ELEKTRONIKA

Appendix for ELQ 30A
Bridge & DMM Measurements

433-000-000

OPERATING MANUAL OM 433- 113-004 E

2011

CONTENTS

25.04.2013.

1 INTRODUCTION

1.1 Application Guide for Fault Location

We are talking about cable fault when the insulation resistance of one or more pairs (between wire and wire or between wire and ground) becomes too low

That usually occurs after strong rains wetting the insulation material in discrete points (typically not along the whole cable).

During the trouble shooting the first task is to find that points. The name of this process is “DC Fault Location”

Performing calculations ELQ 30A always supposes that there is only one faulty point on the tested cable

In the opposite case the cable should be split into sections containing only one faulty point so as to measure them one by one.

The fault location can be disturbed when the fault resistance interconnects the faulty wire with a DC voltage source (e.g. an active pair using DC voltage)
The applicable fault location method depends on the features of cable fault. In **DMM TESTS**/**PAIR CONDITION** survey mode ELQ 30A provides an extremely useful help for the user to find the best method.
From the point of view of disturbing voltages the cable faults can be included into two groups:

- The disturbing voltages are low
- The disturbing voltages are high

The bridge option of ELQ 30A 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

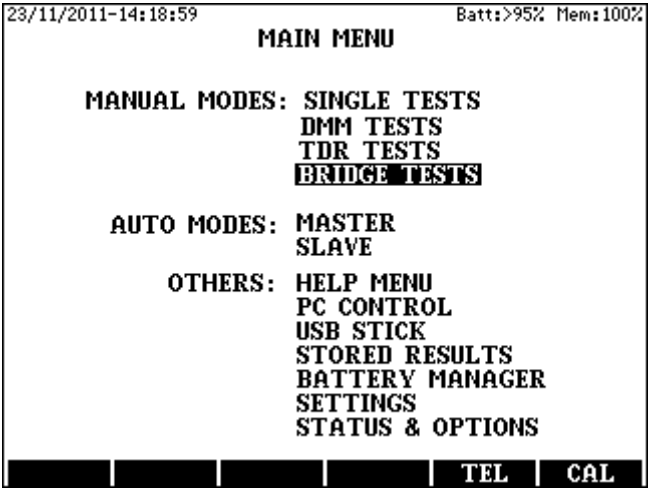
It is recommended to start the measurement with sensitive mode. When the disturbing voltages overload the indicator a warning appears informing the user that the result can be inaccurate. In that case the measurement should be repeated in protected mode.

1.2 Bridge Calibration

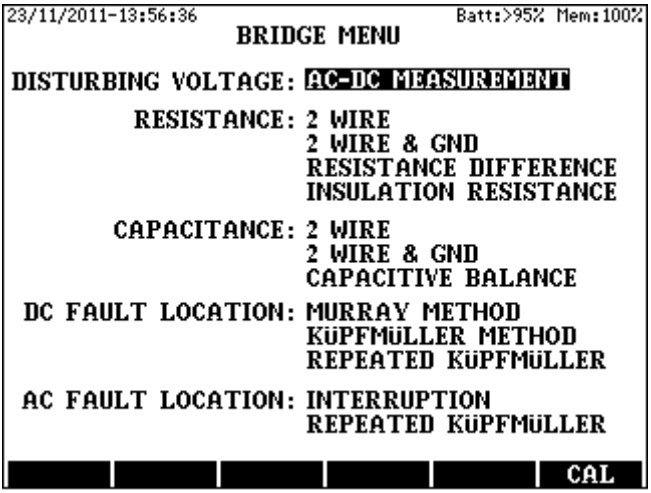
ELQ 30A is a very stable instrument but, the specified accuracy can be guaranteed only after calibration.

The steps of bridge calibration

Enter the **BRIDGE TESTS** option of **MAIN MENU**



Doing so the following display appears:



Press the **CAL (F6)** key and then the **CALIBRATION** menu appears providing two bridge calibration options:

- Calibration of test leads
- Self-calibration

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:

- Select the **CAL OF TEST LEADS** option of **CALIBRATION** menu
- Press **ENTER**

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 Küpfmüller- Methods

Self calibration

- Select the **SELF CALIBRATION** option of **CALIBRATION** menu
- Start the calibration process with pressing **ENTER**

During the calibration process the offset voltages of amplifiers are measured and stored.

The accuracy of bridge is based on the measurement of a built in normal resistor of high preciosity. The result of that measurement is stored as a reference value.

When the calibration process is completed ELQ 30A is ready for bridge measurements.

1.3 Provided Special Actions after Measurements

ELQ 30A measures the physical parameters of the tested pair like loop resistance, insulation resistance, Lx/L value or capacitance.

Additional parameters can be calculated when:

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

The calculated additional parameters

At fault location modes:

- Cable length (DTS) in meters
- Distance to fault (DTF) in meters

At loop resistance and capacitance measurement:

- Length (DTS) in meters when the cable parameters and cable temperature are known
- Ohm/km value when the cable length is known

At insulation resistance measurement:

- Ohm/km or value when the cable length is known

At insulation capacitance measurement:

- Length (DTS) in meters when the cable parameters are known
- nF/km value when the cable length is known

Steps of calculation

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

To change the cable type

- Press the **C.LIBR (F6**) key
- Select a new cable type and press **ENTER**
- Press **ESC**

To change the cable temperature

- Press the **TEMP.(F4**) key,
- Type in the temperature value and press **ENTER**.

Doing so ELQ 30Aautomatically calculates the new values

When the cable length is known

- Press the **LENGTH (F5**) key
- Type in the length value and press **ENTER**

For returning to the normal display

- Press the **LENGTH (F5**) key
- Press **ENTER**

2 BRIDGE MEASUREMENTS

2.1 AC-DC Disturbing Voltage Measurement

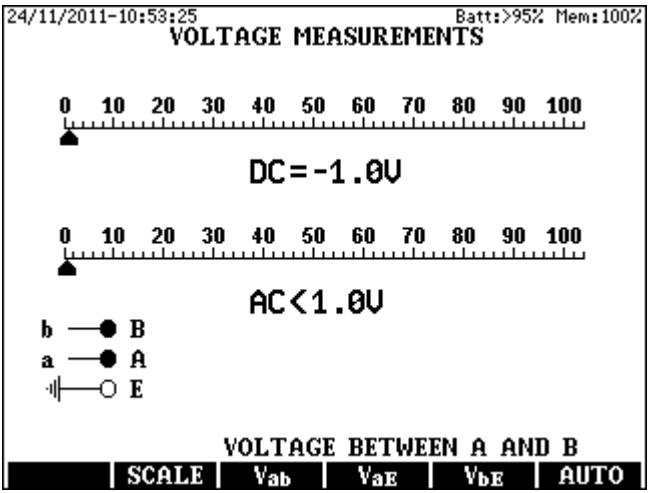
ELQ 30A has a measuring module with balanced input to measure AC and DC voltages at the same time. Measuring range is 1 to 400 V DC and 1 to 250V AC, input impedance 2 MOhm

IMPORTANT NOTE

During that measurement the PC connection must be removed!
High voltages on the line may destroy the instrument or the PC!

Mode selection

- Select the **AC-DC MEASUREMENT** mode and press **ENTER**



Input selection

- Pressing the **Vab(F3**), **VaE(F4)** or **VbE(F5)** key ELQ 30A measures the AC DC voltages continuously between the selected two inputs.
- The measuring range can be changed with the **SCALE (F2)** key
- Pressing **AUTO (F6)** ELQ 30A performs all the AC-DC voltage measurements after each other. In auto mode the results can be saved with key **SAVE (F1).** The measurement can be restarted with key **START/STOP**

2.2 Resistance Measurements

The active bridge of ELQ 30A provides four resistance-measuring modes:

- **2 WIRE**
- **2 WIRE & GND**
- **RESISTANCE DIFFERENCE**
- **INSULATION RESISTANCE**

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.

