LA100 Audio Analyser Manual

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Part number: MN100

This manual describes LA100 software version V6.7. Please refer to any accompanying update sheets if your LA100 displays a version number later than this when it is turned on or reset. Users familiar with earlier software should refer to appendix I.3 for a list of new features.

We are continuously developing and enhancing the software within the LA100 and send major new software EPROMs to all users. You should therefore ensure that you complete and return the enclosed registration card directly to Lindos Electronics and advise of any change of ownership or change of address so that you receive these updates.

All comments and suggestions regarding the LA100 will be gratefully received.

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1.0 Introduction

The first time user should read this chapter, which describes basic features common to both units, but may then proceed to chapters 2 or 3 for a complete introduction to either manual or sequence measurement. Sequence measurement is a very easy way of making a predefined sequence of measurements, at the press of a few keys, without any programming effort, and without any connection between units other than the signal path. New users should refer to chapter 7 for applications advice on testing specific devices and also appendix A which lists the items supplied with the LA100 and the optional accessories which are available. Other sections of the manual give further information on defining sequences, tolerance testing, using printers, remote computer control via the serial (RS232) interface and on servicing the LA100 as there is no separate service manual. In all cases the most important information can be found at the start of each chapter; the sections towards the end of each chapter describe the technical details and more specialist applications.

Although the *LA101 Audio Oscillator* and *LA102 Audio Measuring Set* are two independent units, they are generally used together, and for convenience are then referred to as the *LA100 Audio Analyser*. The *LA100R* is a rack mount version of the LA100 consisting of the LA101 and LA102 bolted together, side by side, to go into a 19" rack. See appendix A for conversion kit details.

1.1 Viewing Angle
The full-graphic liquid crystal display in these units combines great flexibility of display with very low power consumption. Units with serial numbers below 3430 use non-backlit displays, and for good contrast it is essential that light strikes the display from above the normal and is reflected off towards the eye below the normal. This requires a large angle of tilt, or high mounting on a shelf or in a rack. Later units are fitted with high contrast backlit displays, and the viewing angle is less critical. Earlier units can be upgraded to the backlit display. A contrast adjustment is fitted inside the top cover (section 10.14) which gives some optimisation for different viewing angles, but the units are supplied set for best overall results.

1.2 Switching-On
The units can be powered either from the mains or from their internal rechargeable batteries. The ON/OFF button controls the battery power and the units will always be on when the mains is connected. There is no mains switch as power consumption is negligible and continuous operation will do no harm. Units are normally supplied for either 110-120V or 220-240V, 50/60Hz operation and marked accordingly on the back

panel; but they can be altered internally by a competent technician (see section 10.3).

For battery operation, press ON/OFF to turn the battery power on. To turn it off press ON/OFF and hold it briefly. To conserve battery life the unit will switch off automatically five minutes after the last key press unless it is put into battery lock by pressing ✳LOCK (ie hold ✳ and press ON/OFF). A 'B' in the corner of the display indicates battery operation, and a heavy '**B**' indicates the battery lock condition. A flashing 'B' indicates that the battery is nearing discharge, and the automatic switch-off period then shortens to 30 seconds.

The units will operate for around 4-5 hours on a fully charged battery. The battery is trickle-charged whenever the mains is connected and will take 36 hours to fully recharge. (Pressing ON/OFF when the mains is connected will divert current from battery charging to the backlight. The battery will not charge but the light will be brighter.

To achieve optimum power management in the unit, the backlight will operate for about an hour from a fully charged battery. The unit will continue without backlight for about 3-4 hours.

When operating from a mains supply the backlight will be at reduced intensity for about 30 minutes after switch on if the battery is in a heavily discharged condition.

1.3 The Keyboard

In the interest of simple error free operation, the units have only a small number of keys, each clearly labelled underneath with its main function. The deceptively simple keyboard hides the vast range of functions which are obtained by pressing combinations of keys, as described in this manual and in the *Quick Reference Card*, but they need not concern the beginner or occasional user.

The ✳ key is like a computer's shift key: while pressed it gives other keys a second function (it does nothing by itself). In this manual a ✳ in front of another key indicates a second function requiring the ✳ key to be held while the key is pressed. In particular, ✳1 to ✳5 generate the numbers 6-10. Most keys repeat if held for a short while.

1.4 Reset

When turned on, or after a reset, the state of both units is determined by their configuration settings stored in non-volatile memory. As supplied, or following removal of the battery, configurations are set to the *Lindos default* settings, but these can be changed using the *configuration menu* described below. In default configuration the LA101 generates 0dBu (0.775V) at 1kHz and the LA102 goes into its flat level-measurement mode. Tapping ON/OFF briefly at any time causes a *reset*, momentarily displaying the unit's serial number and software version (Fig 1.1) and providing a fresh

start. Using this facility minimises mistakes caused by unwanted settings not being cleared. Some settings are deliberately not cleared by a reset, e.g. measurement options, frequency and level presets, configuration settings and sequence and tolerance definitions. Tapping ON/OFF briefly, and then holding it will keep the start-up message displayed.
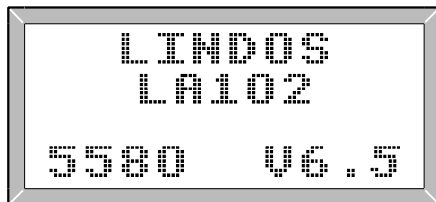
Fig. 1.1 LA102 Start-up Screen   **Fig. 1.2 LA101 Reset Menu**
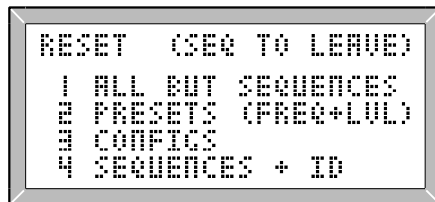
1.5 Memory Clear and Non-Volatile Memory

Both units are equipped with non-volatile memory and the frequency and level presets, measurement options, user configurations, sequence definitions, test sequence results and tolerance specifications are all kept when the unit is turned off. Units are normally supplied in the default condition, but the user should be aware of the fact that accidental setting of non-volatile functions could cause confusion. In case of doubt, a complete reset will restore Lindos default conditions. Press ON/OFF 3 (ie hold ON/OFF and press 3) on either unit and a menu will appear (fig 1.2), with the following options:

Key	LA101 Reset Menu	LA102 Reset Menu
1	All but sequence definitions	All but sequence results
2	Preset keys (frequency and level)	Measurement options and ranges
3	Configuration options	Configuration options
4	Sequence definitions & source ID	Sequence results (memory 0)
5	–	Tolerance definitions

Fig. 1.3 LA100 Reset menus

Press 1 and the unit will be restored to normal operation. Alternatively, a partial reset can be obtained by pressing 2 to 5, as indicated.

Non-volatile memory relies on the internal Lithium-Ion battery having some charge, but will normally persist for some time after the unit has ceased to function. A half-charged battery will provide memory retention for around six months. A memory check is carried out automatically when the unit is switched on, and in the unlikely event of memory corruption the whole memory is cleared automatically and a 'MEMORY CLEARED' message is displayed for 2 seconds.

1.6 The Configuration Menu

The *configuration menu* is obtained on either unit by holding $\boxed{\text{ON/OFF}}$ and pressing $\boxed{2}$ (Figs 1.4 & 1.5). It offers the possibility of changing many configuration parameters such as printer baud rate, printer type, print format, and default impedance. The full list is shown in table 1.6. Each configuration is given a letter (A-Z) and may be set to one of several options, each represented by a number. For example, configuration P1 indicates that the printer configuration (P) is set to Epson (1), while configuration P8 will indicate that the LA102 is configured for a HP Deskjet printer. Similarly, configuration V will determine the default loudspeaker volume in the range 0 (off) to 15 (maximum volume). The configurations in the LA101 and LA102 are completely independent although similar functions have been given the same letter wherever possible.

```
 ┌─────────────────────────────┐     ┌─────────────────────────────┐
 │ CONFIGURATION OPTIONS       │     │ CONFIGURATION OPTIONS       │
 │ T4 START UP FREQUENCY       │     │ P8  PRINTER TYPE            │
 │    PRESET 4   1000Hz        │     │  &  HP DESKJET 150dpi       │
 │ BFRSTUVWZ SEQ=EXIT          │     │ ABCDEFGHIJMNPRTUVWXYZ       │
 └─────────────────────────────┘     └─────────────────────────────┘
```
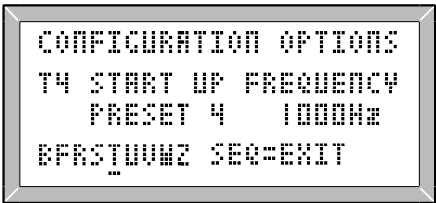
Fig. 1.4 LA101 Configuration Editor   Fig. 1.5 LA102 Configuration Editor
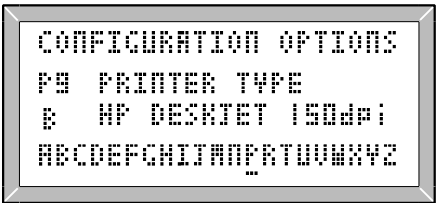
When the configuration options are displayed (figs. 1.4 & 1.5) the left hand pair of keys in the centre row can be used to cycle through the various configurations, and the right hand pair will change the option number (these keys repeat if held). The various options are displayed when selected. Keys $\boxed{1}$ to $\boxed{5}$, and $\boxed{*}\boxed{1}$ to $\boxed{*}\boxed{5}$ (representing 6 to 10) can also be used to set the various options and $\boxed{\text{L/R}}$ will restore the **L**indos/**R**ecommended default option. Exit the menu by resetting or pressing $\boxed{\text{SEQ}}$. The current LA102 configuration settings can be printed by pressing $\boxed{*}\boxed{\text{PRINT}}$ when the configuration menu is displayed (see sections 8.1 & 8.2).

1.7 Connectors

The LA101 output is balanced and floating, with 75Ω or 600Ω output impedance at the front B-gauge jack sockets and 10Ω output impedance at the rear XLR sockets. The LA102 has balanced inputs with 600Ω or 10kΩ input impedance at both the front and rear sockets (which, unlike the LA101, are connected in parallel). See section 2.21 for details of impedance switching and appendix B for pin connections.

The BNC sockets on the back of the LA102 allow monitoring of distortion residue and other filtered signals on an oscilloscope and are also suitable for connecting high

LA101 Configurations:

B	Sequence bank	**User**, Lindos, Tape, Speaker, Filter, Meter, Utility, BBC, BT, Telecom Australia, SAPO
F	Frequency display	**Rounded**, true
R	Remote baud rate	75, 150, **300**, 1200, 2400, 4800, 9600, 110
S	Start up level	MUTE, p/set 1, p/set 2, p/set 3, **p/set 4**, p/set 5, previous value
T	Start up frequency	p/set 1, p/set 2, p/set 3, **p/set 4**, p/set 5, previous value
U	Level units	**dBu/dBm**, dBV, Volts and dBu/dBm, Volts and dBV
V	Monitor volume	Off, Remote error beep, 2,3,4,5,6,7,**8**,9,10,11,12,13,14,15
W	Weighting on ✳ 2	**All**, usr1, usr2, usr3, usr4, usr5, RIAA, CCIR, CCITT, 50µs
Z	Output impedance	**10**Ω, 75Ω, 600Ω

Default options (shown in bold) are: B0 F1 R3 S4 T4 U0 V8 W0 Z1

LA102 Configurations:

A	Auto Print Seq	**Off**, On, 2 Copies, 3 Copies, 4 Copies, 0 copies
B	Printer baud rate	75, 150, 300, 1200, 2400, 4800, **9600**, 110, 19200
C	Compartments per memory	**1**, 2, 3, 4, 5
D	Distortion display	%, **dB**
E	Graph width	**Normal (6cm)**, Wide (12cm), difference
F	Graph fit	0dB, **Peak**, Centre 0dB
G	Graph scale in dB/cm	1/4, 1/2, 1, 2, **4**, 8
H	Graph height in cm	0, 1, 2, 3, **4**, 5, 6, 7, 8, 9, 10
I	Lines per inch	**6**, 7, 8, 9
J	Graph normalisation	Absolute, 315Hz, 400Hz, **1kHz**
M	Top margin in 1/6" lines	**0**, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
N	Page length in 1/6" lines	60-76 lines, default is **66** (ie 11")
P	Printer type	ASCII text only, **Epson FX LX RX/IBM** (9pin), P40 (40 col), P40 (80 col), HP Thinkjet, Epson NLQ, Apple Imagewriter, Epson LQ (24 pin), HP Deskjet 100dpi, HP Deskjet 150dpi, CSV
R	Remote baud rate	75, 150, **300**, 1200, 2400, 4800, 9600, 110
S	Softstrip output	No longer available (contact Lindos)
T	Tolerance	None, **User 1**, 2, 3, 4, 5, Selftest, EPS81A <40km, EPS84 <40km, EPS84 <320km, EPS98 <320km, IBA Tape/general, IBA Tape/restricted, IBA Studio path, Lindos cassette, Studer A812 stereo 15ips
U	Level units	**dBu/dBm**, dBV, V, W
V	Monitor volume	0 (off), 1, 2, 3, 4, 5, 6, 7, **8**, 9, 10, 11, 12, 13, 14, 15, 16
W	Watts into 8Ω display	**V**, V/10
X	Date operation	**Not printed**, printed, advanced at switch on
Y	Auto store SEQ results	**Off**, in memory 1-5 next
Z	Input impedance	600Ω, **10k**Ω

Default options (shown in bold) are:
   A0 B7 C1 D2 E1 F1 G5 H4 I6 J3 M0 N66 P1 R3 T1 U0 V8 W1 X0 Y0 and Z2

Table 1.6 Configuration Options

impedance headphones. See appendix B.3 for further details.

Finally, the 9 pin D-type sockets provide an RS232 compatible serial interface for connecting printers (see chapter 8) and computers (see chapter 9). Wiring details are given in appendix C.

1.8 Technical Support

Lindos takes great pride in the technical support offered to customers, which includes free software updates and applications advice. Our technical support telephone line (+44 1394 380307) is usually manned outside of normal office hours for urgent problems and we aim to reply to technical queries sent by fax or email on the day they are received (Fax +44 1394 385156, email: support@lindos.co.uk). Support is also available through our worldwide agent network although complex queries are best sent directly to Lindos. To help us support you, please ensure that you return your completed registration card directly to Lindos Electronics and ensure that you always supply your serial number and software version number in any correspondence – both are shown on the LCD when the units are switched on or reset (see fig. 1.1).

In the event of a unit developing a fault, Lindos can often diagnose the problem by telephone or fax and forward any necessary parts the same day, but please refer to the service information in chapter 10 first. If phoning, try to have the unit to hand, with the covers removed and both channels directly connected. It is useful to have a multimeter available.

Lindos also operates a fast turn-around repair and recalibration service, and a pcb exchange scheme.

2.0 Manual Operation

Both units operate in *manual* mode when switched on, and can be toggled between this and *sequence* mode by pressing $\boxed{\text{SEQ}}$. The $\boxed{\text{SEQ}}$ key is also used to exit from the various menus and editors which can be called up. Alternatively, the $\boxed{\text{ON/OFF}}$ key can be tapped briefly to reset various parameters and return to manual mode (see section 1.4).

In manual mode the LA101 displays the frequency and level being generated, numerically and on two bar graphs as shown in fig. 2.1, while the LA102 displays the measured frequency, level and phase (depending on the selected measurement). The *function* keys on the LA102 are particularly easy to use because they select a measurement to a predefined standard which is displayed at the top of the screen (fig 2.2). Pressing $\boxed{\text{NOISE}}$, for example, carries out a measurement to CCIR 468-4 (weighted), without requiring the user to specify the measurement standard, weighting curve, rectifier etc., and with the confidence that everything will be correctly set. The *Lindos default settings* represent measurement methods most frequently used by most engineers, with various *options* providing other standards. Options, in this context are built into every unit; they are not optional extras!

The first-time user is advised to link the XLR sockets on the rear of the units and run some of the measurements described below in order to gain familiarity with the LA100.

2.1 Volume Control

The LA102 is fitted with an internal loudspeaker which allows the user to monitor the signal after the filter and gain stages of the LA102. This enables distortion residue, noise and even flutter components to be heard, but remember that the autoranging of the LA102 will make even very good systems sound noisy after 70dB of gain has been introduced! The LA101 does not have a loudspeaker fitted as standard, but one can be fitted, as described in section 10.17, and may be useful when testing lines, for example, where there is no other way to monitor the signal being generated.

Press $\boxed{\text{LISTEN}}$ to turn the loudspeaker on or off, or hold $\boxed{\text{LISTEN}}$ and press $\boxed{<}$ or $\boxed{>}$ to change the volume (hold the keys to make them repeat). The initial volume used when the unit is switched on is determined by configuration V (see section 1.6), and can be set to 0 if you find the loudspeaker intrusive.

2.2 Generating Tones

The LA101 generates 1kHz at 0dBu at switch-on, and this should be displayed on both units (fig 2.1 & 2.2), if connected together. Two arrowed keys marked $\boxed{\text{<Hz}}$ $\boxed{\text{Hz>}}$ permit

the frequency to be stepped up or down between 5Hz and 31.5kHz in convenient one-third octave steps. For finer control (32 steps per octave) hold the ✳ key while operating these keys (see appendix F for a full list of frequencies). Two keys marked <dB (dB> allow similar adjustment of output level between -100dB and +26dBu in 1dB steps, or 0.01dB steps with the ✳ key held. All of these keys repeat if held. The horizontal bar graph indicates output frequency, with marks at 100Hz, 1kHz and 10kHz (the end points of the bar graph represent 20Hz and 20kHz), while the vertical bar graph indicates output level in dB, with marks at +20dB, 0dB, -20dB, -40dB and -60dB.
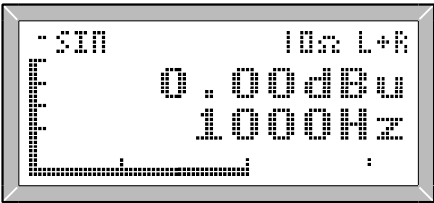
Fig. 2.1 LA101 Manual Mode
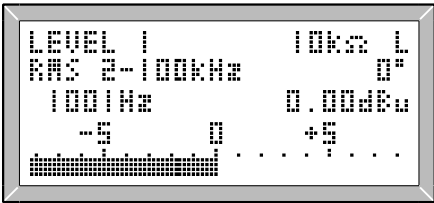
Fig. 2.2 LA102 in Manual Mode

Do not be put off by the fact that some frequencies read differently on the two units (eg 10000Hz on the LA101 is shown as 10080Hz on the LA102). The LA101 can only synthesize a limited number of frequencies, so it displays the true IEC third-octave frequency but generates the nearest synthesised frequency. This is convenient and perfectly satisfactory for most purposes, with the maximum difference between true and displayed frequencies being around 1%.

The LA101 will always display the true frequency after the ✳ key has been used to change the frequency in a fine step, so to see the true frequency being generated for any particular third-octave, simply press ✳ <Hz followed by ✳ Hz>. Changing the frequency using the <Hz or Hz> keys will always set the next third octave frequency. The LA101 can be made to always display the true frequency by setting configuration F2 (see section 1.6), but most users find the rounded values more convenient.

2.3 Measuring Tones

The LA102 displays signal level, frequency and phase difference between channels automatically at switch-on, and displays the level as a bar graph as well as a numerical reading (fig. 2.2). The five function keys, LEVEL, NOISE, CRSTK, DIST, W&F can be used to select the measurement, as described in sections 2.10-2.18 (with various miscellaneous measurements also available on the W&F key).

The measurement range extends from -120dB to +28dB, and all measurements are

autoranging; the bar graph scale changing in 10dB steps when the reading goes outside ±6dB of the centre. This leaves a 'guard band' of 2dB so that no reasonably steady signal should cause the range to 'hunt' up and down. On wildly varying signals, though, manual range setting may be found useful, and the ⊲ and ⊳ keys on the LA102 change the range, automatically disabling autoranging. To hold the current range, press one and then the other. To re-enable autoranging just press the appropriate function key again or press ⟨OPTION⟩ twice.

