

ELEKTRONIKA

ELQ 2+

xDSL LINE QUALIFIER

403-000-000

Operating Manual

OM-403-011-004E

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2011.04.29.

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1 INTRODUCTION

1.1 The Use of This Manual

This Operating Manual is intended to help the user in operating the ELQ 2+ explaining the operation rules. While following the instructions as given below, it is recommended to use the demo program found on the CD inside the back cover of this manual. Running the demo under WINDOWS will show you the front panel of the instrument with display and keyboard. By clicking with the mouse on the keyboard, the “virtual” ELQ 2+ will behave as the real instrument, helping the user to carry out complete measuring procedures, but of course only “virtually”.

1.2 Application

Numerous Digital Subscriber Line systems (xDSL) appeared on the market to fulfill the need of faster data transfer for fast Internet access, remote LAN access and interactive multimedia etc. The “x” in xDSL indicates the different kinds of subscriber line technologies using the conventional copper local loops for fast data transfer. The xDSL modems using higher frequencies can achieve higher data rate than the plain old telephone services (POTS) on the same cable pairs. The main benefit of xDSL is that, there is no cable installation cost. The maximal loop length and the achievable maximal data rate depend on the cable quality.

Before the installation of xDSL modems we must be sure that the quality of the cable pair is sufficient for the given system.

ELQ 2+Line Qualifier provides:

Measurement of all analogue parameters required for ADSL2+, ADSL2, ADSL, READSL, ADSL G.LITE, HDSL, SHDSL, ISDN etc. subscriber line qualification.

- Automatic test-programs producing immediate PASS/FAIL indication and detailed test results in graphic and numeric forms.
- Automatic achievable bit rate calculation for each xDSL system
- Program editor to create user programs with user defined system and cable parameters.
- PC interface for data transfer.
- Cable fault location with TDR
- Basic cable tests and fault location (with Bridge option)

2 MAIN FEATURES

2.1 Measuring Modes

The measuring modes of ELQ 2+ can be included into four groups:

- Single tests
- TDR tests
- Automatic tests
- Bridge tests (option)

Single Tests

The transmitted signal of DSL modem may suffer from impairments due to noises and the frequency dependence of principal characteristics. The data transfer capability of subscriber line depends on:

- Insertion loss
- Unbalance about the earth (LCL)
- Return loss
- Characteristic impedance
- Near-end cross talk
- Wideband noise
- Noise spectrum
- Impulse noise
- Micro interruption measurement (optional)

In this test group ELQ 2+ provides single manual measurements of these cable characteristics.

(Details in chapter 4 Single Manual Tests 4-1 and Annex.)

TDR measurements

- Test of a single pair (short, break, tap etc.)
- Location of cross talk point (NEXT)
- Comparison of two pairs
- Comparison with memory
- Long time measurement

(Details in chapter 6 TDR measurements 6-1)

Automatic Tests

In this test group ELQ 2+ provides automatic bi-directional measurement of principal characteristics of the subscriber line using two instruments. They are connected to the ends of the tested pair in MASTER-SLAVE arrangement. The two instruments communicate over the tested pairs.

- The Master initializes the measurements and collects the results.
- The Slave performs the measurements according to the Master's commands and sends back the results.

ELQ 2+ can be programmed as MASTER and SLAVE as well.

Numerous short and long standard programs are available containing pre-programmed system parameters and cable parameter limits.

User defined parameter sets can be easily created with the **PARAMETER SET EDITOR**.

(Details in chapter 5 Automatic Tests 5-1)

Measurements with the AC/DC Bridge option

- Loop resistance
- Resistance difference
- Insulation resistance
- Cable capacitance
- Cable temperature
- Disturbing AC and DC voltages
- Leakage location
- Break location

(Details in chapter 9 AC/DC Bridge (Built in panel option) 9-1)

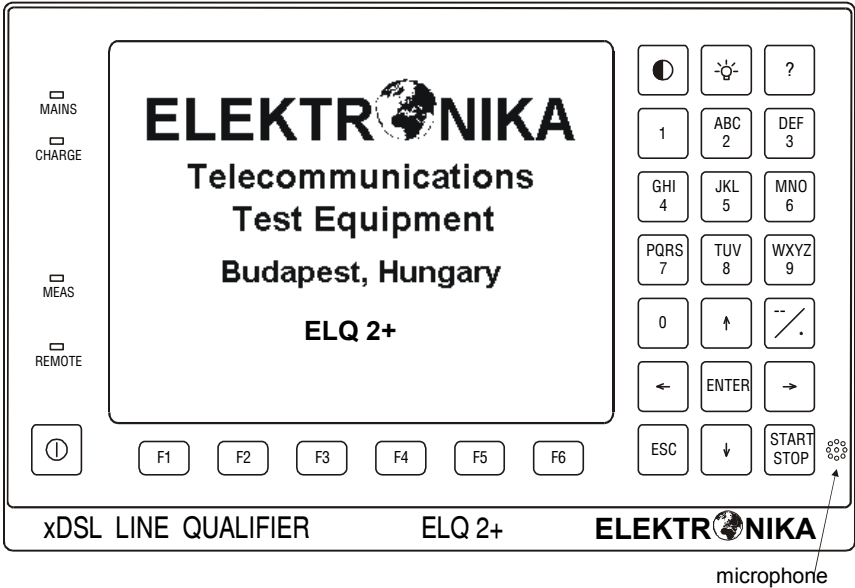
Power Sources

ELQ 2+ can be supplied from rechargeable internal NiMH batteries, which can be charged from 12V car batteries or mains using external AC adapter. The instrument is equipped with a processor controlled battery manager system providing:

- Battery charging level indication
- Initial charging mode
- Normal charging mode
- Fast charging mode
- Regenerating mode
- Protection against deep discharging













(Details in chapter 10 Battery Manager 10-1)

2.2 Keyboard and LEDs



Controls

	Switches the ELQ 2+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 8.)
 	The function of the six Function keys depends on the actual measuring mode.
	Starts or stops the selected measurement, program or process.
	This key is intended to acknowledge a selected measurement mode or a new parameter, or to carry out other changes.

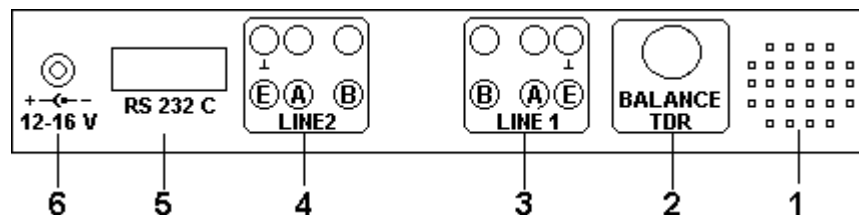
 	These keys are intended to select the required measuring mode or to change a parameter.
 	These keys are intended to select the required option and to adjust the position of vertical line cursor.
	By this key negative sign or decimal point can be added to a number
	This key can be used to cancel something.
	This key is intended to call the help function.
	This key can be used for LCD contrast adjustment.
	This key can be used for the control of back light.
	This key enters '0'.
	This key enters '1'.
	This key enters '2' or A B C letters when required.

DEF 3	This key enters '3' or D E F letters when required.
GHI 4	This key enters '4' or G H I letters when required.
JKL 5	This key enters '5' or J K L letters when required.
MNO 6	This key enters '6' or M N O letters when required.
PQRS 7	This key enters '7' or P Q R S letters when required.
TUV 8	This key enters '8' or T U V letters when required.
WXYZ 9	This key enters '9' or W X Y Z letters when required.

LEDs

<input type="checkbox"/> MAINS	Mains indicator
<input type="checkbox"/> CHARGE	Charge indicator
<input type="checkbox"/> MEAS	Measurement indicator
<input type="checkbox"/> REMOTE	Remote control indicator

2.3 Connectors & Measuring Cables



1	Speaker
2	TDR balance
3	3 pole CF socket for Line1 connection
4	3 pole CF socket for Line2 connection
5	9 way D connector for connecting a PC (V.24/RS232C)
6	2.1/5.5 mm coaxial connector for mains or 12V car adapter

Connector L1

This connector is used for **AUTOMATIC** and **SINGLE** measurements.

In case of automatic End-to-end measurements the two instruments (Master and Slave) communicate via Line L1. This line is used for service telephone connection and pair detection too.

Connector L 2

This connector is used for **BRIDGE** measurements, and the connection of the second pair at **AUTOMATIC** mode.

Measuring Cables

For the connection of the tested pair (pairs) two cables are provided with a 3pole plug on the first end and colored banana plugs on the other end.

The colors of banana plugs:

- Wire A → A terminal **RED**
- Wire B → B terminal **GREEN**
- Earth → E terminal **BLACK**

The way of connection depends on the selected measurement mode.

- In bridge modes a simple diagram is displayed, instructing the user how to connect ELQ 2+ to the cable. If applicable, the diagram shows the necessity of a strap on the far end of the cable and/or the grounding of the E terminal.

Warning: the instrument must not be grounded unless specifically required by the displayed connection diagram!

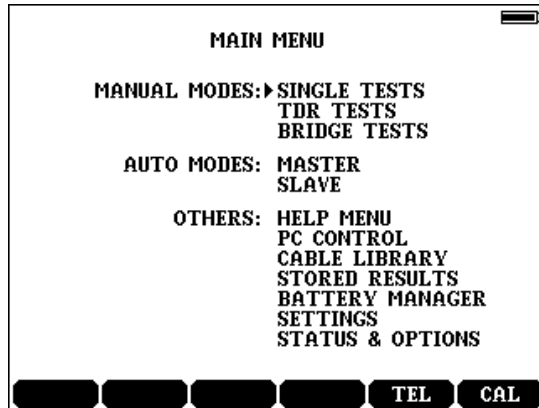
- In other test modes the cable connecting information appears when the ? key is pressed.

Note: at LCL measurement the E terminal should be grounded.

3 OPERATING INSTRUCTIONS

3.1 Start up and general rules

- Switch the instrument on.
- First the opening display appears showing the name and e-mail address of the manufacturer **ELEKTRONIKA**.
- After the percentage of the **BATTERY LEVEL** will be shown.
- 2 seconds later, self-test indication and the **MAIN MENU** appears.



The user should now either start the self-calibration program by pressing the **CAL (F6)** key or skip it. The choice depends on the accuracy requirement. Normally, no further self-calibration is required if the environmental conditions since the previous self-calibration are unchanged. This is allowed because the ELQ 2+ is a very stable instrument storing the self-calibration results. Note, however, that the specified accuracy can be guaranteed only after self-calibration.

(Details in chapter 12 Calibration 12-1)

Basically, the user should follow the instructions appearing at the bottom of each display in all measurement modes!

- In most cases, the measuring, setting and editing modes are selected by the menu-driven operation system. For selection use the vertical cursor keys and then press **ENTER**.
- The various cable and test parameters can be selected with the function keys: **F1 to F6**. To facilitate and speed up operation, some of the measuring modes can be selected directly with them too.
- To return back to the previous display, press **ESC**.

Measurements can be started or stopped with the **START/STOP** key.

3.2 Saving and Recall of Test Results

When a test is completed the result can be saved in each measuring mode under a user given object name. There are four identifiers of each stored results:

- **OBJECT** (user given name)
- **DATE** (automatically added)
- **TIME** (automatically added)
- **MODE** (automatically added)

The automatically added identifiers are very comfortable for the user, as the time is different for each test result, the same object name can be used repeatedly.

Note: The name of operator should be given in before starting a measurement. Enter **SETTINGS/OPERATOR'S NAME** and type the name in as it is usual at mobile phones. A text or a character can be deleted by the left cursor. A space can be placed by the right cursor. For the user's comfort test results are stored in groups according to the measuring modes:

- **AUTOMATIC TESTS**
- **SINGLE TESTS**
- **TDR TEST RESULTS**
- **BRIDGE TEST RESULTS**

Saving of test results:

Having the test finished:

- Press the **SAVE (F1)** key
- Type an object name and press **ENTER**

Recall of test results.

- Enter the **MAIN MENU/STORED RESULTS** option
- Enter the required group
- Select the required result and press **ENTER**

Deleting a test result

- Enter the **MAIN MENU/STORED RESULTS** option
- Enter the required group
- Select the result to be deleted and press **DELETE (F4)**
- If you are sure press **ENTER**

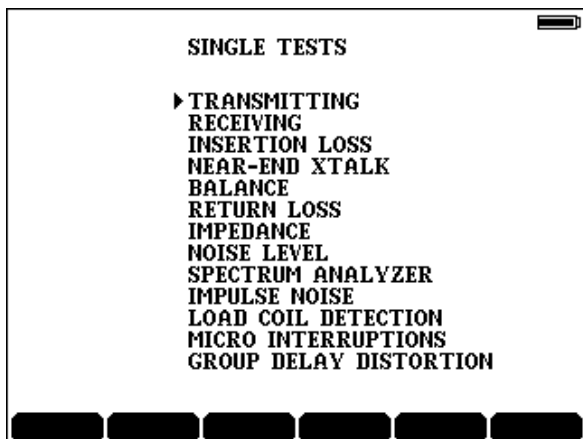
Deleting a complete group of test result

- Enter the **MAIN MENU/STORED RESULTS** option
- Enter the group to be deleted and press **EMPTY (F2)**

If you are sure press **ENTER** twice

4 SINGLE MANUAL TESTS

To call a manual measurement, enter the **SINGLE TESTS** option of **MAIN MENU**. Having the **ENTER** key pressed the following display appears:



4.1 Transmitting

Frequency range: 200 Hz to 2.2 MHz

Output impedances:

- 10kHz to 2.2 MHz 100, 120, 135, 150 Ohm
- 200Hz to 10kHz 600 Ohm

Two transmitting modes are provided:

- **1 FR** (generation of one single frequency)
- **10 FR** (generation of 10 frequencies at the same time)

Output level range:

- In **1 FR** mode: 0 to -24 dBm in 0.1 dB steps
- In **10 FR** mode the output level is fixed
 - 6 dBm / frequency for Z = 100, 120, 135, 150 Ohm
 - 12 dBm / frequency for Z = 600 Ohm

Test Procedure

- Enter **SINGLE TESTS/TRANSMITTING** mode.

1 FR mode settings:

- Press the **FREQ (F5)** key and enter the required frequency
- Press the **Z (F4)** key and enter the required impedance
- Press the **LEVEL (F1)** key and enter the required output level.

10 FR mode settings:

- Press the **10 FR (F6)** key.
- Press the **←FR→ (F5)** key and enter the required frequency range
- Press the **Z (F4)** key and enter the required impedance.

The output can be enabled or disabled with the **START/STOP** key.

4.2 Receiving

In this mode ELQ 2+ can be used as a selective level meter with auto ranging.