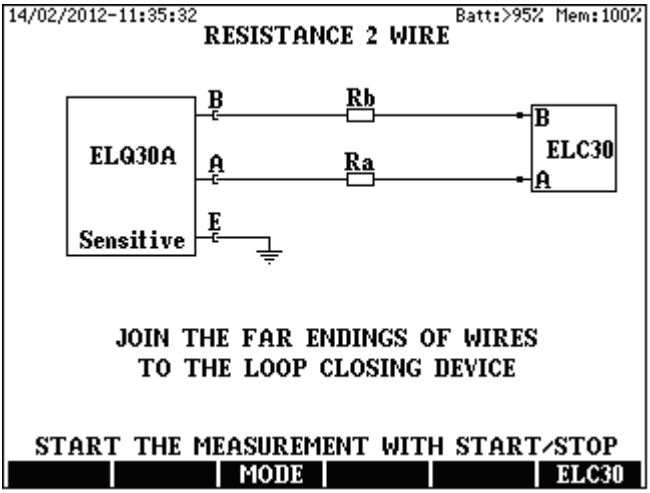
The resistance measurement is automatically performed independently of the results of voltage measurement but in case of high voltage indication a repeated measurement is recommended.

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.

2.3 Loop Resistance Measurement (2 WIRE)

Test Procedure

Select the **RESISTANCE/2 WIRE** mode and press **ENTER** 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.

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 (F3)** key
- Start the measurement with the **START/STOP** key

Having the measurement completed the test results appear.

Displayed Test Results

- Loop resistance **Rl, Ra,** and **Rb** (Ra and Rb is calculated as Rl/2)
- Cable length (calculated out of cable parameters and Rl) To change the cable type
- Press the **C.LIBR (F6**) key
- Select a new cable type and press **ENTER**
- Press **ESC**

To change the cable temperature

- Press the **TEMP.(F4**) key,
- Type in the temperature value and press **ENTER**.

When the cable length is known

- Press the **LENGTH (F5**) key
- Type in the length value and press **ENTER**

For returning to the normal display

- Press the **LENGTH (F5**) key and press **ENTER**

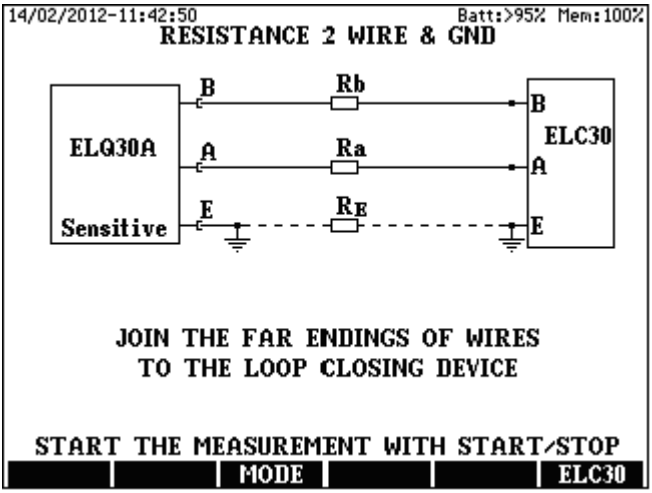
To save the test result press the **SAVE (F1)** key

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

2.3.1 Loop Resistance Measurement (2-WIRE & GND)

Test Procedure

Select the **RESISTANCE/2 WIRE & GND** mode and press **ENTER** 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.

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 (F3)** key
- Start the measurement with the **START/STOP** key

Having the measurement completed the test results appear.

Displayed Test Results

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

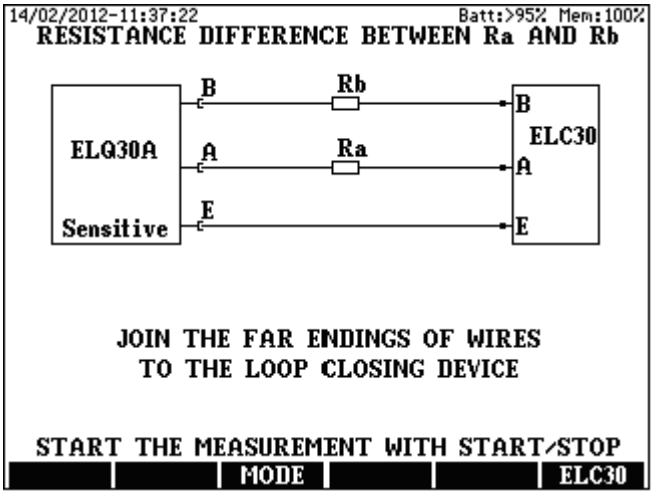
To save the test result press the **SAVE (F1)** key

2.3.2 Resistance Difference Measurement

The difference between the wire resistances of a pair is usually small compared to the wire resistances. ELQ 30A has to measure the small difference of high resistances, therefore the calibration of test leads is recommended.

Test Procedure

Select the **RESISTANCE DIFFERENCE** mode and press **ENTER** 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.

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 (F3)** key
- Start the measurement with the **START/STOP** key

Having the measurement completed the test results appear.

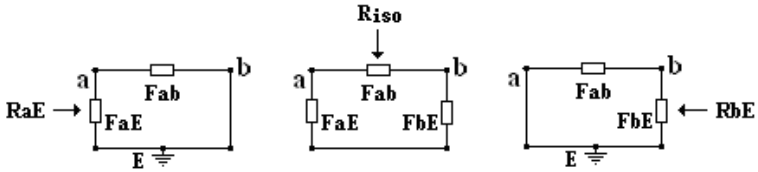
Displayed Test Results

- **Rl = Ra+Rb** loop resistance
- **ΔR = Ra-Rb** resistance difference
- **2 ΔR / Rl** (in %)
- **Ra** and **Rb** calculated out of **Rl** and **ΔR**

To save the test result press the **SAVE (F1)** key.

2.3.3 Insulation Resistance Measurement

The insulation resistance measurement is performed in the following arrangement:

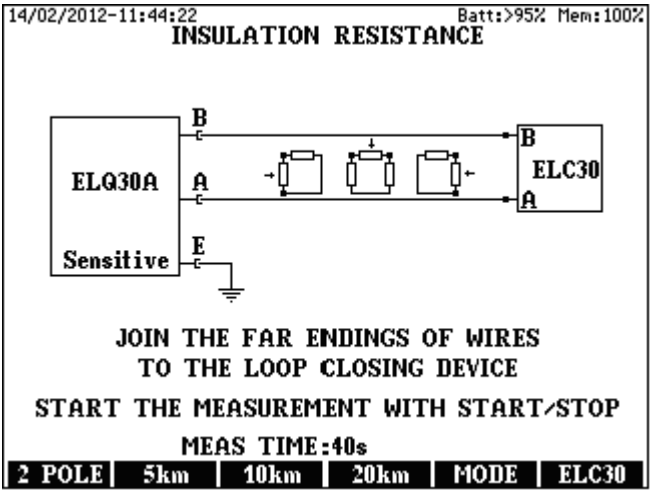


Riso = Fab parallel with (FaE + FbE)
RaE = Fab parallel with FaE
RbE = Fab parallel with FbE

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

Test Procedure

Select the **INSULATION RESISTANCE** mode and press **ENTER**
The measuring arrangement appears on the display.



