USER MANUAL

UMDT51A

LINE TESTER LT51
200 Hz – 2.2 MHz

H HEUER INSTRUMENTS PTY LTD

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WARRANTY

H Heuer Instruments Pty Ltd warrants that this product is free from defects in material and workmanship for a period of one (1) year from the date of shipment. Parts, accessories, product repairs and services are warranted for 90 days. This warranty extends only to the original buyer or end-user customer of a H Heuer Instruments authorised reseller, and shall not apply to any defect, failure or damage caused by improper use or improper or inadequate maintenance and care .

H Heuer Instruments Pty Ltd warrants that software will operate substantially in accordance with its functional specifications for 90 days and that it has been properly recorded on non-defective media. H Heuer Instruments Pty Ltd does not warrant that software will be error free or operate without interruption.

H Heuer Instruments' warranty obligation is limited, at H Heuer Instruments' option, to refund of the purchase price, free of charge repair, or replacement of a defective product which is returned to H Heuer Instruments within the warranty period.

To obtain warranty service, the customer must notify H Heuer Instruments of the defect before the expiration of the warranty period and make suitable arrangements for the performance of service. The customer shall be responsible for all costs (freight, customs, duties & taxes) associated with shipping the defective product to H Heuer Instruments in Sydney, Australia, and also return of the repaired product back to the customer, following the warranty service.

THIS WARRANTY IS BUYER'S SOLE AND EXCLUSIVE REMEDY AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. H HEUER INSTRUMENTS SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES OR LOSSES, INCLUDING LOSS OF DATA, ARISING FROM ANY CAUSE OR THEORY.

SAFETY WARNINGS

The LT51 Line Tester has been designed to meet the requirements of IEC 61010-1:2010 (Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use) and has been supplied in a safe condition. This User Manual contains some information and warnings which have to be followed by the user to ensure safe operation and to retain the instrument in a safe condition.

NOTE: The LT51 Tester is intended for use by qualified personnel only

- Use of this instrument in a manner not specified by these instructions may impair the safety protection provided.

- This instrument has been designed for indoor use in a Pollution Degree 2 environment in the temperature range 5°C to 40°C, 20% - 80% RH (non-condensing). Do not operate while condensation is present.

- Do not allow water to enter the instrument.

- The maximum input to Earth of any RTX (a, b, g) terminal is 60 V dc / 30 V rms / 42 V peak, and either TX (a, b) terminal is 60 V dc.

- Never connect the LT51 to an outdoor circuit during lightning storms.

- Disconnect all external cables before accessing the battery compartment.

- There are no operator-serviceable parts inside. Do not open the case.

- Should the LCD become damaged, the liquid crystal material can leak. Avoid all contact with this material, especially swallowing. Use soap and water to thoroughly wash all skin and clothing contaminated with the liquid crystal material.

- When using an AC-DC power source, use only the supplied AC-DC Adaptor / Charger to power or charge the LT51.

- Do not use the LT51 if it operates abnormally or is damaged. Protection may be impaired.

- When servicing the LT51, use specified replacement parts only.

- Refer to operating instructions for further explanation and precautions.

- This product is not intended to be used to measure mains voltages (CAT I, CAT II, III or IV) and should only be connected to powered circuits where over-voltage protection's have been incorporated.

The following international electrical symbols may be found on the LT51 and are used in this guide:

DANGER: Risk of electric shock.

ATTENTION: Refer to Manual

Equipment is protected by reinforced insulation to protect the user against electric shock.

Functional Earth (Ground) Terminal

Symbol for Waste Electrical and Electronic Equipment (WEEE) Recycling according to EU directive

Care and Maintenance

The LT51 is designed to be maintenance free. Treat it with care to ensure the best performance. The suggestions below will help you to fulfill the obligations of the warranty and enjoy the tester for many years.

- Avoid rough handling
  Although the LT51 is designed for use in a rugged environment, avoid dropping the tester. If you must ship the tester, use the supplied soft bag.

- Clean carefully
  The plastic casing for the LT51 has a finish that should retain its durability for many years. To clean the LT51, use a soft, slightly damp cloth. To remove any stains, use a mild soap. Never use detergents, solvents, or abrasive cleaners on the tester.

Battery

The LT51 uses three AA size Nickel Metal Hydride (NiMH) or Alkaline cells. Typical life of the NiMH cells is two years. Use Alkaline cells only when the NiMH cells are discharged and the AC adaptor is not available. Always replace Alkaline cells with NiMH when available.

Remove NiMH batteries if the LT51 is going to be stored without use for 6-months or more. Always remove Alkaline batteries from the LT51 during storage.

To change the cells:

1) Disconnect all cables from the LT51.
2) Turn battery tube cap ¼ way anti-clockwise using a screwdriver or coin to release (cells are under spring tension and may forcibly eject when the cap is removed).
3) Remove the old cells.

To install new cells:

1) Insert cells into battery tube observing the correct polarity (-ve end in first). The LT51 is protected against incorrect polarity insertion of the batteries.
2) Push and align the bayonets of the cap with the slots of the tube, then using a screwdriver or coin, turn ¼ clockwise to fasten.

CAUTION: Cells may explode, leak or catch fire if exposed to high temperatures or fire. Recycle or dispose of properly.

NOTE: NiMH batteries may be recycled.

DC Power Supply

An external DC power supply between 5 and 6 V supplying 1A can be connected to the LT51 for power during normal operations and to charge the NiMH Battery. The DC supply can be powered by a wall plug-pack from AC mains or an appropriately configured Car battery adaptor. Plug the DC cord into the LT51 DC connector.

NOTE: Use of the external charger for normal measurements will increase the noise floor of spectrum measurements.

Charging

The battery must be charged on a regular basis. You can typically use the LT51 for up to 8 hours between charges. The time between charges may be reduced if you use the backlight frequently, use large Tx output levels for extended time intervals, or if you work in very cold weather. Charging time is approximately 6 hours for 2100mAh cells. When the battery is charging, the Red charging LED illuminates. When charging is complete, the Red LED goes off, and the Green DC LED will illuminate*.*

WARNING: *Do not charge Alkaline cells, as there is no protection against accidental charging.*

Level of Charge

The battery icon in the upper right of every screen indicates the battery charge. Four black bars in the icon indicate full charge. Zero black bars indicate the battery is **very low** and should be charged immediately. A warning screen appears when there is a critical amount of charge left. Charging efficiency is best with a temperature between 10°C (50°F) and 30°C (86° F).

WARNING: *The batteries should only be charged when the battery indicator shows 2 or less black bars (preferably when only 1 bar is showing). Charging the batteries when 4 bars are showing may damage the batteries and the LT51.*

WARNING: ***Do not charge the batteries at temps below 0°C (32°F) or above 40°C (104° F).***

Supplied with the LT51

The LT51 is supplied with the following accessories:

- Soft Carry Bag
- 3 AA NiMH batteries
- DC Power Supply Adaptor / Charger
- User Manual
- 1.8m USB Cable

The 3 AA NiMH batteries are already installed in the LT51 (for international customers, the batteries have been shipped separately to the tester and need to be fitted). You may need to charge the battery before using the unit.

Service and Adjustment

Service and adjustment of the LT51 should be performed by trained H Heuer Instruments service personnel only.

If you experience a problem with the LT51, send an e-mail to info@heuer.com.au or call the following numbers to report a problem:

- Australia: +61-2-9871-8207

Visit our website for the latest list of phone numbers.

If the LT51 requires repair, service centre personnel will provide you with shipping information and repair prices. If the LT51 is covered under warranty, it will be promptly repaired or replaced (at H Heuer Instruments option) and returned to you, postage paid, at no charge. If the warranty has lapsed, H Heuer Instruments will repair the LT51 for a fixed fee and return it, postage paid, to you.

Environmental Protection

Do not dispose of this electronic instrument together with household waste material in observance of European Directive 2002/96/EC on waste electrical and electronic equipment (WEEE), and its implementation in accordance with national law. Electronic equipment that has reached its end of life, must be collected separately and returned to an environmentally compatible recycling facility.

H HEUER INSTRUMENTS Records	H Heuer Instruments Pty Ltd 766 Pennant Hills Road Carlingford NSW 2118 Australia ABN: 74 003 948 016

Declaration of Conformity

Supplier's Name: H Heuer Instruments Pty Ltd
Supplier's Address: 766 Pennant Hills Road
                         Carlingford NSW 2118
                         Australia

Declare under our own responsibility that:

Product Name: LT51 Line Tester
Product Type: Test and Measurement Equipment

to which this declaration refers, conforms with the following relevant standards:

IEC 61326-2-1:2005
IEC 61010-1:2010

According to the regulations in:

European EMC directive (2004/108/EC)
European LVD directive (2006/95/EC)

Place of Issuance: Carlingford, NSW
Date of Issuance: 17 September, 2012

Dirk Heuer:

Director

Table of Contents

1. Product description

The LT51 Line Tester is a portable handheld battery powered instrument. It combines the features of several pieces of test equipment such as a Selective Level Meter / Spectrum Analyser, Distortion Analyser, Oscillator, Handheld DMM and TDR in the one small lightweight package.

It is the ideal instrument for testing, preparing and commissioning copper pairs for many types of telecommunication services such as xDSL, ISDN, voice frequency POTS and testing the analog interfaces of digital exchanges and PCM multiplexers. The LT51 is also very well suited to testing the carrier and information signals used in Power Line Carrier Communication (PLCC) equipment.

The LT51 can be deployed as a stand-alone instrument in single-ending testing configurations to qualify cable pairs, or together with a second remote LT51, can perform more accurate terminated end-to-end testing. In stand-alone configurations (without PC control) testing can be automated with selected test sequences stored in the LT51. Alternatively the LT51 can be remotely controlled by a PC over the isolated USB link.

Common cable faults such as shorts, opens, poor splices, bridged taps, corrosion and X-Talk are easily located with the LT51.

Great care has been taken to achieve easy operation of this instrument. Most functions are accessed by a single button press, or one further soft-key selection. Measurement results can be displayed graphically or numerically (in DMM mode) and can be saved into non-volatile memory for later recall or up-load to a PC for further evaluation and printing.

Some of the features provided by the LT51 include:
- Selectable Impedance of 600 Ω, 150 Ω, 125 Ω, 75 Ω and bridging (~50 kΩ).
- Spectrum Analyser with Zoom function over spans from 4.5 kHz
- Selective Level Meter with 25Hz, 1.74 kHz and 3.1 kHz BWs and AFC.
- Psophometer for noise weighting or WIDE for no filter over selected span.
- Distortion Analyser from 200 Hz to 2.2 MHz (SNR, THD, SINAD, SFDR).
- Fully configurable Oscillator, up-to 2.2 MHz, -60 to +16 dBm.
- Return Loss up-to 2.2 MHz, 75, 125, 150, 600 Ω.
- Tx Mute, Single Tone or Swept measurements.
- DMM functions DC/AC Voltage, DC Current, AC Impedance Magnitude
- TDR for location and identification of low resistance or OC faults.
- Audio monitor (speaker) and Hands-free telephone for communication
- Strong compact PC case designed to withstand rough treatment yet lightweight (< 1 kg)
- High contrast, sunlight-readable graphics display with a back-light
- Large soft-touch keys with good feedback
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- Easy operation – one key press to set measurement then context sensitive soft-keys for configuration
- >8 hours operation with easily replaceable AA NiMH batteries
- Accepts commonly used 4mm banana plug test leads
- Choice of Graphical or Numerical measurement display
- Marker functions for navigating graphical displays using cursor.
- Remote control of LT51 by PC via serial port over opto-isolated USB link
- Easy test result storage and recall, up-load to PC for further evaluation.
- End-to-end testing utilising pair under test to second remote LT51 (dial-up or dedicated pair).
- Automated Self-test sequence.

2. Controls and connections
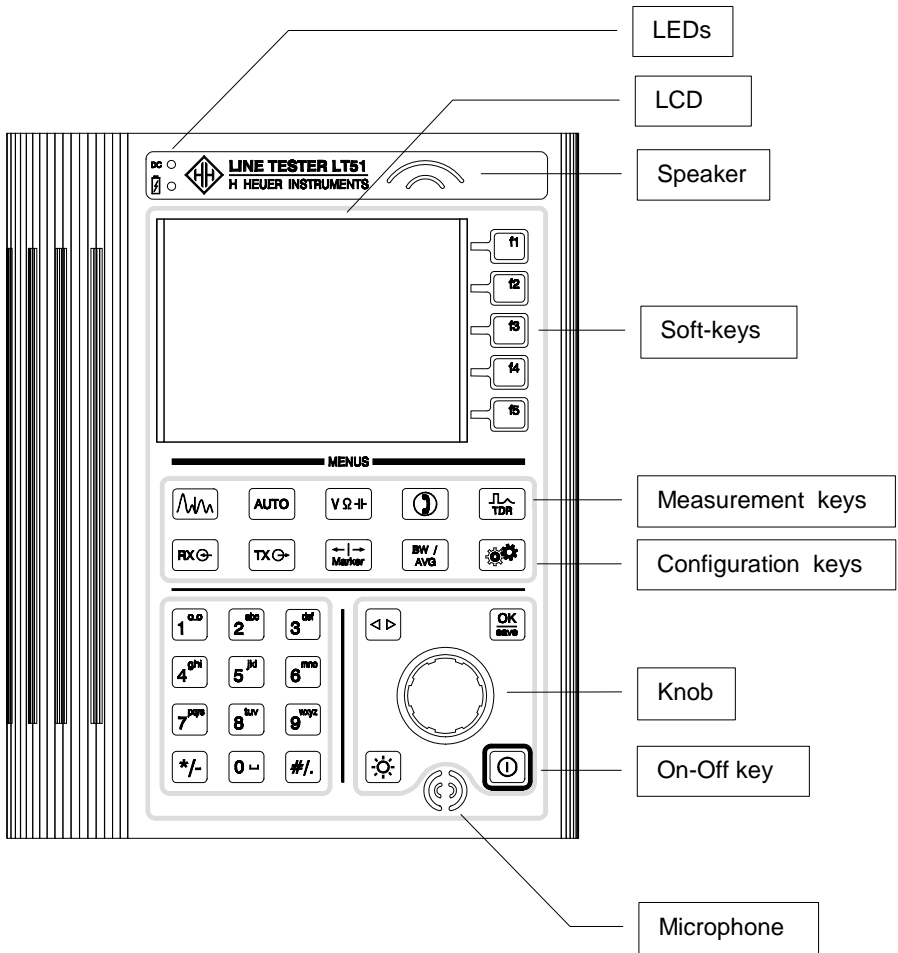
Figure 2-1. LT51 front panel

Welcome screen

This is the screen that you see when you first turn on the LT51. It shows the model name, installed options, serial number and software version.
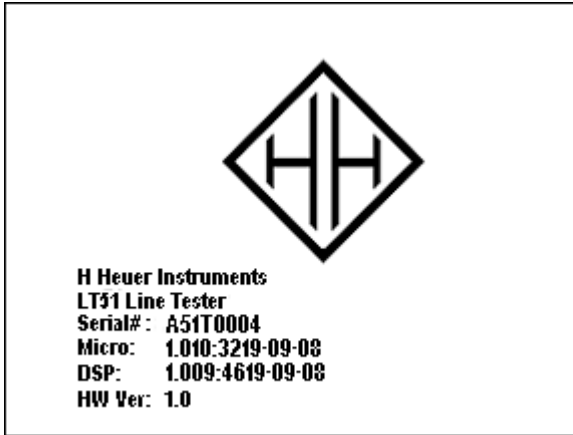
Figure 2-2. LT51 welcome screen

The welcome screen will automatically clear, when the LT51 has successfully started up.

If the screen does not clear, the LT51 tester has a problem. An incompatible version of firmware for the LT51 hardware, will cause the screen to hang and display an error message. Obtain the correct version of the firmware and download it now. Otherwise, the LT51 must be returned to H Heuer Instruments for service.

This screen can be accessed at any time by the following procedure:
• press the ⚙ key, followed by the [f1] "Saved Results" soft-key.
• press the [f4] "Show Splash" soft-key to display the splash screen.

The splash screen can only be cleared by:
• press the [f5] "Exit" soft-key.

LCD

The LT51 has a sunlight-readable, ¼-VGA (320 x 240 pixel), b&w graphic liquid crystal display. A low-power white LED array provides back-lighting to the LCD. The LCD consists of the following areas:
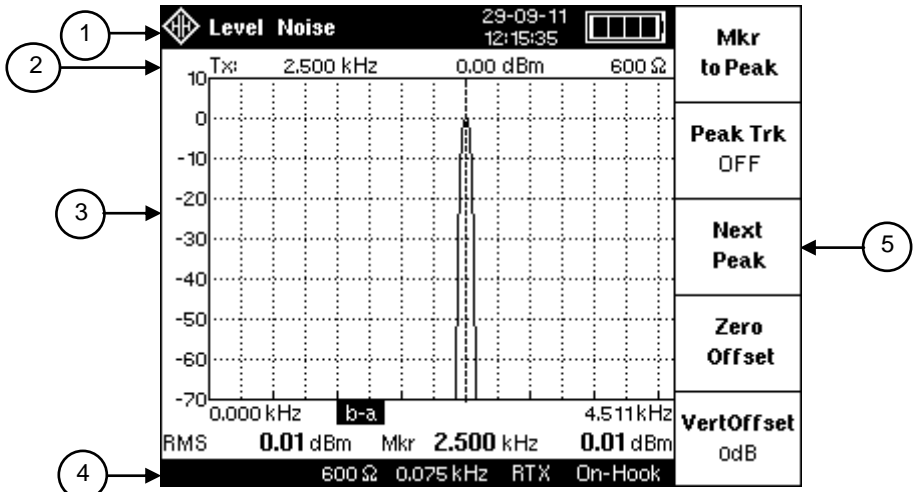
Figure 2-3. LT51 LCD

1	**Title Bar -** displays the current measurement type, RTC and battery information.
2	**TxStatus Bar -** displays the current transmitter settings, including frequency, level and Ztx.
3	**Results -** displays the test results in DMM, graphical format or as lists. The current marker position and value are displayed during graphical displays. The active RTX terminals, filter and range indication are also displayed.
4	**Configuration Bar -** displays averaging setting, Zrtx, Res BW, TX interface mode and hook status, or cable information during RFL.
5	**Five softkey labels -** These labels identify the screen-dependent function keys. To activate a function, press its softkey (f1,f2, f3, f4 or f5), which is located on the tester's keypad directly beside the label.

Table 2-1: LCD description

Keypad

The keypad is molded from silicone rubber and has 31 keys. The following tables describe the function of each key.

∧ᵢ∧ (graphical waveform icon)	Selects graphical / spectrum display mode (default: Level / Noise). Softkeys allow selection of various graphical measurements such as such as Level / Noise, Return Loss and Next / Loss.
AUTO	Initiates sequence to connect to remote LT51 tester (on RTXa-b terminals). Softkeys access Self-test sequence, and measurements that support end-end automatic testing with a remote LT51 such as Remote Loss, OS Balance, FEXT etc.
V Ω ⊣⊢	Selects numeric / DMM display mode (default: previous setting). Softkeys allow selection of various measurements such as Level/Noise, DCV/ACV, Return Loss, Impedance, Next / Loss.
☏ (telephone icon)	Causes the LT51 to go "off-hook" on the RTXa-b test leads and function as a telephone dial set. Hangs up (returns to "on-hook") when this key is pressed again.
⊓⌐ TDR	Perform a TDR measurement on the pair connected to the RTXa-b terminals.

Table 2-2. LT51 measurement keys

RX ⊖	Configure the LT51 receiver parameters at the RTXa-b terminals, such as Zrtx, terminated, HiZ, range setting and RTX (2-Wire) or TX-RX (4-Wire) interface
TX ⊖	Configure the LT51 transmitter parameters at the TXa-b terminals, such as Ztx, output level & frequency, OFF / ON mode, sweep mode
← ¦ → Marker	Controls operation of the marker during graphical display modes. Functions include peak tracking, setting offsets and vertical offset.
BW / AVG	Set the LT51 frequency span, centre frequency, BW, AFC and Averaging / peak hold.
○✿ (gears icon)	Access stored test results, configure measurement settings and display settings such as the RTC, and make adjustments to the LT51 stored calibration constants.

Table 2-3. LT51 configuration keys

⏻	Press and hold until the LT51 turns on. Press and release to turn off. When the LT51 appears stuck on, press and hold the key until LT51 turns off (~5s).
OK **save**	Clears currently displayed parameter entry box or message box. If no box is displayed, save the current measurement to the tester's non volatile memory
◁ ▷	During parameter entry, moves cursor right to next digit or wraps around if at end. If parameter entry is not active, displays current volume setting for speaker, or in TDR mode, enables vertical or horizontal zoom. Adjust by turning knob.
☼	Turns the LCD back-light on or off.

Table 2-4. LT51 control keys

f1 f2 f3 f4 f5	Five square numbered keys that are located directly beside the LCD. These are software-defined keys (called "soft-keys") that carry out commands related to the currently displayed screen. To locate the function of a key, look on the LCD directly beside the key.

Table 2-5. Soft-keys

1 ᴏᴏ 2 abc 3 def 4 ghi 5 jkl 6 mno 7 pqrs 8 tuv 9 wxyz */- 0 ⌴ #/.	Provide a 12-key telephone pad so that you can enter numbers, the asterisk (*), and pound sign (#). In the correct context (such as entering a Save string ID), alphabetic characters can be selected using the multi-tap protocol for keys, widely used when sending an SMS on a mobile phone. Eg. to enter "debug1": • Press "3" once for 'd' • Wait 1s, then press "3" twice for 'e' • Press "2" twice for 'b' • Press "8" twice for 'u' • Press "4" once for 'g' • Press "1" repeatedly until '1' appears • Press OK to enter text To select the 's' character, you would press the '7' digit 4 times in quick succession. After a 1 second delay the next character can be entered in a similar way.

Table 2-6. Alphanumeric keys

Test lead connectors
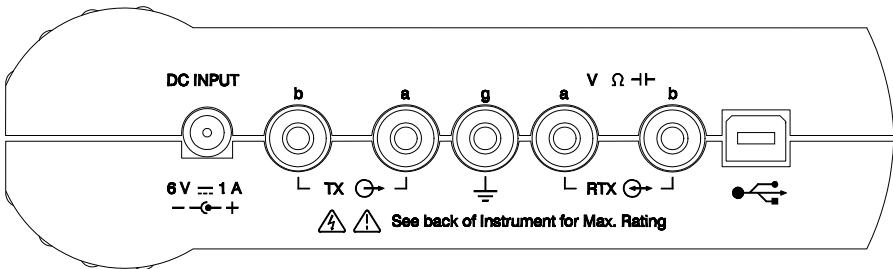
Figure 2-4. LT51 top panel connectors

The top connector panel has five 4 mm safety test lead connectors. These connectors are color-coded for easy identification. The test lead connectors are identified in Figure 2-4 as follows:

- RTX 'a' (black) and 'b' (red)
  The RTXa-b terminals are the main input (RX) measuring terminals for all the functions provided by the LT51. When the LT51 is configured in "RTX" interface mode, the LT51 output (TX) signals also appear at the RTXa-b terminals.