Frequency range: 200 Hz to 2.2 MHz

Input impedances:

- 10 kHz to 2.2 MHz 100, 120, 135, 150 Ohm
- 200 Hz to 10 kHz 600 Ohm
- 200 Hz to 2.2 MHz 20 kOhm || 50 pF

Two measuring modes are provided:

- **1 FR** (measurement on one single frequency)
- **10 FR** (measurement on 10 frequencies at the same time)

Test Procedure

- Enter **SINGLE TESTS/RECEIVING** mode
- Pressing the **HIGH/Z (F3)** key select the required line termination.

Note:

For the proper dBm calculation the nominal line impedance (Z) should be given even if **HIGH** input impedance is set.

1 FR mode settings:

- Press the **FREQ (F5)** and enter the required frequency.
- Press the **Z (F4)** key and enter the required impedance.

10 FR mode settings:

- Press the **10 FR (F6)** key.
- Press the **←FR→ (F5)** key and enter the required frequency range.
- Press the **Z (F4)** key and enter the required impedance

The measurement can be started or interrupted by the **START/STOP** key

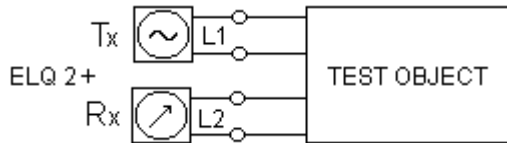
Test Results

Test results are available both in graphic and numeric forms

- In **1 FR** mode they are displayed together
- In **10 FR** mode the result is displayed first in graphic form but pressing the **LIST (F2)** key it appears in numeric form as well.

4.3 Insertion Loss Measurement

ELQ 2+ can be used as a generator and a tracking selective receiver by transmitting on L1 and receiving on L2.



Impedances:

- 10 kHz to 2.2 MHz 100, 120, 135, 150 Ohm
- 200 Hz to 10 kHz 600 Ohm

Two measuring modes are provided:

- **FIX FR.** (Transmitting and receiving on one single frequency)
- **SWEEP** (Sweeping on a selected frequency range)

The number of test frequencies in sweep mode:

- 200 Hz to 4 kHz range (with **10 HZ RESOLUTION** option) 380
- In other sweep ranges 50

Test Procedure

- Enter SINGLE TESTS/INSERTION LOSS mode

Fix frequency mode settings:

- Press the **FREQ (F5)** and enter the required frequency.
- Press the **Z (F4)** key and enter the required line impedance

Sweep mode settings:

- Press the **SWEEP (F6)** key.
- Press the **←FR→ (F5)** key and enter the required frequency range
- Press the **Z (F4)** key and enter the required line impedance.

The measurement can be started or stopped by the **START/STOP** key

Test Results

Test results are available both in graphic and numeric forms.

- In **FIX FR.** mode they are displayed together
- In **SWEEP** mode the result is displayed first in graphic form but pressing the **LIST (F2)** key it appears in numeric form as well.

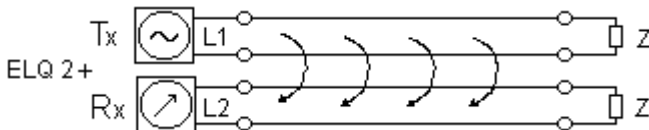
Note for the **10 HZ RESOLUTION** option:

In the 200Hz to 4 kHz sweep range the basic resolution of graphic display is 20 Hz. To change the horizontal resolution to 10 Hz around the cursor, press the **ZOOM (F3)** key.

4.4 Near End Cross Talk (NEXT) Measurement

Near-end cross talk (NEXT) is a major impairment for systems that share the same frequency band for upstream and downstream transmission. The most serious problem of two pair HDSL and primary rate ISDN systems is the noise caused by near-end cross talk between the pairs.

NEXT can be tested by transmitting on L1 and receiving on L2.



ELQ 2+ calculates the NEXT value as the ratio of transmitted and received powers. The higher the NEXT the better the cross talk.

In case the NEXT is out of limit it is very likely that the reason is split. The location of cross talk point can be found by TDR.

(Details in chapter TDR Tests)

Two measuring modes are provided:

- **FIX FR.** (Transmitting and receiving on one single frequency)
- **SWEEP** (Sweeping over a selected frequency range)

Test Procedure

- Enter **SINGLE TESTS/NEXT** mode

Fix frequency mode settings:

- Press the **FREQ (F5)** and enter the required frequency.
- Press the **Z (F4)** key and enter the required line impedance

Sweep mode settings:

- Press the **SWEEP (F6)** key.
- Press the **←FR→ (F5)** key and enter the required frequency range
- Press the **Z (F4)** key and enter the required line impedance.

The measurement can be started or stopped by the **START/STOP** key

Test Results

Test results are available both in graphic and numeric forms

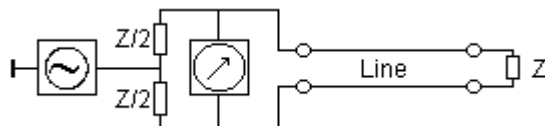
- In **FIX FR** mode they are displayed together
- In **SWEEP** mode the result is displayed first in graphic form but pressing the **LIST (F2)** key it appears in numeric form as well.

Note for the **10 HZ RESOLUTION** option:

In the 200Hz to 4 kHz sweep range the basic resolution of graphic display is 20 Hz. To change the horizontal resolution to 10 Hz around the cursor, press the **ZOOM (F3)** key.

4.5 Longitudinal Balance Measurement

Longitudinal currents can cause noises on the line if the balance is imperfect. Longitudinal balance ratio (LCL) reflects the ability of line to suppress the effects of longitudinal currents. (ITU-T Rec. 0.9). ELQ 2+ provides LCL measurement using the test circuit recommended by ITU-T.



$$LCL = 20 \log U_1/U_2 \text{ dB}$$

The better the balance of a cable pair the higher is LCL in dB.

Two measuring modes are provided:

- **FIX FR.** (Transmitting and receiving on one single frequency)
- **SWEEP** (Selected frequency range with 50 frequencies)

Frequency range: 200 Hz to 2.2 MHz

Impedances:

- 10 kHz to 2.2 MHz.....100, 120, 135, 150 Ohm
- 200 Hz to 10 kHz.....600 Ohm

Test Procedure

- Enter **SINGLE TESTS/BALANCE** mode

Fix frequency mode settings:

- Press the **FREQ (F5)** key and enter the required frequency
- Press the **Z (F4)** key and enter the required line impedance

Sweep mode settings:

- Select sweep mode by pressing the **SWEEP (F6)** key.
- Press the **←FR→ (F5)** key and enter the required frequency range.
- Press the **Z (F4)** key and enter the required line impedance

The measurement can be started or stopped by the **START/STOP** key.

Test Results

Test results are available both in graphic and numeric forms

- In **FIX FR.** mode they are displayed together
- In **SWEEP** mode the result is displayed first in graphic form but pressing the **LIST (F2)** key it appears in numeric form as well.

4.6 Return Loss Measurement

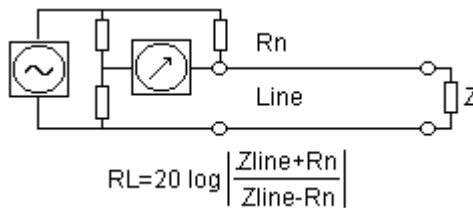
Return loss factor indicates the deviation of line impedance from the nominal value. ELQ 2+ performs a bridge measurement comparing the line impedance to an internal R_n normal resistor.

Frequency range: 200 Hz to 2.2 MHz

Available normal resistors:

- 10 kHz to 2.2 MHz.....100, 120, 135, 150 Ohm
- 200 Hz to 10 kHz.....600 Ohm

The return loss factor:



The closer the impedance of cable pair to the nominal value (R_n) the higher is the return loss in dB.

Two measuring modes are provided:

- **FIX FR.** (Transmitting and receiving on one single frequency)
- **SWEEP** (Selected frequency range with 50 frequencies)

Test Procedure

- Enter **SINGLE TESTS/RETURN LOSS** mode

Fix frequency mode settings:

- Press the **FREQ (F5)** key and enter the required frequency
- Press the **Z (F4)** key and enter the required line impedance

Sweep mode settings:

- Select sweep mode by pressing the **SWEEP (F6)** key
- Press the **←FR→ (F5)** key and enter the required frequency range
- Press the **Z (F4)** key and enter the required line impedance

The measurement can be started or stopped by the **START/STOP** key.

Test Results

Test results are available both in graphic and numeric forms.

- In **FIX FR.** mode they are displayed together
- In **SWEEP** mode the result is displayed first in graphic form but pressing the **LIST (F2)** key it appears in numeric form as well.

4.7 Impedance Measurement

In this mode the line impedance can be measured.

Frequency range: 200 Hz to 2.2 MHz

For the sake of better display resolution there are two measuring ranges:

- 400 Ohm range for the test of lines with a nominal impedance of 100, 120, 135 or 150 Ohm. (Test frequency ≥ 10 kHz).
- 1600 Ohm range for test objects with a nominal impedance of 600 Ohm (Test frequency < 10 kHz.)

Two measuring modes are provided:

- **FIX FR.** (Transmitting and receiving on one single frequency)
- **SWEEP** (Selected frequency range with 50 frequencies)

The impedance measuring range automatically changes from 400 Ohm to 1600 Ohm if:

- In fix frequency mode $f < 10$ kHz is entered or
- In sweep mode the 5 or 10 kHz range is selected.

Test Procedure

- Enter **SINGLE TESTS/IMPEDANCE** mode

Fix frequency mode settings:

- Press the **FREQ (F5)** key and enter the required frequency

Sweep mode settings:

- Select sweep mode by pressing the **SWEEP (F6)** key
- Press the **←FR→ (F5)** key and enter the required frequency range

To return to fix frequency mode press the **FIX FR.** key.

The measurement can be started or interrupted by the **START/STOP** key.

Test Results

Test results are available both in graphic and numeric forms.

- In **FIX FR.** mode they are displayed together
- In **SWEEP** mode the result is displayed first in graphic form but pressing the **LIST (F2)** key it appears in numeric form as well.

4.8 Wideband Noise Measurement

Noises reduce the data transfer capability of subscriber lines. The transmitted signal suffers from impairments due to noises. Noise on the telephone line normally occurs because of improper balance, cross talk and bad splices. The wideband noise can be characterized by power level (RMS value) and frequency spectrum. The received noise signal is named wideband noise when its peaks don't exceed the RMS value more than 12 dB ($U_{PEAK} < 4 U_{RMS}$)

Noise level measurement should be made using weighting filters specified in ITU-T recommendations. ELQ 2+ provides the following filters:

- P For POTS
- 1010 Hz Notch (with **10 HZ RESOLUTION** option)..... For VOICE
- E Filter For ISDN BRA
- G2-E Filter For ISDN PRA HDB3
- F-E Filter For HDSL, 2 PAIR, 2B1Q
- F1-E Filter For HDSL, 1 PAIR, 2B1Q
- G Filter For ADSL, DMT
- 3dB at fmin and fmax Filter For auto modes

The proper measurement time depends on the nature of noise. In case of a quasi stationer noise 1 to 5 sec is enough. If the noise level is slowly changing, a longer measurement time provides the proper test result.

Frequency spectrum gives useful information to find the origin of noise.

ELQ 2+ provides the following special noise spectrum analyzer mode:

- Frequency range 10 kHz to 2.2 MHz
- Frequency step 10 kHz
- Band width 15 kHz

As the bandwidth is larger than the frequency step no disturbing signal can remain hidden.

Test Procedure

- Enter **SINGLE TESTS/WIDEBAND NOISE** mode

Noise level measurement:

- Press the **TIME (F2)** key and enter the required measurement time
- Press the **FILTER (F5)** key and enter the required filter option
(The line impedance is automatically set with the filter)
- Press the **HIGH/Z (F3)** key and select the required termination
- When the **NONE** filter option is selected press the **Z (F4)** key and enter the required line impedance

The measurement can be started or stopped by the **START/STOP** key

Test results

The test results are available both in numeric and graphic forms.

Noise spectrum measurementTest Procedure

- To see the frequency spectrum press the **SPECTR (F6)** key
- Press the **INPUT (F3)** key and enter the required line termination
- Press the **Z (F4)** key and enter the required line impedance
- Press the **MODE (F5)** key and enter the required evaluation mode.

The bandwidth is higher than the frequency step so none of the noise components can remain hidden.

Three evaluation modes are provided:

- **NORM.** Measurement of the actual value of input signal
- **PEAK** Measurement of the peak value of input signal
- **AVG** Measurement of the average value of input signal

Measuring results

ELQ 2+ performs a sequence of repeated measurements.

Test results are available both in graphic and numeric forms, the default is graphic but pressing the **LIST (F2)** key the display changes to numeric form.

4.9 Spectrum Analyzer

In this mode ELQ 2+ can be used as a spectrum analyzer with the following receiver bandwidths:

Frequency range	Bandwidth	
	Zoom OFF	Zoom ON
10 to 2200 kHz	10 kHz	5 kHz
2.5 to 500 kHz	2.5 kHz	1.25 kHz
1 to 200 kHz	1 kHz	0.5 kHz
0.2 to 20 kHz	100 Hz	50 Hz
0.2 to 4 kHz***	20 Hz	10 Hz

****With **10 HZ RESOLUTION** option

Test Procedure

Enter **SINGLE TESTS/SPECTRUM ANALIZER** mode

- Press the **←FR→ (F5)** key and enter the required frequency range
- Press the **INPUT (F3)** key select the required line termination
- Press the **Z (F4)** key and enter the required line impedance

Note: For the proper dBm calculation the nominal line impedance (Z) should be given even if **HIGH** input impedance is set.

The measurement can be started or interrupted by the **START/STOP** key.

Three evaluation modes are provided:

- **NORM.** Measurement of the actual value of input signal
- **PEAK** Measurement of the peak value of input signal
- **AVG** Measurement of the average value of input signal

Settings when the measurement is running

- Press the **MODE (F4)** key select and enter the required evaluation mode
- Press the **F3** key to selected **dBm** or **dBm/Hz** evaluation
- Press the **ZOOM (F6)** key select and enter the required zoom value

Test results

The test results are displayed first in graphic form during the measurement. To get numeric form:

- Interrupt the measurement by the **STAR/STOP** key,
- Press the **LIST (F2)** key and the result appears in numeric form.

4.10 Impulse Noise Measurement

Impulse noise is a non-stationary cross talk from electromagnetic events in the vicinity of phone lines. Examples of impulse noise generators are as diverse as the opening of refrigerator door (the motor turns on/off), control voltages to elevators (phone lines in apartment buildings often run through the elevator shaft) and ringing of phones on lines sharing the same binder.

Any burst of noise that produces a voltage exceeding the power level of the background noise by more than 12dB is declared impulse noise.

In impulse noise-measuring mode ELQ 2+ operates as an impulse counter. An impulse is counted when the received noise signal exceeds a preset threshold for more than 500 ns. (The recommended threshold setting is 14 dB above the measured wideband noise level.)