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 (F5)** key

The measurement time depends on the cable length. The proper range can be selected with the **F2** to **F4** keys

- 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 (wire **b** joined to **GND**)
- **RbE** resistance between wire **b** and GND (wire **a** joined to **GND**)
- **Vab, VaE** and **VbE** AC and DC measured disturbing voltages

Calculation of Ω/km when the cable length is known

- Press the **LENGTH (F5**) key
- Type in the length value and press **ENTER**

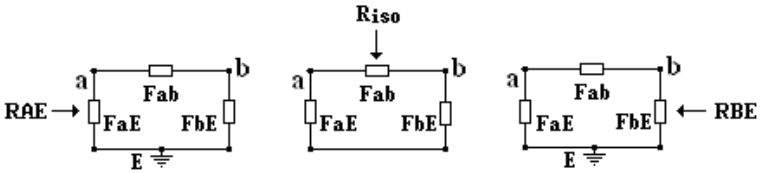
For returning to the normal display

- Press the **LENGTH (F5**) key and press **ENTER**

Notice:

The cheap and simple instruments can perform only 2 Pole measurements. For the sake of comparison ELQ 30A also provides the 2 Pole measuring mode. To select that mode press **2 POLE (F1)** key

The 2 Pole measurement is performed in the following arrangement:

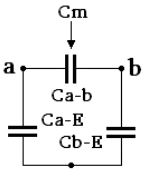


Riso = Fab parallel with (FaE + FbE)
RAE = FaE parallel with (Fab + FbE
RBE = FbE parallel with (Fab + FaE)

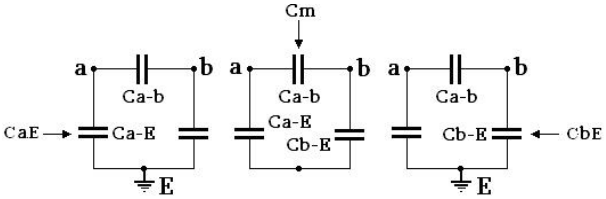
2.4 Capacitance Measurements

The active bridge of ELQ 30A provides several capacitance measuring modes like:

- **2 WIRE** mode for the measurement of Cm mutual capacitance between wire a and wire b in the following arrangement:

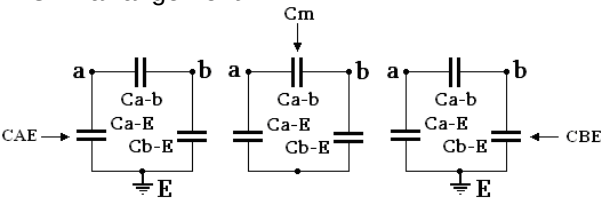


- **2 WIRE & GND** mode for capacitance measurement according to norm EN 50289-1-5:2001 in the following arrangement:



(Measuring results are marked as: Cm, CaE and CbE)

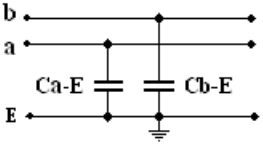
- **2 WIRE & GND** mode for the measurement of capacitances in TWO POLE arrangement:



(Measuring results are marked as: Cm, CAE and CBE)

- **2 WIRE & GND** mode for physical capacitance Measurement (The results are marked as: **Ca-b**, **Ca-E** and **Cb-E)**

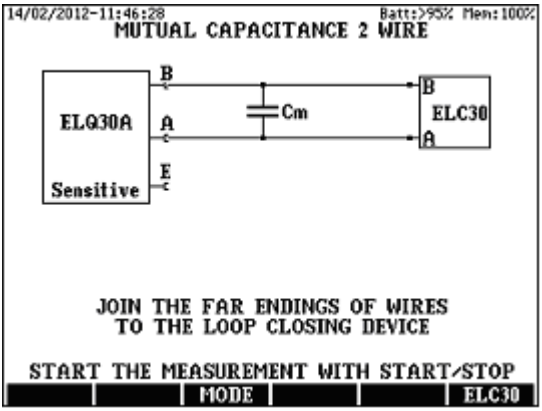
- **CAPACITIVE BALANCE** mode for the measurement of balance between Ca-E and Cb-E with a high accuracy.



2.4.1 Capacitance Measurement (2 WIRE)

Test Procedure

Select the **CAPACITANCE/2-WIRE** mode and press **ENTER** and then 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 (F3)** key
- Start the measurement with the **START/STOP** key

Having the measurement completed the following results appear:

Displayed Test Result

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

To change the cable type

- Press the **C.LIBR (F6**) key
- Select a new cable type and press **ENTER**
- Press **ESC**

Calculation of nF/km when the cable length is known

- Press the **LENGTH (F5**) key
- Type in the length value and press **ENTER**

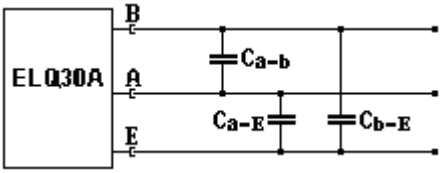
For returning to the normal display

- Press the **LENGTH (F5**) key and press **ENTER**

2.4.2 Capacitance Measurement (2 WIRE&GND)

Test Procedure

Select the **CAPACITANCE/2-WIRE&GND** mode and press **ENTER** and then the measuring arrangement appears:



The far endings of the tested pair should be open.

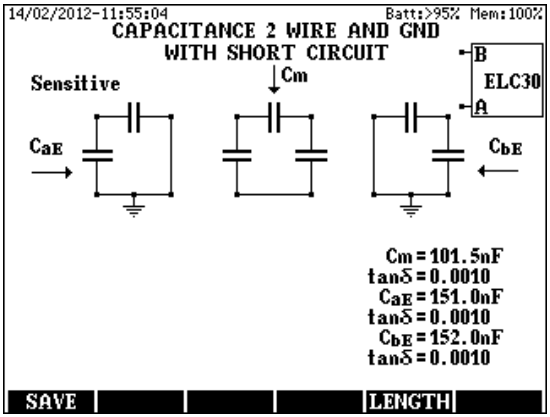
Two measuring modes are provided: **Sensitive** or **Protected** mode.
It is recommended to start the measurement with sensitive mode. When the disturbing voltages overload the indicator a warning appears informing the user that the result can be inaccurate. In that case the measurement should be repeated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

- Select the proper mode with the **MODE (F5)** key
- Start the measurement with the **START/STOP** key

Having the measurement completed the following results appear:

Displayed Test Results (According to norm EN 50289-1-5:200)

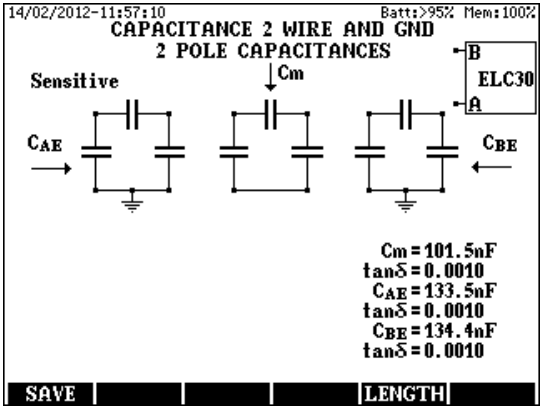
- **Cm** capacitance and **tan δ** between wire **a** and wire **b**
- **CaE** capacitance and **tan δ** between wire **a** and **GND**
- **CbE** capacitance and **tan δ** between wire **b** and **GND**



The cheap and simple instruments can perform only 2 Pole measurements. For the sake of comparison ELQ 30A also provides the 2 Pole evaluating mode. For 2 Pole evaluations press the **2 POLE (F2)** key before starting the measurement

Displayed Test Results in 2 Pole mode.