- Ground 'g' (green)
  This terminal is connected externally to a reference ground (or Functional Earth) for Balance or RFL measurements only (*not available in this model)

- TX 'a' (black) and 'b' (red)
  The LT51 output (TX) signals appear at the TXa-b terminals, See RTX terminal description above when the LT51 is configured in "RTX" mode.

Balanced Interfaces

The RTXab and TXab terminal pairs are electronically balanced interfaces. They are electrically isolated from each other, Earth or any external references when the 'g' terminal is not connected. This is due to the LT51's portable battery powered architecture and transformer coupled TX interface. Isolation is still maintained when working with the supplied AC/DC Adaptor connected.

Unbalanced Interfaces

It is possible to connect the TXa-b and RTXa-b terminals to unbalanced interfaces. The double banana plug to BNC adaptor (Pomona Part#:1269), enables connection to an unbalanced interface via a coaxial cable.

USB port

The USB port on the top connector panel of the LT51 is used for down-loading new software, up-loading test results or instrument control from a PC. A standard USB cable with a type "B" plug (for the LT51) and type "A" plug for the PC is provided. Refer to 'PC Interface' for directions to download new software and upload results.

DC power jack

A 2.1mm barrel jack accepts an external DC input to power the tester and charge the battery. This jack accepts a 5 to 6 VDC centre-positive voltage that is provided either by the supplied AC/DC adaptor or by the optional 12Vdc Vehicle Power Adaptor.

Microphone and speaker

A built-in microphone and speaker is provided for voice conversation when the LT51 is acting as a telephone. Line activity and tone reception on the RTXa-b terminals can also be monitored with the speaker.

Knob

The knob is used for the following functions:
- setting transmit level and frequency information
- moving the marker around the spectral display
- adjusting the speaker volume
- setting the level meter frequency span and centre frequency for selective meter function
- setting TDR distance, PVF, zoom and offset

Depressing the knob serves the same function as the ◁ ▷ key, and can be used at any time.

LEDs

- DC power (green) – illuminates when a 5 to 6 VDC input is applied to the DC power jack, and the batteries are fully charged.
- Charging (red) – illuminates when charging internal NiMH cells from ext. DC power. When the charging is complete, the red LED turns off & the green LED turns on.

Battery cover
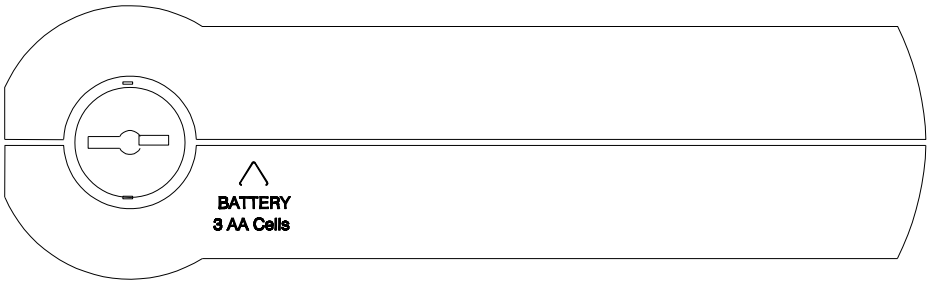
Figure 2-5. LT51 bottom panel showing battery Cover

Numerical Keypad

Wherever a numerical input quantity is requested (eg. TX Frequency), it is possible to set the value using the knob, or directly via the keypad.

Once the first digit is entered via the keypad, a selection of units appears in the menu next to the soft-keys.
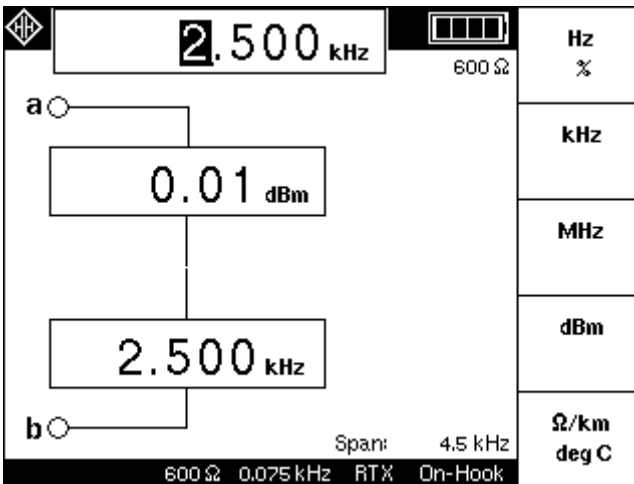
When the desired value has been entered, choose the appropriate units to complete the entry of the value. If an incorrect digit is entered, press the ◁▷ key to erase the last entered digit, and then continue.

3. Testing VF-PCM Multiplexers
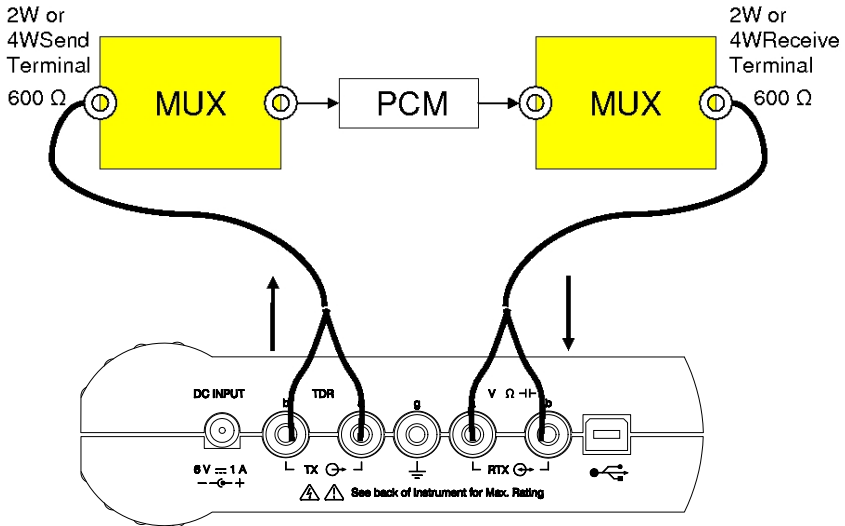
Figure 3.1: Test Setup – VF PCM Testing with LT51

Idle Channel Noise

1. Make the connections between the Test circuit and the LT51 as in Fig. 3.1.

2. Turn the LT51 ON. [after Reset: Ztx = 600Ω, Zrtx = HiZ 600Ω, TX Source = OFF, TX Freq =10 kHz, Mode = TX-RX (4W)].

3. Press the [RX⊖] button, then the [f2] soft-key to set *Input* to 'Term'. The LT51 RTX (input) impedance is now 600 Ω terminated.

4. Press the [BW / AVG] key, followed by the [f1] soft-key to set the frequency *Span*. Use the knob to set the span to 4.5 kHz.

5. Press the [f3] soft-key to set *BW* to 'PSOPH' to make psophometric weighted measurements.

6. With *TX Source* set to OFF, a 600 Ω termination is provided by the LT51 TXab terminals.

7. The display will show the idle channel noise weighted by the Psophometric filter measured at the LT51 RTXab terminals. Press [/\/\/\] (Spectral) or [V Ω +⊦] (Numerical) to toggle between displays of the signal.

8. Verify that the measured noise is < -65 dBm.

Audio Level Setting

1. Make the connections between the Test circuit and the LT51 as in Fig. 3.1.

2. Turn the LT51 ON. [after Reset: Ztx = 600Ω, Zrtx = HiZ 600Ω, TX Source = OFF, TX Freq =10 kHz, Mode = TX-RX (4W)]

3. Press the $\boxed{\text{RX}\ominus}$ button, then the [f2] soft-key to set *Input* to 'Term'. The LT51 RTX (input) impedance is now 600 Ω terminated.

4. Press the $\boxed{\substack{\text{BW /} \\ \text{AVG}}}$ key, followed by the [f1] soft-key to set the frequency *Span*. Use the knob to set the span to 4.5 kHz.

5. Press the $\boxed{\text{TX}\ominus}$ key followed by the [f4] soft-key to set the TX Freq to 1000 Hz, using the Knob or Keypad, and press the $\boxed{\substack{\text{OK} \\ \text{save}}}$ button to clear the Dialog box, or appropriate [fx] soft-key if using keypad.

6. Press the [f2] soft-key to set the TX Level. This will automatically change *TX Source* to 'SINE' and output a 0 dBm, 1000 Hz signal from the TXab outputs.

    Set the desired TX level using the Knob or Keypad, and press the $\boxed{\substack{\text{OK} \\ \text{save}}}$ button to clear the Dialog box, or appropriate [fx] soft-key if using keypad.

7. Repeat for different levels at 2W / 4W interfaces.

8. The display will show the received level and frequency over the 4.5 kHz BW at the LT51 RTXab input terminals. Press $\boxed{\wedge\!\!\wedge\!\!\wedge}$ (Spectral) or $\boxed{\text{V}\,\Omega\,\text{Ⱶ}}$ (Numerical) to toggle between displays of the signal.
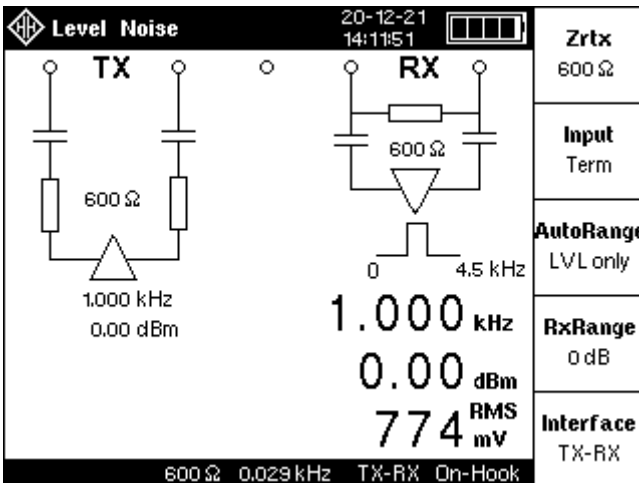
Frequency Response

1. Make the connections between the Test circuit and the LT51 as in Fig. 3.1.

2. Turn the LT51 ON. [after Reset: Ztx = 600Ω, Zrtx = HiZ 600Ω, TX Source = OFF, TX Freq =10 kHz, Mode = TX-RX (4W)]

3. Press the [f5] soft-key to select the 'NEXT Loss' measurement. This will enable the SINE Transmitter at 10 kHz, 0 dBm on the LT51 TX terminals and set the LT51 RTX (input) impedance to 600 Ω terminated.

4. Press the $\boxed{\substack{\text{BW /} \\ \text{AVG}}}$ key, followed by the [f1] soft-key to set the frequency *Span*. Use the knob to set the span to 4.5 kHz.

5. Press the $\boxed{\text{TX} \ominus}$ key followed by the [f4] soft-key to set the TX Freq to 1000 Hz, using the Knob or Keypad, and press the $\boxed{\substack{\text{OK} \\ \text{save}}}$ button to clear the Dialog box, or appropriate [fx] soft-key if using keypad.

6. Press the $\boxed{\substack{\leftarrow | \rightarrow \\ \text{Marker}}}$ key, followed the [f4] soft-key to set the *Zero Offset* for the level measured at 1000 Hz.

7. Press the $\boxed{\text{TX} \ominus}$ key followed by the [f4] soft-key to set the next TX Freq using the Knob or Keypad, and press the $\boxed{\substack{\text{OK} \\ \text{save}}}$ button to clear the Dialog box, or appropriate [fx] soft-key if using keypad. Repeat for all frequencies in the Specification template.

8. Press the [f5] soft-key, to set *Sweeping* to 'ON'. This will automatically sweep across the 4.5 kHz BW to show a graph of the Frequency Response in the spectral display. Use the Marker to read the frequency response at each frequency.

9. The display will show the received level and frequency over the 4.5 kHz BW at the RTXab input terminals. Press $\boxed{\text{\scriptsize /\\/\\}}$ (Spectral) or $\boxed{\text{v}\,\Omega\,\text{+}}$ (Numerical) to toggle between displays of the signal.

Variation of Gain with input level

1. Make the connections between the Test circuit and the LT51 as in Fig. 3.1.

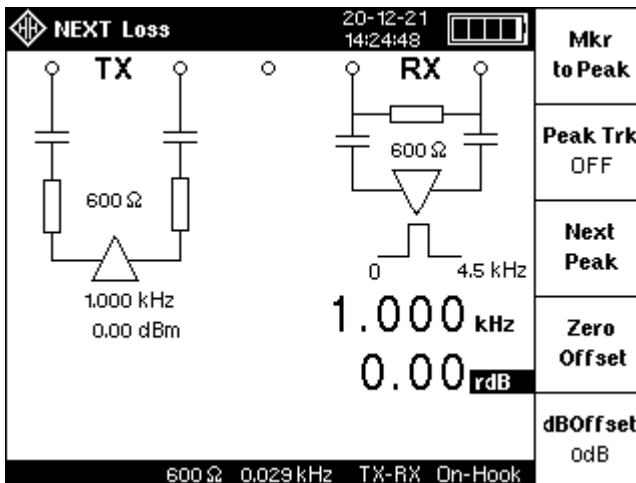2. Turn the LT51 ON. [after Reset: Ztx = 600Ω, Zrtx = HiZ 600Ω, TX Source = OFF, TX Freq =10 kHz, Mode = TX-RX (4W)]

3. Press the $\boxed{\text{RX}\ominus}$ button, then the [f2] soft-key to set *Input* to 'Term'. The LT51 RTX (input) impedance is now 600 Ω terminated.

4. Press the $\boxed{\text{TX}\ominus}$ key followed by the [f2] soft-key to set the TX Level to –10.00 dBm using the Knob or Keypad, and press the $\boxed{\frac{\text{OK}}{\text{save}}}$ button to clear the Dialog box, or appropriate [fx] soft-key if using keypad.

    Press the [f4] soft-key to set the TX Freq to 1014 Hz using the Knob or Keypad, and press the $\boxed{\frac{\text{OK}}{\text{save}}}$ button to clear the Dialog box, or appropriate [fx] soft-key if using keypad.

5. Press the $\boxed{\frac{\text{BW /}}{\text{AVG}}}$ key, followed by the [f1] soft-key to set the frequency *Span*. Use the knob to set the span to 4.5 kHz.

    Press the [f2] soft-key to set *Centre Frq* to 1014 Hz using the Knob or Keypad, and press the $\boxed{\frac{\text{OK}}{\text{save}}}$ button to clear the Dialog box, or appropriate [fx] soft-key if using keypad.

6. Press the $\boxed{\frac{\leftarrow|\rightarrow}{\text{Marker}}}$ key, followed the [f4] soft-key to set the *Zero Offset* for the level measured at –10 dBm.

7. Repeat for all levels at the steps in the Specification template. Note that a correction for the input level (relative to –10 dBm) must be applied to the result. E.g., for an input level of +3 dBm, you must subtract 13 dB from the result, ie. +3dBm – (-10dBm) = 13dB, to get the gain variation.

8. The display will show the received level at 1014 Hz at the RTXa-b input terminals.
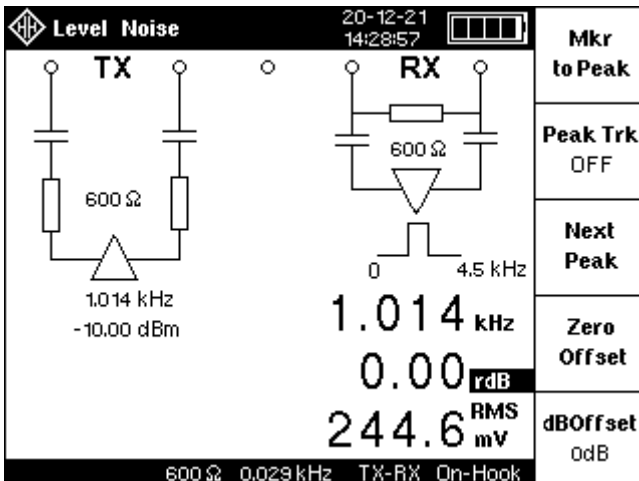
Signal to Quantization Noise

1. Make the connections between the Test circuit and the LT51 as in Fig. 3.1.

2. Turn the LT51 ON. [after Reset: Ztx = 600Ω, Zrtx = HiZ 600Ω, TX Source = OFF, TX Freq =10 kHz, Mode = TX-RX (4W)]

3. Press the $\boxed{\text{RX} \oplus}$ button, then the [f2] soft-key to set *Input* to 'Term'. The LT51 RTX (input) impedance is now 600 Ω terminated.

4. Press the $\boxed{\text{BW / AVG}}$ key, followed by the [f1] soft-key to set the frequency *Span*. Use the knob to set the span to 4.5 kHz.

5. Press the [f3] soft-key to set *BW* to 'PSOPH' to make psophometric weighted measurements.

6. Press the $\boxed{\text{TX} \oplus}$ key followed by the [f3] soft-key to set the *TX Source* to 'SINE'.

   Press the [f4] soft-key to set the TX Freq to 1014 Hz using the Knob or Keypad, and press the $\boxed{\text{OK save}}$ button to clear the Dialog box, or appropriate [fx] soft-key if using keypad.

7. Press the $\boxed{\text{V} \Omega \text{-}|\text{-}}$ key, followed by the [f1] soft-key to set *Level* to make a 'S/ND' (Signal to Noise and Distortion) measurement, which is equivalent to the S/Nq measurement.

8. Repeat for all levels at the steps in the Specification template.

9. The display will show the Psophometric weighted Signal to Quantisation Noise ratio measured at the LT51 RTXab input terminals. Press $\boxed{\text{W}}$ (Spectral) or $\boxed{\text{V} \Omega \text{-}|\text{-}}$ (Numerical) to toggle between displays of the signal.

Cross-Talk

[if G.227 TEL Noise Option is fitted]

1. Make the connections between the Test circuit and the LT51 as in Fig. 3.1.

2. Turn the LT51 ON. [after Reset: Ztx = 600Ω, Zrtx = HiZ 600Ω, TX Source = OFF, TX Freq =10 kHz, Mode = TX-RX (4W)]

3. Press the [f5] soft-key to select the 'NEXT Loss' measurement. This will set the LT51 RTX (input) impedance to 600 Ω terminated.

4. Press the $\boxed{\begin{smallmatrix} BW\ / \\ AVG \end{smallmatrix}}$ key, followed by the [f1] soft-key to set the frequency *Span*. Use the knob to set the span to 4.5 kHz.

5. If required, press the [f3] soft-key to set the *BW* to 'PSOPH' to make psophometric weighted measurements.

6. Press the $\boxed{\text{TX} \odot}$ key, followed the [f3] soft-key to set the *Source* to 'G227 TEL' to transmit the 0 dBm Telephone Noise signal on the TXab terminals.

7. The display will show the received level and frequency over the 4.5 kHz BW at the RTXa-b input terminals. Press $\boxed{\wedge\!\!\wedge\!\!\wedge}$ (Spectral) or $\boxed{\text{V}\,\Omega\,\text{+}}$ (Numerical) to toggle between displays of the signal.

8. For NEXT measurements, the RTXab terminals should be connected to the PCM timeslots that are adjacent to the timeslot that the TXab signal is connected to, at the TX side of the PCM connection.

9. For FEXT measurements, the RTXab terminals should be connected to the PCM timeslots that are adjacent to the timeslot that the TXab signal is connected to, at the RX side of the PCM connection.

10. Verify that the measured noise is < -65 dB for both NEXT and FEXT.
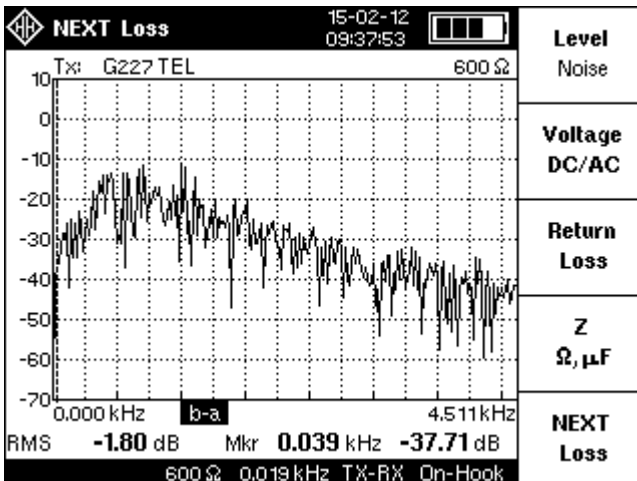
Ring Detect VAC / VDC when on-hook *

1. Make the connections between the Test circuit and the LT51 as in Fig. 3.1.

2. Turn the LT51 ON. [after Reset: Ztx = 600Ω, Zrtx = HiZ 600Ω, TX Source = OFF, TX Freq =10 kHz, Mode = TX-RX (4W)]

3. Press the [f2] soft-key to select the 'Voltage DC/AC' measurement.

4. The DC voltage of the line is displayed.

5. Apply ring signal to the RTXab terminals of the LT51.

6. You will hear an audible tone indicating the presence of the ring signal. When the ring signal is present, the AC (rms) voltage of the signal is displayed.
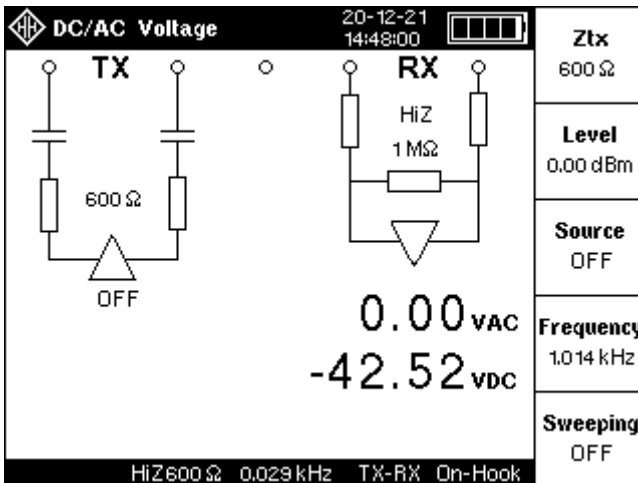
*Ring voltage cannot be measured when the protection voltage is 60V. See specifications.
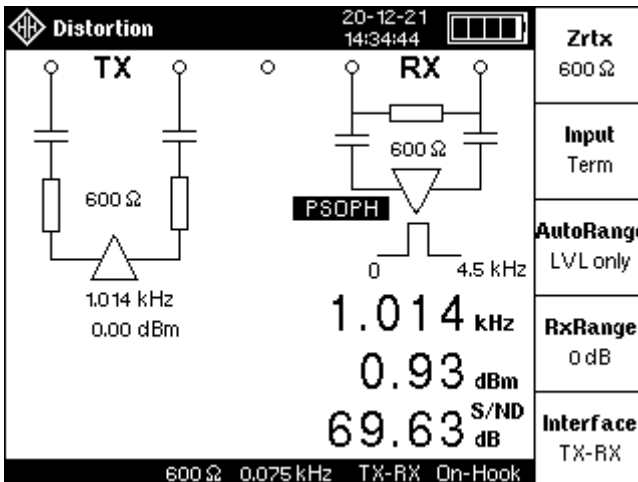
VDC and IDC when off-hook, level measurement

1. Make the connections between the Test circuit and the LT51 as in Fig. 3.1.

2. Turn the LT51 ON. [after Reset: Ztx = 600Ω, Zrtx = HiZ 600Ω, TX Source = OFF, TX Freq =10 kHz, Mode = TX-RX (4W)]

3. Press the ⟨ 📞 ⟩ key to go off-hook (Loop-hold) or DC terminate (with 600Ω) the line connected to the RTXab terminals. The interface Mode is automatically set to RTX (2W).