The bar graph shows the absolute level in dBu or dBV and is normally labelled in 5dB steps, with each pixel representing a 0.2dB step. This is about as good as an analogue meter, taking into account the very low levels of zero error and non-linearity, but for greater precision ⟨✳⟩⟨5⟩ can be pressed to expand the bar graph scale by a factor of 5. The 1dB steps will now be labelled, with each pixel representing 1/25th of a dB (0.04dB). Press ⟨✳⟩⟨5⟩ again to return to the normal scale. ZOOM (fig. 2.3) is displayed for a second when it is selected, and NORM (fig. 2.4) when it is cancelled. For accurate readings on steady signals the numerical readout is preferred, reading to 0.01dB.
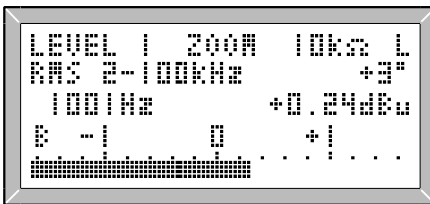
Fig. 2.3 Zoom bar graph
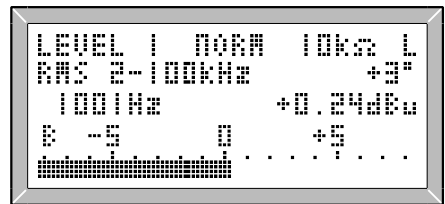
Fig. 2.4 Normal bar graph

The LA102 indicates if the input level is too high or too low for the range by flashing an arrow (fig. 2.5). If the level is too high (flashing >) the displayed reading is incorrect because the LA102 is overloaded, while a low level (flashing <) indicates that accuracy is being lost (when the level is more than 30dB below the centre scale value). In either case the range should be changed if possible (an LA102 will change range automatically unless it has been locked).
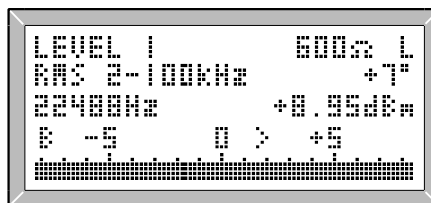
Fig. 2.5 Flashing overflow indicator

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2.4 Channel Switching

$\boxed{\text{L/R}}$ on the LA102 selects input channel (displaying 'L' or 'R' on the screen). $\boxed{\text{L/R}}$ on the LA101 cycles through 'L+R', 'L' and 'R' channels, while $\boxed{\text{MUTE}}$ mutes both channels and displays 'MTD'. Pressing $\boxed{\text{MUTE}}$ again will restore the selected channel state ('L+R', 'L' or 'R') which can be changed even while the output is muted in preparation for de-muting. When an output channel is turned off, it is switched by an internal relay and terminated with the selected output impedance.

2.5 Programmable Presets and Initial Settings

The five numbered keys on the LA101 give instant access to preset levels and frequencies as labelled on the panel. If the last thing changed was frequency then they operate as frequency presets, otherwise they give preset levels. This can be confusing at first, but with proper use it gives very quick access. We recommend always pressing one of the frequency $\boxed{\text{<Hz}}$ $\boxed{\text{Hz>}}$ or level up-down $\boxed{\text{<dB}}$ $\boxed{\text{dB>}}$ keys, to define the mode of operation, before using the presets.

The presets can be programmed by simply selecting the desired frequency or level in the normal way and then pressing $\boxed{*}\boxed{5}$ followed by the preset key (1 to 5) to be re-programmed. The LA101 will prompt for the preset number, by displaying 'P?' beside the frequency or level display. Their settings are retained in non-volatile memory, and many users will prefer to set values like 20Hz, 3150Hz, 15kHz or +8dB permanently.

When the LA101 is turned on (or reset) it will generate the frequency and level of one of the presets. By default this is preset 4 which usually gives 1kHz and 0dB. Any change to preset 4 will therefore change the start-up frequency and level as well. However, the LA101 can be made to select the frequency and level assigned to any preset, by setting configuration S (for level) and T (for frequency) to any preset number (1-6). For example, users testing sensitive microphone inputs might like to set configuration S1 to make the LA101 generate -60dB (the level usually assigned to preset 1). Furthermore, configuration S0 can be used to make the oscillator start up with its output muted. Configurations S6 and T6 will force the output level and frequency to the values set when the unit was last turned off or reset. See section 1.6 for further details of configurations.

To avoid overloading sensitive inputs, it is possible to turn the LA101 on with its output muted, by holding the $\boxed{\text{MUTE}}$ key while switching on.

2.6 Relative Levels – Test Level (TL)

Both units cater for relative level generation and measurement. Pressing $\boxed{*}\boxed{1}$ on the LA101 stores the current output level as a *test level* and displays TL. The output level is now displayed relative to this test level. Pressing $\boxed{*}\boxed{1}$ again, or resetting (by tapping

ON/OFF)), cancels the test level. Note that the level difference between the two channels can be measured easily by setting the test level on one and then selecting the other.

The same key combination, ✱TL, on the LA102 stores the current reading and subsequent readings are shown relative to this on the numerical readout. The bar-graph, however, always reads absolute. A test level may be set for the functions level, noise and crosstalk, and it then operates on all these measurements until cancelled by another ✱TL or a reset. It does not operate on distortion, which uses its own reference level, or on W&F.

2.7 Measurement Options

To select the measurement *option* for the current *function* (level, noise etc), press OPTION followed by the option number, 1 to 5. More obscure measurements are available as options 6 to 10 which are selected by pressing ✱1 to ✱5, and options 11 to 15 which are selected by pressing > followed by 1 to 5. In all cases a menu appears listing the 5 options which can be selected (fig. 2.7 & 2.8). Once options 11 to 15 are selected for a particular function, they will be listed next time the OPTION key is pressed, and < should be used to return to options 1 to 5. Pressing OPTION from the menu display cancels the option menu.

In the case of level measurement, for example, option 1 is wideband rms, option 2 is 22Hz-22kHz bandwidth rms, and option 3 gives the same bandwidth with a VU meter characteristic. Level option 5 provides a PPM (peak programme meter) characteristic, but shows a dB bar graph instead of a true PPM scale (PPM 4 is 0dBu, PPM 5 is +4dBu, PPM 6 is +8dBu etc). Options are described fully in the relevant section below, and a full list of options is given in table 2.6. Once changed, options remain set for each measurement so that the user may switch between his own preferred set of measurements. Options, like presets, are held in non-volatile memory, so remember to set them as required (or use reset option 2 to restore the default options – see section 1.5).

Experienced users will realise that options 11 to 15 are generally similar to options 1 to 5, but with a different filter (this is true for level options 11 to 15, distortion options 11 to 15 and noise options 12 and 13), and may like to know that ✱4 provides a quick way of toggling between options 1 to 5 and options 11 to 15 (where available).

LEVEL
1 RMS, 2-100kHz
2 RMS, 22-22kHz
3 VU 22-22kHz
4 Twin level and phase bar graphs
5 PPM 22-22kHz
6 VU, A weighted
7 RMS, A weighted
8 VU 2-100kHz
9 RMS 2-100kHz slow response
10 PPM 2-100kHz
11 RMS 400-100kHz
12 RMS 400-22kHz
13 VU 400-22kHz
14 Twin bar 400-100kHz
15 PPM 400-22kHz

NOISE
1 CCIR468-3 weighted quasi-peak
2 CCIR468-3 unweighted quasi-peak
3 RMS 22-22kHz
4 RUMBLE unweighted, slow
5 RUMBLE weighted, slow
6 CCIR weighted, ARM-1k
7 CCIR weighted, RMS
8 A weighted, RMS
9 CCIR weighted, ARM-2k
10 2-100kHz, quasi-peak
11 Unused
12 CCIR unweighted, 400-22kHz
13 RMS, 400-22kHz
14 CCIR unweighted PPM
15 CCIR weighted PPM

OPTION 1 to 5 selects options 1-5
OPTION ✳ 1 to ✳ 5 selects 6-10
OPTION > 1 to 5 selects 11-15
OPTION < returns to options 1-5

CROSSTALK
1 100Hz narrow band, RMS
2 315Hz narrow band, RMS
3 1kHz narrow band, RMS
4 6.3kHz narrow band, RMS
5 10kHz narrow band, RMS
6 40Hz narrow band, RMS
7 150-300Hz narrow band, RMS
8 2k-20kHz narrow band, RMS
9 15kHz narrow band, RMS

DISTORTION
1 100Hz RMS THD, 200-22kHz
2 315Hz RMS 3rd harmonic, narrow band
3 1kHz RMS THD, 2k-22kHz
4 6.3kHz RMS THD, 12k-22kHz
5 10kHz RMS THD, 20k-22kHz
6 40Hz RMS 2-400Hz
7 1kHz RMS 3rd harmonic - experimental
8 1kHz notch only, 22-22kHz
9 6.3kHz notch only, 22-22kHz
10 10kHz notch only, 22-22kHz
11 100Hz CCIR weighted quasi-peak
12 Unused
13 1kHz CCIR weighted quasi-peak
14 6.3kHz CCIR weighted quasi-peak
15 10kHz CCIR weighted quasi-peak

WOW & FLUTTER etc
1 W&F IEC386 weighted quasi-peak
2 W&F IEC386 unweighted quasi-peak
3 Q-D 40Hz CCIR weighted quasi-peak
4 Q-D 40Hz RMS, 400Hz-22kHz
5 Difference frequency distortion, 70Hz RMS
6 W&F weighted RMS
7 W&F unweighted RMS
8 FIM (frequency intermod)
11 Speed (3150Hz reference)
12 Speed (3125Hz reference)
13 Speed (3kHz reference)

Table 2.6 Measurement Options
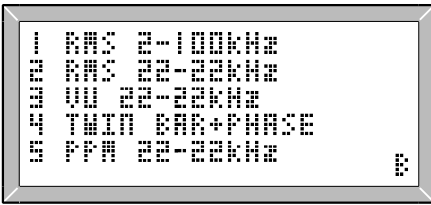
Fig. 2.7 Level options 1-5
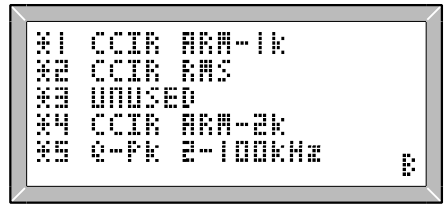
Fig. 2.8 Noise Options 6-10

2.8 Frequency Measurement

The LA102 displays the measured input frequency (of the selected channel) on all level measurements (fig. 2.2). To measure frequency the LA102 times zero-crossings over a variable number of cycles and calculates frequency – commonly referred to as 'reciprocal counting'. This gives rapid results even at low frequencies, together with high accuracy. The algorithm used gives rapid updating after a large change in frequency, but averages for greater accuracy on steady readings. The zero-crossing detector is preceded by the filter and gain stages, so readings are valid down to quite low signal levels (-60dB) where noise starts to cause errors. The frequency range is currently 20Hz to 50kHz, and aliasing will occur above 50kHz (ie 60kHz will read as 40kHz).

2.9 Phase Measurement

Phase (between channels) is also displayed on all level measurements. Again, it is measured by timing zero-crossings and the use of software algorithms. Because the zero-crossing detectors for phase are at the front-end, phase readings are only useful for input signals above -30dBu, and are most accurate around 0dBu. The phase display only operates when a valid phase measurement has been made, it is blanked at low levels (or if the frequency is not reasonably steady). The numerical indication reads ±180°, a negative reading indicating that the R input lags the L input. Accuracy is greatest at low frequencies, with some random variation occurring at frequencies around 10kHz and above, but the reading will be found quite effective for setting tape azimuth. Input-output phase can be measured by connecting the input to the equipment to the LA102's L channel and the output from it to the LA102's R channel.

A graphical display of phase is provided on ⌊LEVEL⌋ ⌊OPTION⌋ ⌊4⌋ (see fig. 2.9) and this will be found ideal for tape head azimuth setting. The top bar graph shows mean phase over a ±40° range. Immediately below that is a white mark indicating instantaneous phase (to show phase jitter) surrounded by two bars showing peak phase deviation. The bottom level bar graph is split into left and right channels (L above R as indicated) and the LA102 measures and updates each channel alternately about 5 times a second, but there is no numerical display of level. The digital readout shows frequency (measured on the left channel), mean phase and peak phase deviation (from the mean). Autoranging

operates on the channel with the greatest level although manual range changing still works normally.
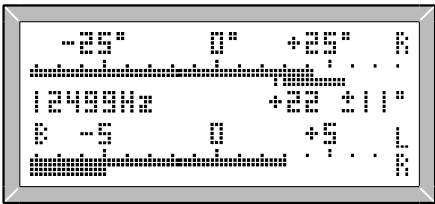
Fig. 2.9 Dual Level & Phase Bars

Fig. 2.10 Noise Measurement

2.10 Noise Measurement

Noise is normally measured using the widely accepted CCIR468-4 weighted measurement (identical to CCIR468-1 to 3 but with different tolerances) which is provided on noise option 1. Pressing NOISE on the LA102 will measure noise using the last noise option (see fig. 2.10, section 2.7 and table 2.6). The display shows the absolute noise level in dBu (relative to 0.775V) unless a 'test level' has been set (section 2.6) in which case the numerical reading is relative to test level (but the bar graph always shows the absolute level). Try silencing the LA101 by pressing MUTE and a reading of around -97dB should be obtained, this being the residual input noise of the LA102. Press MUTE again to restore the signal. The slowness of autoranging when changing to a higher range results from the slow quasi-peak rectifier response. Option 2 gives unweighted measurement to the CCIR468-4 standard and most other standards are incorporated (see appendix G for graphs of CCIR and 'A' weighting curves).

Option 3 gives rms noise measurement (with 22Hz-22kHz bandwidth), equivalent to level option 2 but, like all noise measurements, configured for low signal levels (an extra 20dB of gain is selected, so the maximum level that can be measured is +8dBu on noise compared with +28dBu on level). Options 6 and 7 provide CCIR weighted noise measurement, using the average reading meter and the rms meter respectively. Option 8 gives 'A' weighted noise measurement, and option 9 gives CCIR ARM-2k ('A' weighted, average reading meter, normalised to 2kHz). Option 10 provides a wide band, 2Hz-100kHz noise measurement using the quasi-peak rectifier. Options 12 and 13 are similar to options 2 and 3 but use a 400Hz high pass filter, and options 14 and 15 provide CCIR unweighted and weighted measurements using the PPM rectifier.

2.11 Rumble Measurement

Turntable rumble may be measured by selecting Noise Option 5 (weighted) or 4 (unweighted). Both rumble measurements have the same HF roll-off above 315Hz but the weighted measurement also rolls off below 315Hz to give a measure of the subjective intrusion of rumble (see appendix G). The unweighted measurement is flat down to very low frequencies. To measure rumble, take a reading while playing the quiet grooves of a special test disc, and then take a normal level measurement using a track cut to one of the following reference levels: 315Hz 2.71cms^{-1} rms one channel, 1kHz 5cms^{-1} rms one channel, or 1kHz 10cms^{-1} peak lateral. These are referred to in the various standards but are in fact equivalent. The difference between the two readings is then the relative rumble level. While it is also possible to set a test level and then read the relative rumble, visual averaging may be needed, and this is easier using the bar graph. The LA102 uses VU meter characteristics (with slow software averaging) for rumble measurement, as required by IEC98, but later software may implement the very slow BS4852 characteristic which gives exactly the same result but without the need to average visually. The unweighted measurement differs slightly from all the standards which require a rather odd 10Hz triangular roll-off. As the various standards then go on to require various additional roll-offs to be applied for the measurement (20Hz unspecified IEC, 31.5Hz 6dB/octave DIN, none BS) the precise 10Hz specification seems to be pointless. The LA102 has been left flat down to 2Hz as it is felt that in practice the LF limit for this measurement is set entirely by the rumble filtering invariably included in the cartridge pre-amplifier.

2.12 Crosstalk Measurement

Pressing CRSTK on the LA102 provides a narrow bandpass-filtered level measurement which reduces the contribution from wideband noise by 10dB typically even when the measured signal is close to or below the noise level (fig. 2.11). Measurement at six spot frequencies is possible by selecting options 1 to 6, giving 100Hz, 315Hz, 1kHz, 6.3kHz, 10kHz and 40Hz respectively. Although other applications may arise where such filtered measurement is useful, it is intended primarily for crosstalk measurement, either between channels on a stereo signal or between unrelated channels in a mixer etc. Such measurements are made by sending a tone on one channel and measuring on the other channel, and on a stereo circuit this is simply achieved by appropriate use of the L/R keys on the two units. The reading obtained is absolute in dBu unless a 'test level' has been set. It is NOT referred automatically to the level on the other channel as this may not be the interfering channel in the case of mixer measurements. To refer the crosstalk measurement to the level of the tone on the other channel, simply select level measurement on the other channel and set a test level (eg press L/R LEVEL ✳ TL CRSTK L/R).

Crosstalk options 7 and 8 permit some degree of noise reduction on crosstalk measurement at a variety of frequencies. Option 7 introduces a 150Hz to 300Hz bandpass

filter (-3dB at 80Hz and 400Hz) which is particularly useful for 150Hz *cuetone* breakthrough measurement on cartridge recorders. It reduces tape noise contribution by typically 10dB. Option 8 covers 2kHz to 20kHz (-3dB frequencies are 1.8kHz to 21kHz) and can be used for 8kHz cuetone measurement. Crosstalk option 9 (-3dB at 11kHz and 22kHz) is useful for 15kHz crosstalk. Crosstalk at other frequencies can be measured using the 22Hz-22kHz level measurement facility (on LEVEL OPTION 2), but this will also be measuring noise.

The crosstalk option is automatically selected if a suitable frequency (1kHz, 10kHz, 15kHz etc) is found on the other channel. In cases where there is no tone on the other LA102 input the option may be set explicitly by pressing the OPTION key after pressing CRSTK in the normal way (section 2.7). This manual selection may also be useful when measuring crosstalk from noise or programme material. Note that a crosstalk reading around 0dB usually indicates that the channels are transposed.

Note: The LA100 can measure crosstalk at levels of -100dB or lower and this is usually good enough for all practical purposes. However, a few users have demanded even lower residual crosstalk levels and Lindos has devised a way of reducing the LA102's own crosstalk with a simple board modification. Full details are given in *Application Note 10* available from Lindos free on request.
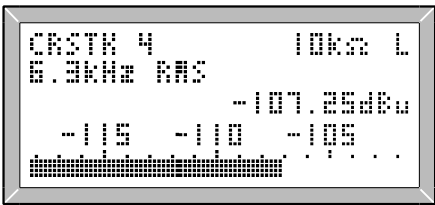
Fig. 2.11 Crosstalk Measurement   **Fig. 2.12 Distortion Measurement**
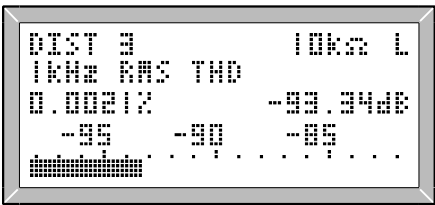
2.13 Distortion Measurement

The LA102 can measure harmonic distortion at 6 spot frequencies (as for crosstalk) selected as options 1-6. Five of these are 'total harmonic distortion' measurements, (or strictly THD+noise, band-limited 2nd harmonic to 22kHz) but the 315Hz measurement reads third harmonic only. This involves a band pass filter centred on 945Hz which greatly reduces the contribution of wideband noise, particularly from tape.

Pressing DIST results in a fully automatic measurement, the LA102 measures the input frequency and selects one of the six notch filters, the fundamental being measured immediately after the key is pressed and stored automatically as the reference level (fig. 2.12). The measurement is very fast, taking only about half a second to settle. The

relative level of distortion is displayed numerically, in dB and percent while the bar graph shows the absolute level in dBu. Unlike most instruments the LA102 uses a multi-stage bandstop-plus-highpass filter to reject the fundamental, and no nulling process is involved. Very low distortion readings require a source of precise frequency, as provided by the LA101 which is quartz synthesised, but the unusually wide notch permits readings down to -60dB with a frequency tolerance of ±2%, giving complete immunity from the effects of wow and flutter or speed drift when measuring off tape Auto-nulling, tracking filters are often too slow to give accurate results.