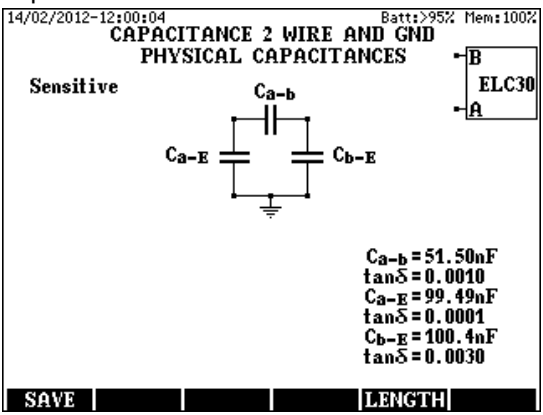
- **Cm** capacitance and **tan δ** between wire **a** and wire **b**
- **CAE** capacitance and **tan δ** between wire **a** and **GND**
- **CBE** capacitance and **tan δ** between wire **b** and **GND**



To see the physical capacitances press the **PHYS (F3)** key

Displayed Test Results in Physical mode

- **Ca-b** capacitance and **tan δ** between wire **a** and wire **b**
- **Ca-E** capacitance and **tan δ** between wire **a** and **GND**
- **Cb-E** capacitance and **tan δ** between wire **b** and **GND**



Calculation of nF/km when the cable length is known

- Press the **LENGTH (F5**) key
- Type in the length value and press **ENTER**

For returning to the normal display

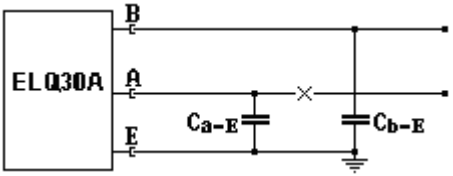
- Press the **LENGTH (F5**) key and press **ENTER**

To save the test result press the **SAVE (F1)** key

2.4.3 Capacitive Balance Measurement

Test Procedure

Select the **CAPACITIVE BALANCE** mode and press **ENTER** and then the measuring arrangement appears:



The far endings of the tested pair should be open.

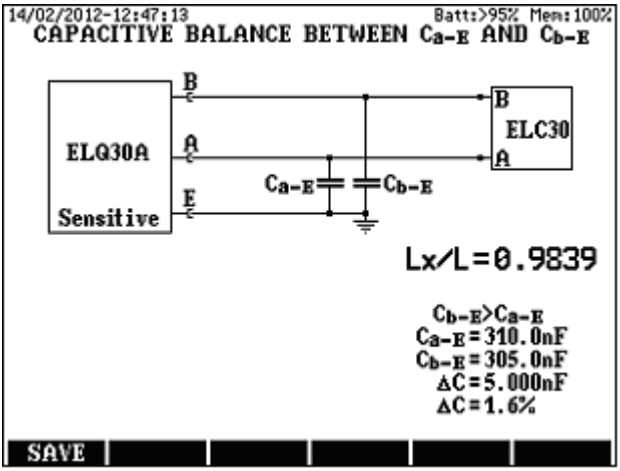
Two measuring modes are provided: **Sensitive** or **Protected** mode.
It is recommended to start the measurement with sensitive mode. When the disturbing voltages overload the indicator a warning appears informing the user that the result can be inaccurate. In that case the measurement should be repeated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

- Select the proper mode with the **MODE (F3)** key
- Start the measurement with the **START/STOP** key

Having the measurement completed the following results appear:

Displayed Test Results

- **Lx/L** relative capacitance rate
- **Ca-E** wire capacitance
- **Cb-E** wire capacitance
- **ΔC = Ca-E – Cb-E** capacitance difference
- **ΔC%** = 2 ΔC / (Ca-E + Cb-E) difference in percents



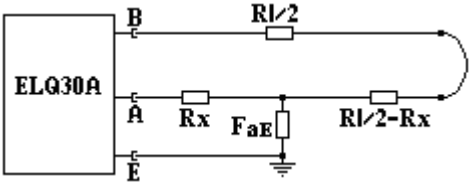
2.5 DC Fault Location

2.5.1 DC Fault Location with MURRAY Method

The Murray-method applicable when the two wires of the pair have the same gauge (∅), 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 then the faulty wire's insulation resistance between wire and ground.
The insulation resistance of the healthy wire must be higher than 10 MΩ even if the fault resistance of the faulty wire is smaller than 10 kΩ.
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

Select the **MURRAY** mode and press **ENTER** 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 (F3)** key
- Start the measurement with the **START/STOP** key

Having the measurement completed the following results appear:

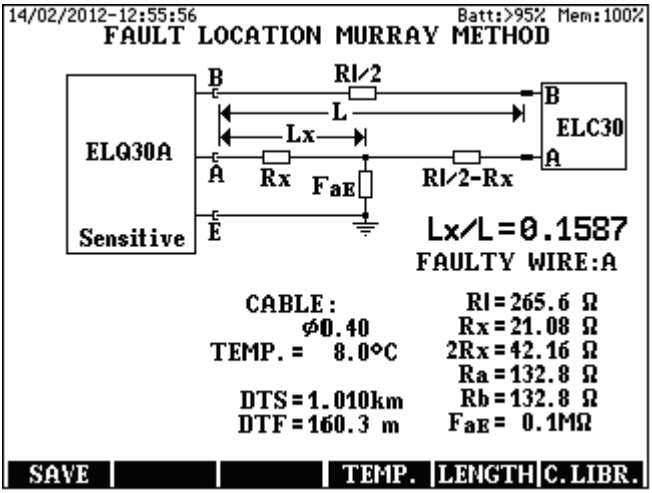
Displayed Test Results

- **Lx/L** relative distance of fault compared to the cable length
- **Rx** wire resistance between the instrument and fault
- **2Rx** the double of wire resistance between the instrument and fault

- **Rl** loop resistance
- **FaE** fault resistance
- **Ua-E** the voltage of a DC source connected serial to FaE.

That voltage shows the short between the faulty and an active wire. It is displayed only when its effect is not negligible.

- **DTS** (calculated out of the cable parameters and Rl)
- **DTF** (calculated out of the cable parameters, Rl and Lx/L)



To change the cable type

- Press the **C.LIBR (F6**) key
- Select a new cable type and press **ENTER**
- Press **ESC**

To change the cable temperature

- Press the **TEMP.(F4**) key,
- Type in the temperature value and press **ENTER**.

Doing so ELQ 30A automatically calculates the new values.

When the cable length is known

- Press the **LENGTH (F5**) key
- Type in the length value and press **ENTER**

For returning to the normal display

- Press the **LENGTH (F5**) key
- Press **ENTER**

To save the test result press the **SAVE (F1)** key

2.5.2 DC Fault Location with Küpfmüller Method

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

FaE +FbE > 100 x Rl

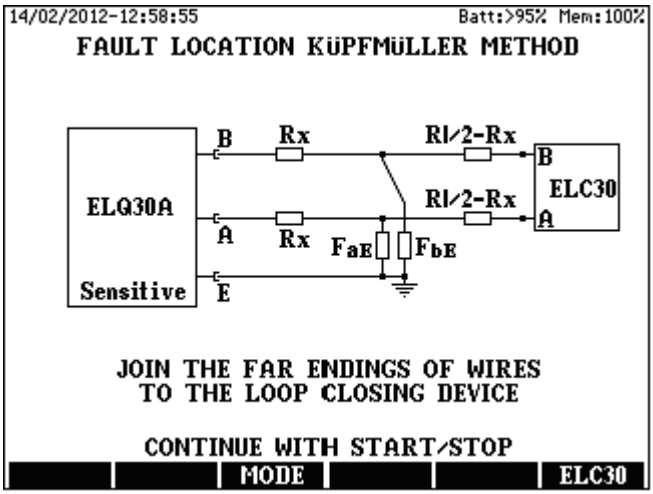
0,5 > FaE / FbE > 2

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

Select the **DC FAULT LOCATION/KÜPFMÜLLER METHOD** and press **ENTER** 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.