4. The DC voltage and current through the 600Ω termination is displayed.

5. If connected to the PSTN, dial DTMF digits using the keypad to make a connection.

6. While TX displays "TALK", use the hands-free telephone to transmit & receive speech from the line connected to the RTXab terminals.

7. Press the ⟨TX⊙⟩ key followed by the [f3] soft-key to set TX source to 'SINE' and transmit a tone to the line connected to RTXab, during Loop-hold.

    Press the [f2] & [f4] soft keys to set the TX Level & Freq using the Knob or Keypad, and press the ⟨OK save⟩ button to clear the Dialog box, or appropriate [fx] soft-key if using keypad.

8. Press the ⟨〰〰〉 key, or to make level measurements at the RTXab terminals.
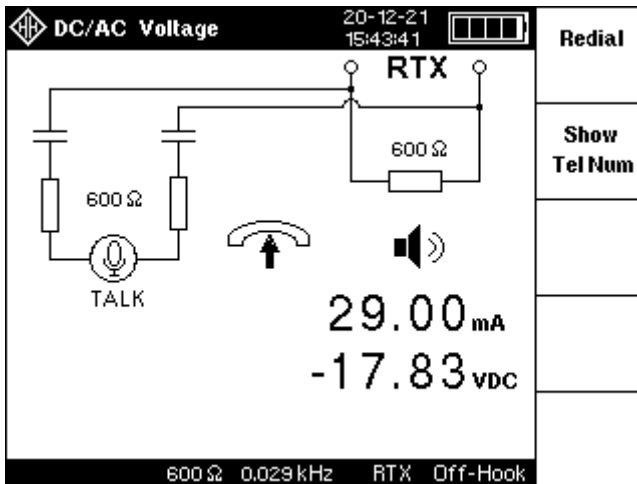
4. Testing PLC Systems
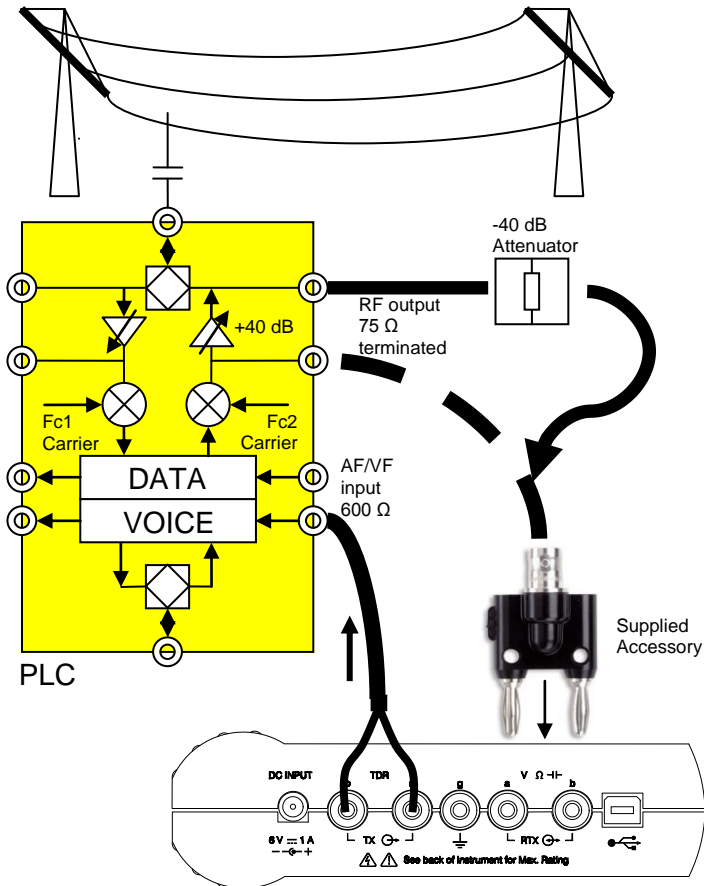
Figure 4.1: Test Setup – PLC Testing with LT51

1. Connect a coaxial cable between the BNC Adaptor (plugged into the LT51 RTXa-b terminals) and the RF coaxial interface of the PLC system unit.

2. Press the ⚙ key, followed by the [f2] "Meas Settings" soft-key. Press the [f2] "Reset LT51" soft-key.

3. Press the RX⊖ button, then the [f1] soft-key to set *ZRTX* to "75 Ω", HiZ.

4. Press [f3] "RxRange" soft-key, and turn the knob to set the range to "0dB".

5. Connect the RF signal to the LT51 RTXab terminals **USING the 40dB attenuator**.
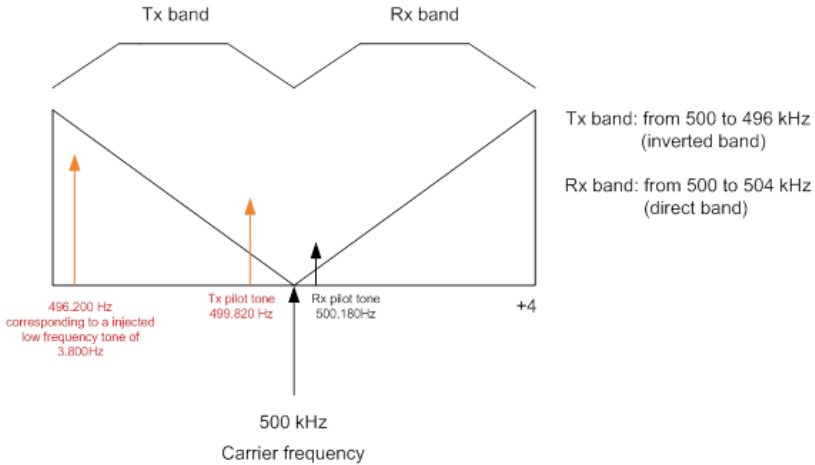
Figure 4.2: Possible RF Frequency Spectrum for SSB PLC System

To measure the levels of the following 3 RF frequencies:

- Tx Pilot at 499.820 kHz
- Rx Pilot at 500.180 kHz
- External 3.800 kHz tone at 496.200 kHz

1. [Optional] Connect the external 3.800 kHz tone from the LT51 TXa-b terminals to the VF/AF 600 ohm input of the PLCC equipment.

2. [Optional] Press the $TX \ominus$ key followed by the [f2] soft-key to set the TX Level. This will automatically change TX Source to 'SINE' and output a 10 kHz signal from the TXa-b outputs.

    Set the desired TX level using the Knob or Keypad, and press the OK save button to clear the Dialog box, or appropriate [fx] soft-key if using keypad.

    Press the [f4] soft-key to set the TX Frequency to 3800 Hz using the Knob or Keypad, and then press the OK save button to clear the Dialog box, or appropriate [fx] soft-key if using the keypad.

3. Press the BW / AVG key, then the [f2] soft-key, and set the centre frequency to 499.820 kHz, then 500.180 kHz and 496.200 kHz using the Knob or Keypad [the 25 Hz selective BW is chosen by default].

    OR

    in spectral mode($\wedge\wedge$), set the centre frequency to 498.000 kHz and display the 3 frequencies in a spectrum.

    When the frequency is entered, press the OK save button to clear the Dialog box, or [fx] soft-key if using keypad.

Adjust the span to 4.5 kHz by pressing the [f1] soft key, then turning the knob to increase or decrease the span.

4. In spectral mode, move the marker using the knob to read the level at each frequency peak.

5. Add 40 dB to each reading because of the 40dB attenuator.

Example Measurement results for 3 frequencies:

	Frequency (Hz)	Theoretical level	Measured levels (with 40 dB attenuator)
Tx pilot	499820	+26 dBm	-14.00 + 40 = +26 dBm
Rx pilot	500180	0 ± 2 dBm*	-40.00 + 40 = 0 dBm*
External tone (3800 Hz)	496200	+32 dBm	-7.98 + 40 = +32 dBm

* reception level is attenuated by 28dB ± 2 dB

Press ⌐∿⌐ **to display the frequency spectrum:**
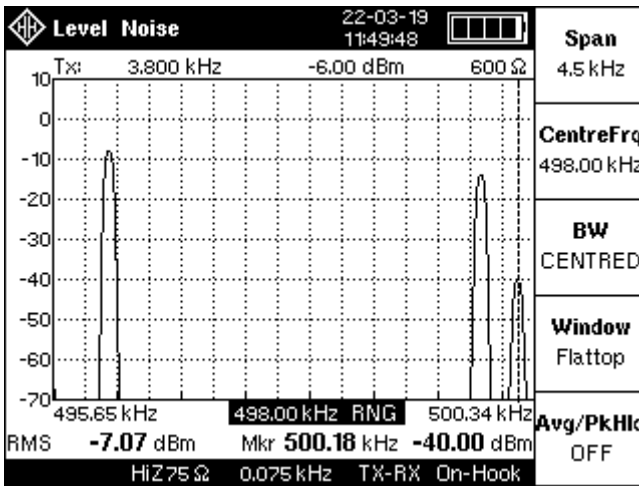
Press ⌐VΩ⊣⊢ **to display the level at different centre frequencies:**
- 499.820 kHz for the TX pilot
- 500.180 kHz for the RX pilot
- 496.200 kHz for the external 3800 Hz tone
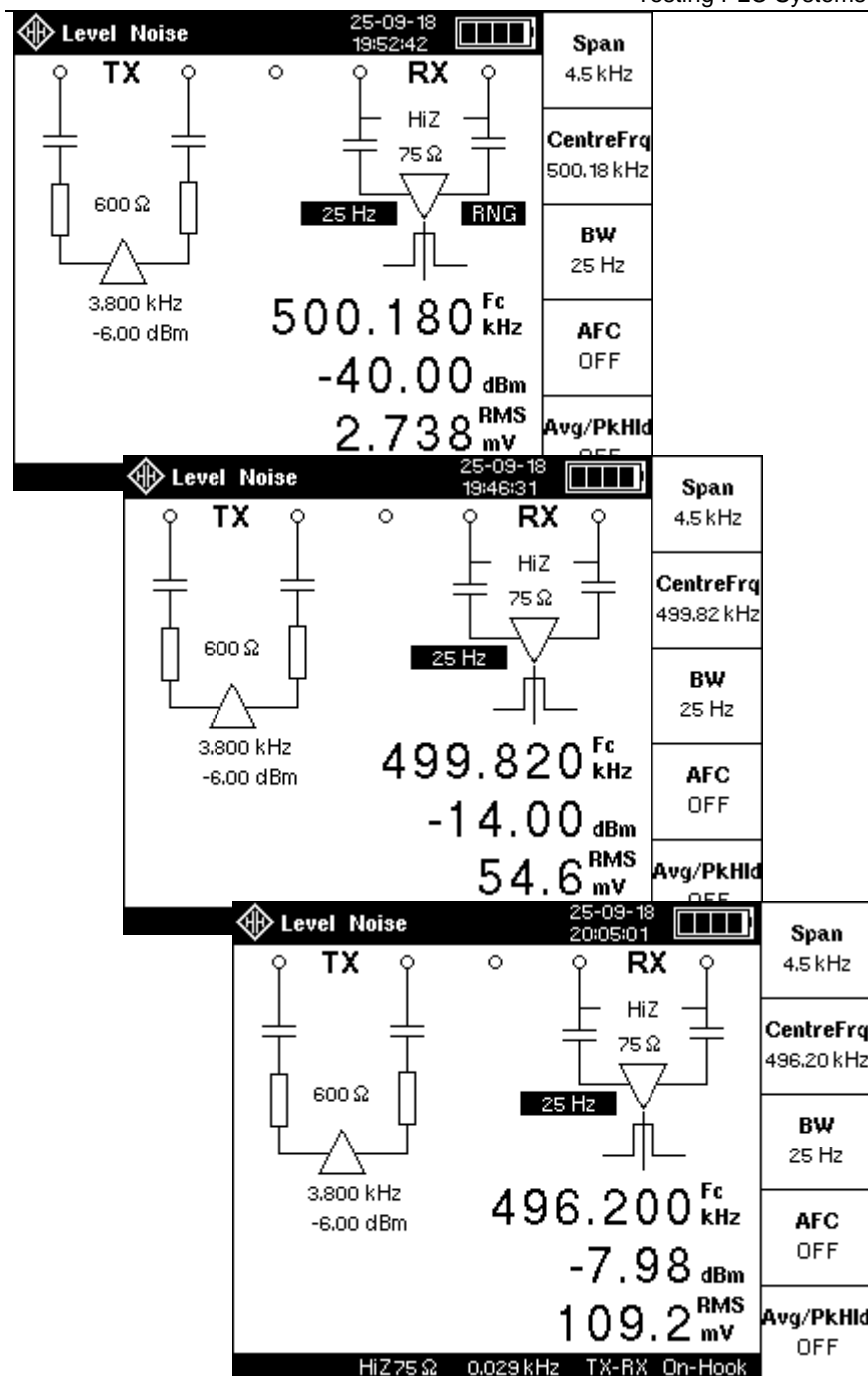
Measuring the Return Loss of Line Matching Units (LMU)

⚠️ **WARNING:** *Ensure that the LMU interface is free of all carrier signals before connecting the LT51 in RTX mode (eg. Return Loss). Permanent damage to the LT51 will result otherwise.*

1. Insert the Double Plug to BNC Adaptor into the LT51 RTXa-b terminals

2. Connect a cable between the BNC Adaptor and the LMU coaxial interface

3. Turn the LT51 ON.[after reset: Ztx = 600Ω, Zrtx = HiZ 600Ω, TX Source = OFF, TX Freq =10 kHz, Mode = TX-RX (4W)].

4. Press the [f3] key to select the Return Loss measurement.

5. Press the $RX\ominus$ button, then the [f1] soft-key to set *ZRTX* to '75 Ω', to make the return loss measurement against a 75 reference.

6. Press the $TX\ominus$ key followed by the [f4] soft-key to set the desired TX Frequency using the Knob or Keypad, and then press the $\frac{OK}{save}$ button to clear the Dialog box, or appropriate [fx] soft-key if using the keypad.

7. To set the frequency span manually, press the $\frac{BW\,/}{AVG}$ key, followed by the [f1] soft-key. Or to make the measurement around a particular centre frequency, press the [f2] soft-key, and set the span using the [f1] soft key [the 25 Hz selective BW is chosen by default].

8. To make a swept Return Loss measurement over the frequency span selected above, press the $TX\ominus$ key, and toggle the [f5] soft-key to enable sweeping. When making swept measurements, Level auto-ranging should be disabled, i.e. OFF).
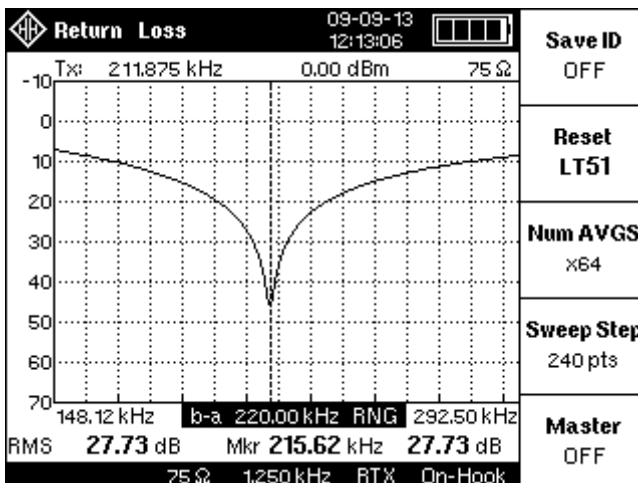
Measuring the Blocking Impedance of Line Traps
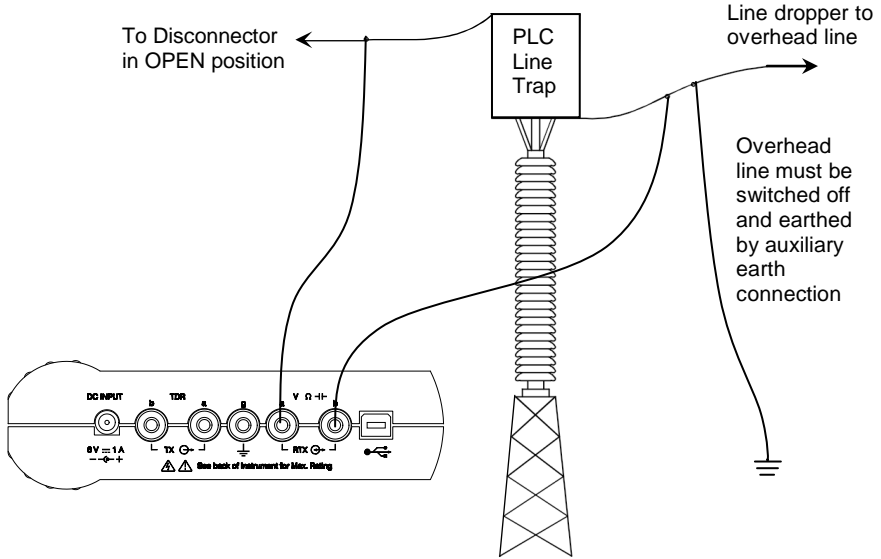
Figure 4.3: Test Setup – Measuring PLC Trap Impedance with LT51

1. Connect the RTX a-b terminals to the PLC Line Trap as shown.

2. Press the $\boxed{V\,\Omega\,+\!\!\!+}$ key, followed by the [f4] soft-key to set the "Mag Z" measurement mode.

3. Set the desired TX frequency, by pressing the $\boxed{TX\,\ominus}$ key, followed by the [f4] "TX Freq" soft-key. Use the Knob or Keypad, and then press the $\boxed{\substack{OK\\save}}$ button to clear the Dialog box, or appropriate [fx] soft-key if using keypad.

    OR

    Press the $\boxed{\wedge\!\!\!\wedge\!\!\!\wedge}$ key to show a graph of the Impedance Magnitude vs. Frequency over the selected frequency span.

    Press the $\boxed{\substack{BW\,/\\AVG}}$ key, followed by the [f1] "Span" soft-key to set the desired frequency span.

5. Configuring the Tester

The flexibility of the LT51 allows considerable freedom in configuring the tester for more advanced testing applications. For most applications, however, the standard configurations do not need to be modified and the automatic test suites offer a simple alternative for more repetitive testing applications.

The more common configuration options are easily available through dedicated keys rather than being buried in menu structures. Following are the LT51 configuration keys:

RX ⊕	Configure the LT51 receiver parameters at the RTXa-b terminals, such as Zrtx, terminated, HiZ, range setting and RTX (2-Wire) or TX-RX (4-Wire) interface
TX ⊖	Configure the LT51 transmitter parameters at the TXa-b terminals, such as Ztx, output level & frequency, OFF / ON mode, sweep mode
←ᐧ→ Marker	Controls operation of the marker during graphical display modes. Functions include peak tracking, setting offsets and vertical offset.
BW / AVG	Set the LT51 frequency span, centre frequency, BW, AFC and Averaging / peak hold.
⚙	Access stored test results, configure measurement settings and display settings such as the RTC, and make adjustments to the LT51 stored calibration constants.

LT51 Transmitter

The LT51 Line Tester can be configured to simultaneously transmit single or swept tones and make spectrum / DMM measurements. The transmitter can be configured in most measurement modes by pressing the [TX⊖] key to access the settings, and its output always appears at the TXa-b terminals when ON. The following settings configure the LT51 transmitter:

- output impedance.
- transmit source.
- transmit level.
- transmit frequency.
- Sweeping.

Output impedance

This is the impedance presented to the load connecting to the TXa-b terminals:

- Press the [TX⊖] key and then [f1] to toggle *Ztx* between *600Ω, 150Ω, 125Ω* and *75Ω.*

The current setting for *Ztx* is displayed on the LCD under the battery indication.

NOTE: When the transmitter interface is set to RTX, any change in the output impedance is reflected back to the input impedance and vice versa.

Transmit source

It is possible to mute the TX output and simultaneously provide a terminated impedance at the TX terminals by setting the *Source* to *OFF*:

- Press the [TX⊖] key and then [f3] to toggle *Source* between *OFF, SINE and G227 TEL (if fitted).*

The current setting for *TX source* is displayed on the LCD under the measurement title in the TXSTATUS area.

When TX Source is set to *G.227TEL*, the Rectangular window function (ResBW = 19.3125 Hz) is used for the FFT processing of the Received signal on the RTX terminals.

Transmit level

Set the level of the signal transmitted at the TX terminals. The output level displayed on the LCD shows the terminated output level for Zload = Ztx:

- Press the [TX⊖] key and then [f2] to select *Level.*
- Turn the knob clockwise to increase, or anti-clockwise to reduce, the TX level.

- Press the knob or $\boxed{\lhd \rhd}$ key to move the cursor to the next most significant digit to change.
- Turn the knob to adjust the level at this selected resolution.
- Repeat this process to a resolution of 0.1dB or until the desired level is obtained.
- Press the $\boxed{\frac{OK}{save}}$ key (or any key) to clear the dialog box.

The current setting for TX level (only if *Source* is not OFF) is displayed on the LCD under the current date/time in the TXSTATUS area.

NOTE: Setting the TX level, automatically sets TX source to SINE.

Transmit frequency

Set the frequency of the signal transmitted at the TX terminals:

- Press the $\boxed{TX \ominus}$ key and then [f4] to select *Frequency.*
- Turn the knob clockwise to increase, or anti-clockwise to reduce, the TX frequency.
- Press the knob or $\boxed{\lhd \rhd}$ key to move the cursor to the next most significant digit to change.
- Turn the knob to adjust the frequency at this selected resolution.
- Repeat this process to a resolution of 1 Hz or until the desired frequency is obtained.
- Press the $\boxed{\frac{OK}{save}}$ key (or any key) to clear the dialog box.