The input frequency is constantly monitored and the filter is switched if it enters the valid zone for a different one. Operation is only valid at six points: the filters do not track, they just switch. Automatic operation only operates for tone levels above -29dB, but the filters can be manually locked by selecting the option explicitly (section 2.7), and unlocked by pressing $\boxed{\text{DIST}}$ again (or by pressing $\boxed{\text{OPTION}}$ twice). Re-normalisation of the level occurs every time the filter changes and also if the other channel is selected with the $\boxed{\text{L/R}}$ key. If in doubt press $\boxed{\text{DIST}}$ to re-normalise.

Distortion option 6 (40Hz) has limited bandwidth to reduce noise and quantising effects from the LA101, a response to the tenth harmonic (400Hz) is considered adequate here. Distortion option 7 is experimental only. Option 8 is a 1kHz notch filter, like option 3, but it passes frequencies below 1kHz. Similarly options 9 and 10 provide a 6.3kHz and a 10kHz notch filter and they too pass frequencies below the notch frequency.

There is growing popularity for distortion measurements using the CCIR468-4 weighting filter and quasi-peak rectifier which, it is claimed, give better correlation with subjective assessment and this is provided on distortion options 11-15. When CCIR weighted distortion is being measured the automatic frequency selector will choose options 11-15 and $\boxed{*}\boxed{4}$ can be used to toggle quickly between options 1-5 and options 11-15.

IMPORTANT: Distortion measurement differs from the other measurements in storing a reference level automatically and calculating a relative reading. As with all relative readings only the numerical display is relative; the bar graph ALWAYS shows the absolute level in dBu or dBV. This is partly for ease of implementation, but it can also be useful. Remember to press $\boxed{\text{DIST}}$ again (or press $\boxed{\text{OPTION}}$ twice) for correct relative readings if the signal level changes, as the level is only stored once.

2.14 Wow and Flutter Measurement

Wow and flutter is measured by replaying a tape that has been recorded with a 3kHz or 3.15kHz tone (at 0VU) and pressing $\boxed{\text{W\&F}}$ (fig. 2.13). Option 1 gives a weighted quasi-peak measurement to the universally accepted IEC386 standard, and option 2 gives the corresponding unweighted measurement. As with other measurements this one is autoranging, and settling may take a few seconds. The result can be read on the bar graph or digital readout (fig 2.13) in dB, a perfectly valid form of measurement which we

suggest is much more manageable than the usual 'point nought five per cent' (-66dB) and should become established practice; as is tending to happen with distortion figures. However, for the less daring, a digital percentage conversion is also displayed! A signal level of -20 to +10dB is recommended for flutter measurement, but the unit does in fact constantly monitor the signal level and frequency and display BAD TONE if either goes out of limits. W&F can only be measured on the left channel which is automatically selected. The measurement complies with IEC386, DIN45507 and BS4847-1972.

Although the ideal might be to use a perfect test tape for flutter measurement, it is usually more practical to make record-replay measurements, a 3.15kHz (0dBu) tone being first recorded on the same machine. The level of W&F on tape recorded on a modern domestic or professional machine is often as good as the W&F present on most test tapes A point to watch for is cancellation of slow rhythmical variations if they happen to synchronise between record and replay. Stopping and starting the tape a few times should show up such effects. Simultaneous record and replay should not be attempted as this may also cause cancellation. Listening to unweighted flutter components can give an interesting indication of 'scrape flutter'.

W&F options 6 and 7 provide weighted and unweighted wow & flutter using an rms rectifier, while the other W&F options are used for miscellaneous measurements (described below).
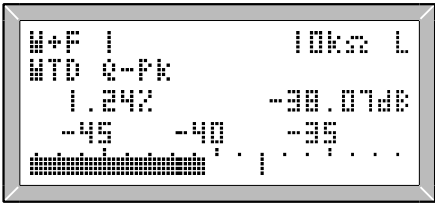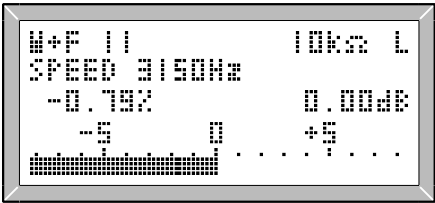
Fig. 2.13 Wow & Flutter   **Fig. 2.14 Speed Measurement**

2.15 Speed Measurement

Tape speed can be measured using a speed reference tape. Wow and flutter options 11 to 13 (W&F OPTION > 1 to 3) provide speed measurement using 3150Hz, 3125Hz or 3kHz reference tones respectively (fig. 2.14). 3150Hz is the most common frequency, but 3125Hz must be used if the speed tape was recorded using the LA101 which cannot generate 3150Hz (see section 2.2). The speed error is displayed as a percentage, accurate to ±0.04%, and a BAD TONE message is displayed if the frequency is out of range. The level bar graph and numerical dB reading indicate the measured level (using an rms rectifier). Unfortunately, it is not possible to measure speed at the same time as measuring W&F, but note that ✳4 will quickly toggle between option 1 and option 11.

2.16 Difference Frequency Distortion Measurement

Several other miscellaneous measurements are provided on the $\boxed{\text{W\&F}}$ key, and one of these is 2nd order difference frequency distortion. This is a form of intermodulation distortion (IMD) similar to the CCIF IMD measurement which has now been superseded by the IEC268-3 standard. The term difference frequency distortion is used to distinguish it from other forms of IMD which are now known as modulation distortion (previously called SMPTE IMD), dynamic intermodulation distortion (DIM) and total difference frequency distortion (based on the Thiele method).

To measure difference frequency distortion, a test signal is used comprising two frequencies, f_1 and f_2, with a difference frequency of 70Hz. Each tone should have an amplitude of -6dB relative to the nominal test level, so the rms value of the test signal will be -3dB and the peak to peak amplitude of the test signal will be the same as that of a 0dB sine wave. The typical intermodulation distortion products for this test signal are shown in fig. 2.15.

The level of the 2nd order difference frequency distortion at the system's output is measured using a 70Hz narrow bandwidth filter. In accordance with the IEC268-3 standard, the distortion is referred to a reference level which is **twice the amplitude of the f_2 tone.** This is different from many older IMD measurements, including that provided in earlier L102 software (prior to V5.6), which simply measured the distortion level relative to rms level of the double tone. This new IEC268 method will therefore give a figure 3dB lower than the old IMD measurement. In practice the LA102 cannot measure the level of the f_2 tone by itself as it is so close to f_1, so it actually measures the rms level and assumes that the f_2 tone is 3dB below that (hence the reference level is 3dB above it).

The LA101 can generate the necessary double tone, but only around 1kHz (see fig. 2.16). Press $\boxed{\ast}\boxed{4}$ on the LA101 until the display shows DOUBLE (see fig. 2.17) and set 0dB. The LA101 actually generates 976.56Hz and 1046.3Hz (69.754Hz separation) with each tone having an rms level of -6dB relative to the displayed output level, and the resulting waveform having an rms level of -3dB, as required by the standard. The peak to peak level is therefore the same as that of a 0dB sine wave.
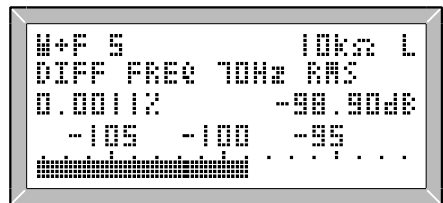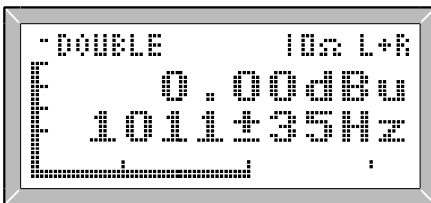
Fig. 2.17 Generating a Double Tone   **Fig. 2.18 Difference Freq. Distortion**
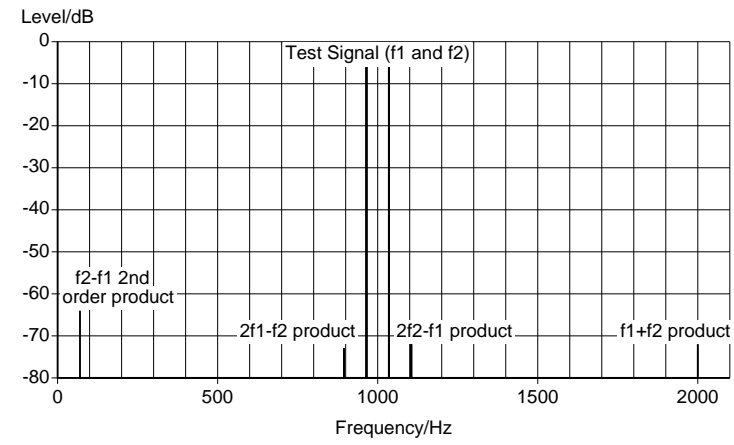
Fig. 2.15 Typical Intermodulation Products from a Double Tone with 1kHz Centre Frequency, and 70Hz Separation (Nominally)
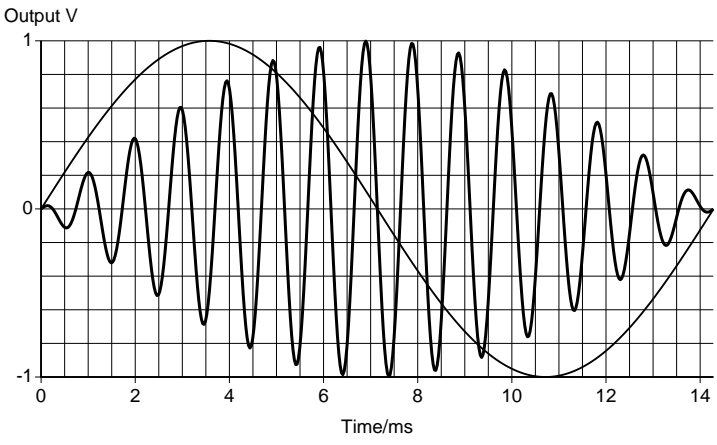
Fig. 2.16 LA101 Double tone Waveform compared with 70Hz Sine Wave

To measure difference frequency distortion, press [W&F] [OPTION] [5]. The LA102 will quickly measure the rms level of the double tone and assume that each component is 3dB below this level. The 70Hz bandpass filter is then used to measure the level of the difference frequency distortion product. This absolute level (in dBu or dBV) is shown on the bar graph, while the normalised result (relative to the reference level, as explained above) is shown numerically (see fig. 2.18). Note that the [W&F] key must be pressed in

the presence of the double tone, and used to re-normalise the reading if the level changes (as for THD measurement).

Another possible signal source is a test CD such as the the *HiFi News test disc III*. This disc contains double tones with centre frequencies of 1kHz, 5kHz, 10kHz and 15kHz (nominally), as well as a digitally generated Lindos test sequence. Residual readings of below -90dB can generally be expected. The Philips test sample 3 disc (410 055-2, SBC421) also contains suitable double tones, together with a double tone sweep.

Difference frequency distortion tests are normally carried out using a test signal having a peak to peak amplitude equivalent to that of a sine wave of the specified test level, and on the test CDs mentioned the level of the double tones has been so adjusted. Any gain adjustments to the system under test should therefore be made using a sine wave from the disc, not the twin tone. Measurements will be valid above about 1kHz, below this the measuring set will not adequately reject the double tone signal itself.

Note that only second order difference frequency distortion, resulting from an asymmetrical transfer characteristic, is detected by this method. Many devices, such as tape recorders, give rise predominantly to third order components. These are close to the signal and more difficult to measure.

2.17 Quantising Distortion (QD) Measurement

The LA100 system measures quantising distortion on a 40Hz tone by notching out the fundamental, and rejecting low harmonics with a 400Hz high-pass filter to leave only high frequency components, which are then measured in one of two ways. W&F option 4 reads rms with 22kHz bandwidth, option 3 uses CCIR weighting and quasi-peak detection. 40Hz was chosen to permit use with the Philips Test CD mentioned above, which has 41Hz tones at 0, -24 and -30dB. Distortion components on the LA101 produce a residual reading of -74dB, but this need not be a limitation as QD measurements are most relevant at low signal level where they will usually be much worse than this. Like THD measurement, the LA102 measures the level of the fundamental when this measurement is selected. The numerical readout indicates the level of the distortion, relative to the level of the fundamental, while the bar graph indicates the absolute level being measured. Remember to press the $\boxed{\text{W\&F}}$ key (or the $\boxed{\text{OPTION}}$ key) to re-measure the level of the fundamental if it changes. Note that this measurement need not be limited to digital systems and has been used to measure modulation noise on tape. It is also a useful measure of low frequency rattles and turbulence on loudspeakers.

2.18 Frequency Intermodulation (FIM) Measurement

FIM or Frequency Intermodulation is a measurement of the degree of frequency modulation of a 3kHz tone by a 300Hz tone, and is normally relevant to gramophone systems where variations in the vertical tracking angle of cartridges results in a

component of motion along the groove equivalent to flutter. This can be measured using W&F option 8 which selects a flutter measurement with special filtering to read only flutter components around 300Hz (3.15kHz and 315Hz tones can also be used). The measurement is normally made using a test disc to DIN45542 and complies with the current ITC (IBA) requirement (DIN45411).

2.19 Standards

The measuring options meet appropriate world standards: Noise CCIR468-4 weighted and unweighted (supersedes 468-1, 2 and 3); Rumble IEC98, DIN45539, BS4852 (except slow response); 'A' weighting IEC179; VU response ANSI; PPM response IEC268-10 type 2, BS4297-1968, BBC ED1477 (except scale details); W&F IEC386, DIN45507, CCIR409-3, BS4847; FIM DIN45411; 2nd order difference frequency distortion IEC268-3 (note 70Hz used in place of 80Hz). See appendix G for frequency response graphs.

2.20 400Hz High Pass Filter

⚹ HPF toggles a 400Hz high pass filter which is useful to ensure that measurements are not being affected by mains hum. It will operate on level options 1 to 5 and noise options 2 and 3, but not on any other measurement. HPF is displayed briefly to indicate the selection, or CAN'T if the filter cannot be switched in for the measurement (crosstalk for example). FLAT is displayed on return to a flat response.

Note for experienced users: The 400Hz high pass filter is actually provided as level options 11 to 15 and noise options 12 and 13 (see table 2.2) and can be selected by pressing OPTION > n (press OPTION < to return to options 1 to 5). ⚹ HPF merely provides a quick way of toggling between options 1 to 5 and 11 to 15 (see section 2.7).

2.21 Impedance & Impedance Correction (ZC)

⚹ Z cycles round impedances on both units. The LA102 provides 10kΩ or 600Ω inputs as displayed, at both the front PO jack sockets, and the rear XLR sockets (which are connected in parallel). The LA101 is more complex, as **only the front jack sockets change impedance (75Ω or 600Ω), the rear XLR sockets are always 10Ω**. The XLR connectors are therefore optimised for studio equipment testing, in line with the standard practise of feeding high impedance inputs from a low impedance output, while the jacks are optimised for 600Ω line tests.

The letters 'ZC' which appear when 75Ω or 600Ω outputs are selected signify 'Z-correction', meaning that the open circuit level has been boosted to give the specified level into a 600Ω load. Pressing ⚹ 3 will toggle between uncorrected and ZC mode as shown at the top centre of the display (this setting is stored for each impedance even when the unit is turned off). With the level uncorrected (ie no ZC displayed) the LA101 displays the open circuit output voltage in dB(0.775V), indicated by the symbol dBu. ZC

corrects the output to give the displayed power in dB(1mW), indicated by dBm, into a 600Ω load for any selected output impedance.

Note that 10Ω output impedance should always be selected on the LA101 when the rear XLR sockets are being used, and that 75Ω or 600Ω should be selected when the front jack sockets are being used.

Table 2.19 summarises the different settings available, for various source and load impedances. Note that it is quite acceptable to feed a 600Ω load from the LA101 with 600Ω output impedance and no ZC providing it is understood that the displayed output level refers to the unloaded open circuit output level. Connecting the 600Ω output will cause a 6.02dB drop which the LA101 will correct if the ZC mode is selected.

Display	Front jacks	Rear XLRs	Load Z	Output correction
10Ω	75Ω	10Ω	high	0.00dB
10Ω ZC	75Ω*	10Ω	600Ω	+6.02dB
75Ω	75Ω	10Ω	high	0.00dB
75Ω ZC	75Ω	10Ω*	600Ω	+1.02dB
600Ω	600Ω	10Ω	high	0.00dB
600Ω ZC	600Ω	10Ω*	600Ω	+6.02dB

* Note that it is meaningless to use these conditions, because the LA101 is trying to correct for a different source impedance to that being used.

Table 2.19 Impedance Correction Modes

It is important that this feature is used correctly. When ZC is selected the displayed power level is only meaningful when a 600Ω load impedance is connected. Using the wrong sockets for the selected impedance may be confusing; for example, the output from the XLRs will increase by around 6dB if 600Ω ZC is selected, though the impedance will still be 10Ω. Using the jack sockets in the 10Ω setting for equipment tests is permissible though: the impedance will be 75Ω, but the lack of Z-correction ensures correct output level provided a high impedance input is being fed.

2.22 dBu, dBV, Volts and Power Measurement

The LA101 normally displays the absolute level being generated in dB relative to 0.775V, or dB(0.775V), indicated by the symbol dBu. When a 600Ω load is connected and ZC turned on, the displayed units change to dBm to show that the level is the power into the load. However, configuration U allows other units to be used (U0 being the default). Setting U1 causes the LA101 to work in dBV units where 0dBV is 1V, or +2.21dBu. Setting U2 displays dBu and Volts (see fig 2.20), while setting U3 displays dBV and Volts (note that the up/down keys still change the level in 1 or 0.01dB steps, they cannot be made to change the level in voltage steps). The voltage displayed represents the

absolute output level in Volts (after taking the test level into consideration, but before the weightings and impedance corrections are added).

Fig. 2.20 dBu and Volts
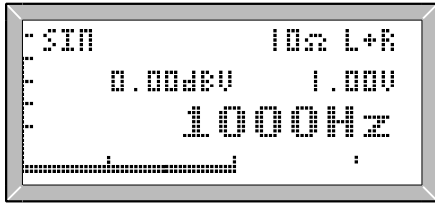
Fig. 2.21 dBV and Volts

The LA102 normally displays the measured voltage in dB relative to 0.775V, or dB(0.775V), indicated by the symbol dBu, with 10kΩ input impedance. When 600Ω input impedance is selected this changes to power, measured in dB(1mW), indicated by the symbol dBm. (Note that this is equivalent to dBu, since a voltage of 0dBu (0.775V) into a 600Ω load gives a power of 1mW, which is 0dBm; the 'dBm' units merely imply the existence of a 600Ω load).

Relative measurements such as distortion, W&F and any measurement with a Test Level set are always displayed in dB regardless of the units selected. The bar graph is always labelled in absolute dBu except when dBV units are selected when it shows absolute dBV.

Pressing ⊛< or ⊛> on the LA102 gives cyclic access to the other units (see fig. 2.21):
  dBu or dBm (depending on input impedance, as described above)
  dBV (relative to 1V, ie 0dBV = +2.21dBu)
  Watts (power equivalent into 8Ω)
  Volts (V, mV or μV)

Configuration U determines the units used after switch-on or reset: U0 selects dBu/dBm (the default), U1 selects dBV, U2 selects Watts (into 8Ω), U3 selects Volts. Test level segment results (T and V) are also displayed in the selected units.

When measuring power in Watts, the LA102 does not provide an 8Ω load which must be provided externally. Configuration W provides a choice of 'W into 8Ω' or 'W into 8Ω V/ 10'. The former measures from 8pW to 47W. The latter assumes an external divide-by-ten voltage attenuator as shown in fig. 2.22 for measurement up to 4700W.
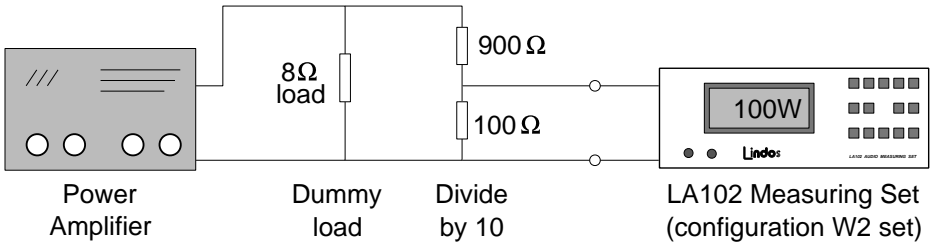
Fig. 2.22 Using an 8Ω Dummy Load and Attenuator for Power Measurement

2.23 Printing the Displayed Values

The LA102 can print the measured frequency, level and phase which are displayed on the LCD. Press ⊛ LISTEN, and a single line will be printed, for example:

```
Level 1  2-100kHz RMS   L 0.01dB  1001.6Hz  0d
```

This facility should be useful when testing equipment manually where results are normally written down by hand. It is possible to print results for any measurement, so a simple test sheet showing level, noise, crosstalk, distortion, W&F and speed can be produced very easily. A printer must be connected and set up correctly (see chapter 8), otherwise a NO HANDSHAKE message will be displayed. For more sophisticated results printouts sequence mode should be used (see chapter 3).