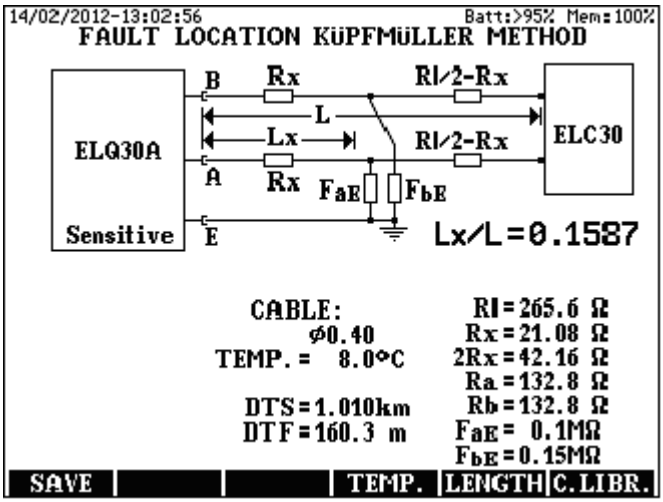
Having the far endings of the tested pair opened

- **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
- **Rx** wire resistance between the instrument and fault
- **2Rx** the double of wire resistance between the instrument and fault
- **Rl** loop resistance
- **FaE** and **FbE** fault resistances
- **Ua-E** the voltage of a DC source connected serial to FaE.or FbE These voltages show the short between the faulty and an active wire. They are displayed only when their effect is not negligible
- **DTS** (calculated out of the cable parameters and Rl)
- **DTF** (calculated out of the cable parameters, Rl and Lx/L)

To change the cable type

- Press the **C.LIBR (F6**) key
- Select a new cable type and press **ENTER**
- Press **ESC**

To change the cable temperature

- Press the **TEMP.(F4**) key,
- Type in the temperature value and press **ENTER**.

Doing so ELQ 30A automatically calculates the new values.

When the cable length is known

- Press the **LENGTH (F5**) key
- Type in the length value and press **ENTER**

For returning to the normal display

- Press the **LENGTH (F5**) key
- Press **ENTER**

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 (F3)** key.

To save the test result press the **SAVE (F1)** key
.DC Fault Location with repeated KÜPFMÜLLER method
That method is a sequence of repeated Küpfmüller measurements. It is applicable when none of the wires of a cable is free of fault. That method is very useful in case of intensely changing fault resistances, DC voltages or electrolytic voltages.

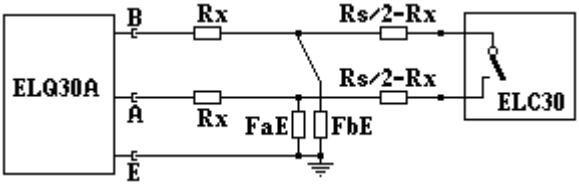
That method requires 16 part measurements alternating:

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

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

Test Procedure

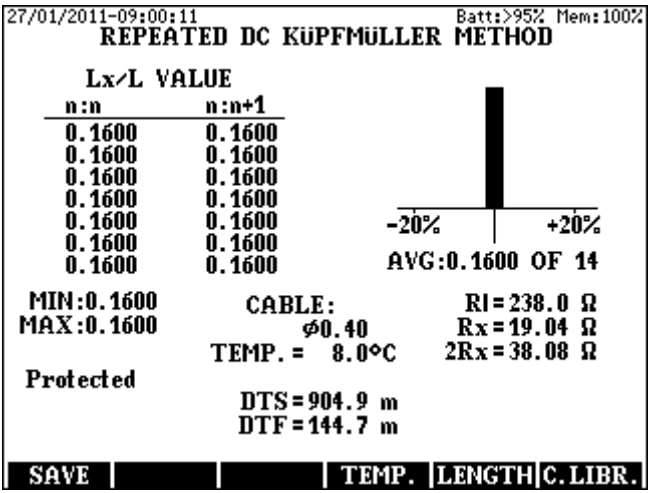
Select the **DC: REPEATED KÜPFMÜLLER** mode and press **ENTER** and then the measuring arrangement appears:



- The measurement can be started with the **START/STOP** key

When the 16 part measurements are ready ELQ 30A 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:



During the calculation process all L and K values are used twice.
That are marked at the header of result display with n:n and n:n+1

The result display contains:

- All the 14 remaining Lx/L values (the unlikely ones are marked with asterisks.)
- The average of Lx/L values
- The number of Lx/L values (used for average calculation)
- The minimum and maximum of Lx/L value
- Histogram showing the distribution of Lx/L values
- **Rx** wire resistance between the instrument and fault
- **2Rx** the double of wire resistance between the instrument and fault
- **Rl** loop resistance
- **DTS** (calculated out of the cable parameters and Rl)
- **DTF** (calculated out of the cable parameters, Rl and Lx/L)

To save the test result press the **SAVE (F1)** key

Evaluation by means of Histogram

In case of high disturbing voltages the Lx/L values calculated out of the results of part measurements my 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 Lx/L values along the horizontal axis.

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

At the evaluation of histogram the user should consider:

- The histogram of a **perfect measurement** is a black bar showing that the results of all part measurements were within a ±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 ELQ 30A.

Notice:

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

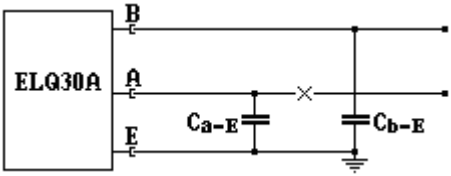
It is recommended to start the measurement with sensitive mode. When the disturbing voltages overload the indicator a warning appears informing the user that the result can be inaccurate. In that case the measurement should be repeated in protected mode. The proper mode can be selected with the **MODE (F3)** key

2.6 AC Fault Location

2.6.1 AC Fault Location with Interruption Measurement

Test Procedure

Select the **INTERRUPTION** mode and press **ENTER** 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 (F1)** 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.

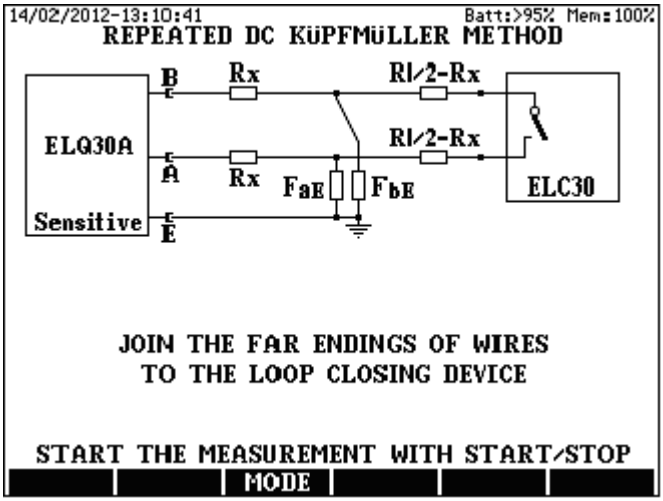
- To enter or change the cable type press the **C.LIBR (F6**) key select a cable type and press **ESC**

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 (F5**) key, type in the length value and press **ENTER**

2.6.2 AC Fault Location with repeated 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

Select the **AC: REPEATED KÜPFMÜLLER** mode and press **ENTER** and then the measuring arrangement appears:

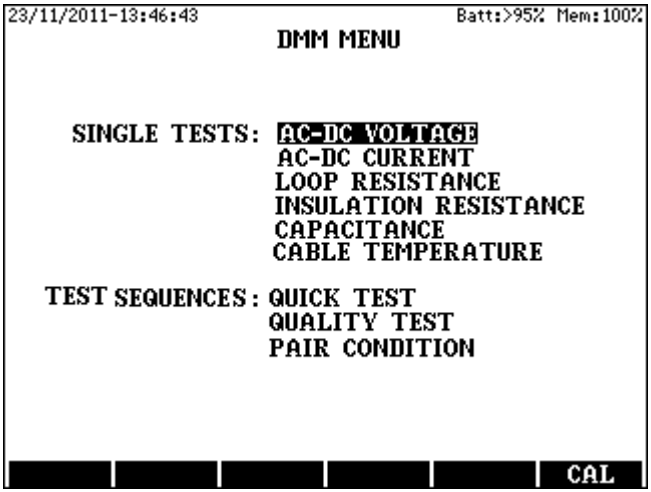


- Start the first measurement pressing the **START/STOP** key

3 DMM MEASUREMENTS

The DMM measurements are included into two groups:

- Single test
- Test sequences



3.1 Single Tests

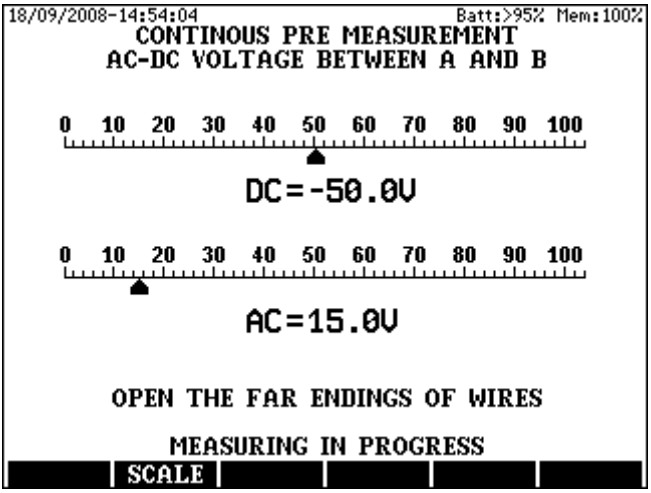
3.1.1 AC DC Voltage Measurement

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 manually or by means of the remote controllable loop-closing device ELC30
- Select the **DMM TESTS /AC-DC VOLTAGE** mode
- Press **ENTER**

ELQ 30A starts the measurements automatically and repeatedly continue it until the next **START/STOP** key stroke.



The sensitivity can be changed with the **SCALE (F2)** key

Displayed Test Results

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

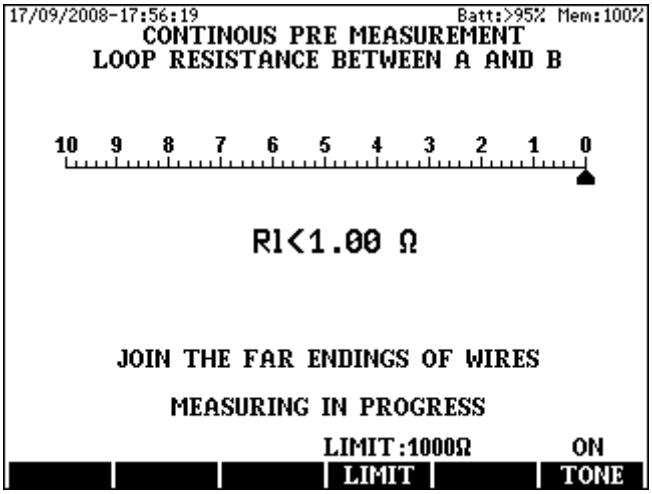
3.1.2 Loop Resistance Measurement

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 manually or by means of the remote controllable loop-closing device ELC30.
- Select the **DMM TESTS /LOOP RESISTANCE** mode
- Press **ENTER**

ELQ 30A starts the measurements automatically and repeatedly cotinue 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 (F4)** key and type in the wanted limit

  The buzzer can be switched on/off with the **TONE(F6)** key

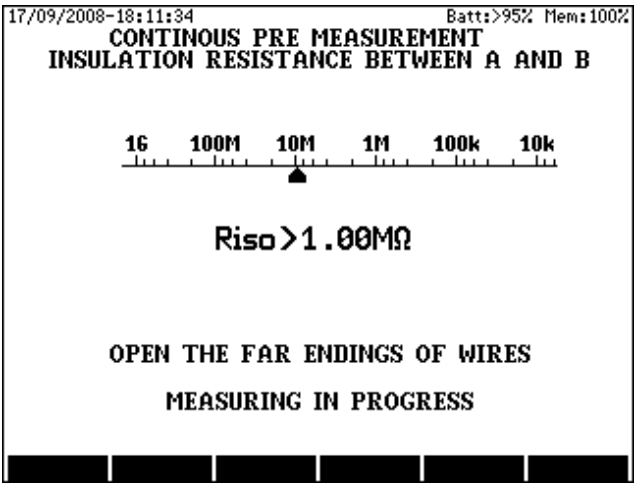
3.1.3 Insulation Resistance Measurement

Purpose of the test is to measure the insulation resistance between the a and b wires. ELQ 30A in this mode provides fast measurement of disturbing voltage free pairs. Measuring range:10 kΩ to 300 MΩ

Test Procedure

- Open the far endings of a and b wires manually or by means of the remote controllable loop-closing device ELC30
- Select **DMM TESTS/INSULATION RESISTANCE** mode
- Press **ENTER**

ELQ 30A starts the measurements automatically and repeatedly continue it until the next **START/STOP** key stroke.



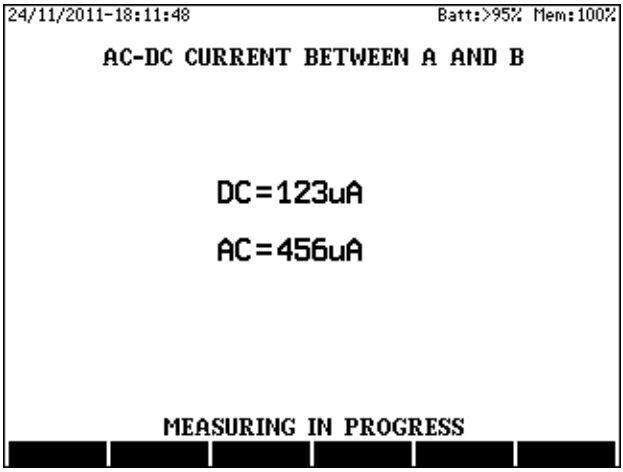
3.1.4 DC Current Measurement

Purpose of the test is to measure the DC loop current. Internal resistance: 1 Ohm, measuring range: 3 µA to 1 A.

Test Procedure

- Close the far endings of a and b wires manually or by means of the remote controllable loop-closing device ELC30
- Select **DMM TESTS/AC-DC CURRENT** mode
- Press **ENTER**

ELQ 30A starts the measurements automatically and repeatedly continue it until the next **START/STOP** key stroke.



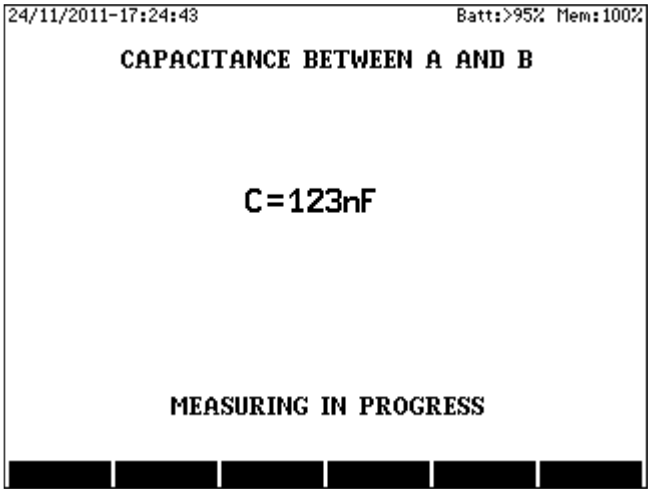
3.1.5 Capacitance Measurement

ELQ 30A in this mode provides fast measurement of capacitance between the a and b wires. Measuring range: 10 nF to 2 µF

Test Procedure

- Open the far endings of a and b wires manually or by means of the remote controllable loop-closing device ELC30
- Select **DMM TESTS/CAPACITANCE** mode
- Press **ENTER**

ELQ 30A starts the measurements automatically and repeatedly continue it until the next **START/STOP** key stroke.