The current setting for TX frequency (only if Source is *SINE*) is displayed on the LCD under the current date/time in the TXSTATUS area.

NOTE: If the sweeping setting is set to ON, the TX frequency is swept over the current frequency span.

Sweeping

- Press the $\boxed{TX \ominus}$ key and then [f5] to toggle *Sweeping* between *ON* and *OFF*

For measurements that transmit a signal to the RTX terminals (eg. Return Loss, LCL and NEXT / Loss), setting *Sweeping* to *ON,* will perform a swept measurement across the currently selected frequency span.

When TX *Source* is set to *SINE,* the *Sweeping* setting controls whether the TX Frequency is swept across the frequency span.

NOTE: Changing Rx Range (manually or during Auto-ranging), resets the TX frequency sweep.

When *Sweeping* is *OFF* for Remote Loss and FEXT measurements, the level spectrum at the selected RTX terminals is displayed. If *Sweeping* is set to *ON* for these measurements, the maximum signal (or Peak Hold) received across the

frequency span is displayed. This is useful for recording swept measurements from an unsynchronised oscillator at the far end of a cable.

Sweep Step

• Press the ⚙ key, followed by [f2] "Meas Settings", then [f4] "Sweep Step" to show the possible settings for the Sweep Step parameter.

The *Sweeping Step* parameter controls the step size between successive sweep frequencies. The parameter can be set from "15 pts" to "240 pts". Selecting "240 pts" will result in a fine and accurate sweep at each possible marker frequency at the expense of time, while "15 pts" will give a coarse, but fast sweep over the current frequency span.

LT51 Receiver

The LT51 Line Tester has powerful receiver measurement modes to display level/power spectrums of signals at the RTX inputs. The following settings, accessed by pressing the [RX⊕] key, control how signals are received and adjusted for correct display on the LCD.

Input Terminals

All measurements are made on the RTXa-b input terminal pair. Balance measurements require the connection of a reference ground to the RTXg terminal (*not available in this model)

Input Impedance

This is the impedance presented to sources connecting to the RTX terminals:

- Press the [RX⊕] key then [f1] to toggle *Zrtx* between *600Ω, 150 Ω , 125 Ω* and *75 Ω.*

NOTE: If the transmitter output is set to RTX, any change in the input impedance is reflected back to the output impedance. In this case, the input impedance is normally bridged, except in the off-hook condition, when it is terminated to sink loop current and hold the loop (see POTS section – a special hybrid is used to ensure the selected AC impedance is provided for making POTS measurements – it is only valid for selected TX levels and RX ranges)

The current setting for *Zrtx* is displayed in the CONFIG bar along the bottom of the LCD.

Input bridging

To select whether the input impedance at the RTX terminals is bridged or terminated:

- Press the [RX⊕] key, then [f2] to toggle *Input* between *Term **&** HiZ.*

NOTE: This setting will only have an effect when the Interface is set to TX-RX.

If the input is bridged, *HiZ* appears before the value for *Zrtx* in the CONFIG bar along the bottom of the LCD. If the input is terminated, only the *Zrtx* value is shown.

Input level range

- Press the [RX⊕] key and then [f3] to select *Rx Range.*
- Turn the rotary control clockwise to increase, or anti-clockwise, to reduce the range.
- Watch as the waveform display updates according to the selected range.

- Press the $\boxed{\substack{\text{OK} \\ \text{save}}}$ key (or any key) to clear the dialog box.

If the currently selected level range is not optimal for the signal being measured, one of the following range indicators appears on the LCD:
- "RNG" if the range should be reduced to measure the smaller signal.
or
- "OVLD" if the range should increased to accommodate the larger signal.

NOTE: setting the RX range, automatically clears AutoRange to OFF.

AutoRange

Enables the tester to automatically select the optimum input level range and frequency span for any given input signal, to avoid overloading input circuits:

- Press the $\boxed{\text{RX} \oplus}$ key and then [f4] to toggle *AutoRange between OFF, LVL only and LVL+BW.*

NOTE: When AutoRange=LVL+BW, and the frequency span is set manually, AutoRange is changed to LVL only.

NOTE: When AutoRange=LVL+BW, and the following conditions are set, BW autoranging is disabled although the setting is not changed:
- *during AutoTest mode.*
- *when sweeping is active.*
- *when connected to a slave LT51.*
- *If any filter is set.*
- *If the centre frequency is > 0 Hz.*

Interface

The transmitter can be selected to output a signal only at the TX terminals (TX-RX interface mode or 4-Wire) or also at the RTX terminals (RTX interface mode or 2-Wire). Ztx and Zrtx can only be set independently when the interface mode is set to TX-RX and the transmitter output is directed to the TX terminals.

When RTX is selected as the interface, the LT51 output circuit is connected to the RTX terminals and hence the input circuit of the LT51. The impedance seen at the RTX terminals is provided by Ztx, and the input impedance is bridged. As the output circuit is still connected to the TX terminals, care must be taken not to load the TX terminals (see also POTS section):

- Press the $\boxed{\text{RX} \oplus}$ key, then [f5] to toggle *Interface between TX-RX and RTX*

The current setting for *Interface* is displayed in the CONFIG bar along the bottom of the LCD.

LT51 Frequency Bandwidth

Frequency span

- Press the [BW / AVG] key and then [f1] to select *Span.*
- Turn the knob clockwise to increase, or anti-clockwise to reduce, the *Span*
- Press the [OK save] key (or any key) to clear the dialog box.
- The frequency span is updated on the frequency axis (in spectral mode) or in the results area if in DMM mode.
- The Span automatically sets the Resolution BW (see Resolution BW below)
- Where the centre frequency is less than half the span selected, the start frequency is set to 0 Hz and the measurement is baseband. Otherwise the start, centre and stop frequencies are adjusted with the centre frequency.

NOTE: if the span selected together with the current centre frequency, would cause the Stop frequency to exceed 2.4 MHz, the span is limited.

NOTE: For all measurement modes where the Interface is set to RTX, and the LT51 Transmitter is ON sourcing a tone (eg. Return Loss, NEXT/Loss, Balance etc.), the span will be automatically set to receive the current Transmit Frequency. This does not apply when making selective measurements or when sweeping.

The following table describes the relationship between frequency spans, marker resolution and bandwidths used to measure signals in the LT51. The Res BW is displayed in the centre of the CONFIG bar along the bottom of the display. The LT51 uses the Hanning for numerical displays and Flattop for spectral displays.

Span (kHz)	Marker Resolution (Hz)	Res BW / ENBW (Hz) Hanning	FlatTop
2,400.0	10,000	15,000	38,750
1,200.0	5,000	7,500	19,375
600.0	2,500	3,750	9,687
300.0	1,250	1,875	4,843
150.0	625	937	2,421
75.0	312.5	468	1,210
37.5	156.25	234	605
18.75	78.125	117	302
9.375	39.0625	58	151
4.6875	19.53125	29	75

Centre Frequency / Selective Level Meter

- Press the [BW / AVG] key and then [f2] to select *Centre Frq.*
- Turn the knob clockwise to increase, or anti-clockwise to reduce, the centre frequency.
- Press the [OK save] key (or any key) to clear the dialog box.

- If the current display is in DMM mode, then the selective level at the current centre frequency is displayed. The Selective BW, is set to '*25 Hz*' by default.
- In Spectral mode, the display is adjusted to show the centre frequency in the centre of the display and the start and stop frequencies on the axis are calculated for the currently set frequency Span. The BW is set to '*CENTRED'*.

NOTE: Making measurements with the centre frequency set, can noticeably slow the update rate of results and spectral displays.

Bandwidth / Selective Level Meter

- Press the $\boxed{\substack{BW / \\ AVG}}$ key and then [f3] to display the *BW* options:

WIDE:	Wideband (from **0 Hz**) measurement over frequency span
PSOPH:	ITU O.41 Psophometric filter (from **0 Hz**) over frequency span
25 Hz:	DMM mode only
1.74 kHz:	Make a Selective Meter measurement at the current Centre
3.1 kHz:	Frequency using the selected BW.

The current setting for *BW* is displayed below the frequency axis or under the frequency result in DMM mode.

AFC – Automatic Frequency Control

- Press the $\boxed{\substack{BW / \\ AVG}}$ key and then toggle [f4] to set *AFC ON* or *OFF*

With a centre frequency set, and the BW set to 25Hz, 1.74 kHz or 3.1 kHz, the LT51 will automatically track small changes in the received signal's frequency, close to the centre frequency. The Centre frequency value will be automatically set to the incoming frequency, to allow for slow moving drift of this signal.

When AFC is active, the symbol "AFC" will be displayed instead of "Fc" next to the centre frequency in main numerical display.

Averaging / Peak Hold

Press the $\boxed{\substack{BW / \\ AVG}}$ key and then [f5] to toggle *Averaging* between *OFF, AVG and PK HOLD.*

To change the number of samples that are averaged:

- Press the $\boxed{\text{o}\phi}$ key and then the [f2] "Meas Settings" soft-key.
- Press [f3] to select *Num of Avgs*.
- Turn the knob clockwise to increase, or anti-clockwise to reduce, the *Num of Avgs*.
- Press the $\boxed{\substack{OK \\ save}}$ key (or any key) to clear the dialog box.

The current setting for *Averaging / Peak Hold* is displayed in the CONFIG bar along the bottom of the LCD.

POTS Connection

Connection to a POTS line must be made at the RTX terminals. Before making any connection ensure the tester is set to *On-Hook.* This will ensure that the input impedance is bridged and that no DC current will flow. In the *On-Hook* condition, the LT51 will respond to ring voltage by emitting an audible tone.

The current setting for *Hook Status* is displayed in the CONFIG bar along the bottom of the LCD.

Going "Off-Hook"

To seize a line and go *Off-Hook* in response to ringing, or to initiate a new connection:

• press the ⟨🕻⟩ key to toggle from *On-Hook* to *Off-Hook*

When going *Off-Hook,* the speaker volume is set to 50% and the Speaker-Phone is active. See the section on Volume Control for more information.

When in the *Off-Hook* condition, and the Interface is set to *RTX* (ie. the Transmitter output is selected to appear at the RTX terminals), the input impedance is terminated to sink loop current and thereby seize the line. To ensure the correct AC impedance is presented at the RTX terminals, a special hybrid circuit is deployed providing accurate TX levels over the selected frequency span.

The following restrictions apply when *Off-Hook:*
- PSD modes are not available.
- the RTX terminals are fixed on *a-b*.

Auto-Answer*

To aid in automatic testing, the LT51 can be configured to automatically seize the line on detection of the second applied ringing signal. When measuring the RMS of Ring Voltage or any AC Voltage, this feature should be disabled:

• Press the ⟨🕻⟩ key, followed by [f3] to toggle *Auto-Answer* between *ON* and *OFF.*

When the LT51 has auto-answered an incoming call, a timer is started. This timer is reset whenever one of the following occurs; a button is pressed, a command from a MASTER is received (if this LT51 is a SLAVE) or a command over the PC interface is received. If the timer is not reset within 1-2 minutes of the last action, the line is disconnected and the LT51 goes *On-Hook.*

*Not available when the protection voltage is 60V. See specifications.

Dialling

When *Off-Hook*, dialling can be accomplished at any time by pressing any numeric keys including [*] & [#] from the keypad. As the DTMF digit is dialled, it is displayed on the LCD in a message box, and is also saved in the Redial buffer. The DTMF digit is also automatically output on the LT51 speaker to give an audible confirmation that it has been dialled. Only the first 16 digits dialled while *Off-Hook,* are saved.

Redial

Press the [f1] key to automatically go *Off-Hook* and dial the digits stored in the Redial buffer. To view the contents of the Redial Buffer on the LCD, press the [f2] key.

Speaker-Phone

The Hands-free Speaker-Phone becomes active (indicated by *"Tx: Talk"* in the TxStatus bar) when the Line Status changes to *Off-Hook,* or a DTMF digit has been pressed. It remains active until the Transmitter Source is set to *SINE ("Tx: SINE")* .

This feature is useful to test the voice quality of the line under test or to communicate to another technician at the other end of the line before making a measurement. The LT51 input level range is fixed during *"Talk"* mode. Press and/or turn the knob to adjust the volume of the receiver.

To reactivate the Speaker-Phone after testing, press any DTMF digit while still *Off-Hook*.

Marker functions

Press the ⬚ key to access the marker functions provided in the LT51. The marker position and the corresponding value of the waveform at this position, are displayed below the graph display.

Marker to peak

Press the [f1] key (*to Peak*) to move the marker to the position of displayed waveform with the highest value at the time the key is pressed.

Peak tracking

Press the [f2] key to toggle the *Peak Trk* function between *ON* and *OFF*.

When peak tracking is *ON,* the marker will always move to the position of the displayed waveform with the highest value, even as the displayed waveform is updated. To disable this feature, toggle the function to *OFF.*

Next peak

Press the [f3] key to move the marker to the *next Peak.* The marker moves to the location of the next peak value on the waveform, either left or right of the current marker position, that is lower than the current marker value.

Zero offset

Press the [f4] key (*Zero Offset*) to set the current value of the displayed waveform at the marker location, as the reference point for any future marker values. As the marker is moved along the waveform or the waveform changes, all marker values displayed are referenced to the point in time at which the [f4] key was pressed.

To cancel the Zero Offset, press the [f4] key again.

NOTE: The Zero Offset can also be set during numerical display of values.

Vertical offset

Press the [f5] key (*VertOfsfset)* to display the options for the parameter from *0dB* to *30dB* in 10dB steps. The spectrum display is automatically adjusted to the new offset setting for the RX range. When the Vertical Offset is set to a value other than 0dB, the maximum gain on the spectrum's vertical axis is highlighted.

Volume control

Any audio signal present at the RTX terminals can be monitored on the LT51 speaker.

When graphical information is being displayed, the speaker volume control is accessed by depressing the knob or pressing the ◁▷ key. During display of DMM functions, rotating the knob will access the volume control.

The current volume setting is displayed as a bar graph. Rotating the knob clockwise will increase the volume. The speaker can be turned off by rotating the knob counter-clockwise until no more bars are visible. This is recommended to save battery power when not in use.

Adjusting the contrast of the LCD

To adjust the contrast of the LCD, complete the following:

*   Press the ⚙ key, followed by the [f3] "LT51 Settings" soft-key.
*   Press the [f5] "Contrast" soft-key.
*   Turn the knob clockwise to increase, or anti-clockwise to reduce, the contrast of the LCD.

This value is permanently stored in the LT51's non-volatile memory.

Turning the backlight on and off

When you use the LT51 in low ambient light conditions, you can turn on the white LED backlight. To toggle the backlight on and off, press the ☼ key.

To save battery power, the backlight should only be used when necessary.

Switch-Off timeout

The automatic switch-off timeout is set ON by default when the LT51 is powered on. It can be disabled by:

*   Press the ⚙ key, followed by the [f3] "LT51 Settings" soft-key.
*   Toggle the auto switch-off by pressing the [f4] "Auto OFF" soft-key.

With Auto OFF set to ON, a warning message is displayed after 10 minutes of inactivity (ie. no key press) . If there is still no activity for a further 2 minutes, the LT51 will automatically power off.

Setting the date and time

To set the date and time of the RTC, follow these steps:

*   Press the ⚙ key, followed by the [f3] "LT51 Settings" soft-key.
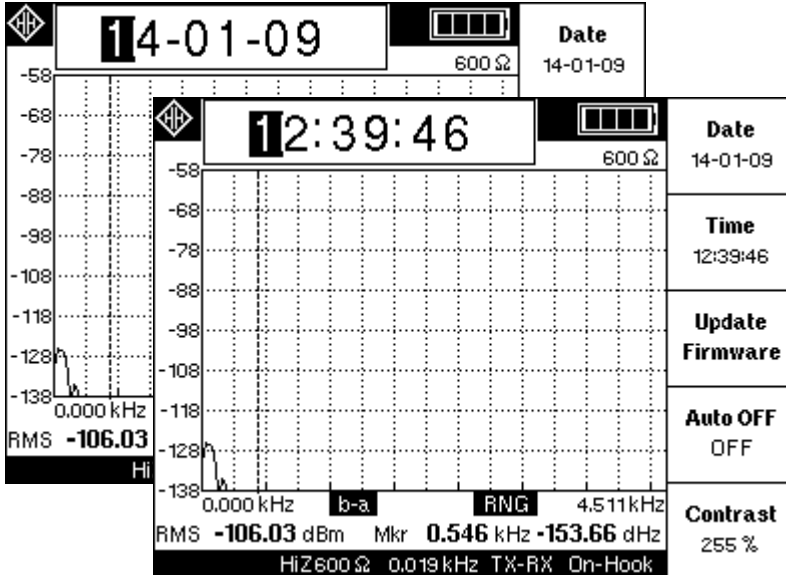
*   To modify the date, press the [f1] "Date" soft-key.
*   Enter the current date using the keypad digits.
*   Pressing the ◁ ▷ key will advance the cursor to the next digit.
*   When the date is correct, press any non-digit key to exit.
*   To modify the time, press the [f2] "Time" soft-key.
*   Enter the current time using the keypad digits.
*   Pressing the ◁ ▷ key will advance the cursor to the next digit.
*   When the date is correct, press any non-digit key to exit.

6. Making measurements

Measurements on the LT51 are selected by pressing the following keys:

⩗ (graphical icon)	Selects graphical / spectrum display mode (default: Level / Noise). Softkeys allow selection of various graphical measurements such as such as Level / Noise, Return Loss and Next / Loss.
AUTO	Initiates sequence to connect to remote LT51 tester (on RTXa-b terminals). Softkeys access the Self-test and measurements that support end-end automatic testing with a remote LT51 such as Return Loss, FEXT etc.
V Ω ⊣⊢	Selects numeric / DMM display mode (default: previous setting). Softkeys allow selection of various measurements such as Level/Noise, DCV/ACV, Return Loss, Impedance, Next / Loss.
☎ (telephone icon)	Causes the LT51 to go "off-hook" on the RTXa-b test leads and function as a telephone dial set. Hangs up (returns to "on-hook") when this key is pressed again.
TDR	Perform a TDR measurement on the pair connected to the RTXa-b terminals.

Most measurements made by the LT51 can be displayed either in graphical or numerical format by pressing the ⩗ key or V Ω ⊣⊢ key once the measurement has been selected.

The AC/DC Voltage and AC Impedance measurements can only be displayed in numerical format and can only be accessed by pressing the V Ω ⊣⊢ key.

The TDR function is always in graphical format.

Swept measurements make more sense in the graphical format, however can also be displayed in numerical format.

Level (Spectrum measurements)

⚠️ **WARNING**: *Connection of the 'g' terminal to a reference ground can introduce errors when an imbalance between the 'a' and 'b' lines exists. In this case, disconnect the 'g' terminal from reference ground on one end of the measurement.*

This single-ended measurement displays the level spectrum of the signal at the RTX terminals:

* press the ⌇⌇ key and then [f1] twice to select *Level Noise*
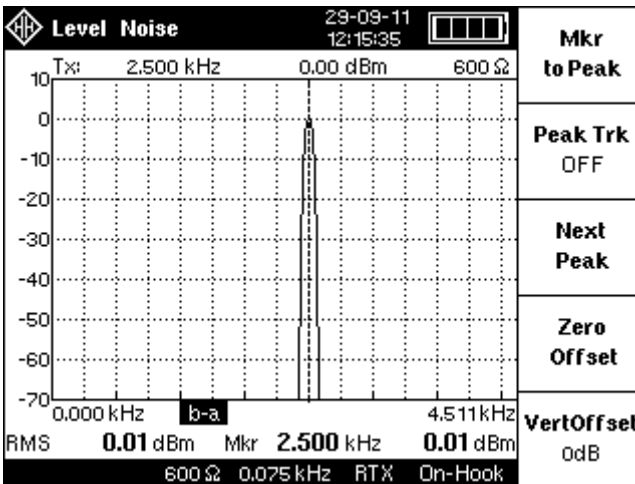
The RMS value is the total signal power across the frequency span.

The following settings are relevant to Level Noise measurements and should be set according to requirements:

* select the frequency span / centre frequency.
* select the filter to apply for noise measurements.
* Transmitter interface is either *TX-RX* or *RTX*.
* select the *Input* impedance - use a terminated(*TERM*) impedance on spare pairs and a bridging(*HiZ*) impedance on active pairs.
* adjust the input level range or use the AutoRange feature.

Use the marker to determine the signal/noise level at a particular frequency.

Setting the centre frequency and adjusting the frequency span, enables a portion of the frequency spectrum to be expanded (or zoomed in). The following example, where there are two tones close to 1,000 kHz illustrates this feature.

Examining the spectrum from baseband with a span of 1,200 kHz, it is clear there are two peaks close to 1,000 kHz, but they cannot be resolved easily.
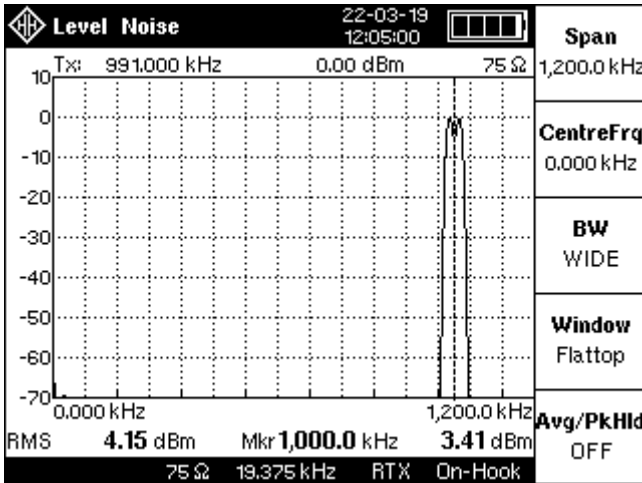
Setting the Centre frequency to 1,000 kHz and the frequency span to 75 kHz, zooms in on the peaks and reveals peaks at 991 kHz and 1,009 kHz.
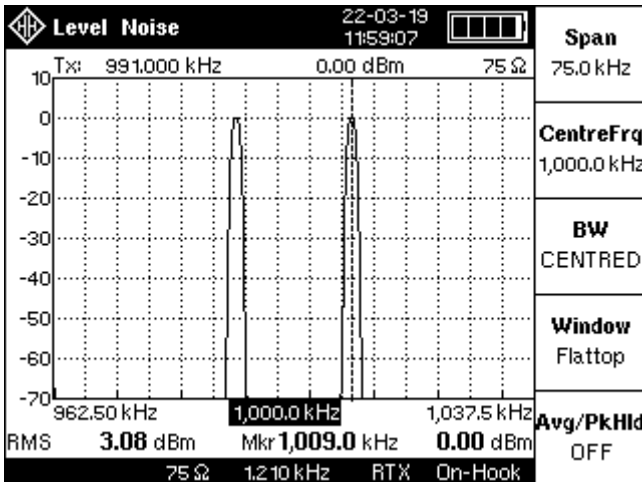
Level (Numerical measurements)

To display the frequency and level in volts, of the maximum signal for the current measurement, press the $\boxed{\vee\Omega\text{+}}$ key. The RMS value displayed, represents the total RMS signal level for the measurement selected across the current frequency span / BW, and the frequency displayed is that of the signal with the maximum peak.
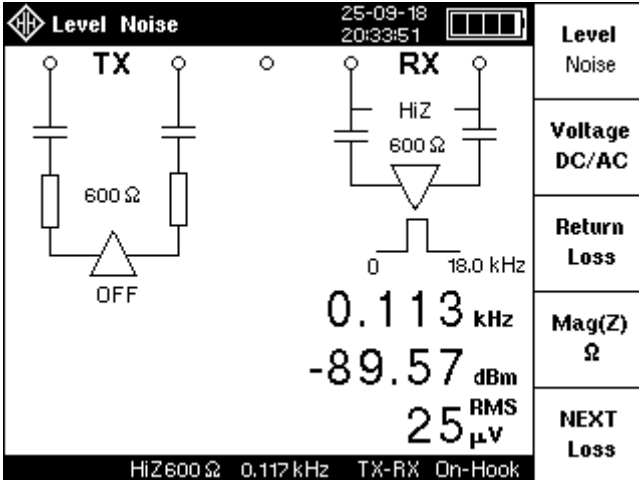
The signal to be measured must be connected to the RTXa-b terminals.