2.24 Output Waveform

The LA101 generates a sine wave output by default (indicated by SIN), because this is most useful for audio testing. Pressing ⊛ SQ will toggle between sine and square waves, while pressing ⊛ 4 will cycle through DOUBLE, DC0, DC+, DC-, TRI, SAW+ and SAW- waveforms (fig. 2.23). Pressing ⊛ SQ after ⊛ 4 will restore sine waves, and another ⊛ 4 will select the last waveform which was selected with ⊛ 4 (this allows quick switching between sine and double tone waveforms, for example).

DC0 is for noise test purposes; the internal oscillator is stopped and the input to its digital to analogue converter (DAC) is set to zero. This is different from MUTE because most of the LA101 circuits are still connected to the output, and the noise level is therefore higher. It is used automatically before tone bursts so that the signal can be turned on very quickly at a zero-crossing, without any glitches caused by relay switching.

DC+ and DC- generate positive and negative DC voltages at the displayed level (ie the same voltage as a positive or negative square wave half-cycle). Square waves are

generated with the same rms level as sine waves (ie less peak to peak amplitude). The peak to peak amplitude of sawtooth and triangular waveforms is the same as that for sinusoids at the same level setting (so the rms level is 1.7dB lower). SAW+ and SAW- provide sawtooth waveforms with positive and negative going slopes.

DOUBLE provides a double tone with 1011Hz centre frequency and 70Hz separation for difference frequency distortion measurement (see section 2.16). No other double tone frequencies can be generated and the bar graph shows the frequency which will be generated when another waveform is selected.
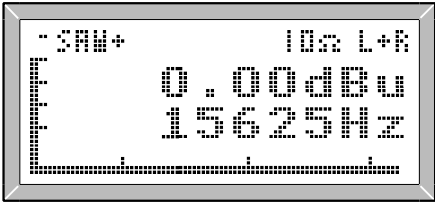
Fig. 2.23 Sawtooth Waveforms   **Fig. 2.24 Peak Hold**
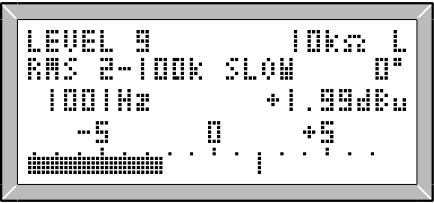
2.25 Miscellaneous Features

Pressing ✳3 on the LA102 inhibits autoranging and sets a fixed range which can be changed using the ◁ ▷ range keys. Selecting a new function changes the range to the range last used for the newly selected function, and this can be useful on test tapes, where autoranging on verbal announcements can be troublesome. Default values (after memory clear) are 0dB, -30, -30, -30, -60dB for Level through to W&F. Autoranging returns on the next ✳3 or reset.

✳PKH toggles a peak hold function on the LA102. The numerical display is held briefly and a marker appears on the bar graph (fig. 2.24). This is always switched in automatically on W&F.

Sometimes, on noisy or low frequency signals the rms bar graph can jump around making it difficult to read. Level option 9 overcomes this problem by providing a slow average of the rms rectifier which is much more stable (although slower at settling), even down to 10Hz. The averaging is performed in software using a first order digital filter.

The LA101 can generate 22.5kHz sine waves for pilot tone continuity detectors. The frequency actually generated is 22.4905kHz and is selected by holding MUTE and pressing 5. <Hz and Hz> keys can be used to go to adjacent frequencies (22321Hz and 22727Hz), but MUTE 5 must be used to return to this special frequency. This frequency can also be used in ! tone segment definitions (section 4.16) and from remote mode (see section 9.11). Also provided is 19.003kHz on MUTE 4 for FM stereo pilot

tone testing.

2.26 LA101 Weighting Curves

⊛2 on the LA101 cycles round weighting curves, currently RIAA-inverse, 50μs pre-emphasis, CCIR468-inverse and CCITT O.41 psophometric inverse weighting for testing disc pre-amps, FM transmitter systems and noise weighting filters.   All levels are generated digitally with high accuracy from look-up tables which are currently limited to third-octave frequencies.   The level can be adjusted using the ⟨<dB⟩ ⟨dB>⟩ keys as usual, and the weighting for the current frequency will be added to the displayed level to calculate the actual output level.   Excessive output excursions will cause the output level to 'slide' to a value that can be managed.   The level can be reduced when testing RIAA phono inputs by setting a level of, say, -60dB; but it is sometimes better to use a potential divider close to the input, as this also reduces stray pickup.   A test with 50kΩ series resistance is often also useful in showing up input impedance variations.   Test levels are still operative with weightings.

In addition to the existing weighting curves provided in the LA101, user weighting curves can be entered.   Pressing ⊛2 in manual mode will normally cycle through the available weighting curves (but see below):

W1-W5	User weighting curves
W6	RIAA inverse (disc recording characteristic)
W7	CCIR 468-3 inverse
W8	O.41 CCITT inverse
W9	50μs pre-emphasis

For quick access to a particular weighting curve configuration W can be set to one of the above weighting numbers to make ⊛2 toggle between that weighting and the flat unweighted state.   Setting configuration W0 (the default) will make ⊛2 cycle through all of the defined weightings.   Only third octave frequencies can be used when a weighting curve is in use and the weighting is applied equally to both left and right channels.

2.27 User Weighting Curves

User weighting curves are useful for testing filters using the inverse filter response which should result in a flat overall response.   They are also useful for making test tapes where the inverse of the record response is entered as a weighting curve to obtain a flat response recorded on tape.   User weighting curves, like pre-programmed weighting curves, can be used to generate weighted frequency sweeps – see section 3.19.

To define one of the user weighting curves in the LA101 hold ⟨ON/OFF⟩ and press ⟨4⟩ and then enter the weighting number (1 to 5), see figs. 2.25 and 2.26.
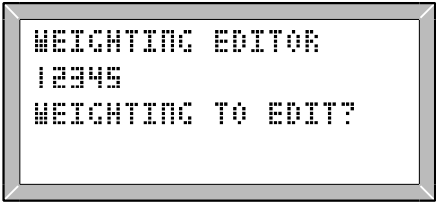
Fig. 2.25 Selecting a Weighting Curve
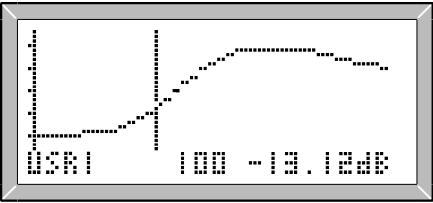
Fig. 2.26 Weighting Curve Editor

The weighting curve will be plotted and if it has not been defined it will be a flat line. It can be edited by moving the cursor and entering the level for each third octave frequency. The editing keys are:

<Hz> & Hz>	move the cursor in third octave steps
<dB> & dB>	change the weight at the cursor frequency by ±1dB
✳ <dB> & ✳ dB>	change the weight at the cursor by ±0.01dB
✳ <Hz> & ✳ Hz>	change the scale of the graph (zoom in/out)
L/R	copy the current weight to the next one for rapid entry
1 to 5	preset keys set the weight to the preset level
✳ L/R	invert the entire weighting curve
✳ 1	normalise the weighting curve to the cursor frequency
✳ MUTE n	copy the weighting curve to user weighting curve n
✳ SEQ	select a new weighting curve to edit
SEQ	exit from the editor.

To apply the user weighting set configuration W to its number (1 to 5) and press ✳ 2 to toggle it on/off (as described in section 2.26). When selected the actual output level will be equal to the displayed level plus the weight for the current frequency being generated. To clear a weighting simply set all of the weights to 0dB (this can be done very quickly by setting the lowest frequency to 0dB and then holding the L/R key to copy this level to the other weights).

3.0 Sequence Testing

Sequence testing, as its name implies, involves the sending of a sequence of test signals for the complete and automatic evaluation of a system. Sequence testing on the LA100 is completely self contained and requires no programming effort, yet it is powerful and flexible, and designed to fully test any circuit or equipment which operates in the audio band in about one minute. The test results can be displayed on the LA102's LCD, printed directly to a printer and downloaded to a PC.

A key feature is the use of test *segments*; standard 'building blocks' from which the sequences are assembled.   Each test segment (identified by a letter A-Z or a-z) consists of a short sequence of tones or a frequency sweep, preceded by an FSK (Frequency Shift Keyed) header code lasting around 200ms. The header acts as the synchronising trigger for the LA102, as well as identifying the segment code: the LA102 then makes the necessary measurements at the right time.   Segments can be sent in almost any combination over any audio path, or recorded and replayed, and any LA102 will still make correct measurements without any programming. The use of short segments brings many advantages over a single long test sequence. Speed errors on tape replay, which could put a long sequence out of synchronism, are well tolerated as each segment is retimed from its own FSK header. 'Breaking-in' on a continuous repeating sequence is also possible, as the LA102 waits and responds to the next FSK header. Perhaps most important, though, is the way in which segmented sequences combine flexibility with standardisation. A relatively small number of segments can be put together to form an almost unlimited number of test sequences, and yet every one will be recognised automatically by any LA102 because the segments are standardised.

Up to 5 sets of results can be stored in the LA102's non-volatile memory to be examined, printed or transferred to a computer later. Tolerance limit tests can be applied to the sequence results and up to 10 sets of user tolerances can be entered allowing limits to be specified for every measurement providing pass/fail testing which is ideal for production testing, or routine checking of equipment. A source identification message can be entered into the LA101 (for all sequences, or for each sequence separately) and this is transmitted to the LA102 as FSK. The heading and the date can be entered into the LA102, to be printed at the top of the page.   All sequences, results, tolerances and messages are preserved in non-volatile memory when the unit is turned off so complex definitions need only be entered once (they can also be entered from a remote computer via the serial port - see chapter 9).

New users should read sections 3.1 to 3.4 which explain the basics of sequence testing. They may then proceed to chapters 4, 5 or 8 for details on modifying the test sequences, pass/fail tolerance testing or results printing respectively.

User Sequences

0   For remote use only – this sequence can only be accessed by a remote computer
1-10 User sequences, initially set to be the same as sequences 11-20. These sequences can be edited by the user or overwritten by copying other sequences over them (either individually, or as a whole bank).

Lindos Default Sequences

11	`"GENERAL/TAPE TEST" TRCINZ`	General purpose test sequence
12	`"LINES/LINKS TEST" TOCENZ`	Test for communications lines and links
13	`"CASSETTE/CARTRIDGE" TPCINWZ`	Cassette and cartridge test with W&F
14	`"SPEAKER/GENERAL" TUD`	Loudspeaker frequency response and distortion
15	`"20-20kHz FAST SWEEP" TX<`	
16	`"LINDOS SELF TEST" /0%10,0`	LA100 Self Test – see section 10.6 of manual
	`"XLR SOCKETS ONLY/0dB"TUCDN±6`	
17	`"FM TEST""ONE CHAN MTD FOR THD"VRA:19,0GNY`	FM transmitter test. Dist. measured on mono tone
18	`"GERMAN SEQ" T+6U-14C+6D+6NZ-4`	German line-up levels
19	`"PPM TEST"`	A test for Peak Programme Meters
	`"100ms PPM6 +8dB"!5000,100,8,0,5000`	Should read PPM 6
	`"10ms PPM5.5 +6dB"!5000,10,8,0,5000`	Should read PPM 5½
	`"5ms PPM5 +4dB"!5000,5,8,0,5000`	Should read PPM 5
	`"1.5ms PPM3.75 -1dB"!5000,1.5,8,0,5000`	Should read PPM 3¾
	`"0.5ms PPM1.75 -9dB"!10000,0.5,8,0,5000`	Should read PPM 1¾
	`"TONES PPM7-1"!1000,4000,12,,,8,,,4,,,0,,,-4,,,-8,,,-12`	Levels PPM 7 to PPM 1
20	`"5S SWEEP (REPEAT)" TU<`	

Tape Test Sequences

21	`"FULL TAPE TEST" TRCINWZ`	As sequence 11, but with W&F
22	`"MULTI-SWEEP" *3 TU0U-10U-20`	Frequency response at 0dB, -10dB and -20dB
23	`"CASSETTE/CARTRIDGE" TPCINWZ`	General cassette/cartridge test
24	`"W+F ONLY" TW`	W&F test (including gain, speed and phase)
25	`"20-20kHz FAST SWEEP" TX<`	Fast repeating sweep
26	`"NOISE+DIST" TIN`	Simple noise and distortion test

Mono Loudspeaker Test Sequences

31	`"SLOW SWEEP-10 DIST":3,1TS-10F0`	Slow frequency sweep at -10dB, distortion at 0dB
32	`"SLOW SWEEP 0 DIST":3,1TS0F0`	Slow frequency sweep at 0dB, distortion at 0dB
33		
34	`"SWEEP+DIST":3,1TUD`	Sweep at 0dB, distortion at +8dB
35	`"SWEEP+DIST ON R"`	Connect LA100 as in fig. 3.16 (Manual, page 51)
	`"SPEAKER ON R CHANNEL":3,2TUD`	L channel carries FSK, measurements made on R

Filter Test Sequences

41	`"RIAA INVERSE" "WEIGHTED SWEEP -40dB"`	Inverse weighted frequency sweep at -40dB for
	`:3,1 =6 TU-40`	RIAA disc equalisation filter. Result should be flat.
42	`"CCIR468 INVERSE" "WEIGHTED SWEEP -40dB"`	Inverse weighted frequency sweep at -40dB for
	`:3,1 =7 TU-40`	CCIR noise filter. Result should be flat.
		To test the LA102, press: NOISE OPTION ✱ 2
		SEQ ✱ FIX and then run sequence 42

Meter Tests (Tone Bursts)

51	`"FLUTTER METER 1%"`	This should produce a 1% W&F reading on a
	`!3125,600,0,3188,,,3188,0<`	flutter meter.
52	`"CCIR468-4 WTD METER"`	CCIR486 noise meter test.
	`"6300Hz -40dB REF" !6300,5000,-52.2`	6.3kHz, -40dB reference (set meter to read -40dB)
	`"100Hz -40±1dB" !100,4000,-20.2`	Response test, meter should read -40dB±1dB
	`" 1kHz -40±0.2dB" !1000,4000,-40`	Response test, meter should read -40dB±0.2dB
	`" 8kHz -40±0.4dB" !8000,4000,-51.4`	Response test, meter should read -40dB±0.4dB
	`"10kHz -40±0.8dB" !10000,4000,-48.1`	Response test, meter should read -40dB±0.8dB
	`"16kHz -40±1.6dB" !16000,4000,-28.3`	Response test, meter should read -40dB±1.6dB
53	`"A WTD METER"`	'A' weighted meter test.
	`"1000Hz -40dB REF" !1000,4000,-40`	1kHz, -40dB reference (set meter to read -40dB)
	`" 100Hz -40±0.5dB" !100,4000,-20.9`	Response test, meter should read -40±0.5dB
	`"2500Hz -40±0.5dB" !2500,4000,-41.3`	Response test, meter should read -40±0.5dB
	`" 10kHz -40±0.5dB"!10000,4000,-37.5`	Response test, meter should read -40±0.5dB

Table 3.1 Sequence Definitions

54	`"CCIR TONE BURSTS"`	CCIR468-4 noise meter, ballistics test
	`"RANGE -40dB SET TL"`	5kHz reference tone, should read -40dB
	`!5000,4000,-51.7,0,3000,-40`	(adjust meter – if testing LA102 set Test Level)
	`"200ms ±1.2dB"!5000,200,-49.8,0,3000`	200ms tone burst should read -40±1.2dB
	`"50ms  ±1.3dB"!5000,50,-47.1,0,3000`	50ms tone burst should read -40±1.3dB
	`"10ms  ±1.2dB"!5000,10,-45.3,0,3000`	10ms tone burst should read -40±1.2dB
	`"2ms   ±1.5dB"!5000,2,-40.2,0,3000`	2ms tone burst should read -40±1.5dB
55	`"CCIR DUAL BURST"`	CCIR468-4 noise meter, ballistics test
	`"FIX-40 SET TL"!5000,6000,-51.7`	5kHz reference tone, should read -40dB
	`"2/SEC -6.4±0.9dB"!5000,5,-51.7,0,495<`	2 pulses per second, should read -40±0.9dB
56	`"CCIR DUAL BURST"`	CCIR468-4 noise meter, ballistics test
	`"FIX-40 SET TL"!5000,6000,-51.7`	5kHz reference tone, should read -40dB
	`"10/SEC -2.3±0.6dB"!5000,5,-51.7,0,95<`	10 pulses per second, should read -42.3±0.6dB
59	`"PPM TEST">19`	

Utility Sequences

61	`"BETACAM CHANNEL ID"`	Audio channel identification for Betacam tapes:
	`"STEADY TONE ON R"!1000,3000,0,,0`	Steady tone on R channel
	`"L MUTED FOR 0.25S":2!1000,250,0,,0:3<<`	Broken tone on L (muted for ¼s every 3¼s)

BBC Sequences

71-73 Not yet defined. 76 and 77 are included as temporary demonstrations!