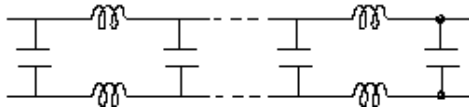
Test Procedure

- Enter **SINGLE TESTS/IMPULSE NOISE** mode
- Pressing the **HIGH/Z (F3)** key select the required line termination
- Press the **Z (F4)** key and enter the required line impedance
- Press the **TRESH (F5)** key and enter the required threshold level
- Press the **TIME (F2)** key and enter the required measurement time
- Start counting by the **START/STOP** key

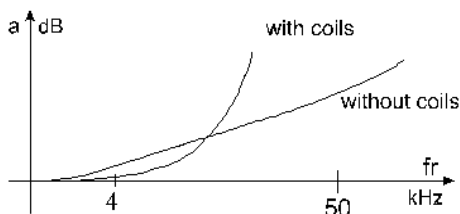
Note: For the proper dBm calculation the nominal line impedance (Z) should be given even if **HIGH** input impedance is set.

4.11 Load Coil Detection

It used to be a common practice to install load coils on long local loops. Load coils with cable capacitances form a low-pass filter improving the frequency response in the pass-band 0 to 4kHz.

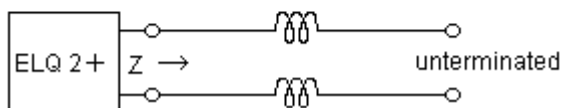
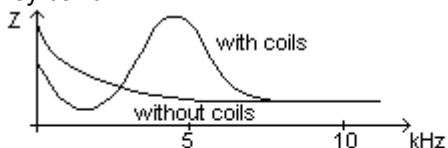


Over 4kHz the load coils cause high attenuation spoiling the frequency range of xDSL systems therefore all the coils must be removed.



The presence of load coils can be detected by impedance measurement.

Load coils make the monotone impedance characteristics waving in the voice frequency band.



Test Procedure

- Enter **SINGLE TESTS/LOAD COIL DETECTION** mode
- Be sure that the other end of the tested pair is open
- Start measurement pressing the **START/STOP** key
- Wait until the test is completed and the test result appears

Test Results

- **NO LOAD COIL DETECTED** indication appears if the impedance characteristic is monotone.
- **LOAD COIL DETECTED** indication appears if the impedance characteristic is waving.

5 AUTOMATIC TESTS

Test Procedure

5.1 Mode Selection

In automatic tests two instruments are used connected to the ends of the tested pair (pairs).

Warning! The instruments must be fitted with the same software. (Software version 4.40 or greater.)

On switching on the instrument, the software version number is visible on the screen for about 2 seconds: "**SOFTWARE VERSION: X.XX**"

The instruments may be shipped with a software version number lower than the required, in these cases the instruments must be upgraded from the supplied CD.

One of them should be programmed to **MASTER**, the other one to **SLAVE** mode. Mode selection is in the **MAIN MENU**.

5.2 Pair identification, service telephone.

Pair identification

SLAVE end.

Enter the **SLAVE** mode and connect the pair to be tested. While waiting for the master's commands the slave ELQ 2+ transmits a 400 Hz tone on the L1 connector for acoustic pair identification.

MASTER end.

Enter the **MASTER** mode and connect the pair to be tested to the L1 connector. To be sure that the proper line is connected switch the acoustic indication on by pressing the **TONE (F6)** key on the **MASTER MODE MENU** display. The 400 Hz tone indicates the proper connection. (The tone generation can be switched on and off from the master side by remote control using the **ON (F3)** or **OFF (F4)** key.)

Service telephone mode

ELQ 2+ is equipped with built-in microphone and loudspeaker providing half duplex telephone connection between the two ends of the line.

The service telephone mode can be reached from **MAIN MENU** or from the **MASTER MODE MENU** by pressing the **TEL (F5)** key.

- The **TEL (F5)** key switches the loudspeaker on and ELQ 2+ is waiting for a call from the other end of the line.
- To send a ringing tone, press the **RING (F4)** key.
- The user can talk when the **MIC (F6)** key is pressed.
(Then the microphone is active and the speaker is disabled)

5.3 System Selection

ELQ 2+ measures the analogue parameters of the line to be used for a specified xDSL system. The system and cable parameters, test frequency range, the tolerances and the test method depend on the specified system. As the parameters of the used systems are very different the system should be defined before measurement. During the automatic test sequence ELQ 2+ measures the analog parameters of the line and evaluates the test result according to the requirements of the defined system. In the **MASTER MODE MENU** the xDSL systems are included into groups:

- **STANDARD SYSTEMS** containing the system and cable parameters of the most popular standard xDSL systems.
- **USER DEFINED SYSTEMS** containing the non-standard system and cable parameters, which may be created according to the requirements of a new system or can be a modified version of a standard system. **PARAMETER SET EDITOR** is provided for creating or modifying a user defined system.

In addition an automatic **SYSTEM INDEPENDENT** measuring mode is provided for trouble shooting

The required system can be selected in two steps:

- System Group selection at the **MASTER MENU** (Fig. 5.1)
- System and data rate selection (Fig 5.2 and 5.3)

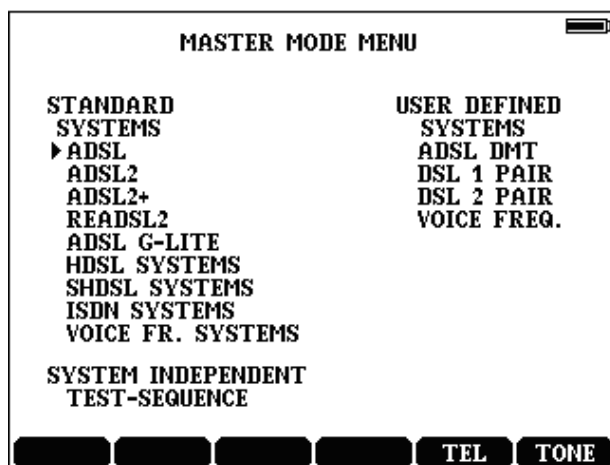


Fig. 5.1 (Select by ↑↓ and press ENTER)

Fig. 5.2 illustrates the selection of ITU-T G.991.2 SHDSL systems.

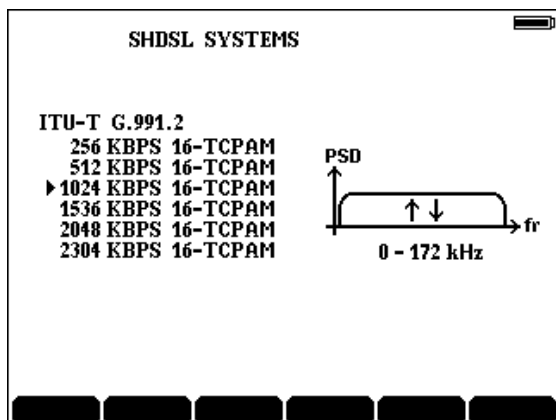


Fig. 5.2

- Select the data rate by $\uparrow\downarrow$ keys.
- Press **ENTER**

Fig. 5.3 illustrates the selection of ITU-T G.992.5 ADSL2+ systems.

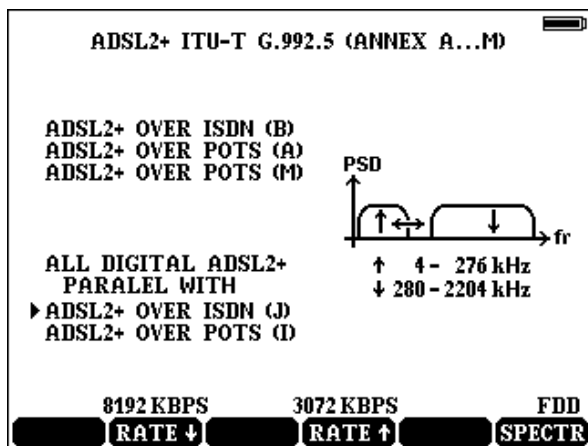


Fig. 5.3

- Select system and data rate with $\uparrow\downarrow$ and function keys.
- Press **ENTER**

Note: ITU-T G.992.5 Annex J and M allows the use of more upstream carriers for the sake of higher data rate. The number of upstream carriers can be changed with the **RATE** ↑ key.

Having the data rate and the system selected the **AUTOMATIC TEST PROGRAM** display appears. (Fig 5.4)

AUTOMATIC TEST PROGRAM			
SYSTEM: ADSL2+D #ADSL>ISDN FDD			
PROGRAM: STANDARD LONG			
TEST			L1
LOSS		✓	
NOISE	REMOTE	✓	
	CENTRAL	✓	
RET.L	REMOTE	✓	
	CENTRAL	✓	
IMPED.	REMOTE	✓	
	CENTRAL	✓	
BALANCE	REMOTE	✓	
	CENTRAL	✓	
MASTER AT REMOTE END			
<div> <div>DISCR.</div> <div>SHORT</div> <div>LONG</div> <div></div> <div>MASTER</div> <div>PARAM.</div> </div>			

SLAVE:
READY

Fig. 5.4

This display (as in case of all such programs) offers three automatic test options:

- **SHORT** test (loss and noise)
- **LONG** test (all the principal characteristics)
- **DISCRETE** test (one measurement selected by the user)

5.4 Preparing the Measurement

To prepare the automatic test the user has to select:

- One of the three automatic test options pressing the **DISCR. (F1)**, **SHORT (F2)** or **LONG (F3)** key.
- When the tested line is for an ADSL system the place of master ELQ 2+ should be declared by using the **MASTER (F5)** key.

5.5 Checking of system and cable parameters

Before running the test program the system and cable parameters of the selected system can be studied.

Pressing the **PARAM (F6)** key the table of **SYSTEM PARAMETERS** will be shown.

Fig 5.5 illustrates the main parameters of an 8/1 MBPS ADSL2+ D FDD system working parallel with an ADSL OVER POTS

SYSTEM PARAMETERS				
PARAMETERS		DOWN	UP	
TONES	n	65	1	Z LINE
	min kHz	280.3	4.3	100 Ohm
	n	255	32	
	max kHz	1099.7	138.0	FILTER
RATES	kbit/sec	8192	1024	SYSTEM
NOISE MARGIN		6.0	6.0	dB
MAX BITLOAD		15	12	n
CODING GAIN		4.5	4.5	dB
<div> <div></div> <div></div> <div></div> <div></div> <div>PAGE ↓</div> <div>PAGE ↑</div> </div>				

Fig. 5.5

- **n (min)** the multiplier of Δf subcarrier spacing, determining the lowest tone, of downstream and upstream
- **min kHz** the lower frequency limit of downstream and upstream band
- **n (max)** the multiplier of Δf subcarrier spacing, determining the highest tone of downstream and upstream
- **max kHz** the higher frequency limit of downstream and upstream band
- **RATES kbit/sec** the specified data rate (payload) in downstream and upstream band
- **NOISE MARGIN** the margin, which will be used to the calculation of the attainable data rate on the actually measured line
- **MAX BITLOAD** determined by the used ADSL system
- **CODING GAIN** when trellis coding is used
- **Z LINE** the nominal impedance of the line.

The **CABLE PARAMETERS** according to the above-mentioned standard are listed on the next page (See Fig. 5.6), which can be called in by pressing the **PAGE ↑** key. In this table the parameters of the standard test loop are given, which determines the template used as limit to the pass/fail decision.

CABLE PARAMETERS						
Nr.	kHz	LOSS	IMPEDANCE		REFL	LCL
		dB	Ohm		dB	dB
		MAX	MIN	MAX	MIN	MIN
<fmin						
1	4	20.8	98	450		40.0
96	414	39.8	60	450		40.0
204	879	53.5	60	162		40.0
300	1293	63.9	60	162		40.0
408	1759	74.4	60	162		40.0
511	2203	83.7	60	162		40.0
>fmax						
PAGE ↓						

Fig. 5.6

5.6 Running the Program

After selecting the test options the program can be started or aborted by the **START/STOP** key. Before starting or restarting the program be sure that the **SLAVE: READY** indication is on.

Important note: Before starting the program be sure that the Master and Slave instruments have the same software version !

5.7 Test Results

Short Form Test Result

When the test program is completed a **SHORT FORM TEST RESULT** page appears with immediate **PASS/FAIL** information and with the list of detailed result pages.

The reasons of fail indication are marked by asterisks. (See Fig. 5.7)

SHORT FORM TEST RESULT	
SYSTEM: ADSL >ISDN EC	
PROGRAM: STANDARD SHORT	
DATE: 30-07-2007 13:40	
QUALIFICATION: PASS	
CABLE LOSS	L1
NOISE AT R END	L1
NOISE AT C END	L1
S/N & BITRATE DOWN	L1
S/N & BITRATE UP	L1
SELECT BY CURSORS AND PRESS ENTER	
SAVE	PARAM.

Fig. 5.7

Detailed Result Pages

- Use the cursor keys to select the required result page
- Press **ENTER** (To return press **ESC**).

Selecting for example the marked **CABLE LOSS** result the display shown on the Fig. 5.8 appears. On this display the loss/frequency diagram and the template for pass/fail decision is shown. Moving the cursor line by the vertical arrow keys, the loss and frequency values belonging to the cursor position are displayed.

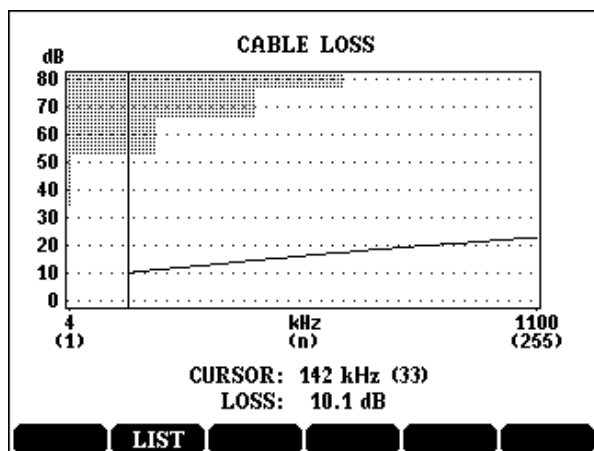


Fig. 5.8

Pressing the **LIST (F2)** key a table appears with the measured data

MASTER					
n	dB	n	dB	n	dB
33	-72.0	50	-68.6	67	-66.1
34	-71.0	51	-68.1	68	-66.9
35	-70.9	52	-68.7	69	-66.6
36	-70.4	53	-68.3	70	-66.1
37	-71.4	54	-68.7	71	-66.0
38	-70.1	55	-67.7	72	-66.7
39	-70.5	56	-67.4	73	-66.3
40	-70.2	57	-67.6	74	-66.0
41	-70.4	58	-68.1	75	-66.4
42	-70.9	59	-67.4	76	-65.9
43	-70.3	60	-66.7	77	-66.5
44	-69.1	61	-67.5	78	-66.5
45	-69.5	62	-67.0	79	-66.1
46	-69.1	63	-66.3	80	-65.8
47	-69.0	64	-66.9	81	-65.1
48	-68.2	65	-67.0	82	-66.1
49	-68.9	66	-66.4	83	-65.5

GRAPH. PAGE ↓

Fig. 5.9

Storage of test results

Test results can be saved under the name of the test object when the **SHORT FORM TEST RESULT** page is displayed.