The RMS value displayed in volts, is not affected when a Zero Offset is set.

To return back to the spectrum display, press the $\boxed{\wedge\!\!\wedge\!\!\wedge}$ key.

Selective Level Meter

In DMM mode, the LT51 can make selective level measurements over its full frequency range from 200 Hz to 2.2 MHz with a BW around the centre frequency of *25 Hz, 1.74 kHz or 3.1 kHz.*

Selective measurements are made at the current centre frequency, by pressing the $\boxed{\substack{\text{BW /}\\\text{AVG}}}$ key followed by the [f3] soft-key, and then choosing the BW.

Alternatively, the desired Centre Frequency can be entered directly, in which case the 25 Hz BW is selected by default.

The level displayed is the RMS value over the BW, at the selected centre frequency.

To cancel the selective level mode, press the $\boxed{\substack{\text{BW /}\\\text{AVG}}}$ key followed by the [f3] "BW" soft-key, and select "WIDE"
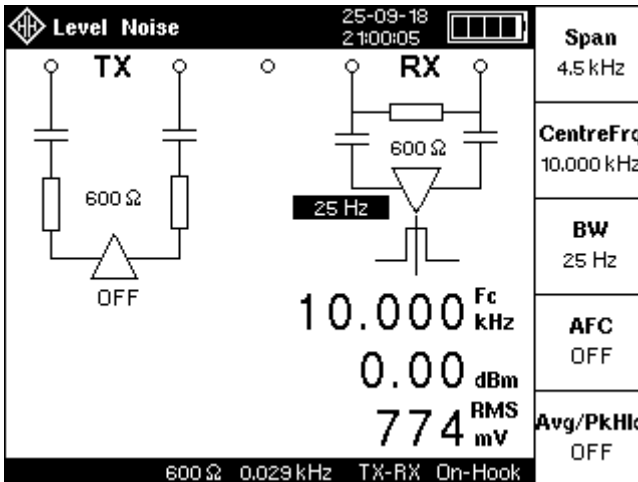
Distortion (THD, S/N, S/ND, SFR)

Distortion measurements can be selected by pressing either the $\boxed{/\!\!\sqrt{\!\!\wedge}}$ or $\boxed{V\Omega \dashv \vdash}$ key, followed by the [f1] key.

The measurement can be displayed in numerical format, where just the values of Level, Frequency and distortion for the input signal are displayed, or spectrum mode, where more information on the type of distortion can be determined.

Once a distortion function has been selected, pressing the $\boxed{/\!\!\sqrt{\!\!\wedge}}$ or $\boxed{V\Omega \dashv \vdash}$ keys, toggles between the spectral and numerical format displays.

When a Distortion function is active during spectrum displays, the marker is automatically set to the highest peak displayed (or for SFR, the peak spurious signal).

Distortion (Spectrum measurements)

Press the $\boxed{/\!\!\sqrt{\!\!\wedge}}$ key followed by the [f1] key to display Distortion spectrum measurements:

- Press the [f1] soft-key again to cancel any active distortion measurement and return to *Level / Noise* measurements.

- Press the [f2] key to measure Total Harmonic Distortion, *THD.*
  The ratio of the RMS sum of harmonic components (maximum of five) to the RMS value of the measured input signal in the current frequency span.
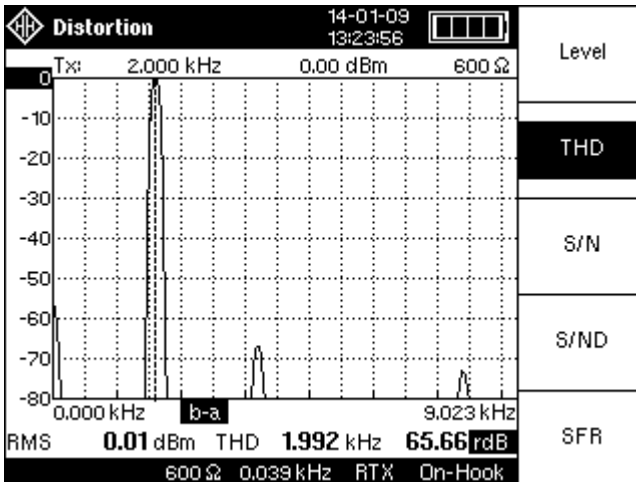
- Press the [f3] soft-key to measure the Signal to Noise ratio, *S/N.*
  The ratio of the RMS signal amplitude to the RMS value of the sum of all
  other spectral components excluding all harmonics, in the current frequency
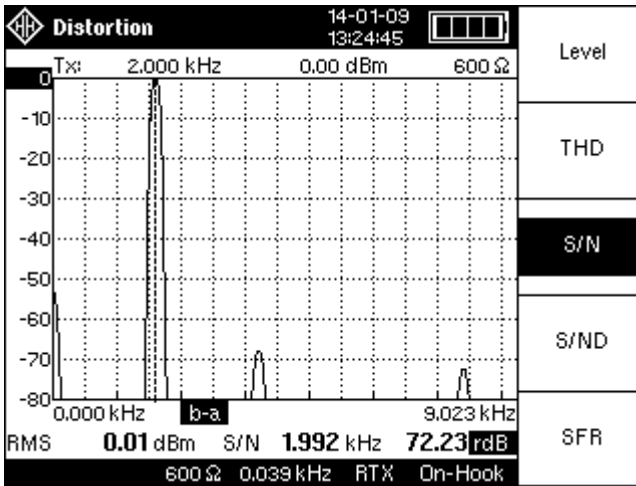
span.

- Press the [f4] key to measure the Signal to Noise and Distortion ratio, *S/ND.*
  The ratio of the RMS signal amplitude to the RMS value of the sum of all
  other spectral components in the current frequency span, including
  harmonics. Also known as SINAD.
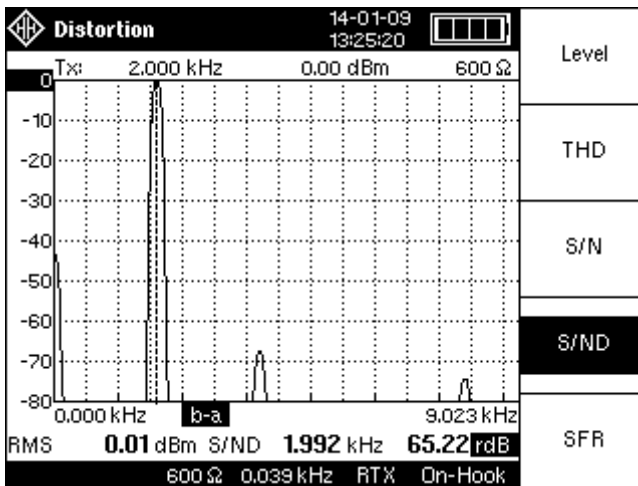
- Press the [f5] key to measure the Spurious Free Range, *SFR*.
  The difference in dB between the RMS amplitude of the input signal and the peak spurious signal (does not have to be a harmonic). Also known as SFDR.
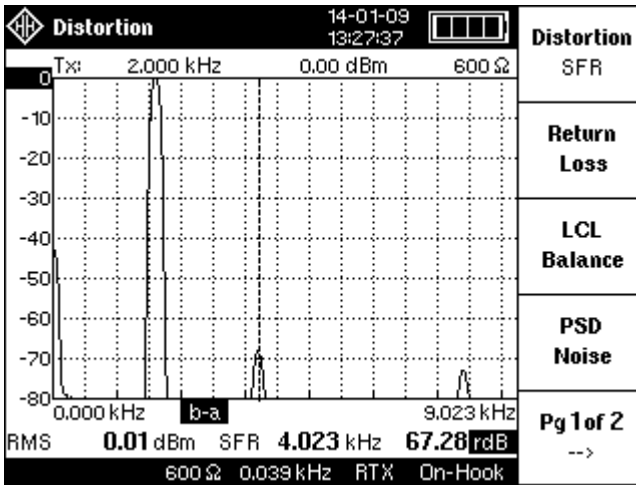
The frequency span should be set to display the desired number of harmonics to include in the calculation. To view the harmonics or noise in more detail use the "VertOffset" setting found by pressing the ⟨Marker⟩ key.

If the "AutoRange" setting is LVL+BW, the LT51 will automatically set the frequency span to 4x the frequency of the fundamental signal (or largest current input signal).

Note: *The Distortion functions can be affected by the noise at the low end of the frequency span due to DC effects. The calculations automatically remove this noise.*

Distortion (Numerical measurements)

To display the level, frequency and distortion of the input signal:

- press the $\boxed{V \Omega +\!\!\vdash}$ key and then [f1] to measure *Level/Distortion.* Select the desired Distortion function by pressing the appropriate soft-key.
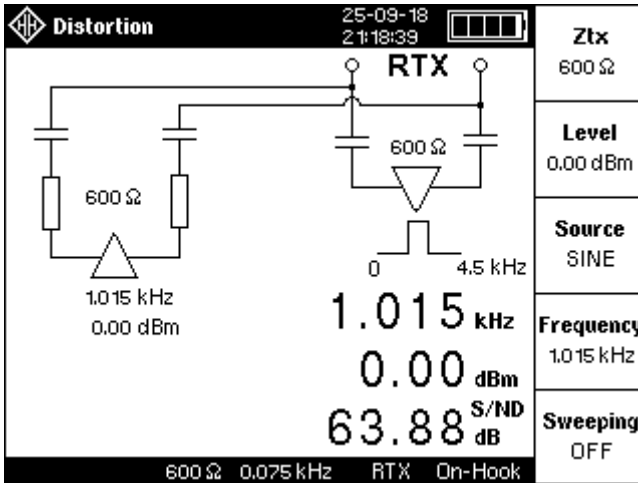
The available distortion functions are:
- Total Harmonic Distortion(THD)
- Signal to Noise ratio (S/N)
- Signal to Noise and Distortion (S/ND)
- Spurious Free Dynamic Range (SFR).

To cancel the distortion function and return to displaying just the level and frequency of the signal, select *Noise*.

To view the spectrum display of the distortion, press the $\boxed{\wedge\!\!\wedge\!\!\wedge}$ key.

See the preceding section on Distortion (Spectrum Measurements) for more information on each distortion measurement.

If the "AutoRange" setting is LVL+BW, the LT51 will automatically set the frequency span to 4x the frequency of the fundamental signal (or largest current input signal).

To make the O.132 Quantising Distortion measurement, setup a 1 kHz tone to be transmitted through the network, set the Distortion function to S/ND, and if desired, select the ITU-T O.41 Psophometric filter to weight the measurement.

Return Loss

⚠️ **WARNING:** *Ensure that the interface is free of all high power signals before connecting the LT51 in RTX mode (eg. Return Loss). Permanent damage to the LT51 will result otherwise.*

This single-ended measurement uses an internal AC bridge circuit to measure the Return Loss of the pair connected to the RTX terminals. The LT51 transmits either a single tone or sweeps over the selected frequency span depending on the sweeping setting. Simultaneously the LT51 measures the level at each sweep frequency at RTX and displays the results:

- press the ⎍ key and then [f3] to select *Return Loss.*
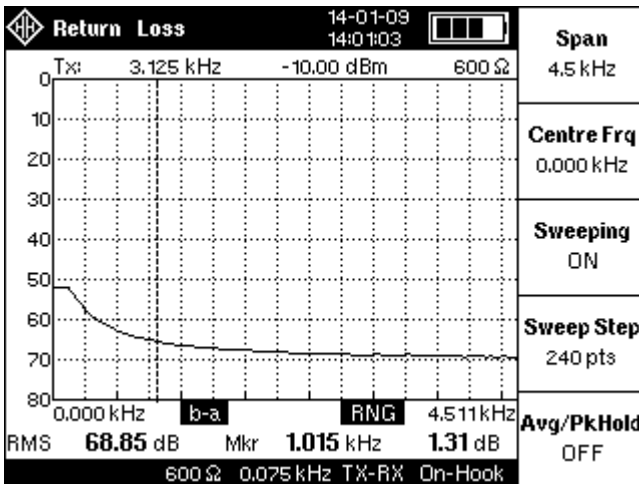
The following settings are relevant to Return Loss measurements and should be set according to requirements:

- select the frequency span / centre frequency.
- Adjust the input level range or use the auto-range feature.
- set *Sweeping* configuration for swept or single tone measurements.
- Adjust TX *Frequency* (if *Sweeping* is *OFF*).

The following settings are fixed during the measurement:

- The TX *Level* is fixed at -10 dBm.
- Transmitter interface is set to *TX-RX*.

Use the marker to determine the Return Loss at a particular frequency (see Marker functions).

Near End X-Talk (NEXT) / Loss

The noise found on local loops is caused by many sources, including light dimmers, radio signals, neon lights, electric trains and adjacent power lines, to name a few. The most common and problematic types of noise are caused by the electromagnetic coupling of signals from one local loop to another within the same cable bundle; this effect is known as "cross-talk". In fact, the reason that the telephone cable is twisted is to reduce cross-talk.

This single-ended measurement displays the cross-talk measured at the near end of the pair connected to the RTX terminals. The LT51 transmits either a single tone or sweeps over the selected frequency span at 0 dBm on an adjacent pair that is connected to the TX terminals. Simultaneously the LT51 measures the level at each sweep frequency at the RTX terminals and displays the results.

This measurement mode is also used to measure the Loss through a network connected between the TX and RTX terminals of the LT51. A 0 dBm tone (or sweep) is transmitted from the TX terminals into the network and the received signal is connected to the RTX terminals. The values / spectrum displayed represent the Loss through the network.

- press the ⎍⎍⎍ key and then [f5] to select *NEXT / Loss.*
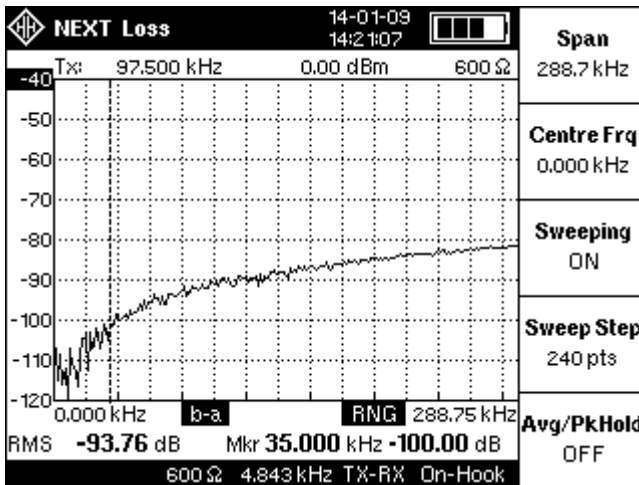
The following settings are relevant to Near End X-Talk measurements and should be set according to requirements:

- select the frequency span / centre frequency. (filter is set to NO FIL).
- select the impedance (always terminated).
- set *Sweeping* configuration for swept or single SINE measurements.

The following settings are fixed for the test and cannot be altered:

- the impedance is always terminated.
- Transmitter interface is set to *TX-RX*.
- TX level is set to 0 dBm.

Use the marker to determine NEXT / Loss at a particular frequency (see Marker functions).

NOTE: The far end of both pairs should be terminated with the selected impedance.

DC / AC Voltage

Measure the voltage between the RTXa-b terminals:

- press the $\boxed{\text{V}\,\Omega\,\text{+}}$ key and then press [f2] to select *Voltage, DC/AC.*

The DC and AC voltage between the RTXa-b terminals is continuously monitored and displayed on the LCD.

The AC voltage displayed is the true RMS value of the signal detected at the selected RTX terminals. It does not include any DC component of the signal.

A high impedance (1 MΩ) is always used to make the Voltage measurements and the Measurement Interface is always set to *TX-RX.*

DC voltages less than 0.5V are displayed as 0.00V.
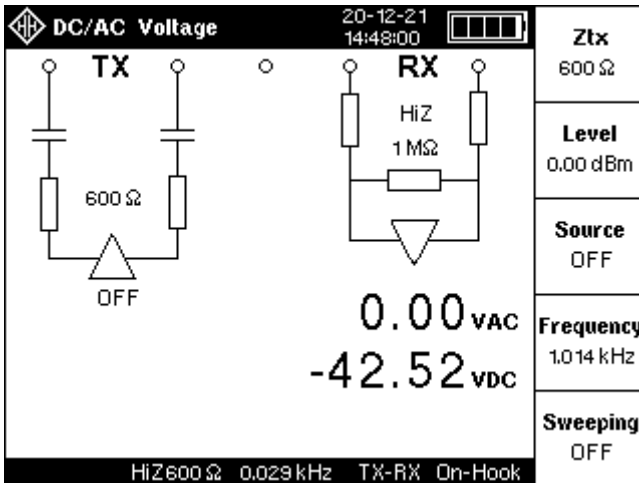
Loop Current

If the LT51 is configured as *Off-Hook,* the loop voltage measurement is made across the selected Zrtx termination and the loop current is calculated and displayed. Otherwise no loop current measurement is made.

NOTE: Other equipment may use a 430Ω shunt to measure loop current.
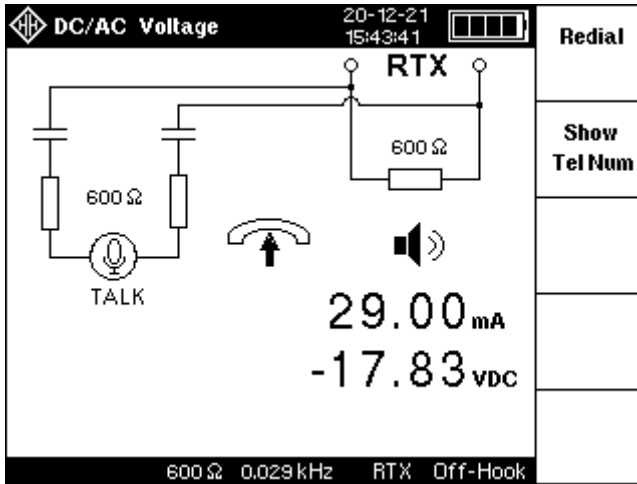
AC Impedance (MAGZ)

Measure the **magnitude** of the AC impedance between the RTXa-b connector terminals in Ω. The internal bridge network with a reference of 75 Ω, is always used to measure the impedance, and provides adequate accuracy for all frequencies from 1 kHz to 500 kHz:

- press the $\boxed{\text{V}\,\Omega\,\text{+}}$ key and then [f4] to select Mag (Z), Ω.
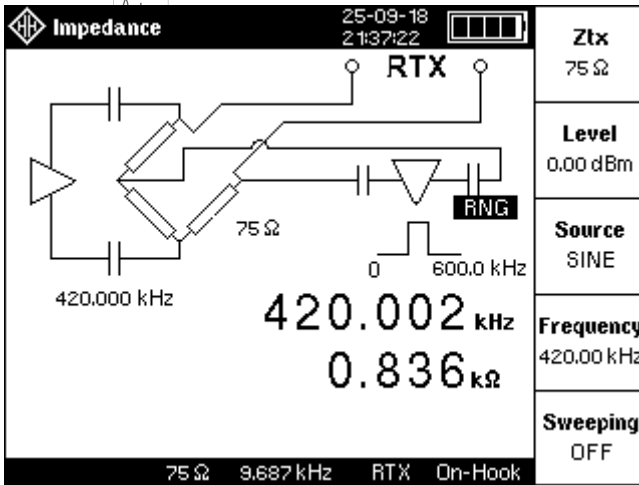
- press the $\boxed{\text{/w/}}$ key to see a plot of the impedance over the frequency span.
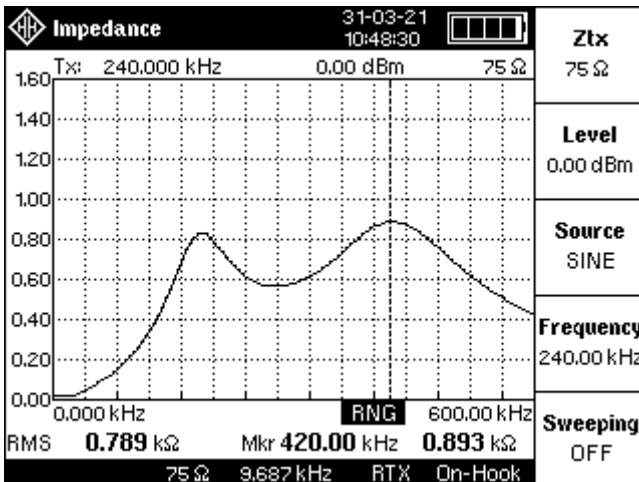
Automatic testing

To enable an LT51 to act as a Master when connecting to another LT51, the *Master* configuration must be enabled (LT51 can always act as Slave):

- press the $\boxed{\circ\!\!\phi}$ key, followed by the [f2] "Meas Settings" soft-key.
- To toggle the *Master* setting, press the [f5] soft-key.