74	`"FM Radio Relay"`	FM Radio relay test, with 400Hz test level.
	`*2:3,1VRCJ:3,2VRCJ"DE-EMPHASIS ON,1=CONT"?`	Distortion is measured twice, and the LA101
	`"STEREO DISTORTION+8":19,1F:19,2F"PILOT`	will prompt before each distortion measurement,
	`OFF,1=CONT"?"MONO DISTORTION+8":3,1F:3,2F`	frst with 'DE-EMPHASIS ON' and then with
	`'PILOT`	'DE-EMPHASIS OFF'. Press 1 to continue.
75	`"FM TEST""ONE CHAN MTD FOR THD"VRA:19,0GNY`	

British Telecom Sequences

81	`"BT DIGITAL LINES"`	BT Digital lines/links test. Crosstalk at 0 & +10dB
	`*3 TOCC+10c0c+7ENZK+10,0,-30,-37,-47,-55`	15kHz crosstalk at 0 & +7dB, response and level.
82	`"BT EPS81 LINES/LINKS"`	Mono broadcast line, checked against EPS81
	`"MONO LINE<40km" :3,1 TOCENZ±7`	tolerance in the LA102
83	`"BT EPS84 LINES <40km"`	Stereo broadcast line, checked against EPS84
	`"STEREO LINE" TOCENZ±8`	(for lines less than 40km)
84	`"BT EPS84 LINES <320km"`	Stereo broadcast line, checked against EPS84
	`"STEREO LINE" TOCENZ±9`	(for lines less than 320km)
85	`"BT EPS98 LINES <320km"`	Stereo broadcast line, checked against EPS98
	`"STEREO LINE" TOCENZ±10`	

Telecom Australia Sequences

91	`"REPEATING SWEEP""40 OHM 0dBm"%40,1TX<`	
92	`"NOISE TEST""40 OHM 0dBm"%40,1TN`	
93	`"THD +14dBm""40 OHM 0dBm"%40,1TF+20`	
94	`"DIFF FREQ DIST""40 OHM 0dBm"%40,1Td`	
95	`"LEVEL CRSTK + PHASE""40 OHM 0dBm"%40,1TC+12Z`	
96	`"MONO LINES TEST""40 OHM 0dBm"%40,1:3,1TUF20Nd`	
97	`"STEREO LINES TEST""40 OHM 0dBm"%40,1TUF20NdC+12Z`	
98	`"MONO LINES O.33 EQVT""L CHANNEL ONLY":3,1T"COMPANDER TEST ON K"`	
	`U-12D+9!K800,1000,+6,,,-6,,,+6,,,+6,,,-6,,,+6N`	
99	`"STEREO LINES (O.33)""COMPANDER TEST ON K"`	
	`*2 TU-12D+9B-12!K800,1000,+6,,,-6,,,+6,,,+6,,,-6,,,+6NZ`	
100	`"LINDOS SELF TEST"`	As sequence 16

SAPO Sequences (South African Post Office)

101	`"BTM/SEL SC"/-17%600,2"600OHM MATCHED"TrCEnz`	
102	`"TV SOUND/BC"/0TOCENZ`	
103	`"GTE SC"/-14%600,2"600OHM MATCHED"TrCEnz`	
104	`"GTE SUB/BB"/-19%150,2"150OHM MATCHED"TOCENz`	
105	`"20-20kHz FAST SWEEP"TX<`	
106	`"LINDOS SELF TEST"`	As sequence 16
107	`"TEST+PATCH SC"%600,2"600OHM MATCHED"TrCENz`	
108	`"NSTD CHANNEL"/-10%600,2"600OHM MATCHED"TrCEnz`	
109	`"PPM TEST"`	As sequence 19
110	`"5S SWEEP (REPEAT)"TU<`	As sequence 15

Seg	Measurement	Default Level	Time	Values
A	Crosstalk 40, 100, 315, 1k, 6.3k, 10kHz	0dB/50μs	6s	6
B	Crosstalk 100, 1k, 6.3k, 10kHz	0dB	2s	4
C	Crosstalk 40, 100, 315, 1k, 6.3k, 10kHz	0dB	6s	6
D	Distortion 100, 1k, 6.3kHz	+8dB	6s	3
E	Distortion 100Hz +9dB, 1kHz -10dB, 1kHz +9dB	-10/+9dB	6s	3
F	Distortion 40, 100, 315, 1k, 6.3k, 10kHz	+8dB	18s	6
G	Distortion 40, 100, 315, 1k, 6.3k, 10kHz	+8dB/50μs	18s	6
H	3% MOL at 1kHz	0 to 8dB	8.5s	1
I	Distortion 100 +8dB, 1k +8dB, 100 -10dB 1k -10dB	+8/-10	8s	4
J	Crosstalk 40, 100, 315, 1k, 6.3k, 10kHz	-10dB	6s	6
K	User levels 1kHz (1, 2, 3, 4, 5, 6)	0 to -50dB	6s	6
L	Noise RMS, A weighted and unweighted		8s	2
M	Noise CCIR468-3 peak wtd, peak unwtd and mean wtd		30s	3
N	Noise CCIR468-3 peak wtd, peak unwtd and mean wtd		8s	3
O	Sweep 20Hz-20kHz, British Telecom spec EPS84 frequencies: 40, 50, 60, 100, 125, 200, 300, 500, 800, 1k, 2k, 3k, 4k, 5k, 6k, 7k, 8k, 8.5k, 9k, 10k, 11k, 12k, 13k, 14k, 15k, 20k	-10dB	5s	26
P	Sweep 20Hz-20kHz Listed frequencies are: 30, 40, 50, 63, 100, 125, 250, 500, 1k, 2k, 4k, 6.3k, 8k, 10k, 12.5k, 14k, 15k, 16k, 18k, 20kHz	-20dB	5s	20
Q	Sweep 20Hz-20kHz (list as for P)	-12dB	5s	20
R	Sweep 20Hz-20kHz (18dB headroom, list as for P)	-10dB	5s	20
S	Sweep 20Hz-20kHz (list as for P)	-10dB	20s	20
T	Test level, 1kHz 0dB	0dB	1s	1
U	Sweep 20Hz-20kHz (max resolution, 8dB headroom, list as for segment P).	0dB	5s	20
V	Test level, 400Hz 0dB (for transmitters)	0dB	1s	1
W	Wow & flutter, 3.125kHz wtd, unwtd, speed and phase	0dB	12s	4
X	Fast sweep 20Hz-20kHz (list as for P)	0dB	1.5s	20
Y	Phase 40, 100, 1k, 6.3k, 10k, 15kHz (Mean)	0dB/50μs	3s	6
Z	Phase 40, 100, 1k, 6.3k, 10k, 15kHz (Mean)	0dB	3s	6
c	Crosstalk 15kHz	0dB	3s	1
d	Difference frequency distortion, 70Hz, 2nd order at 1kHz	0dB	2s	1
h	3% MOL at 315Hz (not available in V5.7T software)	0 to +8dB	8.5s	1
o	Sweep 300Hz-18kHz Listed frequencies: 315, 400, 500, 630, 800, 1k, 1.25k, 1.6k, 2k, 2.5k, 3.15k, 4k, 5k, 6.3k, 8k, 10k, 12.5k, 16k, 18kHz.	0dB	5s	19
n	CCITT O.41 Psophometric noise (see appendix I.5)		8s	2
r	Sweep 30Hz-4kHz Listed frequencies: 30, 40, 50, 63, 80, 100, 125, 160, 200, 250, 315, 400, 500, 630, 800, 1k, 1.25k, 1.6k, 2k, 2.5k, 3.15k, 4kHz.	0dB	5s	22
u	Sweep 10Hz-30kHz. Listed frequencies: 10, 20, 30, 40, 50, 63, 100, 125, 250, 500, 1k, 2k, 4k, 6.3k, 8k, 10k, 12.5k, 14k, 15k, 16k, 18k, 20k, 25k, 30kHz.	0dB	5s	24
x	Sweep 300Hz-18kHz. Listed frequencies: 315,400,500,630,800,1k,1.25k,1.6k,2k,2.5k,3.15k,4k,5k,6.3k,8kHz.	0dB	5s	15
z	Phase 40, 100, 315, 1k, 6.3k, 10k, 15kHz (Mean)	0dB	3.5s	7

Table 3.2 Test Segments available in LA100 V6.5 Software

3.1 Running a Sequence

Over 100 ready-made test sequences are currently available on the LA101, as listed in table 3.1, all constructed from the test segments listed in table 3.2 (and the control segments listed in table 4.1). They differ in the tests that are carried out and the levels of the test signals used; each being primarily intended for a particular purpose. The first-time user should connect the two units directly at first, turn on the LA102 loudspeaker and then try sequence operation.

Press $\boxed{\text{SEQ}}$ on both units to put them into sequence mode. After pressing $\boxed{\text{SEQ}}$ on the LA101 (fig. 3.3), a menu listing the available sequences can be displayed by pressing $\boxed{\text{<dB}}$ (fig. 3.4). Now enter a sequence number on the LA101 (press $\boxed{1}$ to run the general/tape sequence for example). Sequences 6 to 10 are selected by pressing $\boxed{*}\boxed{1}$ to $\boxed{*}\boxed{5}$.

```
SEQ?              L+R
PRESS <dB FOR MENU OR
ENTER 1-10 TO RUN A
USER SEQUENCE
```

Fig. 3.3 The Sequence Prompt

```
1 GENERAL/TAPE TEST
2 LINES/LINKS TEST
3 CASSETTE/CARTRIDGE
4 SPEAKER/GENERAL
5 20-20kHz FAST SWEEP
```
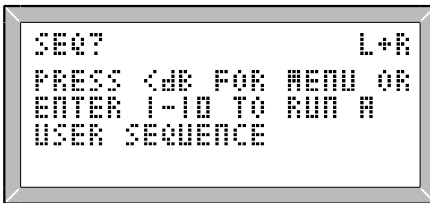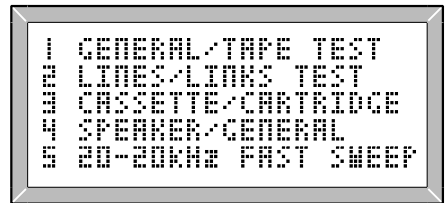
Fig. 3.4 The Sequence Menu

The LA102 should respond immediately by displaying a + character followed by the source message (usually the serial number of the oscillator) and a string of letters denoting receipt of the various test segments for each channel. For sequence 1 this will be 'TRCINZ.' for the left channel and 'TRCIN.' for the right channel (segment Z measures phase between the two channels and therefore only needs to run once). The '.' represents the sequence terminator which the LA101 sends to indicate the end of a sequence.

When both channel tests are complete the LA102 will go into page mode and display a graph of frequency response for the left channel (unless tolerances are in use, in which case it will display the title page with tolerance information). If the unit does not go into page mode automatically, perhaps because an error occurred, pressing $\boxed{\text{PAGE}}$ will ensure that it does.

Note that sequence mode is independent of the frequency, level and measurement option settings made in manual mode, as the sequence system specifies all of these parameters. However, pressing $\boxed{*}\boxed{\text{LPF}}$ on the LA102 when it is in SEQ mode will toggle the 22Hz to 22kHz filter on frequency sweep and tone segments ('22-22kHz' is displayed on the screen) and this will eliminate interference from bias breakthrough on some tape machines. It should not normally be used as it imposes its own response errors.

To abort a sequence when it is running press and hold $\boxed{\text{SEQ}}$ or $\boxed{\text{MUTE}}$ on the LA101 until SEQ? appears (this may take a few seconds). To re-run the last sequence, press $\boxed{\text{MUTE}}$.

3.2 Page Results Mode

Once in *page* mode, the results of a previously run test sequence can be viewed a screenful at a time by pressing $\boxed{\text{PAGE}}$ to cycle forward through the results in the following order: Source ID with segment list and pass/fail tolerance display, frequency response graphs, test level, noise, crosstalk, MOL (Maximum Output Level), distortion, W&F and speed, phase, user levels. See figs. 3.5-3.10. Press $\boxed{\text{OPTION}}$ to step backwards through the pages. If no results were received for a particular page then it is not shown.

Pressing one of the keys in the top row will display the appropriate page for level, noise, distortion etc., though in some cases only the key page is accessed in this way (crosstalk on sequence 1 has two pages). There is also a page for the source ID (fig. 3.5 & section 4.3), segment list (for each channel) and tolerance information (when in use). Note that the quickest way back to the graphs is to press $\boxed{\text{LEVEL}}$ and then step back a page by pressing $\boxed{\text{OPTION}}$. To leave page mode press $\boxed{\text{SEQ}}$ (twice to return to manual mode). Sequence results remain stored in non-volatile memory and can be viewed again at any time by pressing $\boxed{\text{PAGE}}$.

Some results can be displayed using different units and the $\boxed{*}\boxed{\text{UNITS}}$ key will cycle through dBu, dBV, V and W for test level or dB and % for distortion. The printout is also affected by this setting and configurations U and D set the default units to be used (see section 1.6).
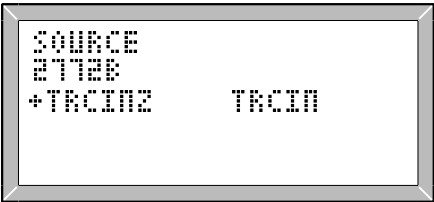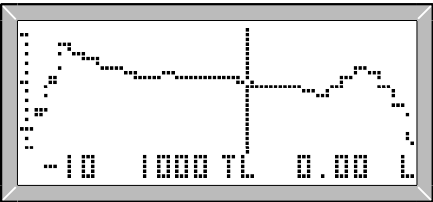

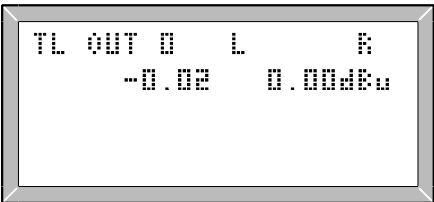**Fig. 3.5 Source ID and Segment List**

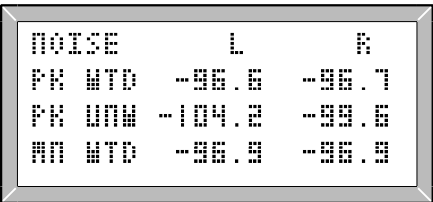**Fig. 3.6 Frequency Response**

Fig. 3.7 Measured Test Level
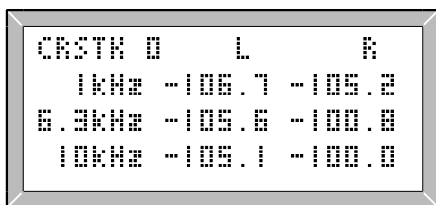

Fig. 3.8 Noise Results
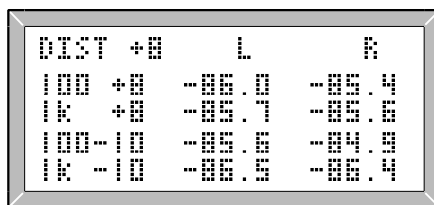
Fig. 3.9 Crosstalk Results

Fig. 3.10 Distortion Results

3.3 Frequency Response Results

The frequency response page shows a graph (fig. 3.6), usually covering 20Hz to 20kHz, with a scale marked at 1dB (single pixel) and 5dB intervals (double pixels). The cursor may be moved to any (third octave) frequency using the arrow keys $\boxed{<}$ and $\boxed{>}$, and the frequency and level (at the cursor position) may be read from the numerical readout which is based on stored information using 256 points per graph, and much more accurate than can be seen directly from the graph. Similarly, the printed frequency response graph is of much higher resolution (typically 512x512 pixels), as shown in fig. 3.11.

The $\boxed{L/R}$ key toggles between left and right graphs, while $\boxed{*}\boxed{L/R}$ displays a difference graph (R-L). An 'L', 'R' or 'D' character is displayed to indicate Left, Right or Difference graph. The level the sweep was transmitted at is shown to the left of the display. $\boxed{*}\boxed{<}$ or $\boxed{*}\boxed{>}$ can be pressed to expand or contract the dB scale of a displayed graph, giving a range of 2, 4, 8, 16 or 32dB. This does not affect the printout, but a similar control of the graph scale on the printout is available with configuration G. The displayed levels are usually normalised to 1kHz, but this can be changed (see section 3.16). When the frequency response results are printed a table of frequency and levels is printed beside the graph, using the frequencies shown for each sweep segment in table 3.2.

3.4 Printing Sequence Results

To print the results of a sequence test ensure that a suitable printer is connected and press $\boxed{*}\boxed{PRINT}$. To print two or more copies press $\boxed{*}\boxed{PRINT}$ and, without releasing the $\boxed{*}$ key, press a number $\boxed{*}\boxed{2}$ to $\boxed{*}\boxed{5}$. A typical printout is shown in fig 3.11.

If the message NO HANDSHAKE appears, or if the output is garbled then the printer connections, the LA102 configuration options or the printer's DIP switch settings may be wrong. The LA102 will drive a wide range of printers directly, and the most likely fault is incorrect setting of configuration P (printer type) or B (printer baud rate). Full details of printer operation and the printout options are given in chapter 8. To abort printing, tap the $\boxed{ON/OFF}$ key.

Automatic printing of sequence results is also possible, by setting LA102 configuration A

```
LINDOS AUDIO SEQUENCE TEST
SOURCE 3514C                    LA102 3514   V6.7    7 JAN 2000
SEGMENTS +TUCDN   TUCDN

FREQUENCY RESPONSE [U] 0dB
    30Hz     -0.09     -0.09
    40Hz     -0.05     -0.06
    50Hz     -0.04     -0.04
    63Hz     -0.02     -0.02
   100Hz      0.00     -0.01
   125Hz      0.00     -0.02
   250Hz      0.00      0.00
   500Hz      0.00      0.00
    1kHz      0.00      0.00
    2kHz      0.00      0.00
    4kHz      0.00      0.00
  6.3kHz      0.00     -0.01
    8kHz      0.00      0.00
   10kHz     +0.02     +0.02
 12.5kHz      0.00      0.00
   14kHz      0.00      0.00
   15kHz      0.00      0.00
   16kHz      0.00      0.00
   18kHz     +0.02     +0.02
   20kHz      0.00      0.00


TEST LEVEL OUT [T] 0dB
            0.00      0.00dBu
NOISE CCIR 468-4 Q-Pk (rel) [N]
PK WTD     -96.5     -96.7
PK UNW     -99.5    -100.7
MN WTD     -96.7     -96.9
CROSSTALK (rel) [C] 0dB
   40Hz    -106.9    -107.2
  100Hz    -106.4    -104.6
  315Hz    -109.9    -112.3
   1kHz    -111.4    -108.8
 6.3kHz     -99.7     -94.6
  10kHz     -95.7     -90.9
DISTORTION (2f-22k) [D] +8dB
  100Hz     -85.1     -84.0
   1kHz     -89.8     -90.0
 6.3kHz     -79.5     -79.4
```
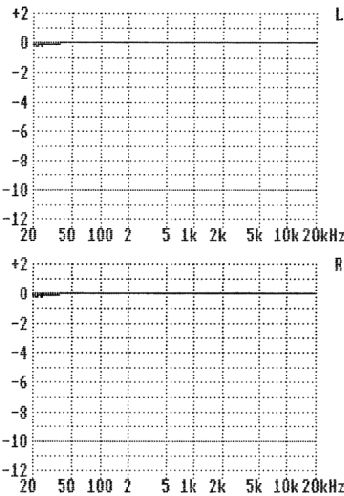
Fig. 3.11 A Typical Printout from the LA102

to 1, 2 or 3 (the number determines the number of copies). This makes the LA102 print the results whenever it receives a sequence and is useful where the LA102 is being used at a remote site to test a line or link, or even where a series of routine tests are being performed and printouts of each are required. Similarly, automatic results storage is also possible, see section 3.20. Setting configuration A to 5 causes the LA102 to enter sequence mode after switching on or resetting. This setting, may be used in conjunction with configuration Y to automatically store up to 5 sets of sequence results without any operator intervention.

3.5 Storing Results in Memory

Up to six sets of stereo sequence results can be held in non-volatile memory for later comparison, printing or transfer to a computer. A menu (fig 3.12), obtained by pressing ✳MEM from PAGE or SEQ mode, lists five operations: ✳2 saves the results from the 'working' memory (0) to a specified memory (1 to 5). ✳3 recalls results (fig 3.13) from a specified memory (1 to 5) to the working memory (0). ✳1, ✳4 and ✳5 are for status (show the source ID and segment list for a memory), exchange (gives, instant comparison between memories) or subtract (each sample in a chosen memory is subtracted from the sample in memory 0). Note that these operations can also be carried out by pressing ✳1 to ✳5 directly without entering the menu (with the small restriction that ✳1 cannot be used from the graph page). When an operation has been selected the memory number should be entered by pressing 1-5. At this stage, the operation can be aborted by pressing SEQ, or a different operation can be selected by pressing the appropriate ✳ key (✳1 to ✳5).
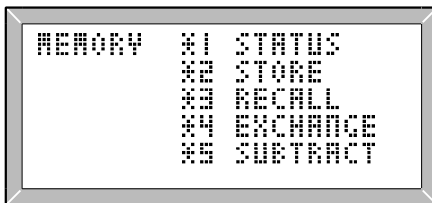
Fig. 3.12 Memory Operations Menu   **Fig. 3.13 Recalling Results**
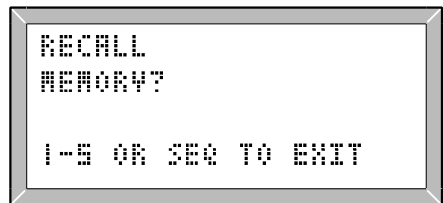
For convenience the same results page is displayed after a memory operation (providing equivalent results are available), so results in different memories can be compared easily. For example, to compare the noise results in the current memory, with those stored in memory 1, press NOISE and then ✳4 1 to exchange the two results memories. The noise figures which were in memory 1 will then be displayed and the same operation can

be repeated to swap the memories back. Similarly, whenever the source ID page is displayed the results are immediately compared with the pass/fail tolerance if one is in use (see section 5.1). This allows memory recall and memory status operations to be used to check quickly whether each set of results would pass the current tolerance.

Usually the unit can hold six complete sets of results in memories 0 to 5 (memory 0 being the main or working memory). However, the number of results memories is reduced when user tolerances are defined (section 5.6) or when the unit is configured for multiple results compartments (section 4.18). In either case, the range of memory numbers available is always shown (as in fig 3.13).

3.6 Cyclic Identification Character

A cyclic identification character (A-Z) is transmitted by the LA101 with the serial number (as FSK) and printed out with the sequence results, as shown:

    LINDOS AUDIO SEQUENCE TEST
    SOURCE 6548A
    ...
    LINDOS AUDIO SEQUENCE TEST
    SOURCE 6548B

This letter advances through the alphabet each time a sequence is run (returning to A after Z), and helps in sorting out a day's tests. It may be set to any letter using the LA101 sequence editor (section 4.3), and it is reset to A when the sequence memory is cleared (or if the SOURCE ID is deleted entirely).