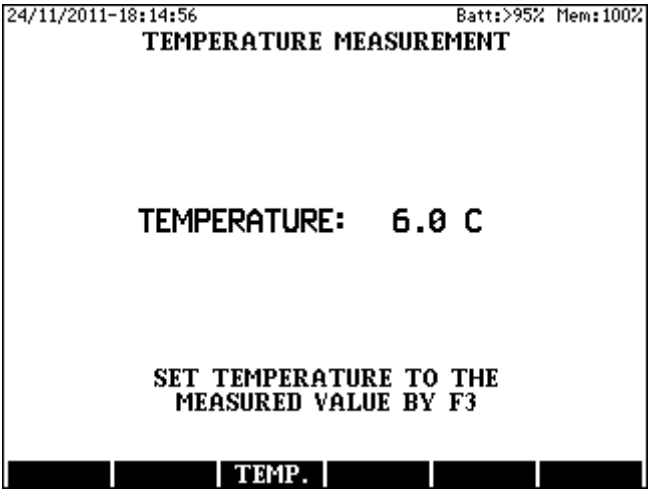


3.1.6 Cable Temperature Measurement

The purpose of the test is to measure the temperature of a cable.

Test Procedure

- Enter **DMM TESTS/CABLE TEMPERATURE** mode.



- Plug the thermometer probe (supplied as option) into ELQ 30A as shown on the display and put the probe near the cable.
- Wait a few minutes until the surface temperature of the probe reaches the cable temperature and start the measurement pressing the **START/STOP** key.

Test Result:

- Cable Temperature **TEMP.**

ELQ 30A is able to measure temperature within –20 C and +60 C.
The measured temperature can be stored by pressing the **TEMP. (F3)** key i.e. the temperature field of the subsequent loop resistant measurement or fault location measurement will be updated to this value.

3.2 Test Sequences

3.2.1 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: ~60 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 MΩ)

- Between wire **a** and wire **b**
- Between wire **a** and **E** (GND)
- Between wire **b** and **E** (GND)

Capacitance

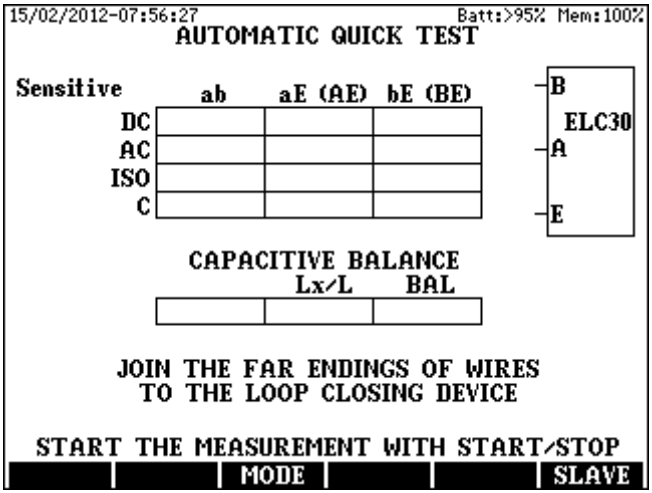
- Between wire **a** and wire **b**
- Between wire **a** and **E** (GND)**,** b connected to ground
- Between wire **b** and **E** (GND)**,** a connected to ground

Capacitive unbalance

- Between CaE and CbE

Test Procedure

- Open the far endings of a and b wires manually or by means of the remote controllable loop-closing device ELC30
- Select **DMM TESTS/QUICK TEST** mode and
- Press **ENTER** and then the following display appears:



- Start the measurement with the **START/STOP** key
- The test results can be saved by pressing the **SAVE (F1)** key

3.2.2 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: ~130 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

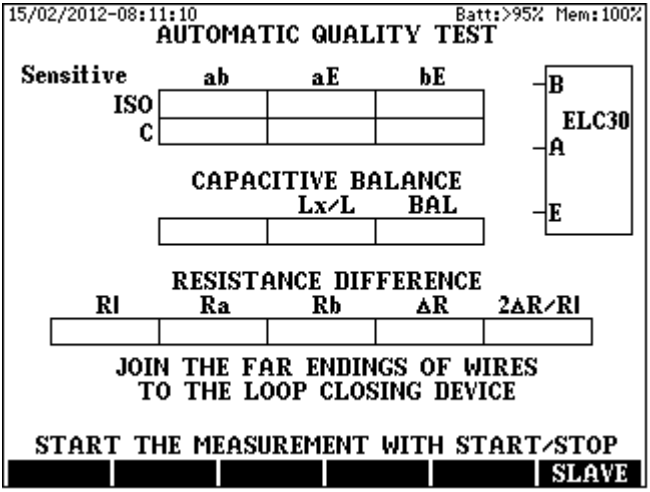
- Between CaE and CbE

Loop resistance

Resistance difference

Test Procedure

- Connect the remote controllable loop-closing device ELC30 to the far end of the tested pair.
- Select **DMM TESTS/QUALITY TEST** mode
- Press **ENTER** and then the following display appears:

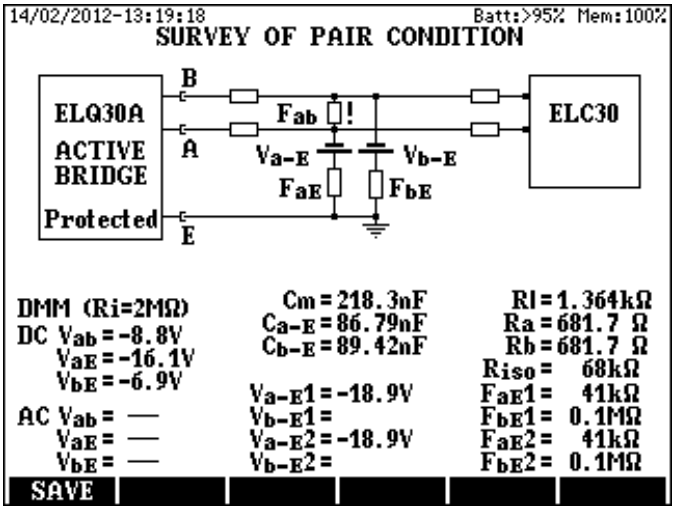


- Start the measurement with the **START/STOP** key
- The test results can be saved by pressing the **SAVE (F1)** key

3.2.3 Survey of Pair Condition

ELQ 30A provides an extremely useful test sequence to find the best fault location method: **DMM TESTS** / **PAIR CONDITION**
The test sequence consists of the following measurements:

- DC and AC disturbing voltage measurement
- Mutual capacitance Cm
- Physical capacitance between wires and GND
- Loop resistance Rl
- 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



Notices:
To perform **LOOP CONDITION** survey program the remote controllable loop closing device ELC30 is definitely necessary!

AUTO mode is set as default in **LOOP CONDITION** measurement.

AUTO mode means:

ELQ 30A 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 ELQ 30A). 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.