- Press the **SAVE (F1)** key and type in the identifier of the object
- Press **ENTER** (Date, time and operator's name is automatically added)

Recall of Stored Results

The stored results can be recalled from the **MAIN MENU**.

Enter the **STORED RESULTS** option, and select one of the result groups by the cursor as it is shown on the display.

6 TDR MEASUREMENTS

6.1 Principles of Operation

ELQ 2+ 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.

ELQ 2+ 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

Measuring Modes

Investigation of a single pair (L 1 or L 2)

Transmission and reception of pulses takes place over the same terminal (L1 or L2). ELQ 2+ performs a sequence of repeated measurements. The last result is graphically displayed and the previous ones are cleared. (The most frequently used basic mode of operation)

Long time measurement of a single pair (L1 LT or L2 LT)

This measuring mode can be used to locate loose contacts. ELQ 2+ performs a sequence of repeated measurements in this mode as well but the results are not cleared. All the results are displayed together. If the features of the tested pair change during the measurement the waveform becomes thick at the place of change.

Location of cross talk points (XTALK)

The measuring pulse is transmitted via L1, and the reflected pulses are received via L2. This mode is typically used for locating splits.

Comparison between two pairs (L1&L2)

Two traces are simultaneously displayed. Even faultless pairs may produce reflections caused by joints or other inherent discontinuities. Comparing the faulty pair to a faultless one, reflections from faults and the regular reflections can be separated.

Comparison with memory (**L1&M**, **L1-M**)

L1&M. The actual trace and a stored one are displayed together.

L1-M The difference between them is displayed.

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

6.2 Settings before Measurement

Mode selection

- Enter **TDR TESTS MENU** and select the required measuring mode
- Press **ENTER**

Measuring range selection

- Press the **RANGE (F5)** key and select the measuring range covering the length of cable.
- Press **ENTER**

Velocity constant (V/2) setting

- Press the **F6** key and enter a new value or modify the actual one.
- Press **ENTER**

Automatic calculation is provided.

(For more details see chapter 6.5 Propagation Velocity 6-4)

6.3 Running a Test

Start

- Connect the cable to the appropriate terminals.
- Start the test by the **START/STOP** key and obtain a waveform.

Balance adjustment

- Adjust the rotary **BALANCE** control to minimize the transmit pulse (In XTALK mode the balance control is not effective.)

Gain adjustment

- To obtain suitable reflected pulse amplitude the gain should be
- Increased until compensates the cable attenuation. Press the
- **GAIN (F2)** key and set the suitable gain.
- Press **ENTER**

Setting the pulse width

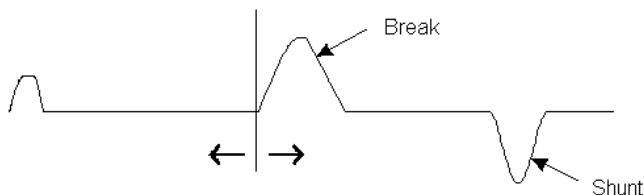
The pulse width is automatically changed with measuring range. In case of high cable attenuation, better reading may sometimes be obtained by using wider pulse. Therefore 3 pulse widths are provided for each range.

- Press the **PULSE (F3)** key and select the best pulse width.
- Press **ENTER**.

6.4 Waveform Evaluation

Reading distance to fault

After the measurement process is completed, move the vertical line cursor by the $\leftarrow \rightarrow$ keys 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.

Trace expansion (ZOOM)

The trace 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:

- Set the vertical cursor line to the critical point of waveform by the $\leftarrow \rightarrow$ keys.
- Press the **ZOOM (F4)** key and select the best zoom
- Press **ENTER**

Use of marker

The marker appears as a vertical dotted line and can be placed to any selected point of the waveform. Displayed are: the position of marker and the cursor, further the true distance from marker to cursor.

To measure the distance between any two points, the marker should be used as follows:

- Move the cursor to the waveform from which the distance is to be measured (e.g. reflection from a known point or from the change of the cable type), and set the marker by pressing **ENTER**.
- Move the cursor to the waveform to which the distance measurement is to be carried out.

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

6.5 Propagation Velocity

Propagation Velocity Units

ELQ 2+ calculates the distance to cable problem using the total travel time and the Propagation Velocity (V) of waves in the tested cable type.

V depends on insulating material, size, etc.

The following units are regularly used to characterize a cable:

- **Propagation Velocity (V)**
- **Half Propagation Velocity (V/2)**
- **Propagation Velocity Factor (PVF)**

By definition, the PVF is the propagation velocity of electromagnetic waves in the cable, divided by the velocity of light in free space.

The following table gives typical values for some insulating materials:

INSULATION	TYPICAL		
	V μs	V/2 μs	PVF
PVC	160	80	0.53
POLYETHYLENE	192	96	0.64
JELLY FILLED	200	100	0.67
PAPER (50nF/km)	216	108	0.72
PAPER (45nF/km)	264	132	0.88
LIGHT IN SPACE	300	150	1

The change of propagation velocity unit

- Press the **F6** key
- Press the required unit key: **F3** or **F4**
- Press **ENTER**

Setting the propagation velocity constant of cable.

- Press the **F6** key
- Type in the new value or press the **RECALL (F2)** key and select your cable from Cable Library
- Press **ENTER**

If the propagation velocity constant is not known ELQ 2+ provides automatic calculation methods to obtain it.

Automatic velocity constant calculation

The unknown 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
- Place the cursor to the start point of the pulse reflected from the known point.
- Press the **F6** key
- Press the **CURSOR (F5)** 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
- 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 **F6** key
- Press the **CUR-MAR (F6)** key
- Type in the known distance between the two points.
- By pressing the **ENTER** key, the proper value will be set automatically.

6.6 TDR application guide

6.6.1 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&L2 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.

6.6.2 Typical Waveforms

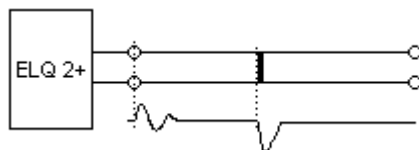
Open circuit (series faults)

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



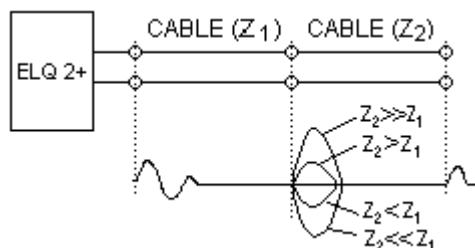
Short circuit (shunt fault)

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



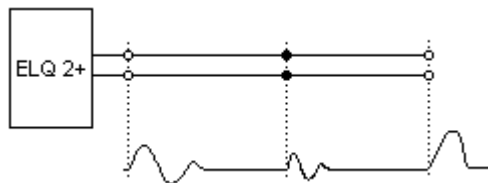
Change of cable type (mismatch)

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



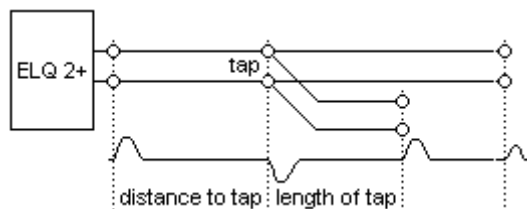
Joints (splices)

The joints produce 'S' shaped reflections.



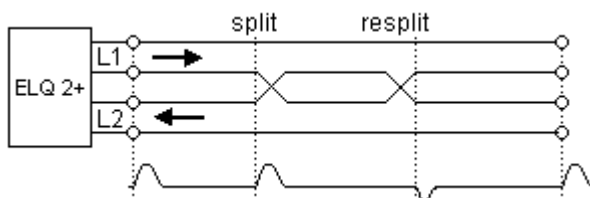
Taps (tee joints)

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, moving from tap to tap the test should be progressively done

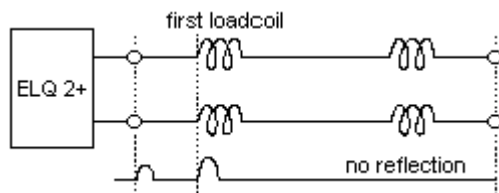
Splits and resplits



Splits and resplits produce cross talk.

Loading coils

Loading coils produce positive (upward going) reflections. Generally, TDR's cannot 'see' beyond the first loading coil. For fault location beyond the loading coil, the ETDR 10 should be connected to another point following the coil.



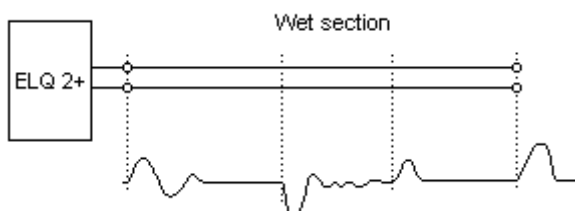
Capacitance network

The reflection is negative (downward going pulse).



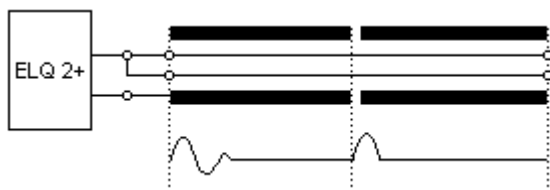
Wet section

The presence of water causes a capacitance increase. Therefore, there are two pulses: one from the beginning, the other from the end of the wet section.



Open sheath

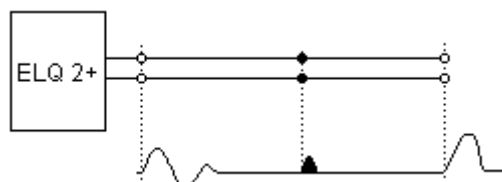
If the metallic sheath of the cable is broken, the position of the break can be located by connecting the test leads to the shield and to as many conductors as possible.



Lose Contacts

The location of lose contacts can be found with Long Time test.

If the features of the tested pair change during the measurement the waveform becomes thick at the place of change.



7 MICRO INTERRUPTION MEASUREMENT (SW OPTION)

7.1 Principles of Operation

A micro interruption is a temporary line interruption due to external mechanical action on the copper wires constituting the transmission path, for example, at a cable splice. Splices can be hand-made wire-to-wire junctions, and during cable life oxidation phenomena and mechanical vibrations can induce micro interruptions at these critical points.

The effect of a micro interruption on the transmission system can be a failure of the digital transmission link. In the presence of an interruption of specified maximum length the xDSL modem may reset.

ELQ 2+ Line Qualifier can be upgraded in order to measure micro interruptions. That option is a very useful tool for troubleshooting.

ELQ 2+ detects the micro interruptions according to the ITU O.62 recommendation using 2 kHz test tone. An interruption is detected when the level of the received test tone drops below a designated threshold for more than 0.3 ms.

The detected interruptions are divided into five categories by duration:

- 0.3 ms to 3 ms
- 3ms to 30 ms
- 30 ms to 300 ms
- 300 ms to 1min
- >1min

The threshold level is adjustable in steps to the values 3, 6, 10 and 20 dB below the normal test signal level. The measuring time is adjustable between 4 min and 72 hours.

ELQ 2+ provides detailed information about

- Number of interruptions divided into five categories.
- Relative duration of interruptions.
- Error seconds.
- Time distribution of interruptions in 240 time slots.

For the interruption measurement two ELQ 2+ s are necessary connected to the ends of the tested pair. One of them transmits a test tone the other one receives and evaluates it.

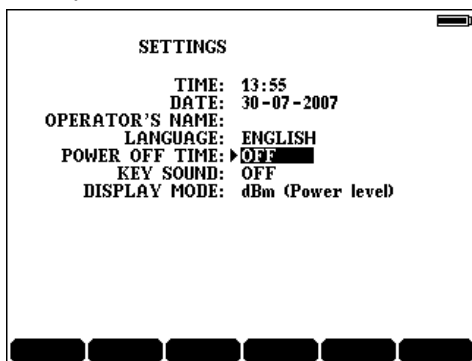
The measurement can be performed even if the test tone must be over the frequency range of basic rate ISDN (50 kHz). In this case the measuring frequency is 82 kHz.

7.2 Settings at the transmitter end

To save the battery life ELQ 2+ has a power down facility switching the instrument off after a preset time. Therefore in case long time interruption measurement ELQ 2+ should be used with mains adapter. If it is not possible then the power off function should be disabled before starting a long time test like interruption

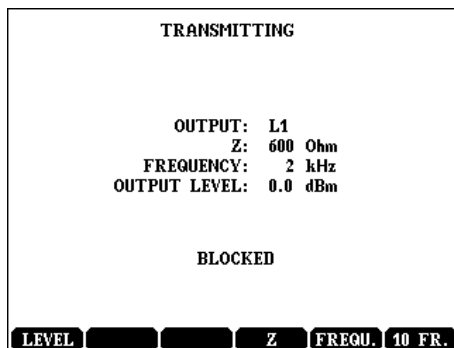
Disablement of power down function

- Enter the **SETTINGS & OPERATOR** mode
- Enter the **POWER OFF TIME** function
- Enter the **OFF** option



Measuring mode selection

Enter the **SINGLE TESTS / TRANSMITTING** mode and when the **TRANSMITTING** display appears set the frequency, level and output impedance.



Test tone frequency setting

Press the **FREQ. (F5)** key and enter 2 or 82 kHz

Output impedance for 2 kHz

In case 2 kHz test frequency 600 Ohm output impedance is set automatically.

Output impedance for 82 kHz

Press the **Z (F4)** key and select 100 Ohm output impedance by the vertical cursors and press **ENTER**.

Output level setting

Press the **LEVEL (F1)** key and set the needed level and press **ENTER**.

Having the settings finished start the transmitting by pressing the **START/STOP** key.

7.3 Settings at the receiver endMeasuring mode selection

Enter the **SINGLE TESTS / MICRO INTERRUPTION** mode and when the **MICRO INTERRUPTION** display appears set the time, frequency and threshold level.

MICRO INTERRUPTIONS	
LINE:	L1 600 Ohm
TEST SIGNAL:	2 kHz
MEAS. TIME:	4 min
TIME LEFT:	
REFERENCE LEVEL:	
THRESHOLD:	3 dB
CATEGORY	COUNT
0.3 ms - 3 ms:	
3 ms - 30 ms:	
30 ms - 300 ms:	
300 ms - 1 min:	
> 1 min:	
RELATIVE DURATION:	
ERRORED SEC:	
PRESS START	
TIME	THRESH FREQ

Measuring time setting

Press the **TIME (F4)** key and select the required measuring time by the vertical cursors and press **ENTER**.

Test tone frequency setting

Press the **FREQ (F6)** key and select the required test frequency by the vertical cursors and press **ENTER**. The input impedance is automatically set with the frequency. (600 Ohm for 2 kHz and 100 Ohm for 82 kHz)

Threshold level setting

Press the **THRESH (F5)** key and select the required threshold level by the vertical cursors and press **ENTER**. (20 dB only for 2 kHz test tone)

Having the settings finished start the measurement by pressing the **START/STOP** key.

