-----------------------------|---------------------------------|
| Loop resistance range | 1Ω to 5 kΩ |
| Accuracy | ±0.2% of loop resistance ±0.2 Ω |
| Resolution | 1/1000 |
| Test results | Ra, Rb, ΔRΩ, ΔR% |

Survey of Pair Condition

Voltage

Measuring range..... Up to 400 V DC, 250 V AC
Test results AC, DC voltage between: wire A and wire B
wire A and GND
wire B and GND
Accuracy..... $\pm 3\% \pm 1\text{ V}$

Insulation

Measuring range..... 10 k Ω to 300 M Ω
Measuring voltage 100 V
DC disturbing voltage compensation..... Enabled
Test results between wire A and GND (FaE)
between wire B and GND (FbE)
Accuracy
10 k Ω to 50M Ω 5 % $\pm 1\text{k}\Omega$
50 M Ω to 100 M Ω 10 %

DC voltage source

Measuring range. up to 100 V DC
Test resultsvoltage source: cascade with FaE (Va-E)
cascade with FbE (Vb-E)

Capacitance

Measuring range 10 nF to 2 μF
Measuring voltage 11 Hz, 100 V
Test resultsCapacitance between: wire a and GND (Ca-E)
wire b and GND (Cb-E)
Accuracy..... $\pm 2\% \pm 200\text{ pF}$

Loop and wire resistance

Measuring range. 1 Ω to 10 k Ω
Test resultsLoop resistance (RI)
Resistance of wire A (Ra)
Resistance of wire B (Rb)
Accuracy..... ca. 1%

Warnings

Events Overloaded, Intermittent
Amplifier Sensitive, Protected, Overloaded

7.4 TDR Measurements

Measuring Modes

| | |
|-------------------|--|
| Single Pair | L1, L2, L1 Long Time, L2 Long Time L1 with auto configuration |
| Double Pair | L1& L2, L1-L2, XTALK XTALK with auto configuration |
| Memory | L1& M, L1- M |

Measuring Ranges

| | |
|--|---------------|
| V/2=100 | 16 m to 32 km |
| The maximum measurable range depends on the cable type and operating conditions | |

Evaluation of Test Results

| | |
|-------------------------------|---------------|
| With Cursor and Marker | in Meter |
| Refreshing the waveform | ~4 times /sec |
| Zoom | 1 to 16 |

Accuracy

| | |
|----------------------|---------------|
| Fault location | 0,2% of range |
| Resolution | 0,01 m |

Propagation velocity

| | |
|-----------|----------------|
| V/2 | 45 to 150 m/μs |
| VOP | 30 to 99 % |

Measuring pulse

| | |
|---|------------------------|
| Widths | 4 ns to 6 μs |
| Amplitude | 1.3 to 12 Vpp on 120 Ω |
| The amplitude automatically changes with pulse width and gain | |

Line Connection

| | |
|-----------------------|----------------|
| Impedance | 120 Ω balanced |
| Balance control | 50 to 270 Ω |

Gain Control

| | |
|------------------|--------------------------|
| Gain range | 0 to 90 dB in 6 dB steps |
|------------------|--------------------------|

Distance Dependent Amplitude Correction

| | |
|-----------------------|----|
| Number of steps | 10 |
|-----------------------|----|

8 Options

HW Option

| | |
|-----------------------------|-------------|
| Passive Bridge..... | 460-460-000 |
| Extension for active bridge | |

Accessories

| | |
|----------------------------------|-------------|
| Loop closing device ELC 30..... | 421-000-000 |
| Intelligent Slave ECFL 30S | 425-000-000 |

SW Options

| | |
|------------------------------------|----------------|
| Test of loaded cables | SW-460-650-000 |
| Test of multi section cables | SW-460-660-000 |