4 SPECIFICATIONS

4.1 Bridge Measurements

Disturbing Voltage

Measuring range
- DC voltage ..... up to 400 V
- AC voltage ..... up to 250 V rms

Accuracy ..... ±3% ±1 V
Frequency range ..... 15 to 300 Hz
Input resistance ..... 1 or 2 MΩ
Test results ..... AC, DC voltage between: wire a and b, wire a and GND, wire b and GND

Loop Resistance

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

Resistance Difference

Loop resistance range ..... 10 to 5000 Ω
Accuracy ..... ±0.2% of loop resistance ±0.2 Ω
Lx/L- value resolution 1/1000
Test results ..... Lx/L, Rl, Ra, Rb, ΔRΩ, ΔR%

Insulation Resistance

Measuring range ..... 10 kΩ to 1000 MΩ
Measuring voltage ..... 100 V
Measuring time (Depends on cable length)
- For < 5 km cable length ..... ~30 sec
- For 5 km to 10 km cable length ..... ~60 sec
- For 10 km to 20 km cable length ..... ~90 sec
- DC disturbing voltage compensation ..... Enabled

Test results ..... Resistance between: wire a and wire b (Rab) wire a and GND, wire b joined to GND (RaE) wire a and GND, wire b joined to GND (RbE
AC, DC voltages: a-b, a-E, b-E

Accuracy
- 10 kΩ to 300 MΩ ..... 2 to 5 % ± 1kΩ
- Over 300 MΩ ..... 10 % ± 1MΩ

Capacitance

Measuring range ..... 10 nF to 2 (10) µF
Accuracy ..... ±2% ±0.2 nF
Measuring voltage ..... 11 Hz, 100 V
Test results ..... Capacitance between: wire a and wire b (Cab) wire a and GND, wire b joined to GND (CaE) wire a and GND, wire b joined to GND (CbE)

Capacitive Balance

Measuring range..... 10 nF to 2000 nF

Accuracy of Lx/L value ..... ±0.2%

Resolution of Lx/L-value 1/1000

Measuring voltage .....11 Hz, 100 V

Test results ..... Capacitance between wire a and GND (Ca-E)
Capacitance between wire b and GND (Cb-E) L

DC Fault Location with Murray, Küpfmüller Methods

Loop resistance range ..... 1 Ω to 10 kΩ

Fault resistance range .....up to 100 MΩ

Accuracy of Lx/L value (R l = 2kΩ, Lx/L=0,1 to 1)
Fault resistance < 1 MΩ ..... ±0.2%
Fault resistance 1 MΩ to 5 MΩ ..... ±0.3%
Fault resistance 5 MΩ to 25 MΩ..... ±0.5%
Fault resistance 25 MΩ to 100 MΩ..... ±2.0%

Resolution of Lx/L-value 1/1000

Measuring voltage ..... 100 V
DC disturbing voltage compensation..... Enabled

Test results
Murray.....Lx/L, Rx, 2Rx, Rl, Ra, Rb, FaE or FbE
Küpfmüller.....Lx/L, Rx, 2Rx, Rl, Ra, Rb, FaE and FbE

DC-AC Fault Location with REPEATED KÜPFMÜLLER Method

Loop resistance range ..... 1 Ω to 2kΩ

Fault resistance range .....up to 5 MΩ

Accuracy of Lx/L value (R l = 2kΩ, Lx/L=0,1 to 1)
Fault resistance < 1 MΩ..... ±1%
Fault resistance 1 MΩ to 5 MΩ..... ±2%

Resolution of Lx/L-value 1/1000

Measuring voltage ..... DC or 11 Hz AC, 100 V

Test results ..... Lx/L, Rl

AC Fault Location Interruption

Measuring range..... up to 20 km (Depends on cable type)

Accuracy ..... ±2% ±0.2 nF

Test results e ..... Lx/L, Ca-E, Cb-E, ΔC, ΔC%

4.2 DMM Measurements Single Tests

Disturbing Voltages

Measuring range
DC voltage. ..... up to 400 V
AC voltage ..... up to 250 V eff
Measuring mode ..... Repeated measurements
Accuracy ..... ±3% ±.1 V
Frequency range ..... 15 to 300 Hz
Input resistance ..... 2 MΩ
Test results ..... AC, DC voltage between wire a and wire b

Loop Resistance

Measuring range ..... 1Ω to 10 kΩ
Measuring mode ..... Repeated measurements
DC disturbing voltage compensation ..... Disabled
Accuracy (without disturbing voltages)
In % of test result ..... ±0.5 % ±0.2 Ω
Test results ..... Resistance between wire a and wire b

Insulation Resistance

Measuring range ..... 10 kΩ to 300 MΩ
Measuring mode ..... Repeated measurements
DC disturbing voltage compensation ..... Disabled
Measuring time ..... ~ 3 sec
Measuring voltage ..... 100 V
Accuracy (without disturbing voltages)
In % of test result ..... 20 %
Test results ..... Resistance between wire a and wire b

DC Current

Measuring range. ..... 5µA to 1A
Accuracy ..... ±0.5 % ± 0.1 µA

Capacitance

Measuring range ..... 10 nF to 2 µF
Measuring voltage ..... 11 Hz, 5 V
Accuracy ..... ±3% ±0.3 nF

4.3 DMM Measurements Test Sequences

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. ..... ±3% ±.1 V

Insulation resistance

Measuring range ..... 10kΩ to 300 MΩ
Measuring voltage ..... 100 V
Measuring time ..... ~3 x 20 sec
DC disturbing voltage compensation ..... Enabled
Test results ..... Resistance between: wire a and wire b (Rab)
wire a and GND, wire b joined to GND (RaE)
wire a and GND, wire b joined to GND (RbE)
Accuracy ..... 20 %

Capacitance

Measuring range ..... 10 to 2000 nF
Measuring voltage ..... 11 Hz, 100 V
Test results ..... Capacitance between: wire a and wire b (Cab)
wire a and GND, wire b joined to GND (CaE)
wire a and GND, wire b joined to GND (CbE
Accuracy ..... ±3% ±0.3 nF

Capacitive Balance

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

Automatic Quality Test

Insulation resistance
- Measuring range ..... 10kΩ to 1000 MΩ
- Measuring voltage ..... 100 V
- Measuring time ..... ~3 x 35 sec
- DC disturbing voltage compensation ..... Enabled
- Test results ..... Resistance between: wire a and wire b (Rab)
  wire a and GND, wire b joined to GND (RaE)
  wire a and GND, wire b joined to GND (RbE)

Accuracy
- 10 kΩ to 300 MΩ ..... 2 to 5 % ± 1kΩ
- Over 300 MΩ ..... 10 % ± 1MΩ

Capacitance
- Measuring range ..... 10 to 2000 nF
- Measuring voltage ..... 11 Hz, 100 V
- Test results ..... Capacitance between: wire a and wire b (Cab)
  wire a and GND, wire b joined to GND (CaE)
  wire a and GND, wire b joined to GND (CbE

Accuracy ..... ±2% ±0.2 nF

Capacitive Balance
- Measuring voltage ..... 11 Hz, 100 V
- Test results ..... Ca>Cb or Cb>Ca, Lx/L, unbalance %
- Resolution 1/1000
- Accuracy of Lx/L value ..... ±0.2%

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

Resistance difference
- Loop resistance range ..... 10Ω 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

Insulation
- Measuring range. ..... 10 kΩ to 300 MΩ
- 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 kΩ to 50MΩ ..... 5 % ±1kΩ
  - 50 MΩ to 100 MΩ ..... 10 %

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

Capacitance
- Measuring range ..... 10 to 2000 nF
- Measuring voltage ..... 11 Hz, 100 V
- Test results ..... Capacitance between: wire a and GND (Ca-E)
  wire b and GND (Cb-E)
- Accuracy ..... ±2% ±200 pF

Loop and wire resistance
- Measuring range. ..... 1Ω to 10 kΩ
- Test results ..... Loop resistance (Rl)
  Resistance of wire a (Ra)
  Resistance of wire b (Rb)
- Accuracy ca.1%

Warnings
- Events ..... Overloaded, Intermittent