7.4 Measuring process

The measuring process consists of two parts.

- First when the measurement is started ELQ 2+ measures the level of the received test tone and stores that value as **REFERENCE LEVEL** of the measurement.
- Having the **REFERENCE LEVEL** stored ELQ 2+ starts to count interruptions.

The following picture is displayed during and after the measurement keeping the user informed about the actual count of interruptions and the measuring time left:

MICRO INTERRUPTIONS	
LINE:	L1 600 Ohm
TEST SIGNAL:	2 kHz
MEAS. TIME:	4 min
TIME LEFT:	0:03:32
REFERENCE LEVEL:	-0.2 dBm
THRESHOLD:	3 dB
CATEGORY COUNT	
0.3 ms - 3 ms:	23
3 ms - 30 ms:	2
30 ms - 300 ms:	3
300 ms - 1 min:	1
> 1 min:	0
RELATIVE DURATION:	2.20E-01
ERRORED SEC:	22.2 %
<div> <div>SAVE</div> <div>LIST</div> <div>GRAPH.</div> <div>TIME</div> <div>THRESH</div> <div>FREQ</div> </div>	

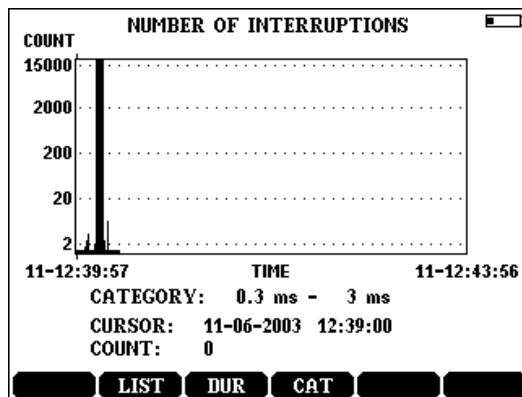
When the measurement is ready the user can get immediate information about the:

- Number of interruptions divided into five categories.
- Relative duration of interruptions.
- Error seconds.

In addition ELQ 2+ provides detailed information about the time distribution of interruptions. The measuring time is divided into 240 time slots.

Number of interruptions in a time slot

Pressing the **GRAPH (F3)** key the number of interruptions appears in graphic form. The displayed picture shows the time distribution for a selected category as a vertical bar graph.



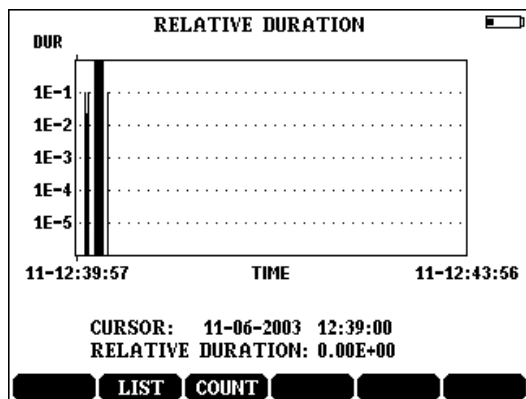
- To see the count of interruptions in a given time slot, use the horizontal cursors.
- To see the count of interruptions in numeric form, press the **LIST (F2)** key. The appearing list shows the count for each category and time slots together.
- To change the category, press the **CAT (F4)** key select the required category with the vertical cursors and press **ENTER**

TIME	NUMBER OF INTERRUPTIONS				
	0.3-3	3-30	30-300	300-1	>1min
11-12:39:57	0	0	0	0	0
11-12:39:58	0	0	0	0	0
11-12:39:59	0	0	0	0	0
11-12:40:00	0	0	0	0	0
11-12:40:01	0	0	0	0	0
11-12:40:02	1	0	1	0	0
11-12:40:03	3	2	0	0	0
11-12:40:04	5	0	1	0	0
11-12:40:05	0	0	0	0	0
11-12:40:06	0	0	0	0	0
11-12:40:07	0	0	0	0	0
11-12:40:08	2	0	0	1	0
11-12:40:09	-				
11-12:40:10	-				
11-12:40:11	-				
11-12:40:12	-				
11-12:40:13	-				
11-12:40:14	3	0	0	0	0
11-12:40:15	0	0	0	0	0
11-12:40:16	4	0	1	0	0

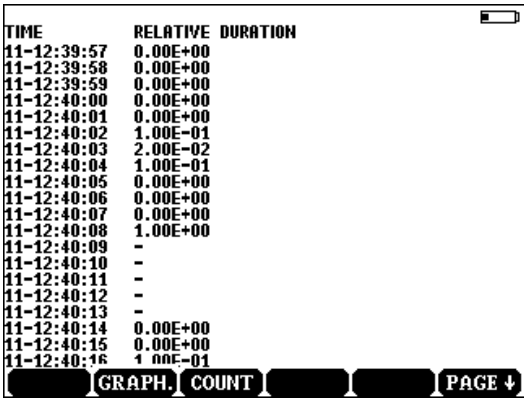
To return press **GRAPH (F2)**

Relative duration of interruptions in a time slot

Pressing the **DUR (F3)** key the test relative duration of interruptions appears in graphic form. The displayed picture shows the time distribution as a vertical bar graph.



- To see the relative duration in a given time slot, use the horizontal cursors.
- To see the relative duration of interruptions in numeric form, press the **LIST (F2)** key.



TIME	RELATIVE DURATION
11-12:39:57	0.00E+00
11-12:39:58	0.00E+00
11-12:39:59	0.00E+00
11-12:40:00	0.00E+00
11-12:40:01	0.00E+00
11-12:40:02	1.00E-01
11-12:40:03	2.00E-02
11-12:40:04	1.00E-01
11-12:40:05	0.00E+00
11-12:40:06	0.00E+00
11-12:40:07	0.00E+00
11-12:40:08	1.00E+00
11-12:40:09	-
11-12:40:10	-
11-12:40:11	-
11-12:40:12	-
11-12:40:13	-
11-12:40:14	0.00E+00
11-12:40:15	0.00E+00
11-12:40:16	1.00E-01

To return press **GRAPH (F2)**

7.5 Storage of test results

The measuring results can be stored by pressing the **SAVE (F1)** key when the short form test result picture is displayed. For the sake of economical utilization of memory the resolution of stored results depends on the count of interruptions as it is shown in the next table:

Count range	Resolution
0 to 15	1
15 to 20	5
20 to 150.....	10
150 to 200.....	50
200 to 1500.....	100
1500 to 2000.....	500
2000 to 15000	1000

8 GROUP DELAY DISTORTION MEASUREMENT (SW OPTION)

8.1 Introduction

ELQ 2+ applies the multi tone test method described in the recommendation ITU-T O.81 Appendix I (Earlier CCITT Blue Book Fascicle IV.4 Supplement No. 3.7)

Since 1981, instruments using multitone test signals have been used by various Administrations all over the world.

Measurement results are obtained quickly and unambiguously and are compatible with those obtained with conventional methods.

The user needs two ELQ 2+ instruments (Transmitter and receiver) for the group delay distortion measurement.

The group delay distortion measuring software SW 370-570-000 includes the serial number of the instrument to be upgraded with it.

When ordering that software to upgrade your ELQ 2 set please inform us about the serial number of the two instruments.

The upgrade software will be supplied in CD form. The CD contains all the necessary instructions for the upgrade process.

8.2 Operating instructions

The group delay distortion measurement can be managed by two ELQ 2+ instruments connected to the ends of the tested pair. One of them transmits a test tone the other one receives and evaluates it.

8.2.1 Settings at the transmitter end

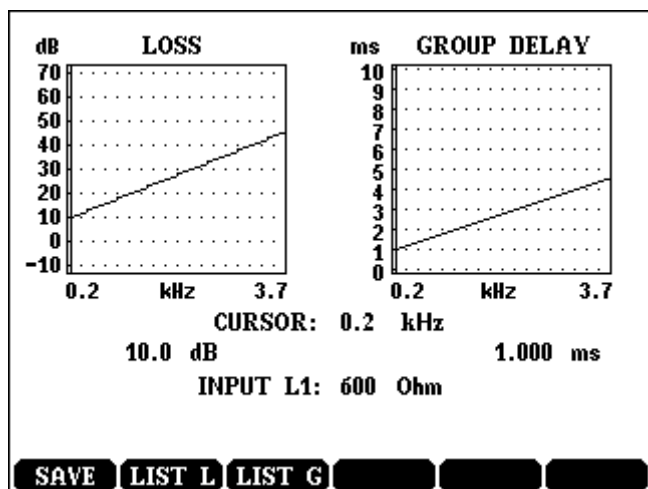
- Connect the tested line to the **L1** socket
- Enter **SINGLE TESTS/GROUP DELAY DISTORTION** mode
- Select the transmitter function by pressing the **F2** key.

Pressing **F2**, the impedance is set to 600 Ohm and the transmitter is switched on automatically.

8.2.2 Settings at the receiver end

- Connect the tested line to the **L1** socket
- Enter **SINGLE TESTS/GROUP DELAY DISTORTION** mode
- Select the receiver function by pressing the **F5** key.

Pressing **F5**, the impedance is set to 600 Ohm and the following display appears:



Test process

ELQ 2DT measures the loss and group delay distortion simultaneously. To start the measurement, press the **START/STOP** key.

Test Results

Test results are available both in graphic and numeric forms. The results are displayed first in graphic form.

- Pressing the **LIST L (F2)** the result of loss measurement appears in numeric form
- Pressing the **LIST G (F3)** the result of group delay distortion measurement appears in numeric form

The test results can be saved by pressing the **SAVE (F1)** key.

9 AC/DC BRIDGE (BUILT IN PANEL OPTION)

All test results can be saved. In order to save your test results do following:

- Having completed the measurement press the **SAVE (F1)** key
- Give in an identifier for the test results
- Press the **ENTER** key

In the menu system you can navigate to the saved results on the **MAIN MENU / STORED RESULTS / BRIDGE RESULTS** way. The results can also be uploaded to a PC.

9.1 Principles of Bridge Tests

ELQ 2+ in bridge mode is much more than a classical Wheatstone bridge: it is rather a special measuring network allowing flexible and versatile applications which would practically be impossible with conventional measuring bridges. This is explained by the fact that in the case of conventional measuring bridges, a single DC or AC generator is used for driving the network under test, and a single voltmeter is used to measure the network response to this driving signal. On the other hand, the structure of the ELQ 2+ allows the DC or AC driving signal to be applied at three junctions, even simultaneously, and to measure, even simultaneously by two meters, the currents in two suitably selected network branches.

The fault location methods of the ELQ 2+ can be applied in place of several well-known classical measurement methods. The equivalent methods are summarized in the following Table.

Fault location method of a classical bridge	Equivalent fault location method of the ELQ 2
Murray's method and Varley's method	Murray's method
Hector's method and Küpfmüller's method	Küpfmüller's method

9.2 Cable Parameter Measurements

9.2.1 Voltage Measurement

The purpose of the test is to measure DC and AC voltages between the two wires of a pair and between the pair and the ground.

Test Procedure

- Enter **BRIDGE TESTS/VOLTAGE** mode
Entering the **VOLTAGE** mode the measurement starts automatically. ELQ 2+ measures continuously until stopping the measurement by pressing the **START/STOP** key.
- Connect the cable wires to the ELQ 2+ as shown on the display.
- The test results can be stored by pressing the **SAVE (F1)** key only after having stopped the measurement.

Definitions

- **Differential mode voltage:** AC and DC Voltage ($V_{ab}=V_{a0}-V_{b0}$) measured between the two wires of the pair.
- **Common mode voltage:** AC and DC Voltage ($V_{com}=(V_{a0}+V_{b0})/2$) measured between the pair and ground.

Test Results

- V_{ab} differential mode DC voltage measured directly between both wires
- V_{a0} , V_{b0} DC voltages between each wire and the ground calculated from the differential mode and common mode DC voltages
- V_{ab} differential mode AC voltage measured directly between both wires
- V_{a0} , V_{b0} approximate values of the AC voltages between each wire and the ground calculated from the differential mode and common mode AC voltages
- V_{com} AC part of the common mode voltage
- **MAX. V_{com}** maximum value of the V_{com} AC common mode voltage

NOTE: The measurement will be periodically repeated every few seconds and the result display accordingly refreshed as long as the **START/STOP** key is again depressed.

If you want to measure the longitudinal voltages induced by traction power in a wire pair (V_{a0} , V_{b0}), then first you should connect both wires' far ends to the ground.

9.2.2 Insulation Resistance Measurement

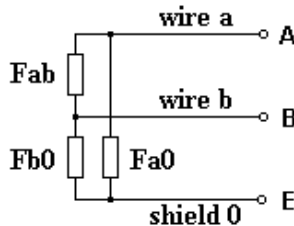
ELQ 2+ provides the measurement of insulation resistance between the two wires of a pair and between any of the wires and the ground. The measured insulation resistances are defined as follows:

$$R_{ins} = F_{ab} \parallel (F_{a0} + F_{b0})$$

$$R_{AE} = F_{a0} \parallel (F_{ab} + F_{b0})$$

$$R_{BE} = F_{b0} \parallel (F_{ab} + F_{a0})$$

F_{ab} , F_{a0} , F_{b0} are the so-called physical resistances. Regarding insulation resistances a pair of wires is like a delta connection of these physical resistors:



Between the wires **a** and **b** attached to the connectors **A** and **B** you can measure the insulation resistance R_{ins} i.e. the total resistance between the points **A** and **B** of the delta.

Test procedure

- Enter **BRIDGE TESTS / INSULATION RESISTANCE** mode
- Connect the wires to be measured and the shield of the cable to the ELQ 2+ as shown on the display.
- The far ends of the two wires under test are NOT to be shorted during the measurement!
- Start the measurement by pressing the **START/STOP** key.
- Before the whole measuring procedure and after measuring any individual parameter (R_{ins} , R_{AE} , R_{BE}) the cable will be discharged automatically. The end of the discharging process always has to be awaited i.e. during discharging the keys (except for the green ones) are inactive.
- You can stop the measuring procedure by pressing the **START/STOP** key.

- If you do not want to wait for the end of the measurement, you can jump to the measurement of the next insulation resistance immediately by pressing the **ENTER** key. In this case the displayed partial result will be kept as the result of the measurement. An “E” will appear indicating that the measurement of that parameter was accelerated by **ENTER**. The ELQ 2+ will start the discharging procedure and then the measuring of the next resistance. If there was no partial result yet, neither a result nor an “E” will appear.

WARNING!

If you force the ELQ 2+ to end the measurement immediately by pressing **ENTER**, the measured resistance value can be inaccurate. The accuracy given in the specification is only guaranteed if you wait until the measurement is fully completed without pressing the **ENTER** key.

- The discharging procedures CANNOT be interrupted or skipped by pressing the **START/STOP** or the **ENTER** key!

Test results

- Insulation resistance R_{ins} between the two wires of the pair,
- Insulation resistance R_{AE} between wire **a** and the ground (shield),
- Insulation resistance R_{BE} between wire **b** and the ground (shield).