3.7 Test Level

Sequence tests operate at a test level which is normally 0dBu but it can be changed to suit the application. A typical example would be when testing a microphone input where a test level of -60dBu might be selected. Similarly, a fixed-gain tape recorder might be tested by setting a test level that produced exactly 0VU on its meters.

To set a test level other than 0dBu first select the desired level in manual mode on the LA101 and then press ✳1. The letters TL will now appear to indicate that a test level has been set, and all sequences will be output relative to this level, unless the maximum output level of the LA101 is exceeded, in which case an error message appears and the sequence stops. To cancel the test level setting press ✳1 again in manual mode, or more simply tap ON/OFF to reset the LA101. Sequences usually begin with a test level segment, and the result (under the heading 'TL OUT') indicates the measured test level, (out of the system under test). If the LA101 test level was 0dBu, then TL OUT represents the gain of the system.

If a sequence is always being used at a particular level then the sequence definition can be modified to make it automatically set the test level when it is run (see section 4.21) and

this avoids having to set the test level every time it is used.

3.8 Input Level

The LA102 looks for FSK signals at a nominal level of 0dBu, being intended for direct connection to professional line levels, but a wide range of levels should give satisfactory operation (-30 to +20dBu). Below this level the FSK may not be received, especially if the system is noisy, but see section 3.13 for direct triggering using a separate channel. Loudspeaker testing can be carried out using a measuring microphone with a suitable pre-amplifier, provided that this has the necessary gain. The actual measurements use autoranging techniques, so they are independent of input level.

3.9 Choosing a Sequence

Although the LA101 has the capacity to store 250 sequence definitions, of which 110 are currently defined as listed in table 3.1, many engineers find the Lindos Default sequences are appropriate for nearly all their testing requirements.

The sequences are arranged in up to 25 *sequence banks*. Each bank contains 10 sequences and the banks are listed in table 3.14. The default sequence bank is Bank 0.

Bank 0 is different from the others because the sequences therein are editable (see chapter 4). By default, Bank 0 contains the Lindos default sequences, and after option 4 is chosen from the reset menu any user defined sequences in Bank 0 will be replaced by the Lindos default sequences. Bank 1 also contains the Lindos default sequences, but this bank cannot be edited. The other banks contain sequences written either by Lindos or third parties.

Bank	Sequences	Allocation
B0	1-10	User sequences. These are held in RAM and can be edited
B1	11-20	Lindos default sequences
B2	21-30	Tape test sequences
B3	31-40	Speaker test sequences
B4	41-50	Filter test sequences
B5	51-60	Meter tone bursts
B6	61-70	Utilities
B7	71-80	BBC sequences
B8	81-90	BT lines/links sequences
B9	91-100	Telecom Australia sequences
B10	101-110	SAPO (South African Post Office) sequences

Table 3.14 Allocation of Sequence Banks in LA100 V6.5 Software

To select a particular sequence, first press SEQ. Subsequently each press of dB> will display the first 5 sequences of the next bank in succession. Pressing dB< will step back a bank. Pressing 1 to 5 will run the corresponding sequence. To view sequence 6 to 10

of each bank press ✳. While holding ✳, press 1 to 5 to run sequence 6 to 10 respectively. For example, to run sequence 27: Press SEQ to enter sequence mode; press dB> until sequence titles 21-25 are displayed; press ✳2 to run sequence 27 (note that ✳1 represents the digit 6, ✳2 represents 7 etc).

When a bank has been selected, it becomes the current bank and will be used next time a sequence is run (ie after running sequence 27, pressing SEQ 1 will run sequence 21). After the LA101 is turned on or reset (by tapping the ON/OFF key), the current bank is set from configuration B.

New users should first gain experience with the default Lindos sequences in Bank 0 before using sequences in other banks or editing sequences.

The 10 Lindos default sequences vary mainly in the levels at which each test is carried out relative to test level, and the levels used are the result of careful analysis of various codes of practice and specifications issued by the BBC, IBA, ITC, British Telecom, IEC, EBU and CCITT. The use of +8dB for distortion tests is fairly standard, except for line testing where +9dB is used. A level of -10dB has been chosen for the sweep in sequence 11, in line with the BBC requirement for testing tape machines, and the IBA code of practice. A sweep (segment Q) at -12dB is available in line with CCITT/EBU recommendation O.33 for line testing. Sequence 12 incorporates a frequency sweep at -10dB which gives a printout to British Telecom specification EPS84 and also incorporates a 'rest' period between the two high level distortion tests to minimise the risk of overloading FDM and satellite systems. Sequence 13 uses a sweep at -20dB as is common in testing cassette machines to avoid high frequency tape saturation.

Sequence 14 is useful for testing loudspeakers and other devices where crosstalk and noise are irrelevant. It is recommended that a working level of say 90dB SPL be adopted for loudspeaker testing, while the distortion test will be found quite meaningful at +98dB SPL.

Sequences 15 and 20 provide repeating frequency sweeps which can be used to see the effect of making changes to a piece of equipment which affect its frequency response (perhaps adjusting tape bias for example). The sweep repeats until stopped by pressing SEQ on the LA101 (press and hold PAGE on the LA102 to stop it updating). Sequence 15 uses a fast 1½s sweep while sequence 20 provides a slower 5s sweep which will be more suitable when testing steep filters. The LA102 plots the frequency response as it is measured and the usual graph keys on the LA102 operate to move the cursor, zoom in or switch channels etc (see section 3.3). These keys operate during sweep measurement, but not during FSK input (which only lasts a small fraction of the repeat cycle anyway) and the display shows 'SEQ' or 'FSK' to indicate the mode. Do not worry that scrolling and cursor movement sometimes causes graph plotting to fall behind fast sweep input, as the sweep input is independently timed and not affected by graph plotting or key presses.

Each channel is measured and the graphs updated on alternate sweeps. When testing mono circuits the channel should be selected on the LA101 with [L/R] before running the sequence (after pressing the [SEQ] key).

Sequence 16 is a Selftest sequence which can be used to test the LA100 using XLR leads to connect the two units back to back. This sequence automatically selects the Selftest tolerance in the LA102, so a PASSED or FAILED display will appear as soon as it has finished. See section 10.6 if it fails.

Sequence 17 is intended for testing FM transmitter systems where a 400Hz reference tone is used and where the high frequency distortion and crosstalk tones are attenuated using a 50µs pre-emphasis curve (see below). Sequence 18 provides a sequence compatible with German standards which specify distortion measured at +6dBu, sweep 20dB below 0dBu, noise referred to +6dBu, crosstalk at +6dBu, W&F at 0dBu and phase at 10dB below +6dBu. Sequence 19 provides a PPM (Peak Programme Meter) test using tone bursts and reference levels. The user should compare the target levels shown in table 3.1 (and on the LA101 display) with the peak meter readings. Note that this test sequence does not generate any FSK as it is not normally used with an LA102 (although it can be used to test the LA102 PPM available on level option 5).

Careful consideration has been given to the level at which crosstalk should be tested. Too high a level can cause more, or less, crosstalk through overload, especially at high frequencies if pre-emphasis is in use. Too low a level makes it more difficult to read crosstalk in the presence of noise. While -10dB was considered it was felt too low to allow discrimination from noise, even with the narrow band filtering in use in the LA102, and so 0dB was adopted. Segment A gets round the problem partially by reducing the level at high frequencies according to a 50µs pre-emphasis curve (-10.36dB at 10kHz) with corresponding correction factors applied in the LA102. This will probably be most useful in testing FM transmitter systems, where 50µs pre-emphasis and limiting are applied. See section 4.1 for details of defining user sequences and section 4.5 for details of altering segment levels.

Sequences need not be limited to the applications listed in their headings of course. Many people will prefer to test cassette machines using sequence 11, and with type II or IV tape the different high frequency saturation levels can be readily demonstrated by running sweeps at different levels. See section 4.18 for details on running multiple sweeps.

The Lindos Default sequences were the only ones provided in early LA100 units. In response to demand from users, the number of inbuilt sequences now exceeds 100, and for ease of access they are arranged in sequence banks.

While the inbuilt sequences provide a variety of useful sequences, many users will want to define their own sequences and this is readily achieved using the sequence editor built

into the LA101. This is essential if some of the less common test segments are to be used as they are not all provided in the default sequences. In particular, the slow, 20s, frequency sweep (segment S), the MOL test (segment H) and the user level segment (K) are extremely useful. Sequence editing is very simple and is explained fully in chapter 4.

3.10 Interpreting Sequence Results

A slight caution is needed with regard to the 5 second sweep used in the default sequences. This gives a quick accurate result for most purposes, but because it is quite fast it is subject to the normal limitations found on any sweep system or spectrum analyser with regard to very steep filters. Low pass anti-aliasing filters for digital systems, for example, cannot be expected to show their true rate of roll-off if the rectifier cannot follow the change quickly enough. Ringing and sidebands can also lead to small errors, and low frequency overshoot can sometimes be observed as the result of a complicated interaction between the output of a high pass filter and its own ringing; even though this is not present in static tests. None of these effects need be feared on normal tape machines etc. but if in doubt always confirm with a manual test or use the 20 second sweep segment (segment S) instead.

In very extreme cases the LA102 may fail to take a valid speed or phase measurement and will indicate this by showing -999° for an invalid phase measurement or -99.9% for an invalid speed measurement. This is very unlikely even on very poor quality cassette machines.

Some clarification of working levels may be appropriate. Distortion measurements are truly relative, (ie harmonic separation) based on the measured level of signal received, but the specified level of the distortion test is of course relative to test level. If TL OUT reads +2dB and the distortion segment operates at +8dB then the measurement was actually done with an output level of +10dB. Crosstalk and noise measurements are relative to the measured test level on the measured channel.

As with any test system, very low level measurements will also be limited by the performance of the oscillator and measuring set (see specification in appendix J), although generally this is unlikely to be a problem. If in doubt, run the sequence with the LA101 connected directly to the LA102.

3.11 Single Channel Operation

Sequences normally measure the left channel of a system and then the right channel by repeating every segment. It is therefore much quicker, when testing a mono circuit, to run the sequence only once, on the channel to be tested. This is readily achieved by pressing the L/R key on the LA101 when in SEQ mode. The display will cycle through L, R and L+R. When a sequence number is entered the sequence will run on the channels indicated.

When running a sequence the FSK data and test tones are generated on both output channels and the LA101 instructs the LA102 which channel to use via data embedded in the FSK header. When testing stereo equipment, both channels are normally connected through the device under test, as shown in fig. 3.15. When testing mono equipment the L input on the LA102 should be used, as shown in fig. 3.16, and the LA101 should be set to run the sequence for the L channel only. This is because the LA102 normally only decodes FSK data on its left channel. It is quite permissible though, to connect both channels through a stereo system and then run the sequence on the right channel only (by selecting the R channel on the LA101). In this case the FSK will be decoded on the L channel, but it will instruct the LA102 to measure on the R channel.

It is also possible to connect the LA101 L channel output directly to the LA102 L channel input, and then connect the R channel through the system under test. This can be useful where the system under test is unreliable at passing FSK; for example a loudspeaker or a notch filter. See section 3.13 for further details.
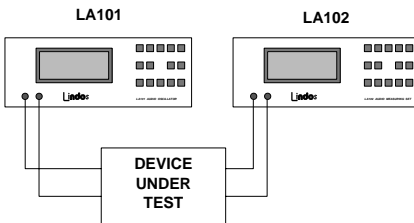
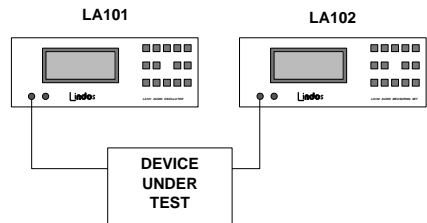**Fig. 3.15 Testing a Stereo Device** **Fig. 3.16 Testing a Mono Device**

A sequence that contains no FSK segments, such as the PPM test sequence, will only run once and will not repeat for the second channel like most sequences do. Changing the channel selection with the [L/R] key will have no effect on these sequences as this setting only influences the channel that the LA102 will measure on – not the physical output channels. Full control of output channels is possible from within a sequence using channel control segments and full details are given in section 4.22.

Note that phase and W&F segments are only sent once in a two channel sequence (because phase is measured between the two channels and W&F is assumed to be the same for each channel).

Note for advanced users: Although the LA102 normally only decodes FSK on the L channel, it is possible to make it decode FSK on either channel by pressing [SEQ] [OPTION] [4] immediately before running the sequence. This feature can be used when

testing two independent mono communication channels. Set LA102 configuration Y1 to automatically store sequence results and press [SEQ] [OPTION] [4]. A sequence can now be sent to the LA102 L channel input by running a sequence with the L channel selected on the LA101 (press [L/R] on the LA101 when in sequence mode to set the LA102 measurement channel). Another sequence can now be sent with the R channel selected and this will leave the results for the first mono channel in memory 1 and the results for the second mono channel in memory 2.

3.12 Single Register Operation

Each results memory has two registers, numbered 1 and 2, which are are normally used to hold the left and right channel results respectively. However, it is often convenient to compare the results of two separate mono test runs on a single printout or display, and this can be done using 'single register' operation to use the two results 'registers' separately. Each register will then hold results for a single channel (and either register can hold L or R channel results).

To run two mono sequences and store the results in the two registers for comparison, first clear the LA102 results memory by pressing [ON/OFF][3][4] and then press [✳][SEQ] on the LA102. The display will show SEQ and REG?. Press [1] on the LA102 to select register 1 and run a single channel sequence test by pressing [SEQ] [L/R] [1] on the LA101. The results will be stored in register 1. Now repeat the operation but press [2] to make the LA102 use register 2.

The results will be displayed and printed as for normal stereo results, but the column headings will show the register numbers '1' and '2' in addition to the channel letter (L or R). Note that it is quite permissible to have two sets of L channel results, one in each register, as shown in fig. 3.17.

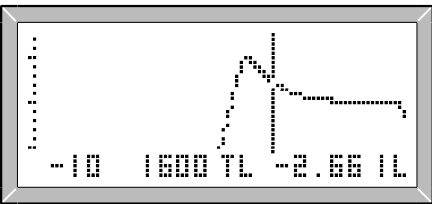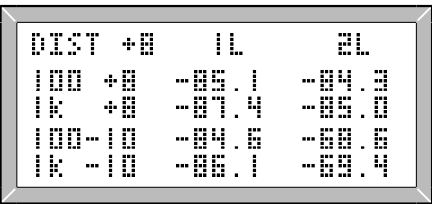**Fig. 3.17 Results for Two Registers**   **Fig. 3.18 Register 1, L Channel**

Frequency response graphs also indicate both the register number and the channel letter (see fig. 3.15). Use the [L/R] key to switch between the two graphs and [✳][L/R] to show the difference between the two responses (register 2 minus register 1) This can be useful when comparing a frequency response in register 2 against a reference response in

register 1 (perhaps from a reference tape, or from a device which is known to be good).

3.13 FSK Failure – Error Codes

The FSK system used is very effective in coping with speed errors on tape replay, because of the repeated resynchronising that it provides (the FSK itself will tolerate speed errors up to ±4%). For optimum FSK operation a signal level of 0dBu into the LA102 is preferred, but levels between -30dB and +20dB are normally satisfactory, permitting use on most professional and domestic equipment. Loudspeaker measurements have proved very successful, using a microphone and pre-amplifier and relying on FSK operation, but careful microphone positioning is sometimes required as room reflections can cause delayed interference with the FSK. Similarly systems that 'ring' badly, have extreme group delay or do not pass the FSK frequencies (1650Hz and 1850Hz) may cause FSK failure, which is indicated by an error message. In many such cases triggering can be guaranteed by a direct connection between the units on the L channel, with the input to be measured applied to the R channel, as shown in fig. 3.16. The R channel should now be selected on the LA101 by pressing the $\boxed{\text{L/R}}$ key when in sequence mode (note that the FSK is still transmitted and decoded on the L channel even though the LA102 will now take measurements on the R channel). 'SEQ ERRORS' 1 to 8 usually indicate FSK failure (as shown in fig. 3.20) and a full list of error messages, together with explanations, is given in appendix E.
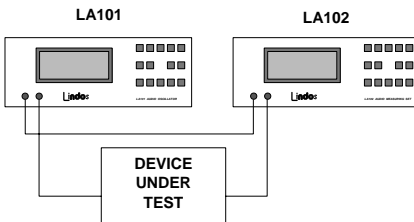

Fig. 3.19 A Separate FSK Path   **Fig. 3.20 FSK Failure Message**
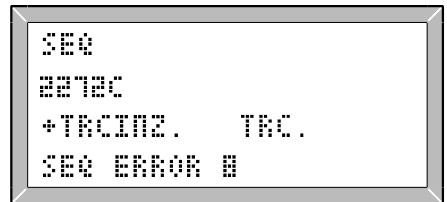
3.14 Sweep Headroom

Since the LA102 cannot be allowed to autorange during a sweep, and has no way of knowing how high the signal will go in advance of the sweep, it is necessary to allow a certain amount of headroom in the measuring set. Generally, the default sequences provide sufficient headroom for most applications without losing too much resolution and the user need take no action except where high accuracy is required, or where a signal path has a large peak.

When testing systems with large peaks in the frequency response (such as one band of an

equaliser) more headroom may be required. An overload during frequency sweep measurement is detected and the message RANGE? is displayed in place of the level on both the screen and the printout where an overload has occurred (see fig. 3.21). Since the LA102 chooses its level based on the measured test level, a system which does not pass the 1kHz test level tone may cause a similar problem. The following notes should give sufficient information for most situations, but section 4.25 describes a technique for setting sweep headroom for systems with very large peaks in frequency response.
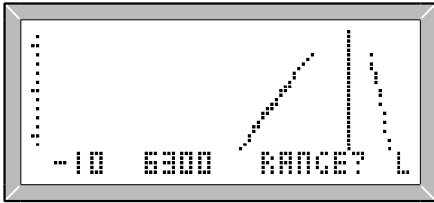

Fig. 3.21 Overload During Sweep

When receiving segment U the LA102 assumes that a 0dB frequency sweep will be received at a level similar to the measured test level and therefore uses the same range as it used for measuring the test level (which itself was determined by autoranging on the test level tone). If the sweep segment has a measurement level (see section 4.5) other than 0dB then this is taken into account. Sweep segment U at 0dB therefore has 9dB of nominal headroom, while all of the other sweep segments all provide an extra 10dB, giving 19dB of headroom, but slightly less resolution.

When testing very flat systems segment U should be used to achieve the best resolution and accuracy (when measuring a 0dB signal on the 0dB range the resolution is around 0.01dB, but when measuring a -20dB signal on this range it is around 0.05dB). If necessary segment U can be used at a level other than 0dB by giving it a measurement level (see section 4.5).

When testing a system with a large peak in the frequency response it is best to use a segment other than segment U (if a 0dB sweep is required this can be achieved by giving the sweep segment a measurement level of 0dB, see section 4.5). If an overload still occurs, then the test level segment can be run at a higher level to make the LA102 use a higher range for the frequency sweep (ie change TR0 to T+10R0). Alternatively, a repeating sweep (as found on sequences 15 and 20) can be used.

When testing a filter with a narrow pass band it is best to run the test level segment at the filter centre frequency. This also means that the test level result will indicate the gain of the filter at its centre frequency which is generally more useful than at the 1kHz default.

The LA102 will now measure the filter's gain correctly and choose a range which will be sufficient to handle the peak level. For example, when testing a 6.3kHz narrow band-pass filter the sequence !T6300,1000,0U should be used, and full details are given in section 4.16.

Repeating sweeps (as used in sequences 15 and 10) use the same rules for the first sweep, but will autorange between successive sweeps to ensure that the optimum range is selected, so it does not matter which segment is used – the results will always be accurate after two or three sweeps. Note that this allows sweeps at low levels to be run and accurately plotted.

An example for experienced users:
(the following assumes sequence 6 contains the Lindos default sequence)

Try sweeping the CCIR weighting filter in the LA102 (at -20dBu):

LA102:	NOISE OPTION ✳ 2 SEQ ✳ FIX
LA101:	dB> -20 ✳ TL SEQ ✳ 1

Press PAGE and move the cursor to 6300Hz where the the CCIR filter peaks. The LA102 will display RANGE? to indicate that an overload occurred (fig. 3.21). To correct this change sequence 6 in the LA101 to one of the following and repeat the test (remembering to set the -20dBu test level before running the sequence):

T+10 U	Run segment T 10dB higher
!T6300,1000,0 U	Run segment T at frequency where peak occurs
TU<	LA102 changes range between repeating sweeps

3.15 Peak Programme Meter (PPM) Testing

The PPM test sequence generates a series of tone-bursts and reference levels for testing the meter ballistics and level accuracy of a Peak Programme Meter, as required by the relevant standards. With practice it is possible to verify correct PPM operation in a single run, looking for the peak excursions on tone bursts. For development work the individual tone bursts can be run over and over again using single segment operation (section 3.23).