Pressing the $\boxed{\text{AUTO}}$ key initiates a hand-shaking sequence to connect to a remote LT51 tester. The pair to be tested, must be connected between the RTXa-b terminals of the local and remote LT51 testers.
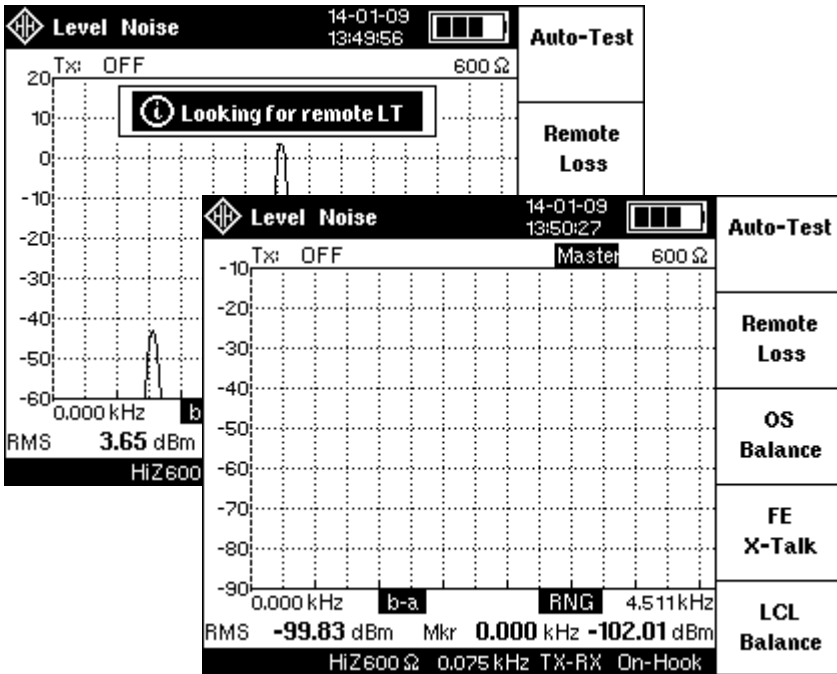
After successfully connecting to a remote LT51, the inverse text message Master appears in the TXSTATUS area of the LCD of the local LT51. Simultaneously the message Slave appears in the TXSTATUS area of the remote LT51.

If unsuccessful, the message "No remote LT51 found" is displayed. It is still possible to perform auto-testing in the absence of a remote LT51.

NOTE: For a connection to be established, the remote LT51 must not be
transmitting a single tone between 1.8 and 3.0 kHz, and the line
attenuation at these frequencies must be less than 30dB (600Ω). The
local LT51 can be used to verify these conditions.

NOTE: When connected as a SLAVE, the remote LT51 will not set TXFREQ to
any frequency between 1.8 kHz and 3.0 kHz, since frequencies within
this range interfere with the modem operation.

Once connected, the current configuration of the local LT51 is transferred to the
remote LT51. The following events will also update the remote LT51:

- changing the measurement mode.
- changing Zrtx, Ztx, Span, sweeping, terminals, or when ⎣OK save⎦ pressed: TX or
  Centre frequency (non-zero centre frequency is not supported).

The following events will close down the connection to the remote LT51:

- pressing the Telephone 🕐 or ⚙ keys.
- timeout waiting for a command acknowledgment from the remote LT51, eg.
  after removing the physical pair connection.

To re-establish the connection, press the ⎣AUTO⎦ key again.

The following table describes the termination conditions the remote LT51
presents to the pair being tested for each measurement mode that can be
selected on the local LT51.

Test	Measurement	Remote LT51 (slave) termination
DC/AC Voltage	a-b	RTX: O/C
Loop Current	a-b	RTX: O/C
Impedance	a-b	RTX: O/C
TDR	a-b	RTX: O/C
DE Loss	a-b	RTX: AC terminated
Return Loss	a-b	RTX: DC terminated
NEXT or FEXT	a-b	RTX: DC terminated TXa-b: AC terminated
OSB	a-b	RTX: AC terminated
Noise	a-b	RTX: DC terminated

Table 5.1 List of available Auto-Tests & termination conditions

Self-Test

* Press the AUTO key, then press [f1] to select *Self-Test*.

```
┌─────────────────────────────────────────┬──────────────┐
│ ◈ Self Test          31-03-21  ▯▮▮▮▮     │ Service      │
│                      11:15:37            │ Custom       │
│   Tx:  10.000 kHz         0.00 dBm  600Ω │              │
│                                          │              │
│  Level          10.000  0.00    50Ω      │              │
│  Level          10.000  0.00    600Ω     │ Start/       │
│  Level          10.000  10.00   600Ω     │ Stop         │
│  Level          10.000  -20.00  600Ω     │              │
│  Freq Accuracy  1,000.0 0.00    75Ω      │ Show         │
│  Freq Response  10.000  0.00    75Ω      │ Details      │
│  Freq Response  2,000.0 0.00    75Ω      │              │
│  AC Voltage     1.000   10.00   600Ω     │              │
│  Return Loss    10.000  0.00    600Ω     │              │
│                                          │              │
│                                          │              │
│    HiZ600Ω  0.302 kHz   TX-RX  On-Hook   │              │
└─────────────────────────────────────────┴──────────────┘
```

NOTE: All connections to the LT51 TXab and RTXab terminals must be removed before starting the self-test.

The Self-test can be performed to give the user general confidence that LT51 Hardware is functioning correctly, and that the basic calibration is still valid. The tests have been designed to cover as much different functionality as possible, to enable crude remote debugging of performance issues if required.

For this version of the LT51, the *Service* parameter is limited to the "Custom" type only.

To start the Self-Test sequence:
* Press [f2] to *Start/Stop* the auto-testing.

As the tests progress they are displayed on the LCD with the suffix "(A)" appended to the measurement description in the Title bar. To stop the self-test at any time:

* press the [f2] key to select *Start/Stop.*

NOTE: While the tests are running, all keys except the softkeys (f1 to f4) are disabled.

When the tests have been completed a summary of the results is displayed on the LCD. To examine the details of each test:

- press the [f3] *Show Details* key repeatedly to view the results of each test in the sequence.

The results of each test, are automatically saved in the LT51 non-volatile memory for later up-load to a PC.

Following completion of the self-test, a summary of the results are displayed, in the final column of each test.

```
◈ Self Test              31-03-21   ▮▮▮     Service
                         11:08:59            Custom
   Tx:    10.000 kHz     0.00 dBm     600 Ω

  Level          10.000  0.00    50 Ω   -0.01
  Level          10.000  0.00   600 Ω    0.07        Start/
  Level          10.000  10.00  600 Ω   10.05         Stop
  Level          10.000 -20.00  600 Ω  -19.93
  Freq Accuracy  1,000.0  0.00   75 Ω  1,000.000      Show
  Freq Response  10.000  0.00    75 Ω   -0.02       Details
  Freq Response  2,000.0  0.00   75 Ω    0.10
  AC Voltage     1.000   10.00  600 Ω    4.86
  Return Loss    10.000  0.00   600 Ω    0.01



         HiZ 600 Ω  0.302 kHz   TX-RX  On-Hook
```

 Column 1: Name of test to be performed
Column 2: Tx frequency in kHz.
Column 3: Tx Level in dBm
Column 4: System impedance (for AC Voltage Zin = HiZ)
Column 5: Result of test in dBm, kHz, Vac, dB as appropriate.

Double Ended Loss

This double-ended Measurement displays the loss and frequency of signals transmitted at 0 dBm from a LT51 at the far end of the pair connected to the RTX terminals:

*   press the AUTO key and then [f2] to select *Remote Loss.*
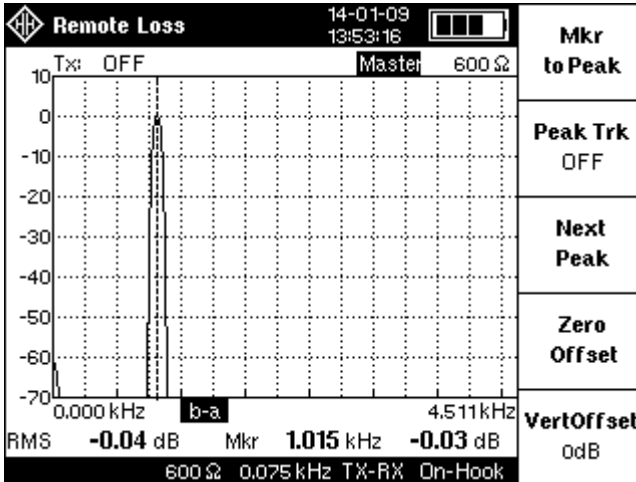
The following settings on the local LT51 are relevant to Doubled Ended Loss measurements and should be set according to requirements:

*   select the frequency span / centre frequency.
*   select the input impedance (always terminated).
*   adjust the input level range or use the auto-range feature.
*   set *Sweeping* configuration for swept or single tone measurements.
*   set the TX frequency on the local LT51. The remote LT51 will transmit this frequency at 0dBm, back to the local LT51.

The following settings are fixed for the test and cannot be altered:

*   Transmitter interface is set to *TX-RX*.

Use the marker to determine the loss at a particular frequency (see Marker functions).

NOTE: If Sweeping is set and BW is set to "*CENTRED*", the remote LT51 will sweep over the smallest baseband span containing the currently set **TX frequency** AND not over the currently displayed start /stop frequency.

Far End X-Talk (FEXT)

This double-ended Measurement displays the cross-talk measured at the near end of the pair connected to the RTX terminals. The far end LT51 transmits a single or swept signal over the selected frequency span at 0 dBm, on the pair connected to it's TX terminals which is physically close to the pair connected between the RTX terminals of each LT51. The near end LT51 measures the level and frequency at the RTX terminals and displays the results. The near end LT51 also terminates the adjacent pair connected to the TX terminals by setting its' Transmitter Source to *OFF*:

* press the AUTO key and then [f4] to select *FE X-Talk.*
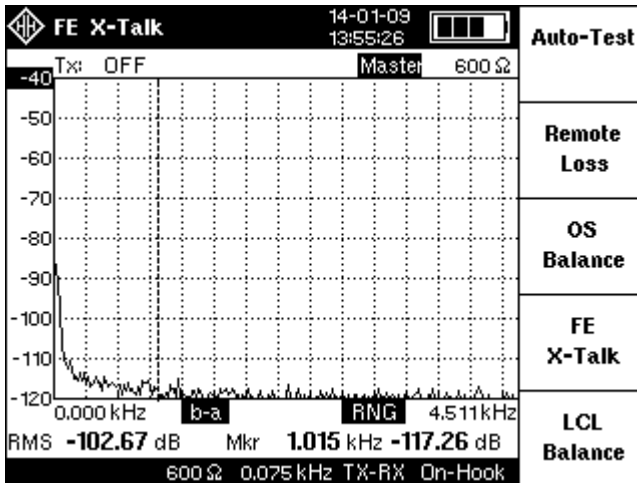
The following settings on the local LT51 are relevant to Far End X-talk measurements and should be set according to requirements:

* select the frequency span / centre frequency.
* select the impedance (always terminated).
* set *Sweeping* configuration for swept or single tone measurements.
* set the TX frequency on the local LT51. The remote LT51 will transmit this frequency at 0dBm, back to the local LT51.

The following settings are fixed for the test and cannot be altered:

* the impedance is always terminated.
* Transmitter interface is set to *TX-RX*.
* Transmitter is *OFF*.

Use the marker to determine FEXT at a particular frequency (see Marker functions).

TDR Measurement

You can use the TDR Measurement to determine the length of a cable and to precisely locate faults such as Shorts, Breaks or Opens, Bridged Tap, Load Coils, Splices or Splits. During the TDR measurement, the LT51 continually applies a Pulse to the RTXa-b terminals. As the pulse travels down the pair (connected to the RTXa-b terminals), any impedance change or fault encountered will result in some of the pulse being reflected back to the LT51. These reflections together with the launch pulse are recorded by the LT51 as a trace and displayed on the LCD, so that the distance between the events can be measured:

- Connect the pair to be tested to the RTXa-b terminals.
- Press the $\boxed{\text{TDR}}$ key, to select the TDR measurement of the LT51.

Auto-TDR

When the $\boxed{\text{TDR}}$ key is pressed, the LT51 will automatically search for the first impedance discontinuity (open, short, bridged tap upto 3km, PVF=67%) and place the marker at the start of the event, displaying the distance to the event. It will automatically search all ranges from the lowest to the highest, and zoom the waveform to show all features in the display.

Zo Impedance

An impedance of *75,125 or 150 Ω* can be set (via $\boxed{\text{TX}\ominus}$ or $\boxed{\text{RX}\ominus}$ keys) for TDR.

TDR Range

The TDR Range needs to be set to cover the expected length of the cable being tested:

- Press the [f1] soft-key to select *TDR Range.*
- Turn the knob clockwise to increase, or anti-clockwise to reduce, the *TDR Range.*
- Press the $\boxed{\text{OK}\atop\text{save}}$ key (or any key) to clear the dialog box.

NOTE: The values for TDR Range are affected by the PVF setting.

PVF (Propagation Velocity Factor)

For the LT51 to display the trace with accurate distance information, the correct PVF of the cable being measured must be set:

- Press the [f2] soft-key to select *PVF.*
- Turn the knob clockwise to increase, or anti-clockwise to reduce, *PVF.*
- Press the $\boxed{\text{OK}\atop\text{save}}$ key (or any key) to clear the dialog box.

.

NOTE: Changing the PVF will automatically update the TDR range, distance resolution (centre of bottom bar) and distance display on the LCD.

In a vacuum, electricity, like light, travels at about 300,000 km/second. In cables, it travels slower than this and we refer to the speed as a % of the speed of light. This is usually expressed as the Propagation Velocity Factor or PVF. You may also see it referred to as Velocity of Propagation or VOP. Typical PVFs for electric cables are from 50 to 68 (50 % to 68 % of the speed of light). Water in cable will increase the value of PVF.

If the PVF is unknown, you can start with a typical value for that type of cable. To obtain a more accurate value, test a known length cable of the same type with a discontinuity at the end (either S/C or O/C). Adjust the PVF until the cursor, which is placed at the beginning of the reflection due to the discontinuity at the end of the cable, reads the known length. Another possible method, involves measuring the fault from both ends of the cable, add the distances together and either adjust the PVF or use a ratio calculation to find the position.

Some commonly used cables and there PVFs are listed below:

Cable	PVF (%)
Coaxial - 50 Ω, RG58C/U (PE), RG178/U (PTFE)	69
Coaxial - 75 Ω, RG59B/U (PE), RG179/U (PTFE)	67
Coaxial - 50 Ω, LMR-200,HDF-200,CFD-200 (PF)	83
Coaxial – 92 Ω, RG-62/U (PF)	84
UTP – Polyethylene (PE)	67
UTP – Air PIC, 19 AWG / 0.90mm	69
UTP – Air PIC, 22 AWG / 0.64mm	68
UTP – Air PIC, 24 AWG / 0.50mm	67
UTP – Air PIC, 26 AWG / 0.40mm	66
UTP – PTFE (Teflon)	71
UTP – Pulp, 19 AWG / 0.90mm	70
UTP – Pulp, 22 AWG / 0.64mm	69
UTP – Pulp, 24 AWG / 0.50mm	68
UTP – Pulp, 26 AWG / 0.40mm	67
UTP – Jelly PIC, 19 AWG / 0.90mm	66
UTP – Jelly PIC, 22 AWG / 0.64mm	65
UTP – Jelly PIC, 24 AWG / 0.50mm	64
UTP – Jelly PIC, 26 AWG / 0.40mm	63
FTP – Air PIC, 24 AWG / 0.50mm	78
Power – Cross Linked Polyethylene (XLPE)	52 – 58
Power – Paper Oil Filled (PILC)	49 - 54

Table 6.3: PVF for common cable types

where: UTP – Unshielded Twisted Pair, FTP – Foil-screened Twisted Pair
PIC – Plastic Insulated Cable
Pulp – Paper slurry filled cable
PE – solid polyethylene, PF - polyethylene foam
PTFE - polytetrafluoroethylene

Pulse width

The pulse width can be quite short for short cables, but needs to be longer for greater length cables so that enough energy is introduced in the cable. If the energy is too low, there won't be enough energy in the return wave to be detected reliably. The LT51 allows a choice between 50 and 2500 ns. The 2500ns pulse width will produce enough energy for a 5 to 10 km cable:

- Press the [f3] soft-key to select a *PulseWidth* between *50ns, 200ns, 500ns, 1000ns, 2500ns.*

NOTE: The LT51 automatically chooses the pulse width appropriate for each TDR range selected (5000ns for max. Range). However the pulse width can still be changed independent of TDR range.

Adjusting the TDR display

There are several options for optimising the view of the TDR waveform on the LT51 LCD. The transmit pulse will be seen at the left of the display when the horizontal zoom is set to 1x.

Cursor

Use the knob to move the cursor across the screen (ensure that any dialog boxes are cleared by pressing the $\boxed{\substack{OK \\ save}}$ key). The distance from the LT51 RTXab terminals to the event marked by the cursor is always shown next to the "Mkr:" text. Always place the cursor to the left side of an event to determine the distance to the event.

NOTE: Always subtract the length of the test leads from the distance measurement for highest accuracy.

Vertical zoom

The size of the features in the TDR display (ie. how tall or small they are) can be set by varying the vertical zoom in multiples of 8x:

- Toggle the [f4] soft-key to set *Zoom* to *Vertical.*
- A Dialog box appears with the text "Vertical Zoom".
- Turn the knob (anti) clockwise to (decrease) increase the vertical zoom*.*
- The bar on the vertical axis adjusts to indicate the active zoom size.
- Press the $\boxed{\substack{OK \\ save}}$ key (or any key) to clear the dialog box.

Note: Vertical zoom only changes the size of the displayed waveform. It does not increase / decrease the amplitude of the TDR pulse which remains fixed.

Tip: If Zoom is set to Vertical, pressing the knob or $\boxed{\triangleleft \triangleright}$ key, is a shortcut to enable the zoom to be set by turning the knob.

Horizontal zoom

The features in the TDR display can be spread out or compressed by setting the horizontal zoom in multiples of 2:

- Toggle the [f4] soft-key to set *Zoom* to *Horizontal.*
- A dialog box appears with the text "Horizontal Zoom".
- Turn the knob (anti) clockwise to (decrease) increase the horizontal zoom.
- Press the $\boxed{\text{OK save}}$ key (or any key) to clear the Dialog Box.

NOTE: The amount of horizontal zoom available varies between TDR ranges. Horizontal zoom is unavailable for the shortest TDR range as the highest resolution is already displayed. As the TDR range is increased, the amount of horizontal zoom available also increases.

TIP: If Zoom is set to Horizontal, pressing the knob or $\boxed{\triangleleft \triangleright}$ key, is a shortcut to enable the zoom to be set by turning the knob.

Horizontal offset

The horizontal offset and Horizontal Zoom settings operate together to enable sections of the displayed waveform to be examined in greater detail over the whole TDR range:

- Toggle the [f5] soft-key to set *Offset* to *Horizontal.*
- A dialog box appears with the text "Horizontal Offset".
- Turn the knob (anti) clockwise to (decrease) increase the horizontal offset*.*
- Press the $\boxed{\text{OK save}}$ key (or any key) to clear the dialog box.

NOTE: The horizontal offset can only be changed when the horizontal zoom is > 1x, on the maximum range.

TIP: Moving the Cursor beyond the display limits will automatically pan the TDR display and adjust the horizontal offset.

Vertical offset

The vertical offset allows the TDR waveform to be moved so that all elements of the waveform can be observed particularly when the vertical zoom is > 1x:

- Toggle the [f5] soft-key to set *Offset* to *Vertical.*
- A Dialog box appears with the text "Vertical Offset".
- Turn the knob (anti) clockwise to move the displayed waveform (down) up.
- The bar on the vertical axis moves up or down to indicate the portion of the original waveform that is now visible.
- Press the $\boxed{\text{OK save}}$ key (or any key) to clear the dialog box.

'Peak' Events

Launch pulse: The first peak on the screen is the "launch pulse" which occurs where the LT51 connects to the test leads (at a distance of 0 metres). The distance to the cursor includes the length of the test leads.
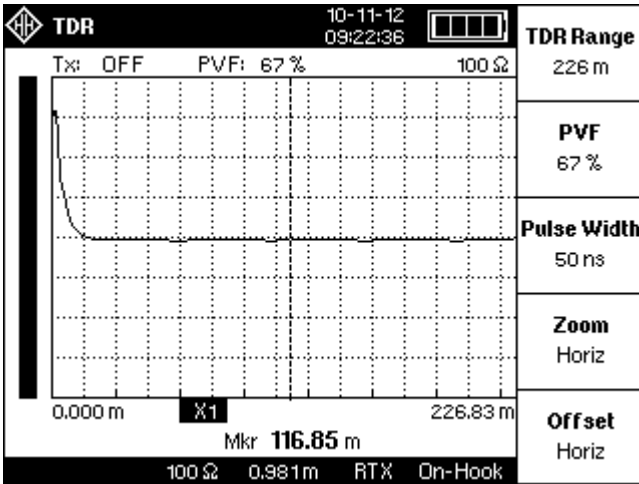
Open: A clean or partial open will show up as a peak on the screen. The "cleaner" the open, the taller the peak. A complete open will be the tallest peak (other than the launch pulse). You can not see events past a complete open.
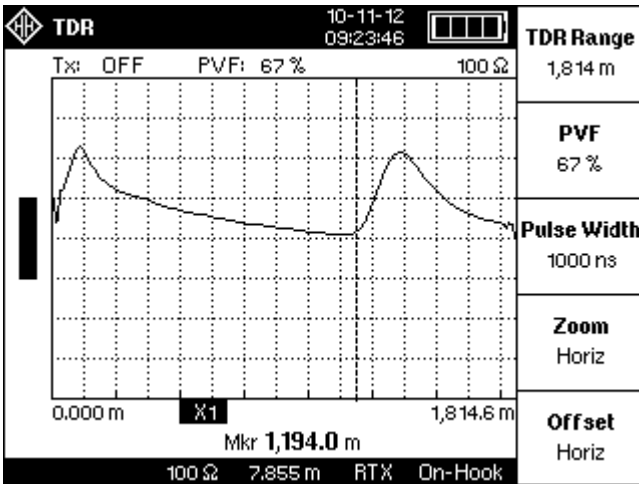
Load Coil: A load coil looks very similar to an open. If you think there is a load coil on the pair, use the LT51 Load Coil function to verify its presence. You can not see events past a Load Coil.

'Dip' Events

Fault: A resistance fault will show as a dip on screen. The lower the value of resistance, the lower the dip.