Calculation of GOhm/km values if the cable length is known:

- Press the **LENGTH (F5)** key
- Enter the known length.

Instructions for use of filter EFF 51

Using the filter EFF 51 in most cases it is possible to measure insulation resistances even if there is a longitudinal voltage present in the cable. The EFF 51 has to be plugged into connector **L2**, the pair of wires and the shield of the cable (ground) has to be attached to EFF 51. EFF 51 is a passive filter also containing serial resistors. These resistors can decrease the accuracy of the measurement. In order to eliminate the effect of these resistors on the accuracy the user should switch on/off the filter mode manually by pressing the **FILTER (F3)** key. I.e. if you measure insulation resistances using EFF 51 then you should switch the filter on: in this case ELQ 2+ will display **“THE FILTER EFF 51 IS ON”** and the test results will be corrected automatically. If you measure without the EFF 51, you should switch the filter off (**“THE FILTER EFF 51 IS OFF”**), so the correction does not happen. Below the test results ELQ 2+ will tell you if the filter was switched on during the measurement.

NOTE

During the insulation resistance measurement NO wire may be attached to the **L1** connector or else the accuracy of the results will be degraded.

The filter EFF 51 may be used in the insulation resistance mode only.

9.2.3 Loop Resistance Measurement

Purpose of the test is to measure the loop resistance.

IMPORTANT NOTE

If your test leads have relative high resistances, i.e. the serial resistances of the test leads have a considerable effect on the result of the measurement, then it is recommended to do the "Bridge Cal. Of Test Leads" before the measurement. If you use the test leads ELQ 2+ had been shipped with, then in most cases you need not do this calibration. To do the calibration press the **CAL (F6)** key in the **MAIN MENU** and select **BRIDGE CAL OF TEST LEADS** in the appearing submenu. You can learn more about this calibration in chapter Calibration.

Test Procedure

- Enter **BRIDGE TESTS /LOOP RESISTANCE** mode
- Connect the two wires under test to ELQ 2+ as shown on the display
- During this measurement the far ends of the two wires under test must be strapped (i.e. shorted)!
- Start measurement pressing the **START/STOP** key.

Measured Test Results

- Loop resistance **R_L**

Calculation of cable length

For the correct calculation of the cable length (i.e. DTS = Distance To Strap) from the measured loop resistance (**R_L**) first the user should enter the temperature of the cable and the cable type:

- To enter the temperature of the cable press the **TEMP.(F3)** key, type in the temperature value and press **ENTER**.
- To enter the cable type either press the **CABLE (F4)** key, use the vertical arrow keys to select a cable and press **ENTER**, or press the **LIBRARY (F6)** key and recall a cable from the Cable Library. If there is no suitable cable in the list, then you can define a new cable in the Cable Library among the User-Defined Cu-Cables.

Note: the Multi-Section Cable cannot be used for calculation of length in this measurement!

Calculation of the cable parameters if the cable length is known

- Press the **LENGTH (F5)** key
- Enter the known cable length and press **ENTER**
- Now the calculated cable parameters appear on the display i.e. \varnothing -value (=gauge), m/Ω -value and Ω/m -value
- If the calculated \varnothing -value is inside the range 0.29 – 1.40 mm, then the device thinks it for sensible so you can store it in the Cable Library:
 - * Press the **STO CAB (F2)** key
 - * Select a free place for the new cable using the vertical arrow keys. If you select an occupied place, the old cable will be overwritten.
 - * Press the **STO CAB (F1)** key to store the cable (or press **ESC** to cancel the operation). If the selected place has already been occupied, the device asks you for confirmation before it overwrites the old \varnothing -, m/Ω - and Ω/m -values. Press the **YES (F1)** key to confirm the action or the **NO (F3)** key to cancel operation.
 - * A cable cannot be stored without a name. To enter a name (type) for the cable press the **TYPE (F2)** key, enter the name and press **ENTER**.
 - * If you know the wave velocity in the cable you can enter it pressing the **F6** key, typing in the value and pressing **ENTER**.
 - * Press **ENTER** to accept the new cable.
 - * Press the **ESC** key to return to the measurement.

9.2.4 Resistance 2 Wire & Ground Measurement

Purpose of the test is to measure both wire resistances of the pair and the resistance of the shield (ground) simultaneously.

IMPORTANT NOTE

If your test leads have relative high resistances, i.e. the serial resistances of the test leads have a considerable effect on the result of the measurement, then it is recommended to do the "Bridge Cal. Of Test Leads" before the measurement. If you use the test leads ELQ 2+ had been shipped with, then in most cases you need not do this calibration. To do the calibration press the **CAL (F6)** key in the **MAIN MENU** and select **BRIDGE CAL OF TEST LEADS** in the appearing submenu. You can learn more about this calibration in chapter Calibration.

Test Procedure

- Enter **BRIDGE TESTS / RESISTANCE 2WIRE&GROUND** mode
- Connect the two wires and the shield of the cable to ELQ 2+ as shown on the display
- During this measurement the far ends of the two wires must be strapped (i.e. shorted) and connected to the cable's shield (ground)!
- Start measurement pressing the **START/STOP** key.

Measured Test Results

- Wire resistances R_a , R_b
- Resistance of the shield (ground) R_0

Calculation of each wire's length

For the correct calculation of lengths (i.e. L_a , L_b) from the measured wire resistances first the user should enter the temperature of the cable and the cable type:

- To enter the temperature of the cable press the **TEMP.(F3)** key, type in the temperature value and press **ENTER**.
- To enter the cable type either press the **CABLE (F4)** key, use the vertical arrow keys to select a cable and press **ENTER**, or press the **LIBRARY (F6)** key and recall a cable from the Cable Library. If there is no suitable cable in the list, then you can define a new cable in the Cable Library among the User-Defined Cu-Cables.

Note: the Multi-Section Cable cannot be used for calculation of lengths in this measurement!

9.2.5 Search For Short Or Strap

Purpose of the test is to find the pair of wires that has a strap or is shorted (perhaps at its far end). It is a simple resistance measurement between two points.

Test Procedure

- Enter **BRIDGE TESTS / SEARCH FOR SHORT OR STRAP** mode
- Connect the two wires of the pair to ELQ 2+ as shown on the display
- You need not start this measurement and need not stop it either. It will be running until you exit it by the **ESC** key.
- If the resistance measured between the two points is smaller than about 10 kOhm, then you will hear a continuous buzzing sound.
- If you cannot find the short or strap, then try measuring the next pair of wires etc.
- In order to exit the measurement press the **ESC** key.

9.2.6 Resistance Difference Measurement

The purpose of the test is to measure the difference between the resistances of the two wires of a pair. The measurement is realised as a Murray-measurement.

IMPORTANT NOTE

If the difference to be measured is too small, i.e. the serial resistance of the test leads have a considerable effect on the result of the measurement, then it is recommended to do the Bridge Cal. Of Test Leads before the measurement. Even if you use the test leads that ELQ 2+ had been shipped with, you may have to do this calibration. To do the calibration press the **CAL (F6)** key in the **MAIN MENU** and select **BRIDGE CAL OF TEST LEADS** in the appearing submenu. You can learn more about this calibration in chapter Calibration.

Test procedure

- Enter **BRIDGE TESTS/RESISTANCE DIFFERENCE** mode
- Connect the two wires and the shield of the cable to ELQ 2+ as shown on the display
- During this measurement the far ends of the two wires must be strapped (i.e. shorted) and connected to the cable's shield (ground)!
- Start measurement pressing the **START/STOP** key.

Test Results

- $R_a + R_b$ loop resistance
- $R_a - R_b$ approximate value of the resistance difference

NOTE

This is calculated from the measured Lx/L value and the loop resistance. The Lx/L value has an accuracy of up to three decimal digits. So if you want to measure the small difference of high resistances, $R_a - R_b$ can be inaccurate. That is why we say approximate value.

- **Lx/L**: The measurement is realized as a Murray-measurement. The strap to the ground at the far end plays the role of the leakage. Lx/L has the same meaning as at the Murray-method fault location measurement.
- the resistance difference referring to the average wire resistance displayed in percent:

$$2 \bullet \frac{R_a - R_b}{R_a + R_b} = \frac{R_a - R_b}{\frac{R_a + R_b}{2}} = \frac{R_a - R_b}{\frac{R_s}{2}}$$

WARNING!

If any of the two wires has a leakage (i.e. the insulation resistance between wire and ground is less than about 1000 times the value of the loop resistance), then this measurement can be inaccurate!

9.2.7 Mutual Capacitance Measurement

The purpose of the test is to measure the mutual capacitance of a pair of wires.

Test procedure

- Enter **BRIDGE TESTS/MUTUAL CAPACITANCE** mode
- Connect the cable wires to the ELQ 2+ as shown on the display.
- During this measurement the far ends of the wires under test must not be shorted (strapped)!
- Start measurement pressing the **START/STOP** key.

Test Results

- **C_m** calculated mutual capacitance:
$$C_m = C_{ab} + \frac{C_{a0} \bullet C_{b0}}{C_{a0} + C_{b0}}$$
- **Ca_b** capacitance between both wires and its loss angle $\tan\delta$.
- **Ca₀** capacitance between wire **a** and ground and its loss angle $\tan\delta$
- **Cb₀** capacitance between wire **b** and ground and its loss angle $\tan\delta$

Calculation of nF/km value if the total cable length is known:

- Press the **LENGTH (F5)** key.
- Enter the known length.

Calculation of cable length if nF/km value is known:

- Press the **nF/km (F4)** key
- Enter the known nF/km.

9.2.8 Capacitive Unbalance Measurement

The purpose of the test is to measure the capacitive unbalance of a pair of wires. The measurement is realised as a “Break Without Leakage”-measurement.

Test procedure

- Enter **BRIDGE TESTS/CAPACITIVE UNBALANCE** mode
- Connect the cable wires to the ELQ 2+ as shown on the display.
- During this measurement the far ends of the wires under test **MUST NOT** be shorted (strapped)!
- Start measurement pressing the **START/STOP** key.

Test Results

- **Lx/L** has the same meaning as at the measurement “Break Without Leakage”, the unbalance will be calculated from this measured value
- the difference of the two capacitances (measured between wire **a** and the ground / wire **b** and the ground) referring to the average wire to ground capacitance displayed in percent:

$$2 \bullet \frac{C_{a0} - C_{b0}}{C_{a0} + C_{b0}} = \frac{C_{a0} - C_{b0}}{\frac{C_{a0} + C_{b0}}{2}}$$

9.2.9 Cable Temperature Measurement

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

Test Procedure

- Enter **BRIDGE TESTS/CABLE TEMPERATURE** mode.
- Plug the thermometer probe (supplied as an option) into ELQ 2+ 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 Results

- Cable Temperature T

ELQ 2+ is able to measure temperature within -20 Celsius and +60 Celsius.

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.

9.3 Fault Location Methods

The ELQ 2+ offers two methods for finding the location of leakage, which is due to the decreased insulation resistance between the wire and the shield.

- The first is the well-known **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 second method is an improved version of the well-known **Küpfmüller's method**. This method is applicable when the two wires of the pair have the same gauge (\varnothing), the same length, are made of the same material and both wires are leaky. The leakage resistances do not need to be higher than the loop resistance, but the insulation resistance between the two wires has to be at least 100 times the measured R_x resistance. (Explanation of R_x see below)

In order to get the correct location of the fault (i.e. DTF Distance To Fault) and to get the correct cable length (i.e. DTS Distance To Strap) based on the measured resistances, after the measurement the user should enter the actual temperature and parameters of the cable under test:

- To enter the temperature of the cable press the **TEMP.(F3)** key, type in the temperature value and press **ENTER**.
- To enter the cable type either press the **CABLE (F4)** key, use the vertical arrow keys to select a cable and press **ENTER**, or press the **LIBRARY (F6)** key and recall a cable from the Cable Library. If there is no suitable cable in the list, then you can define a new cable in the Cable Library among the User-Defined Cu-Cables.

Note: the Multi-Section Cable can also be used for calculation of DTF, DTS at the fault location measurements!

When the total length of a cable, i.e. the distance from the near end to the strap at the far end, is known (e.g. from a cable layout plan), the user can invert the calculation system of the ELQ 2+. This means that the user, instead of selecting the cable type and reading out the DTS, can enter the length of the cable, and the ELQ 2+ then calculates the DTF based only on the measured L_x/L value. This method of fault location provides improved accuracy.

To enter the cable length, do the following after the measurement:

- Press the **LENGTH (F5)** key.
- Type in the cable length and press **ENTER**.
- Now the calculated new DTF value appears on the display.
- If you want to enter a new cable length (correction), press the **LENGTH (F5)** key and enter the new value. You can repeat this as many times as you want to.
- If you want to return to the calculation system based on the measured resistances and selected cable type, press the **CABLE (F4)** key, select the cable type and press **ENTER**.

NOTE

If your test leads have relative high resistances, i.e. the serial resistance of the test leads have a considerable effect on the result of the measurement, then it is recommended to do the Bridge Cal. Of Test Leads before the measurement. If you use the test leads ELQ 2+ had been shipped with, then you need not do this calibration. To do the calibration press the **CAL (F6)** key in the **MAIN MENU** and select **BRIDGE CAL OF TEST LEADS** in the appearing submenu. You can learn more about this calibration in chapter Calibration.

9.3.1 MURRAY Method

The purpose of the test is to find the location of the wire-to-ground insulation fault. Note that this test is applicable when the two wires of the pair have the same resistances and only one of them is leaky. The ratio of the good wire insulation to the leaky wire insulation must be at least 1000.

Test procedure

- Enter **BRIDGE TESTS/FAULT LOCATION/MURRAY** mode.
- Connect the wires under test and the shield (ground) of the cable to ELQ 2+ as shown on the display.
- The far ends of the two wires must be strapped (shorted) during this measurement!
- Start measurement pressing the **START/STOP** key

Test Results

- Loop resistance R_L
- Wire resistance R_x of the faulty wire between the fault and the ELQ 2+
- The insulation resistance F between the faulty wire and the ground
- The relative distance Lx/L of the fault location

Parameter needed for calculation of the fault location

- Temperature
- Cable type

You can learn from chapter Fault Location Methods how to enter these parameters.

9.3.2 KÜPFMÜLLER Method

The purpose of the test is to find the location of the wire-to-ground insulation fault. This method is applicable when the two wires of the pair have the same resistances and both wires are leaky. The insulation resistance need not be higher than the loop resistance, but the insulation resistance between the two wires (R_{ins}) has to be at least 100 times the measured R_x resistance.

Test procedure

This procedure requires two measurements. During the first measurement, the far endings of the pair are open. During the second measurement they are interconnected.

- Enter **BRIDGE TESTS/FAULT LOCATION/KÜPFMÜLLER** mode.
- Connect the wires under test and the shield (ground) of the cable to ELQ 2+ as shown on the display.
- The far ends of the two wires must be open (must NOT be strapped/shorted) during the first measurement!
- Start the first measurement pressing the **START/STOP** key.
- When the first measurement is completed the far ends of the two wires should be strapped (shorted) as shown on the display! Short them together.
- Start the second measurement pressing the **START/STOP** key.
- When the second measurement is completed the test result appears.