Five tone bursts are used to test the meter ballistics and in each case the expected target which the PPM should reach is shown on the LA101 display after the tone burst. A 5s delay follows each tone burst to prevent retriggering before the meter has settled properly. After the tone bursts seven levels are generated for 4s each ranging from PPM7 down to PPM1 to enable the level accuracy to be checked.

Segment	Frequency	Duration	Level	Target Reading
1.	5kHz	100ms	+8dBu	PPM6
2.	5kHz	10ms	+8dBu	PPM5½
3.	5kHz	5ms	+8dBu	PPM5
4.	5kHz	1.5ms	+8dBu	PPM3¾
5.	10kHz	0.5ms	+8dBu	PPM1¾
6.	1kHz	4s	+12dBu	PPM7
	1kHz	4s	+8dBu	PPM6
	1kHz	4s	+4dBu	PPM5
	1kHz	4s	0dBu	PPM4
	1kHz	4s	-4dBu	PPM3
	1kHz	4s	-8dBu	PPM2
	1kHz	4s	-12dBu	PPM1

Note that the PPM test sequence 18 does not output any FSK and therefore only runs once (even if both channels, L+R are selected). Other meters can also be tested by programming the suitable tone bursts (see section 4.16).

3.16 Normalisation of Frequency Response

Frequency response graphs are usually normalised to 1kHz initially (ie the 1kHz level is set as a test level) with each channel being normalised independently to its own 1kHz level. However, other frequencies can be used for normalisation by setting configuration J1 for 315Hz, J2 for 400Hz or J3 for 1kHz. Alternatively, absolute results (in dBu) can be displayed by setting configuration J0.

This default normalisation can be overridden when the graph is displayed by pressing ✳ TL to turn test level on and off. The letters 'TL' indicate that the displayed level is relative to a test level (similar to the test level facility in manual mode), and initially the test level will be set so as to normalise the frequency response results to a frequency determined by configuration J (as described above). Pressing ✳ TL when 'TL' is displayed will turn the test level off causing the frequency response results to be shown as absolute levels (in dBu). Pressing ✳ TL again will set the test level to the displayed cursor level, normalising the results to the frequency at the cursor; so positioning the cursor at 100Hz and operating ✳ TL twice will leave a graph normalised to 100Hz (leaving the graph display resets the test level to its default). Printed graphs are not affected by the test level setting as they always use the normalisation determined by configuration J.

Normalisation operates independently on each channel, so it is quite possible to normalise the left channel to 315Hz (using the ✳ TL facility) while leaving the right channel normalised to 1kHz. The difference graph is calculated from the normalised level on the right channel minus the normalised level on the left channel, but it is also possible to set a third, independent test level on the difference graph.

3.17 Subtracting Reference Curves

The LA102 can subtract a reference response curve from the frequency response results. This has many applications: loudspeaker and microphone measurements often need to be corrected to allow for deficiencies in the system; similarly, record frequency response measurements on a tape machine may be corrected to allow for errors in the replay response.

The reference response should be measured either by using a normal Lindos test sequence containing a frequency sweep, or by using the test tape or frequency sweep mode (see chapter 6). The reference results should then be stored in one of the memories (by pressing ✳2 and the memory number when the results are displayed). The results to be corrected should be obtained in the same way and the reference results may then be subtracted by pressing ✳5 when the frequency response is displayed and then entering the memory number for the reference results. The frequency response results in memory 0 will be modified by subtracting the frequency response results in the reference memory, but none of the other results will be affected.

The subtraction works by subtracting each sample in the reference memory from each sample in memory 0. The left channel is subtracted from the left channel, and the right channel is subtracted from the right channel.

The subtraction can only be used when configuration C1 is set, otherwise an error message will be displayed (because if more than one frequency response curve was in each memory it would not be clear which should be subtracted from which). The memory to be subtracted must contain valid frequency response results covering the same frequency range, otherwise it will produce meaningless results (eg do not subtract a 10Hz-30kHz response from a 20Hz-20kHz response).

3.18 Tests Which Always Subtract a Reference Curve

Some measurements will always require the subtraction of a reference curve, and this can be achieved by using the \n control segment which instructs the LA102 to subtract the reference curve in memory *n*. The \n segment must appear after the frequency response segment, otherwise the subtraction would occur before the frequency response had been measured (the LA101 only sends this segment once, and if sending a two channel sequence it will only send it when both frequency sweeps have been run). Some care should be taken when using this segment to ensure that the correct reference curve is stored in memory *n* before the sequence is received, and that LA102 configuration C1 is set.

3.19 Oscillator Weightings

An oscillator weighting can be used when running sequences (see section 2.27). The weighting is selected on the LA101 by pressing ✳2 in manual mode before running the

sequence, and the weighting name will appear at the top of the screen (in manual and sequence modes). As the LA101 can only apply weightings to third octave frequencies, some segments cannot be used. In particular, segments O, S, X, Y, Z, !, c, d, o, r, u, x and z are not allowed and will generate a CANNOT USE WEIGHTING error message if used.

Weighted frequency sweeps are possible using segments P, Q, R or U. A third octave frequency sweep will be generated by these segments with fewer frequency steps than the fine sweeps normally used. It is important to remember that the sweep only contains third octave frequencies and the result will therefore be a stepped frequency response graph, but this is quite satisfactory for most purposes. This feature allows filters to be tested by using an inverse weighting curve to obtain a flat frequency response (providing the curve is not too steep and covers a suitable level range).

As an example, we can test the CCIR weighting filter in the LA102. First of all, try testing it with a normal, flat frequency sweep:

LA102:	NOISE OPTION ✳2	Select CCIR RMS measurement
	SEQ	Enter sequence mode
	✳ FIX	Test the LA102 CCIR filter
LA101:	dB> -40 ✳ TL	Set a test level of -40dB
	SEQ ✳5	Run sequence 10 (repeating sweep)

The result is shown in fig. 3.23, but accuracy has been lost due to the steep roll-off of the filter, the slowness of the rectifier to respond to the rapidly changing level, and the large dynamic range over which the measurements have been taken.
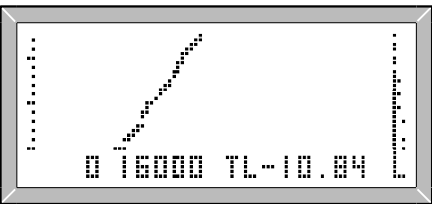

Fig. 3.23 Test with a Flat Sweep   Fig. 3.24 Test with a Weighted Sweep

The solution is to use a weighted frequency sweep using the inverse of the CCIR weighting filter, as provided by the LA101. Stop the LA101, and return to manual mode by pressing SEQ, leave the -40dB test level set and then enter the following:

LA101:	✳2 ✳2	To select CCIR-inverse weighting
	SEQ ✳5	Run sequence 10 (repeating sweep)

This time the result will be a flat frequency response, as shown in fig. 3.24. By using a weighted frequency response with the inverse characteristic of the filter under test we have measured the deviation from the ideal response and the cursor can now be moved to any frequency to read the frequency response error. This gives more accurate results than a flat sweep as it was measured over a small dynamic range with no steep slopes.

The CCIR 468-4 weighting curve specification shown in fig. G.2 (appendix G) demands that the response at 16kHz should be -11.7dB within ±1.6dB. The display in fig. 3.23 would suggest that the 16kHz response is +0.86dB high, but we know that the accuracy is dubious, and we haven't checked the 6.3kHz level which should be used as a reference level (since its tolerance is 0). Using the weighted sweep (fig. 3.24) allows us to read the error directly from the graph. By moving the cursor to the 6.3kHz frequency and setting a test level by pressing ✼ 1 twice we can examine the errors at other frequencies relative to the assumed 0dB error at 6.3kHz, as required by the specification. As fig. 3.21 shows the actual error was +0.50dB (less than the +0.86dB measured earlier) and well within the allowed ±1.6dB tolerance. A manual test using steady tones gives exactly the same +0.50dB value.

Most filters can be tested in this way. Enter the filter's response into the LA101 weighting editor and press ✼ L/R to obtain the inverse response. Select the user weighting in manual mode, by pressing ✼ 2 and run a sequence containing a suitable sweep segment. Note that the LA102 does not need any special settings (the operations in the above example were to force it to test its own internal filter for demonstration purposes – see section 3.24).

Some care is needed with filters which have very deep notches. For example, if a filter rejects 1kHz by 90dB, then this technique would require a level of +90dBu in order to obtain a 0dBu output, and this is clearly impractical. In such cases the weighting should be modified so that the system is not overloaded and the results around that frequency should be ignored. Weightings can also be switched on from within a sequence definition - see section 4.29.

3.20 Automatic Results Storage

The LA102 can be configured to automatically store sequence results in the next available memory by setting configuration Y. This is provided for receiving several sequences at a remote site without user intervention and is especially useful for receiving overnight test transmissions. It can also be useful where several sets of sequence results need to be recorded for later examination or simply for logging the last few tests for reference. The LA102 can be configured to power up in sequence mode, and automatic results printing is also possible (see section 3.4).

Setting configuration Y1 (AUTO STORE SEQ RESULTS, IN MEMORY 1 NEXT) will cause the sequence results to be stored in memory 1 immediately they are received.

Configuration Y will then be advanced to 2, so the next set of results will be automatically stored in memory 2, and the LA102 will remain in sequence mode, waiting for the next sequence. When all of the available memories have been used configuration Y will return to 1 and the first results will be overwritten by the next sequence. Memory 0 (the current memory) always contains the latest results which can be displayed by pressing [PAGE] in the normal way, and the results can easily be identified by the cycle character appended to the LA101's serial number. Note that the number of memories will depend on the setting of configuration C (see section 4.18) and whether any user tolerances are defined.

3.21 Printout Heading

A message (up to 40 characters), such as a company name or receiving station can be entered into the LA102 to be printed at the top of every printout (as in fig. 3.11). Hold [ON/OFF] and press [1] to display the Tolerance Editor Menu and then press [✳][SEQ] (fig 3.25). The [PAGE] and [OPTION] keys now move the cursor, the [<] [>] keys change the character at the cursor and the [L/R] and [✳][Z] keys insert and delete characters respectively. Press [SEQ] to exit. All of the editing keys available in the tolerance editor, operate in this mode, and full details are given in section 5.6 while a summary of the keys can be found in the quick reference card. The LA101 source message is edited in a similar manner (see section 4.3).
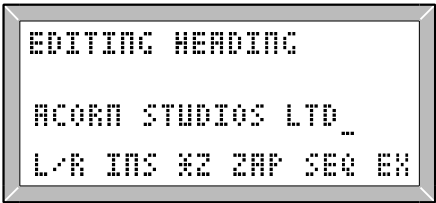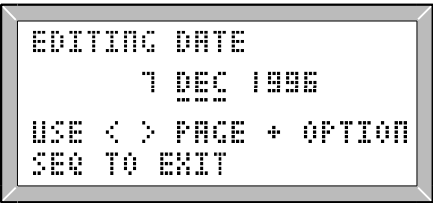
Fig. 3.25 Printout Heading

Fig. 3.26 Setting the Date

3.22 Printout Date

It is sometimes convenient to include a date heading with results printouts and this is done automatically if the results are printed using the Lindos Support software (see appendix A.2). The LA102 can also print the date at the top of a test sheet (as shown in fig. 3.11), but it does not have a real-time clock so it is necessary for the user to ensure that the date is set correctly each day it is used.

The date is stored in non-volatile memory and can be changed manually every day or can be made to advance by one day every time the unit is switched on. Hold [ON/OFF] and

press $\boxed{4}$ to enter the date editor shown in fig. 3.26. Use the $\boxed{<}$ and $\boxed{>}$ keys to change the date by one day. The $\boxed{\text{OPTION}}$ and $\boxed{\text{PAGE}}$ keys can be used to move the cursor under the month or year so that $\boxed{<}$ and $\boxed{>}$ will change them quickly. Press $\boxed{\text{SEQ}}$ to exit.

Configuration X controls the date operation and the default X0 does not print the date. Setting X1 will cause the date to be printed at the top of every test sheet and also displayed on the start up screen (as a reminder). Configuration X2 is similar to X1 but causes the date to be automatically advanced by one day every time the unit is turned on and this will be useful when the unit is controlled by a mains power timer, or when it is switched on once at the start of every day. When configuration X1 or X2 is set the date will be printed at the top of every printout. When using the Lindos Lin4win Windows® support software, the date is set to that of the host computer each time the LA100 is addressed by the PC.

3.23 Running Single Segments

Lindos test sequences are built from individual test segments. For example, sequence 11 consists of the segments TRCIN and Z. Usually the entire test sequence is run, taking about a minute, but occasionally it can be useful to run a single segment on its own. For example, suppose a sequence test reveals that the noise results are very poor. The connecting leads are suspected and replaced, and then need to be tested. It would be possible to use the LA100 in manual mode to check the results, or it would be possible to run the entire test sequence again to see if any improvement is observed. A much quicker way though is simply to run the noise segment again, on its own, taking a few seconds.

To run a single segment press $\boxed{\ast}\boxed{\text{SEQ}}$ on the LA101, enter the sequence number in the usual way, and then enter the segment number (in each case the numbers 6 to 10 are represented by $\boxed{\ast}\boxed{1}$ to $\boxed{\ast}\boxed{5}$ as usual). Segment 1 is the first segment (usually segment T), so pressing $\boxed{\ast}\boxed{\text{SEQ}}$ $\boxed{1}$ $\boxed{5}$ will run the fifth segment in sequence 1 which is noise segment N. The LA102 may generate a warning message ('SEQ ERROR 12') to indicate that the old results have been over-written by the new results, but this warning can be safely ignored as the old results are no longer needed.

When finished the LA101 will prompt for another segment number (from the same sequence). Pressing $\boxed{\ast}\boxed{\text{SEQ}}$ will remove the segment number prompt and allow a different sequence to be selected. Press $\boxed{\text{MUTE}}$ to run the last sequence or segment again. After running a single segment the output is normally silenced (to the DC0 state), but some segments cause their tone to be held after they have finished (segment T for example), allowing the tone to be checked manually if necessary. The LA102 will remain in sequence mode, waiting for further segments to be received, and the $\boxed{\text{PAGE}}$ button should be pressed to see the results when all of the segments have been sent.

An alternative way to run a segment is to run a sequence in the normal way and then interrupt it by holding the $\boxed{\ast}$ key to make the LA101 prompt for a segment number.

Single segments can be run on a single channel by pressing ⊛ SEG as described above and then selecting the channel by pressing L/R.

Single segments only overwrite their own segment (or segments of the same type) in the LA102 leaving the rest, but running a whole sequence always clears the results memory completely, ready for the new results. Some segments, such as crosstalk and noise, give measurements relative to the measured Test Level from a test level segment, and if such a segment is run on its own it is important that the LA102 has a test level segment in its results memory (ie from a T segment run previously).

Notes for advanced users:

1. If multiple results compartments are configured and single segments are run they will be added to the results in the results memory. So setting configuration C3 and then running 3 noise segments will leave all three sets of noise results in memory, and allow them to be stepped through by pressing PAGE in the normal way. Running a fourth noise segment will overwrite the first and generate SEQ ERROR 12 to indicate that some results have been lost.

2. It is the + segment which causes the LA102 results memory to be cleared by a new sequence, and this is automatically generated whenever a sequence is run. It can also be defined within a sequence definition and then run as a single segment to achieve the same effect.

3.24 Using Filters for Sequence Measurements

For advanced users: The LA102 measurement option selected in manual mode normally has no effect on sequence measurements which are determined by the test segments used. However it is possible to test the LA102's internal filters and rectifiers by forcing them to be used for all test level and frequency response measurements. To do this, first select the measurement option (in manual mode) to be tested and then press SEQ ⊛ FIX (the option name will be displayed). Some care is needed when using this mode to ensure that the internal circuits are not overloaded because all but the level measurement options actually have an extra 20dB of gain built in. Similarly, anything other than the rms rectifier may give unexpected results since the other rectifiers have a much slower response. For these reasons, this feature is really for very specialist use, as well as for testing the internal filters and rectifiers of the LA102. See the examples on testing the CCIR filter in section 3.14 and 3.19.

3.25 Remote Trigger

It is possible to make the LA101 automatically run a sequence, triggered by a remote push-button or timer circuit connected to the serial DIN socket on the LA101, and this is useful where the LA101 is positioned away from an operator, perhaps at a remote or

unmanned site. This can also be used for generating overnight test transmissions under timer control.

The application of a voltage in the range +3 to +12V to pin 3 relative to pin 1 (see appendix C.1) for at least 300ms initiates transmission of sequence 1. The sequence can of course be programmed as required. If the voltage is still present when the sequence has finished then it will run again. (Note that this does not interfere with serial communication data which never lasts for more than 120ms even at 75 baud).

3.26 Breaking into a Repeating Sequence

When testing a line or link with the oscillator at an unmanned site, or even when testing a tape machine, it is often convenient to leave the LA101 repeating a sequence which can then be 'broken into' at any time. The LA102 will generate a SEQUENCE ERROR 8 (missed segments), if it only receives the last part of a sequence, but this can be safely ignored as the LA102 will stay in sequence mode until the whole sequence has been received successfully when it will go into page results mode (this is true for single channel and for stereo sequences).

To generate a repeating sequence the sequence definition must have '<<' added to the end of it, and this is explained fully in section 4.17.

3.27 CCITT O.33 Compatibility

Although work has been done using the EBU/CCITT O.33 specification for sequence testing, this sequence has been removed with the development of our more versatile system of segmented sequences. Our FSK format is based on the CCITT O.33 specification but the actual data carried in the FSK header and the test tones used are different.

The O.33 sequence is primarily suited to instruments that measure simultaneously on both channels. While this can potentially result in a shorter sequence time for given settling times it carries a heavy penalty in complexity and cost and is only worthwhile if the sequence has already been optimised for speed. Four factors determine the settling time needed for each measurement on a line: group delay, echoes, autoranging, and switching transients in the instruments. Group delay affects low frequencies the most, delaying their arrival when frequency response is being measured, echoes are likely to effect low level measurements such as distortion and crosstalk, which also require time to autorange for greatest flexibility, and switching transients can be minimised by not changing channels more often than necessary. For these reasons distortion and crosstalk deserve a larger time allocation than simple level measurements, but the O.33 sequence allocates a whole second to every measurement. It would be possible to implement a stereo O.33 sequence on the LA100 by reading both channels in turn during each tone, but it makes more sense to minimise switching transients by changing channels only once and

optimise the timings.

The Lindos sequence system is now in widespread use by several major broadcast and telecommunications companies world-wide, in addition to the hundreds of smaller manufacturers and studios, and it has become the industry standard. It is suitable for line testing, but unlike the O.33 specification, Lindos sequences can also be used to test tape machines which may have large speed errors (up to ±4%). Our system is also more flexible because it allows the user to build test sequences from test segments, thus enabling a sequence to be designed which contains only the tests which are required and relevant for the device being tested (wow & flutter and MOL test segments for example, which can be used to test tape machines, but clearly would have no place in line testing).

For these reasons, and because of its greater flexibility, the Lindos system is felt to offer better performance at lower cost, and the O.33 sequence will not be included as standard, though compliance with the CCITT and EBU measurement standards will be maintained as far as possible.

4.0 User Defined Sequences

The ten test sequences in LA101 Bank 0 are editable via the front panel, or remotely with Lindos Lin4win software. All other sequences may be viewed, but cannot be edited unless they are first copied into one of the user sequences (sequences 0-10 are held in RAM, while the other sequences are held in EPROM). When new, or after reset (4), Bank 0 contains the Lindos default sequences. Many users find that these make good starting points when designing their own sequences.

The Lindos sequence system is very flexible and easy to use. Each test segment is allocated a letter, and a sequence is built by simply specifying the segment letters, together with an (optional) number which specifies the level that the segment will run at. A typical sequence is therefore around 10 characters long and easily entered from the front panel using the up-down keys to cycle through the character set. It is also possible to enter messages to be displayed when the sequence is run, or transmitted to the measuring set via FSK (useful for source identification when testing lines and links).