Short: A short (or 0 Ω resistance fault) will show up as the lowest dip on the screen. You cannot see events past a short.
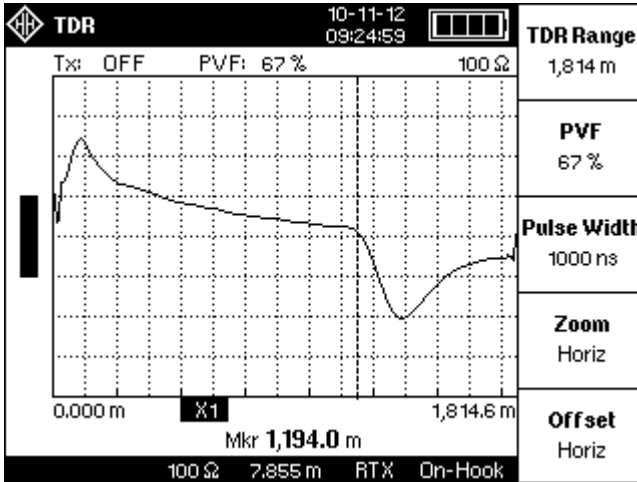
Bridge Tap: A bridge tap will look like a resistance fault and an open. (A dip followed by a peak.) The distance between the two events is the length of the bridge tap. The start of a bridge tap looks like a resistance fault. Use the LT51 Resistance function to measure the resistance on the pair. If there is no resistance, and you see a dip followed by a peak, you might suspect a bridge tap. Also for a bridged tap, the absolute value of the dip is always greater than the absolute value of the peak.

Blind spot

Reflections due to faults that are located very close to the LT51 RTXa-b terminals, and hence occur before the TDR pulse has been completed, can still be measured if the cable has an impedance close to 100 Ω. This is due to hybrid echo cancelling hardware built-in to the TDR circuit. However, when the cable impedance is not close to 100 Ω, a known length of cable (exceeding the TDR pulses width) of the same type as being measured should be inserted between the LT51 and the cable being tested. To locate the fault on the measured cable, the length of the inserted cable needs to be subtracted from the result displayed on the LT51 LCD.

Saving measurements

To save a measurement, press the $\boxed{\substack{\text{OK} \\ \text{save}}}$ key.

NOTE: *Pressing the* $\boxed{\substack{\text{OK} \\ \text{save}}}$ *key while a dialog box or status information is displayed, will not save the measurement, but clear the display.*

To save a short ID (max. 14 characters) with each saved measurement (or Auto-Test), the *Save ID* configuration must be enabled:

*   press the $\boxed{\text{o}^{\text{❈}}}$ key, followed by the [f2] "Meas Settings" soft-key.
*   To toggle the *Save ID* setting, press the [f1] soft-key.

If the SAVE ID Configuration is set to ON, then before saving the measurement, the user is prompted to enter a max. of 14 characters to save as an Identifier string with the measurement. A message box with the text " Enter ID:" is displayed. If the Save ID configuration is not set to ON, then the measurement is immediately saved.

The user enters the string using the multi-tap protocol (similar to SMS on mobile phones), using the alphanumeric keypad of the LT51. Once the 14 character limit is reached, further characters are ignored. To erase previous characters, repeatedly press the $\boxed{\triangleleft \triangleright}$ key until the desired position is reached. To store the ID string and save the measurement, press the $\boxed{\substack{\text{OK} \\ \text{save}}}$ Key. If you no longer want to save the measurement, press any menu or soft-key.

The waveform and or text results, on the screen at the time the $\boxed{\substack{\text{OK} \\ \text{save}}}$ key is pressed, are automatically saved to the instrument memory together with the LT51 time/date stamp. All relevant LT51 configuration information is also automatically saved with the result.

LT51 measurements are stored as one of two types:

*   Text – The 3 terminal pair values measured by the DMM functions of Voltage, Impedance and RMS & Frequency (one pair at a time), are stored when the measurement is saved.
*   Graphical – All measurements that display a graphical result such as Level Noise, PSD, NEXT, FEXT, TDR store each value and set-up associated with the graph when the measurement is saved.

The LT51 stores the measurement results in two circular buffers: one for text (max. 7), the other for graphical (max. 10) result types. Saving new measurements will overwrite the oldest stored measurements. Note that results of the Auto-Tests are automatically stored in these same circular buffers and that these tests can consist of up to 15 measurements (both text and graphical).

Recalling saved measurements

To view a list of all the saved measurements:

- press the ⚙ key, followed by the [f1] "Recall Tests" soft-key.

A list of all the saved graphical measurements is displayed on the LCD, identified by the measurement type, it's time/date stamp and User ID string. To display the saved text or DMM measurements, press the [f2] "Recall DMM" soft-key.

To display the details of an individual test, move the highlight bar to the desired test by turning the knob clockwise or anti clockwise. When the desired test is selected:

- press the [f3] "Show Detail" soft-key to display the details saved for the measurement.

When the saved measurement is displayed on the LCD, the text"(S)" appears next to the measurement title. This distinguishes the display from a real time measurement. For saved measurements that were performed as part of an auto-test, a limit line mask is also displayed.

Marker functions (eg. Mkr to Peak) are unavailable during the display of saved graphical measurements.

To return to real-time measurements, press the [f5] "Exit" soft-key.

Recorder Mode

When looking for intermittent faults or interference, the LT51 Recorder mode can be used to monitor a measurement over an extended period. Recordings at a specified sampling interval, are saved to internal non-volatile flash memory for later update to a PC for analysis. The memory can hold over 200k samples, which can be spread over a maximum of 10 recordings, or just 1 occupying the total memory.

NOTE: New recordings can possibly overwrite (all)previous recordings.

To use the Recorder feature follow the steps below:
* Setup the Level or DC Voltage measurement to monitor.
* Press and hold the $\boxed{\substack{\text{OK}\\\text{save}}}$ key down for greater than 1.5 s.
* The menu changes to allow control of the Recorder, such as Start/Stop, selection of the sampling interval, and to display the start time/duration of the measurement.

With the LT51, it is possible to record a measurement every second for over 60 hours. Increasing the sampling interval enables measurements to be recorded over weeks:
* Before starting the Recorder, select the sampling interval by pressing the [f2] soft-key. The options are: 1s, 2s, 5s, 10s, 60s.
* To start the Recorder, press the [f1] soft-key to display "RUNNING".

While the Recorder is running;
* the current measurement is continuously displayed, together with the maximum and minimum values that have been recorded.
* The start time of the measurement together with a timer indicating how long the measurement has been running, are displayed in the menu area. The timer is displayed in the format: "dd:hh:mm:ss"
* All keys, except the [f1] soft-key are disabled.
* Press the [f1] soft-key to "STOP" the Recorder.
* If the Recorder runs out of memory or the battery is near empty, the function will automatically stop.

NOTE: Only the minimum and maximum values that have been recorded in the memory are displayed. Hence if the currently displayed measurement has not been sampled, it may be outside these displayed min. / max. values.

The result of a Recorder measurement can be up-loaded to the PC, where a graph of all the sampled Level/DCV values are displayed. See the PC Interface section for more information.

7. PC interface

The LT51 opto-isolated USB interface can be connected with a standard USB cable, to a PC running a Windows 98, 2000, XP, Vista or 7 OS. This interface allows a user to upload stored results, control the instrument and update the LT51 firmware.

USB drivers

Before using the LT51 PC interface, the appropriate USB drivers must be installed on the PC. These drivers are automatically installed when installing the freely available *LT51View* Application on a PC with a Windows 98, 2000, XP, Vista or 7 OS.

The USB drivers may also be installed manually by downloading the required files (according to your OS) from the FDTI website: http://www.ftdi.com, or using the Windows Update feature during the "Found New Hardware Wizard" for Windows OSs.

One driver is required to support the USB interface, while a second Virtual COM Port (VCP) driver, enables the USB device to appear as an additional COM port available to the PC. Application Software can then access the USB device in the same way as it accesses a standard COM port. The next available COM port will be assigned permanently to a unique LT51.
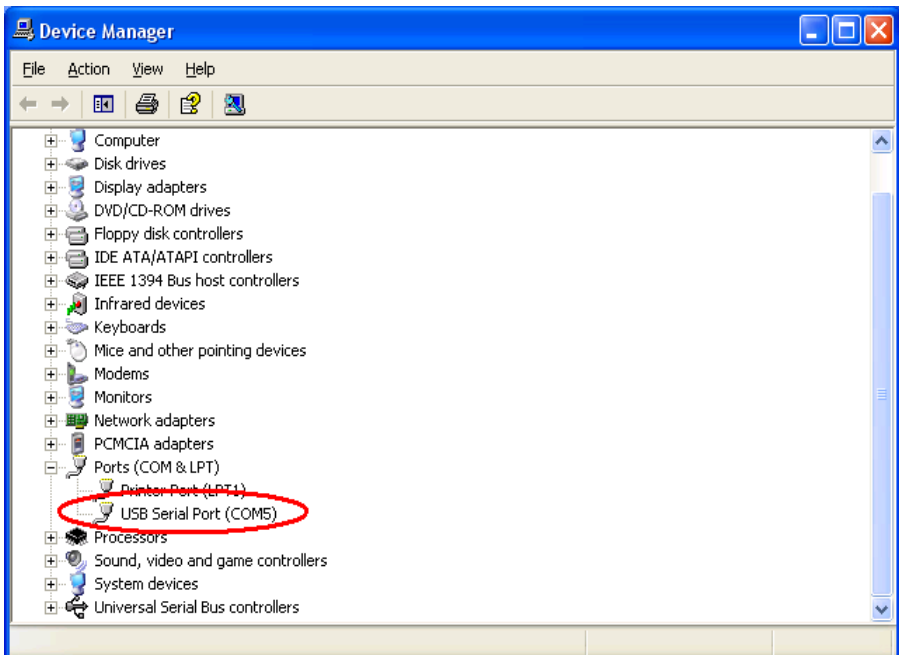
LT51View application program

LT51View is a PC application program for Windows 98, 2000, XP, Vista, or 7 OS's, developed by H Heuer Instruments Pty Ltd specifically for interfacing the PC to the LT51 Line Tester.

This PC program will enable:

- Up-loading of saved measurements on the LT51 to the PC, and then saving the results as BMPs or text files (*.csv).
- Configuration or remote control of the LT51 via sequences of commands stored in text files or issued direct from the application.
- Down-loading of the LT51 firmware when new releases become available.

The latest version of the *LT51View* Application program can be obtained without charge for all customers, by emailing a request to: info@heuer.com.au. After down-loading, this program must be installed onto your PC before communication with the LT51 can commence.

Up-loading saved measurements

With the LT51 connected to the PC, launch the *LT51View* PC program.

Select the "Upload" tab in the main window of the application. In the displayed combo-box, choose either "Graph Results" or "DMM Results". The list of saved measurements is displayed beneath the combo-box.

To view a particular saved measurement, select the measurement from the list.

For graphical displays, the cursor can be updated by clicking the mouse on the graph, pressing the displayed "<<","<",">",">>" buttons or selecting a pair of values displayed in the box below the list of saved measurements

Clicking the "Copy Image" or "Copy Values" (for graphical measurements) buttons, allow either a BMP of the current LCD screen, or a comma delimited list of all the values being displayed, to be saved to the clipboard for insertion into any Windows application of choice.

Clicking the "Save Test" button will save all results and configuration information for the test, to a comma separated list to a CSV file.

Up-loading Recorder results

Select the "Upload" tab in the main window of the application. In the displayed combo-box, choose "Recorder Results". When all results have been up-loaded a list of each sample showing the date/time and their level together with a graph of the values is displayed.

Controlling the LT51

Control of the LT51 by a PC is possible over the USB connection, which appears as a COM port on the PC.

The *LT51View* PC application also provides an ability to interface to the LT51 via commands read from a text file. Please see the documentation for the *LT51View* program for a description of this interface and the specific commands.

The USB virtual COM port needs to be configured with the following settings for successful communication:

· 9600 Baud, 8-bit data, 1 Stop Bit, No parity.

Commands from the PC to LT51 always consist of 5 bytes:

· <CMD><D1><D2><D3><D4>

Upon successful reception of the 5-byte command, the LT51 will respond by returning an ACK(0x99) byte OR data byte(s).

NOTE: The LT51 will wait until it receives 5 bytes. This can lead to synchronisation issues if an incorrect number of bytes is transmitted for a command. To ensure the PC-LT51 control link is correctly synchronised, the PC can repeatedly transmit the ACK byte (0x99) until the LT51 responds with an ACK (0x99). At this point the PC-LT51 is synchronised and ready to accept a new command.

Command	CMD	D1	D2	D3	D4
CONFIGSETTING	0xAD	Config	Value	xx	xx
CONFIGTXLEVEL	0xAE	LevHi	LevLo	xx	xx
CONFIGTXFREQ	0xAF	Freq1	Freq2	Freq3	Freq4
CONFIGCENTREFREQ	0xB0	Freq1	Freq2	Freq3	Freq4
READDATA1	0xB1	xx	xx	xx	xx
READDATA2	0xB2	xx	xx	xx	xx
READDATA3	0xB3	xx	xx	xx	xx

LT51 Commands
CONFIGSETTING

Syntax: <0xAD><Config><Value><xx><xx> (LT51 returns <0x99>)

This command will set an internal LT51 <Config>uration to <Value>. The following Configurations and their values can be set with this command:

Configuration	<Config>	<Value>
MEASMODE	0x00	0x20 = LEVSPCTM 0x21 = PSD 0x23 = IPNOISE 0x26 = TDR 0x28 = OSB 0x30 = NEXT / Loss 0x31 = FEXT 0x32 = ILOSS 0x34 = RLOSS 0x38 = LCL 0x41 = VOLTAGE 0x43 = TRACETONE 0x47 = R & C 0x73 = MAGZ
RXRANGE	0x03	0x00 = +30 dB 0x01 = +20 dB 0x02 = +10 dB 0x03 = 0 dB 0x04 = -10 dB 0x05 = -20 dB 0x06 = -30 dB
BW	0x04	0x00 = Max Span to 0x0A = Min Span
SWEEPING	0x05	0x00 = OFF 0x01 = ON
ZRTX	0x06	0x00 = 75 Ω 0x01 = 125 Ω 0x02 = 150 Ω 0x03 = 600 Ω
ZTX	0x07	0x00 = 75 Ω 0x01 = 125 Ω 0x02 = 150 Ω 0x03 = 600 Ω
INPUT	0x08	0x00 = Terminated 0x01 = HiZ
LTYPE	0x09	0x00 = RTX 0x01 = TX-RX

TXSOURCE	0x0A	0x00 = OFF 0x01 = ON
HOOK	0x0B	0x00 = ONHOOK 0x01 = OFFHOOK
MKR	0x0C	BIN#(0..239)
FILTER	0x0D	0x00 = WIDE 0x01 = PSOPH 0x02 = 25 Hz 0x03 = 1.74 kHz 0x04 = 3.1 kHz
AUTORANGE	0x11	0x00 = OFF 0x01 = LVL only 0x02 = LVL+BW
AVERAGING	0x1C	0x00 = OFF 0x01 = Averaging ON 0x02 = Peak Hold ON
PEAKTRK	0x1E	0x00 = OFF 0x01 = ON
DISTORTION	0x1F	0x00 = LEVEL 0x01 = SNR 0x02 = THD 0x03 = SINAD 0x04 = SFDR
NUMOFAVGS	0x20	0x00 = No Averaging 0x01 = 2 Samples TO 0x04 = 16 Samples
SWEEPSTEP	0x22	0x01 = 240 pts TO 0x04 = 15 pts
IPNTHRES	0x24	0xC4 = -60 dBm TO 0x10 = +16 dBm

CONFIGTXLEVEL

Syntax: <0xAE><LevHi><LevLo><xx><xx> (LT51 returns <0x99>)

The TX Level is set to:

TxLevel = [((LevHi * 256) + LevLo – 6000) / 100] dBm

Example:

For TxLevel = -25.50 dBm, LevHi = 0x21, LevLo = 0x66

CONFIGTXFREQ

Syntax: <0xAF><Freq1><Freq2><Freq3><Freq4> (LT51 returns <0x99>)

The TX Frequency is set to:

TxFreq = [(Freq1* 16,777,215) + (Freq2* 65,536) + (Freq3 * 256) + Freq4] Hz

Example:

For TxFreq = 2,000,000 Hz,
Freq1 = 0x00, Freq2 = 0x1E, Freq3 = 0x84, Freq4 = 0x80

CONFIGCENTREFREQ

Syntax: <0xB0><Freq1><Freq2><Freq3><Freq4> (LT51 returns <0x99>)

The Centre Frequency is set to:

CentreFreq = [(Freq1* 16,777,215) + (Freq2* 65,536) + (Freq3*256) + Freq4] Hz

Example:

For CentreFreq = 1,000,000 Hz,
Freq1 = 0x00, Freq2 = 0x0F, Freq3 = 0x42, Freq4 = 0x40

READDATA1
READDATA2
READDATA3

Syntax: READDATA1   <0xB1><xx><xx><xx><xx>
Syntax: READDATA2   <0xB2><xx><xx><xx><xx>
Syntax: READDATA3   <0xB3><xx><xx><xx><xx>

LT51 returns: <D0><D1><D2><D3>

The LT51 will return 4 bytes (signed 32-bit value with MSB D3, LSB D0) representing the data for:

READDATA1 – the **currently** selected terminals
READDATA2 – the AG terminals
READDATA3 – the BG terminals

depending on the following current measurement mode:

Command	Mode	Data

READDATA1
READDATA2
READDATA3
	R & C	R = (D3 * 256) + D2 Ω
		C = (D1 * 256) + D0 nF
		If (R < 500)
		     R & C are in series
		Else
		     R & C are in parallel

	VOLTAGE	DCV = [((D1 * 256) + D0) / 100] V, NB: signed ACV = [((D3 * 256) + D2) / 100] V
READDATA1	MAGZ	32-bit Data Ω
READDATA1	Others	(32-bit Data / 100) dB / dBm / none
READDATA2	Others	32-bit Data (Hz), NB: = Frequency at RTX
READDATA3	Others	(32-bit Data / 100) dB / dBm / dHz Value at Marker or Distortion if set

Updating LT51 firmware

H Heuer Instruments Pty Ltd may release new firmware for the LT51 Line Tester which can be downloaded from the H Heuer Instruments website at http://www.heuer.com.au and programmed into the LT51.

Updating the firmware in the LT51 consists of the following steps:

1. Save the new firmware file in a known location on the PC.

2. Connect the LT51 to the PC using a USB cable.

3. Power the LT51 ON, and place into Download Mode by:

    *   pressing the ⚙ key, followed by the [f3] "LT51 Settings" soft-key.
    *   Press the [f3] "Update Software" soft-key.

    The screen on the LT51 will display the message "Setup for PC Download", for 2s, then go blank.

    NOTE: To cancel the download at this point without modifying the LT51software, hold the ① key down until the LT51 switches off. Press the ① key again to power the LT51 ON, and resume operation with the existing software.

4. Start the *LT51View* application program, and select the "Download" Tab on the main displayed form. Manually select the *.a43" file by pressing the "Browse File" button to locate the file. When ready, press the "Program" button to begin the download.

    NOTE: During the download, the behaviour of the LT51 can be unpredictable (eg. the screen may go completely blank, or audible sounds may be heard from the Tester). Ignore this behaviour until the download has completed.

    ⚠ *WARNING: Once the download has commenced by pressing the Start button, the existing software is erased. Should the download fail to complete successfully for any reason, the LT51 remains in a state ready to accept new software. Ensure the LT51 is powered ON (by holding the ① key down if necessary) and restart the download procedure by pressing the "Start" button again. If this still fails, please contact H Heuer Instruments.*

The progress of the download can be monitored on the PC. When the download has completed, the LT51 will automatically reset.

8. Adjustment procedures

Adjustment should be carried out at a temperature of 20°C to 25°C and (20 to 80) % RH Humidity.

NOTE: Warm-up Time
When adjusting or calibrating the LT51Transmitter, the LT51 should be configured to transmit a tone at 10 kHz, 0 dBm for a period equal to the automatic switchoff time for the LT51. Thereafter, the LT51 should be turned back on, and the adjustment or calibration commenced.

Required test equipment

Description	Requirement
Digital Multimeter	ACV: >100 kΩ, 10 kHz, 0 dBm ± 0.02 dB FREQ: 100,000.0 Hz ± 0.1 Hz
50V DC Standard	50.0 ± 0.05 V
75Ω, 125Ω, 150Ω, 600Ω	± 0.1%

The LT51 can be fully adjusted without opening the instrument case.

- press ⚙ key and then [f4] to select *Adjust Menu.*

TX Level
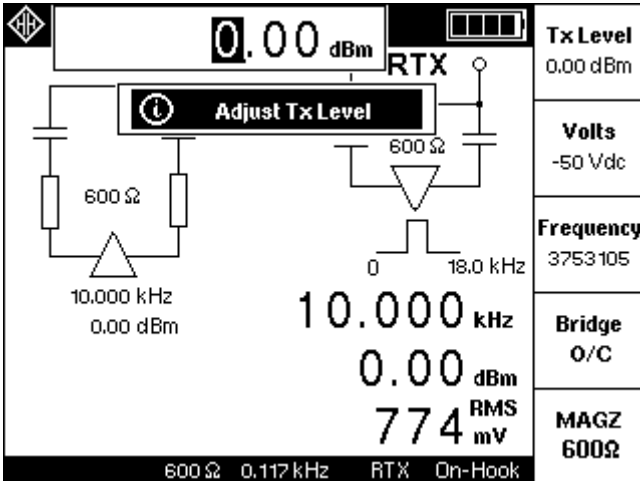
To adjust the transmitter output level of the LT51 press the [f1] *Tx Level* key.

Press the [f1] softkey until 600Ω is displayed for the ZRTX and ZTX impedances.

Terminate the LT51 TXa-b terminals with an external 600 Ω load. Using a short, low capacitance cable connect the TXa-b terminals to the high impedance input of a DMM configured to measure ACV and display the measurement in dBm referenced to 600 Ω.

Use the knob on the LT51 to adjust the level displayed on the DMM to 0.00 dBm and then press the $\boxed{\frac{OK}{save}}$ key.

NOTE: *The knob must be turned (even if the default TxLevel is correct) to zero the calibration constant, before pressing the $\boxed{\frac{OK}{save}}$ key to save the new value. If the knob is turned without saving the value, power cycle the LT51 before continuing.*

When the 600 Ω Tx Level has been adjusted, press the [f1] softkey to adjust the Tx Level for 150 Ω, 125 Ω and 75 Ω. For each impedance follow the procedure outlined above for the 600 Ω adjustment, but with the appropriate termination. For these two impedances, the level ranges of the LT51 are not adjusted, since the values obtained during the 600 Ω adjustment are sufficient.