Test Results

- Loop resistance R_L
- Wire resistance R_x of the faulty wire between the fault and the ELQ 2+
- The insulation resistances F_{a0} and F_{b0} between each wire and the ground
- The relative distance Lx/L of the fault location

Parameter needed for calculation of the fault location

- Temperature
- Cable type

You can learn from chapter Fault Location Methods how to enter these parameters.

9.3.3 Break Location

The procedure for finding the location of the break of a cable depends on the number of wires broken in the pair.

If both wires of a pair are broken then the break location can be found by measuring the capacitance of the faulty pair and of one of the faultless (good) pairs, as detailed in chapter Mutual Capacitance Measurement. After this measurement the relative distance of the break (Lx/L) can be calculated as

$$Lx / L = \frac{C_{faulty}}{C_{good}}$$

If only a single wire of a pair is broken then the procedure of finding the break location depends on whether it is a simple break, i.e. a break without leakage, or a break with leakage.

9.3.4 Break Without Leakage

The purpose of the test is to find the location of the break in a single wire of a pair.

Test procedure

- Enter **BRIDGE TESTS /FAULT LOCATION/BREAK WITHOUT LEAKAGE** mode.
- Connect the two wires of the pair under test and the shield (ground) of the cable to ELQ 2+ as shown on the display.
- The far ends of the two wires must be strapped (shorted) during this measurement!
- Start measurement pressing the **START/STOP** key.

Test Results

- **Lx/L** relative distance of the break.
- Measured **C_{a0}**, **C_{b0}** capacitances of the two wire parts (i.e. capacitance between wire and ground).

Calculation of distance to break when the total length is known:

- Press the **LENGTH (F5)** key
- Enter the known length.

9.3.5 Break With Leakage

The purpose of the test is to find the location of the break in a single wire of a pair when a simultaneous leakage is present.

Test procedure

- Enter **BRIDGE TESTS / FAULT LOCATION / BREAK WITH LEAKAGE** mode.
- Connect the two wires of the pair under test and the shield (ground) of the cable to ELQ 2+ as shown on the display.
- The far ends of the two wires must be strapped (shorted) during this measurement!
- Start measurement pressing the **START/STOP** key.

Test Results

- **Lx/L** relative distance of the break.
- Measured **C_{a0}**, **C_{b0}** capacitances of the two wire parts (i.e. capacitance between wire and ground).
- The insulation resistance **F_{a0}** between the wire **a** and ground,
- The insulation resistance **F_{b0}** between the wire **b** and ground.

Calculation of distance to break when the total length is known:

- Press the **LENGTH (F5)** key
- Enter the known length

10 BATTERY MANAGER

Battery Charging Modes

ELQ 2+ is equipped with a processor controlled automatic charger-discharger circuit providing the following functions:

- Battery capacity indication

Charging process control:

- Normal charging
- Fast charging
- Battery regeneration
- Battery initialization
- Protection against deep discharging

10.1 Battery Capacity Indication

The battery manager system continuously measures the battery state.

When ELQ 2+ is switched on battery information appears showing the actual state of battery in % form.

10.2 Normal charging

When the mains adapter is connected and the battery level sinks below 60% the automatic circuit starts normal charging with 0.1C (C is the nominal capacity of the built in battery)

When the full charge is reached the control system automatically stops charging and the **BATTERY LEVEL > 95 %** indication appears.

The **CHARGE** indicator LED is lighted while the charging is in progress. When full charge is reached, the charger is automatically switched off, and the **CHARGE** indicator LED goes out.

10.3 Fast charging

When **FAST CHARGING** or regenerative charging is selected in the **BATTERY MANAGER MENU** the battery is charged with a relatively high current (0.5C) for approx. 2 to 3 hours during which the instrument can't be used. In this mode after a short time the instrument is automatically switched off. If temperature of the battery exceeds the environment by 10°C the charging is automatically finished.

The blinking of **CHARGE** indicator LED indicates that the process is in progress.

When the charging is completed the charge indicator goes out, and the instrument stays switched off.

Switching the instrument on during the process:

- Information can be obtained about the current battery level and the charging time left.
- The process can be aborted by pressing the **ABORT (F3)** key.

10.4 Regenerating charge process

In this mode the battery is discharged and fast charged. The instrument can't be used during this process. To start regenerating process:

- Enter **BATTERY MANAGER**
- Select the **REGENERATING** option and press **ENTER**

In the first phase, discharging message is displayed. In the second phase, the instrument is automatically switched off, and the charge indicator LED is blinking.

The process can be interrupted by pressing the **ABORT (F3)** key.

10.5 Initial charging

The initialization is the first charging of battery. It is necessary when the **INITIAL CHARGING RECOMMENDED** warning appears (The same process is required when the battery is replaced.) The process can be started by the **START/STOP** key

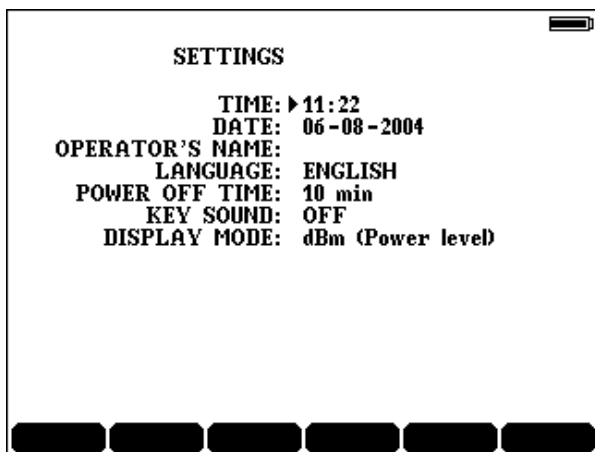
During the 2 to 3 hour process the battery state measuring system will be calibrated. The initial process can be skipped or interrupted but in these cases always the **BATTERY LEVEL IS UNKNOWN** battery charging level indication appears when the instrument is switched on. Therefore the skipping or interruption of the process is not recommended.

DO NOT CHARGE THE BATTERIES WHEN THE AMBIENT TEMPERATURE IS BELOW +5 °C OR OVER +45 °C.

11 SETTINGS, STATUS.

11.1 Settings

In setting mode some important parameters can be set:



Date and time can be typed in by the number keys.

The name of operator can be typed in like an SMS at mobile phones.

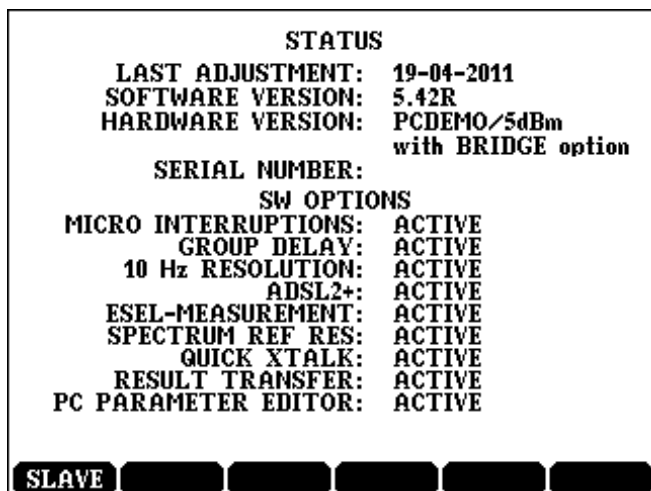
To change the other parameters:

- Select the parameter by the vertical cursors and press **ENTER**.
- Change parameter by the vertical cursors and press **ENTER**.

Note: In **SLAVE** mode the power off system is not active.

11.2 Status & options

STATUS & OPTIONS point of the **MAIN MENU** provides useful information:



In this mode the actual status of the instrument can be seen. The status includes the following parameters:

- Serial number
- Calibration date
- Hardware and software ID.

In case of "Master-Slave" measurements, the version number of the master and the slave instruments must be the same.

In case of PC transfer option the version number of the instrument and the PC program must be the same.

This screen shows the list of the activated software options.

If you order additional software options, please send the status data to Elektronika.

12 CALIBRATION

The accuracy given in Specifications is only valid for ELQ2+ if the device has been properly calibrated!

ELQ2+ has two calibration systems:

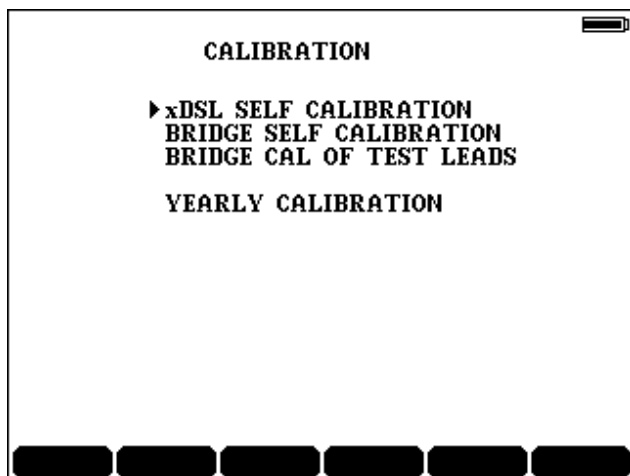
- Self Calibration
- Yearly Calibration

If the device has been shipped with bridge option, then there is also a 3rd calibration:

- Bridge Cal. of Test Leads

In order to do a calibration

- Press the **CAL (F6)** key in the **MAIN MENU**.
- Now the **CALIBRATION** menu appears:



- Select the calibration you want to do with the vertical cursor keys and press **ENTER**
- Follow the instructions appearing on the display regarding the wire connections
- Start the calibration by pressing the **START** key
- If you discover that there was any mistake during the calibration process (e.g. wrong cabling/wiring), then you should repeat the calibration under proper conditions!

The Self Calibrations do not have to be done before every measurement in order to measure accurately. They have to be done only if the ambient conditions have changed since last self calibration. The results of the last self calibration are stored in the device's memory also in switched off state if the battery is not discharged. There are following self calibrations in the device:

- **xDSL SELF CALIBRATION** is needed for all xDSL (and TDR) measurements.
- **BRIDGE SELF CALIBRATION** (only with bridge option) is needed for all bridge measurements. All test leads must be disconnected during this calibration! This calibration must not be interrupted!

The Bridge Cal. of Test Leads is important for the following bridge measurements only:

- Resistance Difference!
- Loop Resistance
- Resistance 2Wire&Ground
- fault location with Murray, Kupfmüller-methods

If the serial resistance of the test leads have a considerable effect on the result of the measurement, then it is recommended to do this calibration before the measurement. If you use the test leads that ELQ 2+ had been shipped with, then in most cases you need not do this calibration, but if you measure short wires or small resistances or small difference of high resistances, you also need to do this calibration even if you use the test leads that ELQ 2+ had been shipped with.

Without this calibration the program assumes all test lead resistances to be equal to 0 Ohm.

When doing this calibration you should connect to the device the three test leads only! The free „far“ ends of the three test leads are to be shorted.

If the sum of the three test lead resistances is greater than 4500 Ohm, then the device will take the measurement for invalid and set the values of all test lead resistances to 0 Ohm.

The result of this calibration will be valid only until you switch off the device. When you switch on the device all test lead resistance values will be reset to 0 Ohm.

Yearly calibration

According to the regulations of the user organizations calibration is obligatory in every year or every two years. The yearly calibration should be done by authorized persons. There are two levels of yearly calibration:

- First level: the authorized inspector is allowed to check the accuracy of the selected parameters, but he has no possibility to do adjustments.
- Second level: the authorized inspector has the right to modify the internal calibrating constants of ELQ 2+.

There are two code numbers belonging to the two levels.

- The first code number is: 123456
- The second one may be given to the authorized inspector of a service station, against an official statement undertaking the responsibility of adjustment.

To start the program, enter the **YEARLY CALIBRATION** option and type in the first code number.

(Details in Service Manual (SM 379-000-000))

13 PC PROGRAMS

13.1 Software Upgrade.(EL2u.exe)

The software of ELQ 2+ can be upgraded without disassembling the instrument. The new software version can be downloaded from a PC using the upgrade file made by the manufacturer. This file contains the description of the upgrade process.

13.2 Data Transfer program option (ELQ2c.exe)

The purpose of the program:

- Transfer of test results from ELQ 2+ to PC
- Transfer of test results from PC to ELQ 2+
- Creating test protocols in Excel-format.
- Creating printed test protocols in numeric and graphic form.
- Creating archives of test results saving them for the future.

13.3 Parameter Set Editor option (ELQ2e.exe)

Running this program user defined test parameter sets can be compiled and down loaded to ELQ 2+.

13.4 Demo Program (ELQ 2d.exe)

Running the demo program the front panel of the instrument with display and keyboard is shown. By clicking with the mouse on the keyboard, the “virtual” ELQ 2+ will behave as the real instrument, helping the user to carry out complete measuring procedures, but of course only virtually.

13.5 PC Control Mode

Select the **PC CONTROL** item of **MAIN MENU** and press **ENTER**.

Doing so ELQ 2+ is ready for PC control. To return to keyboard control, press the **ESC** key.

14 SPECIFICATIONS

14.1 General specifications

Power supply:

Internal rechargeable NIMH battery pack

Operation time approx. 8 hours
(Without backlight)

Charging (without taking the battery pack out)

From 230 V mains with mains adapter

From 12 V car battery with car adapter

Charging time less than 3 hours
(Fast charging mode)

Display 320 x 240 dot graphic LCD with backlight

Connectors

Serial interface RS232C

Line connectors 2 pcs of 3 pol CF sockets

Over voltage protection

For high impedance input 250 V DC

For terminated input/output 60 V DC

Ambient temperature ranges

Reference $23 \pm 5^{\circ}\text{C}$

Rel. humidity 45% to 75%

Normal operation 0 to $+40^{\circ}\text{C}$

Rel. humidity 30% to 75% * ($<25\text{g/m}^3$)

Limits of operation -5 to $+45^{\circ}\text{C}$

Rel. humidity 5% to 95% * ($<29\text{g/m}^3$)

Storage and transport -40 to $+70^{\circ}\text{C}$

Rel. humidity 5% to 95% * ($<29\text{g/m}^3$)

Dimensions $224 \times 160 \times 44$ mm

Weight (Including battery pack) approx. 1.5 kg

Memory Locations

38 locations for standard system templates

36 locations for user defined system templates

50 locations for single test results

28 locations for automatic test sequences

30 locations for TDR measurements

50 locations for Bridge or DMM option

100 locations for cable parameters

14.2 Single Manual Tests

Transmitter

Frequency range 200 Hz to 2.2 MHz

Impedances:

10 kHz to 2.2 MHz 100, 120, 135, 150 Ohm

200 Hz to 10 kHz 600 Ohm

Transmitting modes:

Generation of 1 single frequency

Generation of 10 frequencies at the same time

Single frequency mode

Frequency resolution:

200 Hz to 4 kHz (with **10 HZ RESOLUTION** option) 10 Hz

4 kHz to 10 kHz 100 Hz

10 kHz to 100 kHz 1 kHz

100 kHz to 2.2 MHz 10 kHz

Output level:

Level range +5 to -19 dBm

Resolution 0.1 dB

Accuracy at 0 dBm 0.3 dBm

10 frequency mode

Frequency raster 1, 5, 10, 20, 50, 100, 200 kHz steps

Frequency sets with **10 HZ RESOLUTION** option

Frequency set 1 300, 500, 1000, 1600, 2000 Hz

2200, 2500, 2800, 3000, 3400 Hz

Frequency set 2 300, 400, 500, 600, 1000 Hz

2000, 2500, 2800, 3000, 3600 Hz

Output level:

Z = 100, 120, 135, 150 Ohm -6 dBm / frequency

Z = 600 Ohm -12 dBm / frequency

Receiver

Frequency range.....200 Hz to 2.2MHz

Input Impedances:

10 kHz to 2.2 MHz 100, 120, 135, 150 Ohm

200 Hz to 10 kHz 600 Ohm

200 Hz to 2.2 MHz >20 kOhm || 50 pF

Input Level Range:

Z line=100, 120, 135, 150 Ohm -90 to +5 dBm

Z line=600 Ohm -90 to +0 dBm

Resolution 0.1 dB

Accuracy at 0 dBm ± 0.2 dB

Receiving modes:

Receiving of 1 single frequency

Receiving of 10 frequencies at the same time

Single frequency mode

Frequency resolution:

200Hz to 4 kHz with **10 HZ RESOLUTION** option..... 10 Hz

4 kHz to 10 kHz 100 Hz

10 kHz to 100 kHz 1 kHz

100 kHz to 2.2 MHz 10 kHz

10 frequency mode

Frequency raster..... 1, 5, 10, 20, 50, 100, 200 kHz steps

Frequency sets with **10 HZ RESOLUTION** option

Frequency set 1 300, 500, 1000, 1600, 2000 Hz

2200, 2500, 2800, 3000, 3400 Hz

Frequency set 2 300, 400, 500, 600, 1000 Hz

2000, 2500, 2800, 3000, 3600 Hz

LOSS, NEXT and FEXT Measurement

Frequency range.....200 Hz to 2.2 MHz

Line impedances:

10 kHz to 2.2 MHz 100, 120, 135, 150 Ohm

200 Hz to 10 kHz 600 Ohm

Measuring range..... 0 to 80 dB

Accuracy:

In frequency range 200 Hz to 1 MHz

LOSS, NEXT, FEXT <50 dB ± 0.5 dBLOSS, NEXT, FEXT <70 dB ± 1 dBLOSS, NEXT, FEXT >70 dB ± 1.5 dBIn frequency range 1 to 2.2 MHz ± 2 dB

LCL Balance Measurement

Frequency range	200 Hz to 2.2 MHz
Measuring range.....	0 to 40 dB
Line impedances:	
10 kHz to 2.2 MHz	100, 120, 135, 150 Ohm
200 Hz to 10 kHz	600 Ohm
Accuracy:	
10 kHz to 2.2 MHz	±2 dB

Return Loss Measurement

Frequency range	200 Hz to 2.2 MHz
Measuring range	
Return loss measurement.....	up to 40 dB
Impedance	Z/2 to 2Z
Line impedances:	
10 kHz to 2.2 MHz	100, 120, 135, 150 Ohm
200 Hz to 10 kHz	600 Ohm
Accuracy at 20 dB:	
10 kHz to 1 MHz	±1 dB
200 Hz to 2.2 MHz	±2.5 dB

Impedance Measurement

Frequency range.....	200 Hz to 2.2 MHz
Measuring range:	
200 Hz to 10 kHz	300 to 1600 Ohm
10 kHz to 2.2 MHz	up to 400 Ohm
Accuracy:	
10 kHz to 1 MHz	±5% ± 5 Ohm
0.2 kHz to 2.2 MHz	±10% ±5 Ohm

Wide Band Noise Measurement

Input Impedances:

10 kHz to 2.2 MHz	100, 120, 135, 150 Ohm
200 Hz to 10 kHz	600 Ohm
200 Hz to 2.2 MHz	>20 kOhm 50 pF

Noise Level Measurement

Weighting filters:

* P	For POTS
* 1010 Hz Notch (with 10 HZ RESOLUTION option)	For VOICE
* E Filter	For ISDN BRA
* G2-E Filter	For ISDN PRA HDB3
* F-E Filter	For HDSL, 2 PAIR, 2B1Q
* F1-E Filter	For HDSL, 1 PAIR, 2B1Q
* G Filter	For ADSL, DMT
* 3dB at fmin and fmax Filter	For auto modes

Measuring Range:

With P and E filter	0 to -80 dBm
With F and G filters	0 to -70 dBm
Without filter	0 to -65 dBm

Measurement times	1, 5, 10, 15, 30 s
	1, 5, 10, 15, 30 min

Noise Spectrum Measurement

Frequency range	10 kHz to 2.2 MHz
Frequency step	10 kHz
Band width	15 kHz

Spectrum Analyzer

Frequency range: 200 Hz to 2.2MHz

Input Impedances:

10 kHz to 2.2 MHz	100, 120, 135, 150 Ohm
200 Hz to 10 kHz	600 Ohm
200 Hz to 2.2 MHz	>20 kOhm 50 pF

Bandwidth: Zoom ON / OFF

10 ÷ 2100 kHz	5 / 10 kHz
2.5 ÷ 500 kHz	1.25 / 2.5 kHz
1 ÷ 200 kHz	0.5 / 1 kHz
0.2 ÷ 20 kHz	50 / 100 Hz
0.2 ÷ 4 kHz (with 10 HZ RESOLUTION option)	10 / 20 Hz

Evaluation Normal, Peak, Average

Impulse Noise Measurement

Input Impedances:	
10 kHz to 2.2 MHz	100, 120, 135, 150 Ohm
200 Hz to 10 kHz	600 Ohm
200 Hz to 2.2 MHz	>20 kOhm 50 pF
Pulse width	> 500 ns
Interval size	> 10 ms
Threshold range	0 to -60 dBm
Maximum count:	65000
Measurement times:	1, 5, 10, 15, 30 s; 1, 5, 10, 15, 30 min

14.3 Automatic Measurements

Preprogrammed Parameter Sets

ADSL2+ (ITU-T G.992.5 Annex A, B, I, J, M) (Option)

EC : 8 MBPS, 16 MBPS, 24 MBPS

FDD: 8 MBPS, 16 MBPS, 24 MBPS

ADSL2 (ITU-T G.992.3 Annex A, B, I, J, M)

EC : 4 MBPS, 6 MBPS, 8 MBPS

FDD: 4 MBPS, 6 MBPS, 8 MBPS

ADSL (ITU-T G.992.1 Annex A, B)

EC : 2 MBPS, 4 MBPS, 6 MBPS

FDD: 2 MBPS, 4 MBPS, 6 MBPS

ADSL (ETSI TS 101 388 v 1.3.1)

EC : 2 MBPS, 4 MBPS, 6 MBPS

FDD: 2 MBPS, 4 MBPS, 6 MBPS

READSL2 (ITU-T G.992.3 Annex L)

EC : 768 KBPS, 1 MBPS, 1.5 MBPS

FDD: 768 KBPS, 1 MBPS, 1.5 MBPS

ADSL G.LITE (ITU-T G.992.4 Annex A)

EC : 768 KBPS, 1 MBPS, 1.5 MBPS

FDD: 768 KBPS, 1 MBPS, 1.5 MBPS

ADSL G.LITE2 (ITU-T G.992.4 Annex I)

EC : 768 KBPS, 1 MBPS, 1.5 MBPS

FDD: 768 KBPS, 1 MBPS, 1.5 MBPS

HDSL (ITU-T G.991.1)

1 PAIR 2B1Q/CAP, 2 PAIR 2B1Q/CAP

SHDSL (ITU-T G.991.2 Annex B)

1 PAIR 16 TC PAM 256, 512, 1024, 2048, 2304 KBPS

2 PAIR 16 TC PAM 512, 1024, 2048, 4096, 4608 KBPS

SHDSL (ETSI TS 101 524 v 1.3.1 Annex E)

1 PAIR 16 UC PAM 512, 1024, 2048, 3848 KBPS

2 PAIR 16 UC PAM 1024, 2048, 4096, 7696 KBPS

1 PAIR 32 UC PAM 768, 1536, 3840, 5696 KBPS

2 PAIR 32 UC PAM 1536, 3072, 7680, 11392 KBPS

ITU-T VOICE FREQUENCY MODEMS

2.4 KBPS (V26), 56 KBPS (V92), Fax14.4 KBPS(V17)

ISDN

ITU-T G.962 Basic Rate, ETSI ETR 080 Primary Rate

14.4 TDR measurements

Measuring Modes

Single pair

Short time..... L1 or L2

Long time L1LT or L2LT

Pair comparison..... L1 & L2

Comparison to memory L1 & M, L1-M

XALK point location

Transmitting on L1

Receiving on L2

Measuring range up to 20 km (depends on cable)

Ranges..... 100m, 250m, 500m, 1km, 2.5km, 5km, 10km, 20km

Zoom..... 1 to 4

Gain range 0 to 72 dB

Gain regulation..... in 6 dB steps

Measuring pulse

Width..... 10 to 5000ns
automatically changed with range

Amplitude into 120 Ohm

For 25 to 5000 ns pulse ≈ 5 V

For 10 ns pulse ≈ 4 V

Propagation velocity

V..... 90 to 299m/ μ s

V/2..... 45 to 150 m/ μ s

PVF 0.3 to 0.999

Resolution $\pm 0.1\%$ of range

Accuracy $\pm 0.4\%$ of range

14.6 Group delay distortion measurement (SW option)

Transmitter

Test Signal

37MTT signal200 to 3700 Hz

Output level-30 dB/tone (-7dB peak)

Impedance

Z output 600 Ohm

Receiver

Impedance

Z input 600 Ohm

Group delay measurement

Frequency range200 to 3700 Hz

Resolution100 Hz

Group delay distortion range.....0 to 10 ms

Resolution 1 μ s

Input level range..... -60 to -20 dB/tone

AccuracyAccording to ITU.O.81 (4.1.1)

Loss measurement

Frequency range200 to 3700 Hz

Resolution100 Hz

Measuring range 10 to 40 dB

Resolution 0.1 dB

Accuracy ± 1 dB

14.7 AC/DC Bridge (Built in panel option)

Loop Resistance Measurement (RL)

Measuring range: up to 10 kOhm

Accuracy (RL>100 Ohm) $\pm 0.4\% \pm 0.1 \text{ Ohm}$

Resistance difference (ΔR)

Measuring range of RL: 1 Ohm to 5 kOhm

Measuring range of ΔR : up to 1 kOhm

Accuracy

1 Ohm to 10 Ohm $\pm 1\% \pm 0.1 \text{ Ohm}$

10 Ohm to 100 Ohm $\pm 1\% \text{ to } 0.2\% \pm 0.1 \text{ Ohm}$

100 Ohm to 1000 Ohm $\pm 0.2\% \pm 0.1 \text{ Ohm}$

Insulation Resistance Measurement

Measuring range: 10 kOhm to 10 GOhm

Accuracy

0.1 to 100 MOhm: $\pm 2\%$

100 MOhm to 1 GOhm: $\pm 10\%$

Capacitance Measurement

Measuring range: 1 nF to 10 μF

$\tan \delta$: 0.0001 to 10

Accuracy (10nF to 10 μF): $\pm 5\% \pm 1 \text{ digit}$

Measuring frequency: 11 Hz

Voltage Measurement

DC voltage: up to 100 V

AC voltage: up to 100 V_{RMS}

Frequency range: 15 to 300 Hz

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

Leakage Location

Measuring methods Murray, Küpfmüller

Loop resistance range (RL) 1 Ohm to 10 kOhm

Leakage resistance range (F) 0,1 to 100 MOhm

Accuracy of Lx/L (RL=2 kOhm, Lx/L=0.1 to 1)

F<1 MOhm $\pm 0.1\% \pm 1 \text{ digit}$

F=1 to 5 MOhm $\pm 0.2\% \pm 1 \text{ digit}$

F=5 to 25 MOhm $\pm 1\% \pm 1 \text{ digit}$

F=25 to 100 MOhm $\pm 5\% \pm 1 \text{ digit}$

Break Location

Measuring range up to 10 km (depending on cable)

Accuracy (C=20nF to 10 μF): $\pm 0.2\% \text{ to } \pm 1\% \pm 1 \text{ digit}$

Measuring frequency: 11 Hz

15 ORDERING INFORMATION

15.1 Basic Setup

	Ordering number	
	Elektronika	JDSU
xDSL LINE QUALIFIER ELQ 2+	403-000-000	EL403/000
Operating Manual	OM 403-011-004E	EL403/OME
Short form operation instructions	ML 403-000-000E	EL403/MLE
Set of measuring cables	403-800-000	EL403/MLS
Mains adapter	Y 146-025EU	EL146/025EU
Battery (built-in)	355-140-000A	EL355/140A
Carrying case	Y 147-014	EL147/014
Calibration Certificate	CC 403-000-000E	EL403/CCE
CD Disk with:	SW403-900-xxxE	EL403/SWE
• PC Software for data transfer between ELQ 2+ and PC	ELQ2Plus_c.exe	EL403/001
• Demo Software	ELQ2Plus_d.exe	EL401/003
Serial cable for connection to PC	Y 107-390	EL107/390

15.2 Options

	Ordering number	
	Elektronika	JDSU
PC software		
For parameter set edition	SW 403-520-000	EL 403/520
Measuring Software for ELQ 2+		
Micro interruption	SW 370-530-000	EL 370/530
Group delay distortion	SW 370-570-000	EL 370/570
10 Hz resolution	SW 403-550-000	EL 403/550
Spectrum as Reference	SW 403-630-000	EL 403/630
Quick XTALK	SW-403-640-000	EL 403/640
ESEL measurement	SW-403-600-000	EL 403/600
ESEL dependent templates	SW-403-610-000	EL 403/610
Others		
ER 20 Direction Coupler 4 - 2200 kHz	430-000-000	EL 430/000
Built in AC/DC bridge panel	355-300-000	EL 355/300
Cable for car battery connection EAA10	367-000-000	EL 367/000
Filter EFF 51	408-000-000	EL 408/000
High impedance probe	Y 107-395	EL 107/395
Calibration Report	CR 355-000-000E	EL 355/CRE
Service Manual	SM 370-000-000E	EL370/SME

Note:

The software options include the serial number of the instrument to be upgraded with them.

- When ordering a software to upgrade your ELQ 2+ please inform us about its serial number.
- In case ELQ 2+ is ordered with optional software(s) there is nothing to do for the user.

The upgrade software will be supplied in CD form. The CD contains all the necessary instructions for the upgrade process.