DC Voltage

To adjust the DC voltage function of the LT51 press the [f2] *Volts* key.

```
┌──────────────────────────────────────┬──────────────┐
│ ◈ DC/AC Voltage    31-03-21  [▮▮▮▮]  │ Tx Level     │
│                    11:30:34           │ 0.00 dBm     │
│   TX    ○     ○     ○    RX    ○      ├──────────────┤
│  ┌─────────────────────────────┐     │              │
│  │ ⓘ  Select CAL Func ...      │     │ Volts        │
│  └─────────────────────────────┘1 MΩ │ +50 Vdc      │
│                                       ├──────────────┤
│   600 Ω                               │ Frequency    │
│                                       │ 3753105      │
│    △                    ▽             ├──────────────┤
│   OFF                                 │              │
│                 0.00 VAC              │ Bridge       │
│                50.00 VDC              │ O/C          │
│                                       ├──────────────┤
│                                       │ MAGZ         │
│                                       │ 600Ω         │
│ HiZ 600 Ω  0.117 kHz  TX-RX On-Hook  │              │
└──────────────────────────────────────┴──────────────┘
```
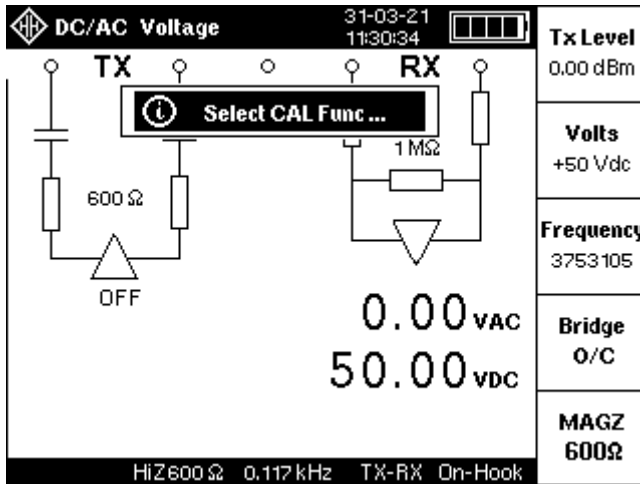
Toggle the [f2] *Volts* key until +50 Vdc is displayed.

Connect a DC Voltage Source of +50.00 V ± 0.05 % to the RTXa-b terminals with the +ve terminal to the RTXb (red) terminal. When the LT51 measurement has stabilised press the OK save key to record the *+50.0 Vdc* value.

Connect a DC Voltage Source of -50.00 V ± 0.05 % to the RTXa-b terminals with the +ve terminal to the RTXa (black) terminal. When the LT51 measurement has stabilised press the OK save key to record the *-50.0 Vdc* value.

Frequency (TX and RX accuracy)

To adjust both the Transmitter and Receiver Frequency accuracy of the LT51, press the [f3] *Frequency* key.
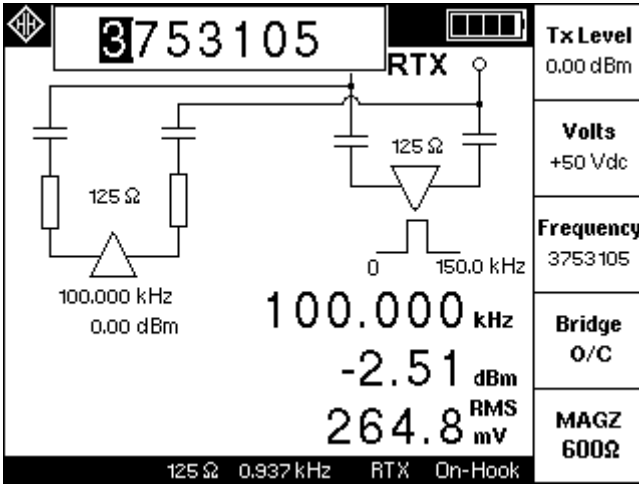
Using a short, low capacitance cable connect the TXa-b terminals to the high impedance input of a DMM configured to measure Frequency to at least 8 digits (0.1 Hz resolution). The RTXa-b terminals should not be connected to any loads.

Use the knob (press to move the cursor) on the LT51 to adjust the TX Frequency constant, so that the frequency displayed on the DMM is 100,000.0 Hz.

Press the $\boxed{\frac{OK}{save}}$ key when the reading has stabilised.

The LT51 will then automatically calculate the adjustment required for the RX frequency at 1 MHz.

Bridge O/C

To adjust the Bridge function of the LT51, press the [f4] *Bridge O/C* key.

Ensure that both the TXa-b and RTXa-b terminals are not connected to any loads, ie. they are O/C.

Press the $\boxed{\frac{OK}{save}}$ key when the reading has stabilised.
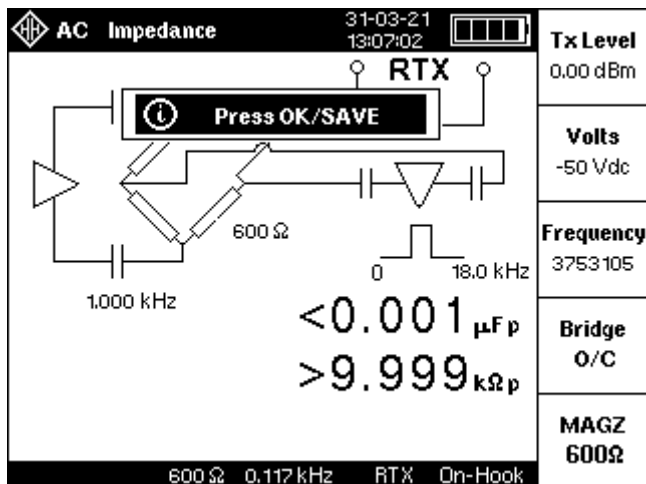
Impedance Magnitude (600 Ω)

To adjust the Impedance Measurement function of the LT51, press the [f5] *MAGZ 600 Ω* key.

Connect a 600 Ω pure resistance to the RTXa-b terminals.

Press the OK save key when the reading has stabilised, to adjust the MAGZ measurement for each LT51 system impedance.
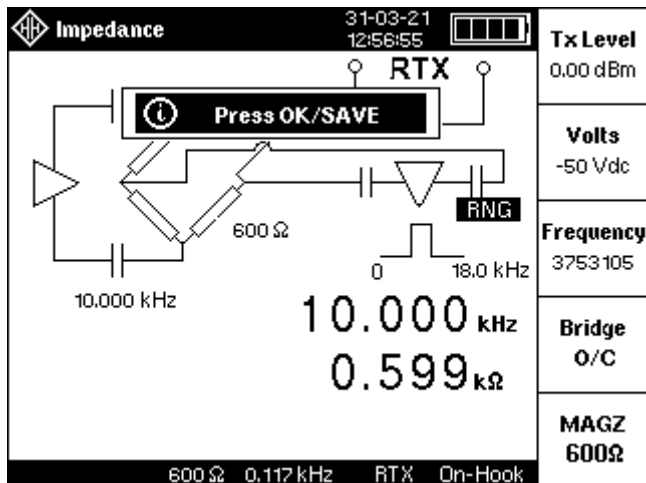
9. Performance Testing

The recommended Calibration Interval is two years. Performance Testing should be performed at a temperature of 20 - 25 °C and (20 to 80) % RH Humidity.

The LT51 should be adjusted as specified in the Adjustment Procedure if performance testing reveals any measurement to be out of specification.

NOTE: Warm-up Time
When adjusting or calibrating the LT51Transmitter, the LT51 should be configured to transmit a tone at 10 kHz, 0 dBm for a period equal to the automatic switchoff time for the LT51. Thereafter, the LT51 should be turned back on, and the adjustment or calibration commenced.

Required test equipment

Description	Requirement
Digital Multimeter	ACV: >100 kΩ, 10 kHz, -50 dBm to +10 dBm $\pm$ 0.02 dB
Oscillator	600 Ω, 10 kHz, -50 dBm to +10 dBm $\pm$ 0.02 dB 50 Ω, 1kHz - 2 MHz, 0 dBm $\pm$ 0.05 dB Distortion < -50 dB, 1 kHz to 1 MHz
50V DC Standard	50.0 $\pm$ 0.05 V
30V AC Standard	30.0 $\pm$ 0.03 V / 50 Hz
0Ω, 75Ω, 125Ω, 150Ω, 100Ω, 590Ω, 600Ω, 10kΩ Resistors	$\pm$ 0.1 %
Thermal Voltage Converter	75 Ω terminated input 10 Hz to 3 MHz : 0 dBm $\pm$ 0.03 dB

Transmitter Level Accuracy

a) Set the LT51 to TX-RX interface mode. Set the TX frequency to 10 kHz.
b) Set the LT51 Ztx impedance and TX level as indicated in Table 8.1 below.
c) Connect a suitable DMM to the LT51 using a short low capacitance cable to the TXa-b terminals.
d) The DMM must be terminated with the indicated impedance at its input terminals.
e) Step down the levels in Table 8.1 and check that the readings are within the ranges specified.

LT51 Tx Level	LT51 Ztx	DMM reading
0 dBm	125 Ω	0 dBm ± 0.05 dB
0 dBm	75 Ω	0 dBm ± 0.05 dB
0 dBm	150 Ω	0 dBm ± 0.05 dB
0 dBm	600 Ω	0 dBm ± 0.05 dB (ref.)
+10 dBm	600 Ω	+10 dBr ± 0.20 dB
-10 dBm	600 Ω	-10 dBr ± 0.20 dB
-20 dBm	600 Ω	-20 dBr ± 0.20 dB
-30 dBm	600 Ω	-30 dBr ± 0.30 dB
-40 dBm	600 Ω	-40 dBr ± 0.30 dB
-50 dBm	600 Ω	-50 dBr ± 0.30 dB

Table 8.1

Transmitter Level Response

a) Set the LT51 to TX-RX interface mode. Set the TX level to 0.0 dBm.
b) Set the LT51 Ztx impedance and TX frequency as indicated in Table 8.2
c) Connect a terminated DMM / Thermal Voltage Converter to the LT51 using a short, low capacitance cable to the TXa-b terminals.
d) With the TX Frequency set to 10 kHz, set the reference on the DMM / TVC. All subsequent readings will displayed relative to the reading at 10 kHz.
e) Step down the frequencies in Table 8.2 and check that the readings are within the ranges specified.

LT51 Tx Freq	LT51 Ztx	DMM reading
10 kHz	75 Ω	0 dBm ± 0.05 dB (ref.)
2 kHz	75 Ω	0 dBr ± 0.25 dB
200 kHz	75 Ω	0 dBr ± 0.25 dB
1,000 kHz	75 Ω	0 dBr ± 0.5 dB
2,000 kHz	75 Ω	0 dBr ± 0.5 dB
10 kHz	600 Ω	0 dBm ± 0.05 dB (ref.)
200 Hz	600 Ω	0 dBr ± 0.25 dB
20 kHz	600 Ω	0 dBr ± 0.25 dB

Table 8.2

Receiver Level Accuracy

a)   Set the LT51 to Level Spectrum and TX-RX interface mode
b)   Set the LT51 Zrtx impedance to terminated and the appropriate value in the
     table.
c)   Connect a Level Oscillator (with the correct level for each impedance) to the
     LT51 using a short low capacitance cable to the RTXa-b terminals.
d)   Set the Oscillator frequency to 10 kHz and Level to 0 dBm.
e)   Step down the levels in Table 8.3 and check that the readings are within the
     ranges specified.

Oscillator Tx Level	Impedance	LT51 reading
0 dBm	75 Ω	0 dBm ± 0.10 dB
0 dBm	125 Ω	0 dBm ± 0.10 dB
0 dBm	150 Ω	0 dBm ± 0.10 dB
0 dBm	600 Ω	0 dBm ± 0.05 dB (ref)
+10 dBm	600 Ω	+10 dBr $\pm$ 0.20 dB
-10 dBm	600 Ω	-10 dBr $\pm$ 0.20 dB
-20 dBm	600 Ω	-20 dBr $\pm$ 0.20 dB
-30 dBm	600 Ω	-30 dBr $\pm$ 0.30 dB
-40 dBm	600 Ω	-40 dBr $\pm$ 0.30 dB
-50 dBm	600 Ω	-50 dBr $\pm$ 0.30 dB

Table 8.3

Receiver Level Response

a)   Set the LT51 to Level Spectrum and TX-RX interface mode
b)   Set the LT51 Zrtx impedance to 75 Ω, terminated.
c)   Connect a 75 Ω Level Oscillator to the LT51 using a short low capacitance
     cable to the RTXa-b terminals.
d)   Set the Oscillator level to 0 dBm and Frequency as indicated in Table 8.4.
e)   With the Oscillator Frequency set at 10 kHz, set the reference on the LT51.
     Set the Marker to the peak and press the *Zero Offset* [f3] key.
f)   Step down the frequencies in Table 8.4 and check that the readings are
     within the ranges specified.

Oscillator Tx Frequency	LT51 reading
10 kHz	0 dBm ± 0.05 dB (ref)
200 Hz	0 dBr $\pm$ 0.25 dB
1 kHz	0 dBr $\pm$ 0.25 dB
200 kHz	0 dBr $\pm$ 0.25 dB
1,000 kHz	0 dBr $\pm$ 0.50 dB
2,000 kHz	0 dBr $\pm$ 0.50 dB

Table 8.4

Return Loss Measurement Response

a) Set the LT51 to Return Loss mode.
b) Set the LT51 Zrtx impedance to 75Ω and ensure the RTXa-b terminals are shorted together.
c) Set the Oscillator level to -10 dBm and frequency as indicated in Table 8.5
d) Step down the frequencies in Table 8.5 and check that the readings are within the ranges specified.

Tx Frequency	Ret. Loss reading
10 kHz	0 dBm ± 0.25 dB (ref)
100 kHz	0 dBr $\pm$ 0.5 dB
1 MHz	0 dBr $\pm$ 0.5 dB
2 MHz	0 dBr $\pm$ 0.5 dB

Table 8.5

Return Loss Measurement

a) Set the LT51 to Return Loss mode.
b) Set the LT51 TX frequency to 10 kHz and TX level to -10 dBm.
c) Set the LT51 RTX impedance as indicated in Table 8.6 and connect the load impedance to the RTX terminals.
d) Check that the readings are within the ranges specified.

RTX Impedance	Load Impedance	LT51 reading
75 Ω	100 Ω	9.54 dB ± 1 dB
125 Ω	100 Ω	16.90 dB $\pm$ 1 dB
150 Ω	100 Ω	19.08 dB $\pm$ 1 dB
600 Ω	590 Ω	41.5 $\pm$ 2 dB

Table 8.6

NOTE: For other value resistors (Rm) at a Zrtx ref., calculate the Return Loss:

Return Loss = 20 log ((Zrtx - Rm) / (Zrtx + Rm)).

Intrinsic NEXT (Near End CossTalk)

a) Set the LT51 to NEXT mode and TX-RX interface mode.
b) Set the LT51 RTX impedance to 600 Ω and ensure the RTXa-b terminals are terminated with 600 Ω.
c) Set the LT51 Tx Source to SWEEP and the BW to 200 kHz.
d) Ensure that the measured NEXT is <75dB for all freqs < 200 kHz.

DC Voltage Measurement

a)   Set the LT51 to DMM – AC/DC Voltage mode.
b)   Ensure that the Terminals are set to AB.
c)   Connect a 50 V DC Source to the LT51 RTXa-b terminals.
d)   Check that the LT51 displays the DC voltage as 50.0 $\pm$ 0.5 V.
e)   Select the a-g and b-g terminals and ensure that the LT51 displays the DC voltage as 0 V.

AC Voltage Measurement

a)   Set the LT51 to DMM – AC/DC Voltage mode.
b)   Ensure that the Terminals are set to AB.
c)   Connect a 30 V / 50 Hz AC Source to the LT51 RTXa-b terminals.
d)   Check that the LT51 displays the AC voltage as 30.0 $\pm$ 0.8 V.
e)   Ensure that the Ringing tone is present during the application of the AC voltage.
f)   Select the a-g and b-g terminals and ensure that the LT51 displays the AC voltage as 0V.

AC Impedance Measurement

a)   Set the LT51 to DMM – AC Impedance "Mag (Z)" mode (75 Ω ref).
b)   Connect the 600 Ω impedance to the RTXa-b terminals.
c)   Check that the LT51 measures 600 $\pm$ 60 Ω.

10.   Specifications

Physical

Case	PolyCarbonate (FV-0 rating)
Display	320 x 240 Graphic LCD with LED backlight
Keypad	Silicone rubber with 31 keys
Rotary Control	21mm knob with integrated push switch
LEDs	Charging, external DC power
Operating Temperature	+5 °C to 40 °C, 20% to 80% RH
Storage Temperature	-20 °C to 60 °C
Battery Charging Temp	10 °C to 40 °C
Environmental	altitudes up to 2000m, Pollution Degree 2
Dimensions	190 mm x 155 mm x 40 mm (L x W x H)
Weight	700g

Power supply

Battery Type	3 AA (NiMH, NiCd or Alkaline)
Battery Life	8 hours typical (2100mAh NiMH)
Battery Recharge Time	5 hours in LT51
AC Operation (charging)	Ext. adaptor: 240Vac to 5 or 6 Vdc (1 A)
Auto Power-Off	12 mins after last button press

Interfaces

RTX a-b-g	3 balanced, 4mm sockets (ab 19mm pitch)
Rated Voltage	RTXa-b: 60 V, RTXa or RTXb to g : 30 V
TX a-b	2 balanced, 4mm sockets (ab 19mm pitch)
Rated Voltage	TXa-b: 60 V, TXa or TXb to g: 30 V
External DC	2.1 mm DC socket
Communication Port	USB type B receptacle

Standards compliance

Analog Parameter Measurement:	IEEE 743-1995, ITU-T O.133

Regulatory compliance

Safety	IEC 61010-1:2010
EMC	IEC 61326-2-1:2005 Class A

Sine signal generator (transmitter)

Frequency	1 Hz to 2.2 MHz (1 Hz resolution)	
Accuracy	5 ppm $\pm$ 1 Hz	
Impedance (balanced)	600 Ω, 150 Ω, 125 Ω, 75 Ω	
Level	0.1 dB resolution	

	200 Hz to 20 kHz	**up to 2.2 MHz**
600 Ω	-50 dBm to +10 dBm	-50 dBm to +5 dBm
75, 125, 150 Ω	-50 dBm to +16 dBm	-50 dBm to +10 dBm

Attenuator accuracy	As for Level Meter below
Frequency Response	600Ω: 200 Hz to 20 kHz: $\pm$ 0.25 dB
(ref: 0dBm/10kHz)	75,125 & 150 Ω: 2 kHz to 200 kHz:$\pm$ 0.25 dB
	75,125 & 150 Ω: 2.2 MHz: $\pm$ 0.5 dB
SFDR (0dBm, 600Ω, typ.)	*< 50 dBc*

Level meter (receiver)

Frequency Range	200 Hz to 2.2 MHz (upto 7 digits)
Accuracy	5 ppm $\pm$ 1 Hz
Level Range(TX-RX mode)	<-120 to +30 dBm (600/150/125/75Ω, Term)
	auto-ranging or manual range setting
BWs (see Selectivity below)	25 Hz, 1.74 kHz, 3.1 kHz, Psoph (ITU 0.41)
Impedance (balanced)	Terminated: 600 Ω, 150 Ω, 125 Ω, 75 Ω
	Bridged: > 47 kΩ,
Attenuator accuracy	+30 dBm to -30 dBm: $\pm$ 0.2 dB
(ref: 0dBm/10kHz/600Ω)	-30 dBm to -60 dBm: $\pm$ 0.3 dB
	less than -60 dBm: $\pm$ 0.5 dB
Frequency Response	600 Ω: 200 Hz to 20 kHz: $\pm$ 0.25 dB
(ref: 0dBm/10kHz)	600 Ω: 200 kHz: $\pm$ 0.5 dB (TX-RX only)
	75,125 & 150 Ω: 2 kHz to 200 kHz:$\pm$ 0.25 dB
	75,125 & 150 Ω: 2.2 MHz: $\pm$ 0.5 dB
Level Display	absolute (dBm), relative(rdB)
Resolution	0.01 dB
Input Return Loss	> 25 dB, 75 Ω, 200 Hz to 2.2 MHz
Noise Floor	< -130 dBm/Hz

Selectivity

BW	Passband	Transition	Stopband
25 Hz	$\pm$ 5 Hz, < 0.5 dB	$\pm$ 12 Hz, < 3 dB $\pm$ 50 Hz, > 30 dB	$\pm$ 100 Hz, > 50 dB $\pm$ 500 Hz, > 90 dB
1.74 kHz	-	1.85 kHz, < 3 dB	$\pm$ 2 kHz, > 50 dB
3.1 kHz	-	2.7 kHz, < 3 dB	$\pm$ 2.5 kHz, > 80 dB

Spectrum analyser

Frequency range	200 Hz to 2.2 MHz
Frequency spans	4.5, 9,18 … 600 kHz, 1.2 MHz, 2.4 MHz
Dynamic range	>60 dB (typically better than 70dB)
Max displayed range	110 dB (80dB+30dB offset)
Frequency resolution	< 0.5% of span

Distortion

Fundamental Frequency range	200 Hz to 2.2 MHz
Harmonic Measurement range	2.2 MHz
Distortion Factor	Max: 10dB, Min: 60dB, typically >70dB

Loss, NEXT & FEXT measurements

Impedance	600 Ω, 150 Ω, 125 Ω, 75 Ω
Frequency Range	200 Hz to 2.2 MHz
Level range	-90 to +10 dB
Accuracy	$\pm$ 1 dB
Intrinsic NEXT (75 Ω)	< 1 MHz: <-80 dB, <2.2 MHz: < -70 dB

Return Loss measurement

Impedance	600 Ω, 150 Ω, 125 Ω, 75 Ω
Tx level	-10 dBm
Range	0 to 40 dB
Accuracy	$\pm$ 0.5 dB $\pm$ 5 % of reading for reference impedance
Intrinsic Return Loss (75 Ω)	< 200 kHz: > 50 dB, <2.2 MHz: > 40 dB

TDR

Impedance	150 Ω, 125 Ω, 75 Ω
Pulse Velocity Factor (PVF)	0.01 to 0.99
Range (PVF = 0.70)	7,500 m $\pm$ 1 % + PVF uncertainty
Resolution (PVF=0.70)	0.8m (lowest range)
Pulse Amplitude	4 Vpp into 600 Ω
Pulse Width	50 ns, 200 ns, 500 ns, 1 μs, 2.5 μs, 5 μs

Voltage*

DC	$\pm$ 160 V $\pm$ 1 % + 0.5V
AC	100 Vrms $\pm$ 2% (< 100Hz), True RMS

Impedance Magnitude

200 Hz to 500 kHz (50, 75 Ω ref) 10 Ω to 400 Ω ± 5% ± 5Ω
20 kHz to 500 kHz (50, 75 Ω ref) < 1000 Ω ± 10% ± 5Ω

Signalling / Voice Communication

Dial Method DTMF
Redial Up to last 16 digits
Talk/Listen built-in Speaker / Microphone
600 Ω Shunt 0 to 90 mA ± 1 % + 0.5 mA
Ring Detector Range & Meas* 40 to 100 Vrms, 15 –70 Hz

*Maximum values capped by protection to Rated Voltage at inputs.

Data subject to alterations without notice