A wide range of segments are provided (table 3.2, page 40) to perform all of the measurements available from manual mode including level, noise, crosstalk, distortion, wow and flutter, speed and phase. Extra measurements not available in manual mode include frequency response (over different ranges) and maximum output level (MOL). Various *control segments* allow channel and impedance selection, pauses and repetition of segments or sequences.

Most sequences will be built from these Lindos test segments which the LA102 automatically responds to. However, it is also possible to construct a sequence of tone bursts (section 4.16) and this has many uses: a sequence can be used to test the level accuracy and ballistics of a meter, similar to the PPM test available on sequence 19; tones can be defined with record response corrections for making a test tape or disc; audio channel identification for video tapes using intermittent tones can be generated. It has even been used to demonstrate DCC compression on *Tomorrow's World (*a popular science and technology programme on BBC TV) and to generate morse code messages to identify communication channels via a satellite link into a war zone.

The sequence definition is entered into the LA101, where it is held in non-volatile memory; the LA102 will automatically respond to the segment letters and levels which are transmitted in the FSK header at the start of each segment without any programming.

Test sequences can be created to perform tests at different levels and it is possible to perform the same test at up to 5 different levels (frequency sweeps at different levels can

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be used to test for compression effects on tape, for example). Some users define sequences to test different pieces of equipment, and make each sequence select a different tolerance within the LA102. For example, sequence 1 might be set up to test a Studer tape machine and select the Studer tape tolerance, while sequence 2 might test a Sonifex cartridge machine and select a suitable user tolerance. The sequences may even perform exactly the same tests, but just generate different source messages, or select different tolerances to be applied.

Sequence definitions can be entered using the built-in LA101 sequence editor or by using Lin4win Support Software running on a remote computer. The latter approach allows sequence definitions to be saved to disk and edited more easily.

Most users will find that they only need a few short sequences to meet their requirements, and these can easily be entered using the LA101 keyboard. Since sequences are held in non-volatile memory, they should not need to be entered again, although in case of a battery failure it is best to keep a written copy, or a copy on disc using our support software.

4.1 The Sequence Definition

The sequence definition begins with an optional sequence title (up to 21 characters), within quotes, and is followed by a string of test segments, each comprising a single segment letter, optionally followed by a segment level.

For example, the default sequence 1 is:

<div align="center">"GENERAL/TAPE TEST" T R C I N Z</div>

The title string is displayed on the LA101 when the sequence is run, and the test segments will measure test level at 0dB (T), frequency response at -10dB (R), crosstalk at 0dB (C), distortion at +8dB and -10dB (I), CCIR weighted and unweighted noise (N), and phase (Z). The full list of segments is given in table 3.2. To add a MOL test (segment H) and a W&F test (segment W), and to make the sweep (R) run at -4dB, this sequence could be changed to:

<div align="center">"GENERAL/TAPE TEST" T R-4 C I N Z H W</div>

Sequences should usually start with a test level segment (T or V) as some other segments use this as a reference (noise, for example is referred to the measured test level, while the level range used to measure frequency sweeps is calculated from the measured test level). Segment W if present, should be at the end of the sequence as its de-selection may create a transient signal. Otherwise the order of the test segments is not important.

Test segments are indicated by a letter, A-Z or a-z, and the case is important (Z is not the same as z). Some care must be exercised, especially when entering these characters

directly into the LA100 without a computer as the small, low resolution characters can be confusing to new users, but they are soon learnt, and the segment description provided by the LA101 can always be used as a confirmation.

When designing a sequence you should choose the measurements that you want to include from the list shown in fig. 3.2 (page 40), and refer to the sections below for further details on each segment.

Normally sequences will only contain one segment for each type of measurement (eg one frequency sweep, one distortion measurement etc). However, it is possible to include more than one segment of each type providing the LA102 memory is configured (by setting configuration C) before the sequence is received, otherwise, a SEQUENCE ERROR 12 will result. See section 4.18 for further details.

The sequence may be up to 250 characters long (most sequences contain typically 10 segments, but messages and long lists of tone specifications can make them much longer).

It is possible to include messages of up to 21 characters within double quotes (") which are displayed on the LA101 when the sequence is run. The PPM test sequence displays the target values before each tone burst using message segments. The messages are displayed as encountered and if referring to a segment should be placed before the segment letter so that the message is displayed while sending the segment. The message will remain on the display until another message segment is encountered. To clear a message, simply use an empty message segment, ie "".

In addition to the test segments the sequence can include *control segments* (which are allocated symbols, such as < % > ! etc). The message segment described above is a typical example, and other control segments are provided, as shown in table 4.1. They

---

Control Segments

!*f,d,l*	Tone bursts/tone sets. !frequency,duration,level,frequency,duration... (section 4.16)
+"*txt*"	Send *txt* message to the LA102 measuring set, up to 21 characters (section 4.3)
"*txt*"	Display *txt* message on the LA101 display, up to 21 characters (section 4.1)
<	Repeat last segment, until interrupted by a key press (section 4.17)
<<	Repeat whole sequence, until interrupted by a key press (section 4.17)
±*n*	Select tolerance *n* (1-20) in the LA102 (section 4.19)
%*n,m*	Set output impedance *n* (10, 75 or 600) in ohms and ZC mode *m* (section 4.20)
/*n*	Set oscillator test level to *n*dB. (section 4.21)
:*n,m*	Select physical output channel *n* and logical channel *m* (section 4.22)
>*n*	Run sequence *n* as a sub-sequence and then continue (section 4.23)
?	Pause until a key is pressed on the LA101 (section 4.24)
^*n*	Set sweep headroom to *n*dB. (section 4.25)
n	LA102 to subtract reference curve in memory *n* from sweep results (section 4.26)
-"*txt*"	Generate O.33 compatible FSK header (section 4.28)
=*n*	Select weighting to be applied to sequence (section 4.29)

Table 4.1 Control Segments

may be mixed freely with other segments and may occur several times within a sequence although most will usually be positioned at the start of the sequence to set output impedance, channel and sequence test level before the test segments. Control segments only affect the sequence while it is running, and anything which they change will be restored when the sequence has finished.

Note for computer users: Because of the limited character set of the LA100, it is best to use only the characters shown in section 4.2 within comments. Capital letters are preferred. Double quotes enclosing titles and comments should be plain (") as open and close quotes are not recognized (""). The ± character should be entered as a vertical bar character (|), although the Lindos Support Software will show this correctly if possible.

4.2 The LA101 Sequence Editor

Hold ON/OFF and press 1 to enter the LA101 sequence editor (fig. 4.2). The sequence prompt will appear (see fig. 4.2) and the sequence can now be selected. Pressing 1 to 5 or *1 to *5 will select one of the sequences in the current bank. Pressing <dB or dB> will produce a menu listing the first 5 sequences in the bank (hold * to see the next 5), and pressing either of these keys again will change the bank. Whether the sequence number is selected directly or via the menu, the LA101 LCD should be similar to fig 4.3 when a sequence is being edited.
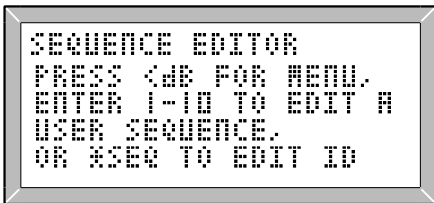
Fig. 4.2 The Sequence Editor Prompt   Fig. 4.3 Editing a Sequence
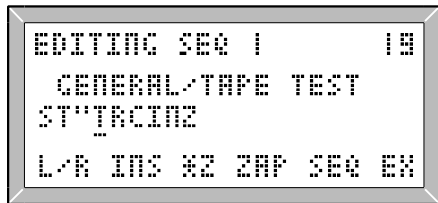
The <dB dB> keys now move the cursor through the sequence definition which is a single line of text up to 250 characters long. The <Hz Hz> keys change the character at the cursor and cycle through the character set:

> <space> ABCDEFGHIJKLMNOPQRSTUVWXYZ
> bcdhkmnoruxz @!?%<>=±*/+− . 0123456789 ,"

Note that the cursor is initially positioned after the sequence title (if there is one), but may be moved back over the title to edit it as required. All keys repeat if held and the display will scroll as necessary. When the cursor is under a segment letter the segment title is displayed on the bottom line of the display. Pressing SEQ (or resetting) will leave the

new sequence definition in non-volatile memory, ready to be run in the normal way. Holding ⊛ while using the ⟨dB⟩ ⟨dB⟩ keys scrolls 21 characters (a screen width) through the text providing quick access to any part of the sequence definition. Holding ⊛ with the ⟨Hz⟩ ⟨Hz⟩ keys limits the characters that are cycled through. For example ⊛ ⟨Hz⟩ will cycle through the alphabet only (Z-A), so to select segment Y for example simply press ⊛ ⟨Hz⟩ twice, or to select a small 'c' character press ⊛ ⟨Hz⟩ and then ⟨Hz⟩ twice. Similarly ⊛ ⟨Hz⟩ gives quick access to the symbol characters, so pressing ⊛ ⟨Hz⟩ four times will give a '!' character. Digits can also be entered directly by pressing 1 to 5 or ⊛ 1 to ⊛ 5 (for 6-9 and 0). With a little practice it is possible to become very quick at using the sequence editor.

⊛ SEQ will return to the 'SEQ TO EDIT?' prompt, and ⊛ MUTE will copy the sequence being edited to another sequence number. This is useful if you want to modify a sequence slightly but still keep the original, or simply to move sequences around for convenience. The sequence editor displays the cursor position in the top right of the screen to help find sequence errors and to show the user how long the sequence is so far. A summary of all the editor keys can be found in the LA100 quick reference card.

For example: To add wow & flutter measurement on to sequence 1 (assuming it currently contains the default sequence), press the following keys:

ON/OFF 1		Sequence editor
1		To choose sequence 1
dB⟩	6 times	To move the cursor after the last segment letter
⊛ ⟨Hz⟩	4 times	To enter a W segment
⊛ SEQ		To finish and return to manual mode

All sequences can be restored to their default definitions using the reset menu. Hold ON/OFF and press 3 to obtain the reset menu, then press 4 (this also clears the source ID, see sections 1.4 and 4.3).

4.3 Source Identification

The LA101 will automatically send a source message at the start of the sequence (via FSK) to identify the source of the test signal. This might be used to identify an originating site or company testing a communication link, or it might be used to identify a brand of tape and a recording date when making a test tape. It is will be displayed by the LA102 as it is received and will be stored with the sequence results (fig. 4.4).
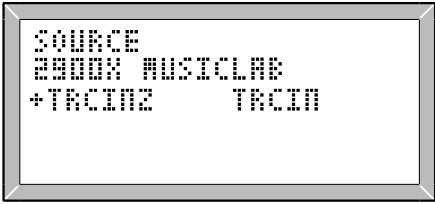
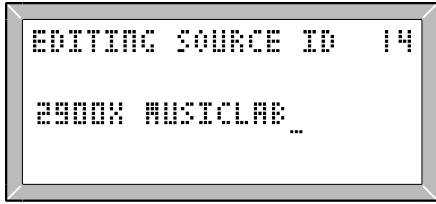**Fig. 4.4 LA102 Source ID Display   Fig. 4.5 Editing the LA101 Source ID**

The LA101 has a source ID which by default will be the serial number and a cyclic identification character, A-Z (see section 3.6). This is normally sent automatically at the start of every sequence which contains a test segment, and can be edited by pressing ✳ SEQ from the sequence editor menu and using the normal sequence editor keys (fig. 4.5). The serial number and cyclic identification character are normally left at the start of the source ID and the user's text added after it, up to a maximum length of 21 characters total.

It is also possible to make each sequence add its own message to the serial number and cycle character by placing a source message segment (+) near the start of the sequence, before any test segments. The message is placed in quotes after the + character, and usually starts with a space to separate it from the cyclic identification character. Since it is being appended to the 5 character serial number and cycle character, the maximum length is normally 16 characters. For example:

<div align="center">"LINES TEST" +" RADIO SUFFOLK" T O C E N Z</div>

The advantage of using the + segment in a sequence rather than editing the source ID is that each sequence can have a different message on it. The LA101 will still send its serial number and cyclic identification character, so the message received and displayed by the LA102 will be:

<div align="center">SOURCE: 2834A RADIO SUFFOLK</div>

Technical note for experienced users: It is normal to leave the serial number and cyclic character in the source ID, but they may be changed if the extra space is needed to hold a long message. If deleted from the source ID then the LA101 will assume that the serial number and cyclic character are not wanted and so it will omit them from + segment messages as well. This means that the + segment text can then be up to 21 characters in length. However, if the source ID is deleted entirely then it will be reset to its default value. Finally, it is possible to edit the cyclic identification character in the editor, perhaps to restore it to 'A' before performing a series of tests.

4.4 Copying a Sequence

When a sequence is being edited, or viewed, it may be copied to a user sequence by pressing ✳ MUTE. The LA101 will ask which user sequence (1-10) you want to copy the sequence to. Press 1 to 5 or ✳1 to ✳5 (for sequences 6-10). The sequence can now be edited.

It is also possible to copy a whole bank of sequences into the user bank, by pressing ✳ MUTE when the sequence editor prompt is displayed (fig. 4.6). The sequence editor will prompt for a bank number, 1 to 10, where bank 1 contains sequences 11-20, bank 2 contains sequences 21-30 etc.   Note that this operation will overwrite all 10 user sequences.
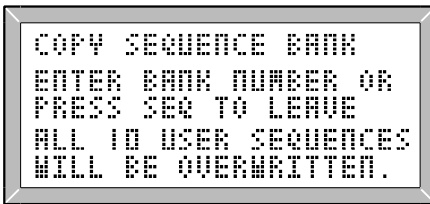
Fig. 4.6 Copying a Sequence Bank
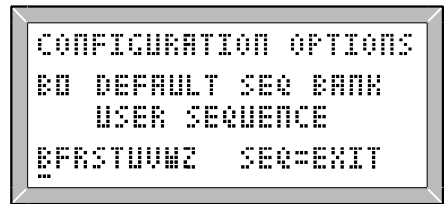
Fig. 4.7 Selecting the Default Seq Bank

4.5 Measurement Levels

Although many of the segments have been designed to conform with various standards (using BBC, CCITT, ITC, EBU and BT levels), it is often necessary to use different levels, and the LA101 allows each segment to have its level specified independently. This is done by entering an integer level in dB (in the range -63 to +31) after the segment letter, called the *Measurement level* for the segment. The measurement level of each segment is transmitted in the FSK header for each segment and displayed and printed by the LA102 next to each segment's title.

The measurement level is relative to any Test Level that is in use when the sequence is run. Note that a Test Level allows the whole sequence to be run at a different level, while this measurement level allows each segment to be given its own relative level. The Test Level plus measurement level must be within the working range of the unit (-101dB to +26dB), otherwise a 'MAX LEVEL EXCEEDED' error will occur. Some segments already have an intrinsic measurement level, for example, segment Q runs at -12dB and can be said to have an intrinsic measurement level of -12dB. The intrinsic measurement level is always overridden by the measurement level specified, so a segment definition of 'Q+6' is exactly equivalent to 'P+6' and both run a sweep at +6dB (relative to Test Level which defaults to 0dBu).

Sequence 18 makes use of this facility to define a sequence compatible with German standards which specify distortion measured at +6dBu, sweep 20dB below +6dBu, noise referred to +6dBu, crosstalk at +6dBu, W&F at 0dBu and phase at 10dB below +6dBu. The definition is:

<div align="center">T+6 U-14 C+6 D+6 N W Z-4</div>

 It could have been be defined as:

<div align="center">T U-20 C D0 N W-6 Z-10</div>

and run with a Test Level of +6dBu set but this would generate the FSK at +6dBu instead of 0dBu since the FSK is always generated at the Test Level. Note that no level is given for crosstalk as segment C runs at 0dB anyway ('C0' would have the same effect), but 0 is given for segment D which would otherwise run at +8dB. No measurement level is specified for noise which is always relative to the measured test level segment (segment T in this case), and similarly, the crosstalk segments should normally be run at the same level as the test level segment, since the measured crosstalk is always referred to the measured TL OUT result.

The Test Level segments (T and V) are not normally given a measurement level, as they are normally run at the Test Level so that the result (TL OUT) shows the true test level which was in use for the sequence.

All segments except noise segments can be given a measurement level. Multi-level distortion segments (E and I) can be given a measurement level but this is not recommended as the displayed and printed levels will not be changed. For example, I+4 will measure distortion at +4dB and at -14dB and will display +4dB in the heading but will still display +8 and -10dB which are the default levels. The FSK header is always transmitted at 0dB (relative to Test Level).

4.6 Test Level Segments (T,V)

Segment T generates a 1kHz reference tone at 0dB for 1s. Segment V is similar, but uses a 400Hz tone, and is intended for use with FM transmitter systems. The level is measured by the LA102 and displayed under the heading 'TL OUT', and gives an indication of the gain of the system.

These segments are called Test Level segments because they normally run at the Test Level (which is set globally for the whole sequence, as described in sections 3.7 and 4.21). Although it is possible to give these segments a measurement level to make them run at a level different from the test level, this would not normally be done as it makes more sense to adjust the level for the whole sequence by setting the global test level.

A test level segment should usually be the first segment of a sequence as it is used to

determine the nominal level (used for frequency sweeps) and is also used to normalise crosstalk and noise measurements. If run as a single segment the tone is held after the segment has finished.

4.7 Frequency Sweep Segments (OPQRSUXorux)

Various frequency sweep segments are available, providing a range of sweep speeds (1½s, 5s or 20s), different frequency ranges (20Hz-20kHz, 10Hz-30kHz, 300Hz-18kHz and 300Hz-8kHz), different amounts of headroom (see section 3.14) and different printout frequencies. All of the frequency sweeps take 256 level measurements per channel over their frequency range and the LA102 sampling rate is varied accordingly.

Segment U is a standard 5s frequency sweep segment covering the frequency range 20Hz to 20kHz. Segment S is a slow sweep, 20 to 20kHz in 20 seconds, which is better able to follow steep filters. Segment X is a fast 1.5s sweep but care is needed when interpreting the results as it cannot follow fast changes in the level. However it is very useful for the setting up of tape head alignment, especially if it is repeated ('X<'). To achieve the fast speed the resolution of this fast sweep is less than the slower sweeps (causing obvious steps at low levels, especially if the graph scale is increased).

The spot frequencies used in the printout and for tolerance testing are shown in fig. 3.2. Segment O is a 5s sweep with special frequency listing on printout to comply with British Telecom (BT) lines tests EPS81/EPS84.

4.8 Noise Segments (L,M,N,n)

Segments N and M measure peak (PK) noise as required by the CCIR standard as well as peak unweighted noise and mean (MN) weighted noise. 'Peak weighted noise' is the peak reading of the quasi-peak rectifier taken over the measurement period, which will normally be slightly worse than the mean, but some circumstances, such as telephone dialling pulses on lines, may result in a larger peak to mean difference. Segment N (8s) is usually used, but segment M (30s) can be used where a longer sampling window is required (again where the noise is intermittent). Segment L measures 'A' weighted noise, and 22-22kHz noise using the rms rectifier. Segment n measures CCITT O.41 weighted and unweighted psophometric noise but is only recognized by LA102 sets equipped with a suitable filter board (see appendix I.5).

All noise measurements are relative to the measured test level. For example, if 'TL OUT' is +2dBu, and the noise level is displayed as -95dB, then the absolute level of the noise is -93dBu. It is therefore important that the noise segment is preceded by a test level segment (T or V) otherwise a SEQ ERROR 13 will be generated.

4.9 Crosstalk Segments (A,B,C,J,c)

Crosstalk segments A, C and J measure crosstalk at six frequencies (40, 100, 315, 1kHz, 6.3kHz and 10kHz) taking 1s per frequency. The result is always calculated relative to the 'TL OUT' level as for noise measurements. Segment C operates at 0dB, while segment J operates at -10dB (as specified by the IBA for tape testing). Segment A is similar to segment C but has 50µs de-emphasis applied to avoid overload when testing FM transmitter systems.

Segment B is a fast crosstalk segment which takes 2s and produces crosstalk figures for 100Hz, 1kHz, 6.3kHz and 10kHz (½s each tone, default level is 0dB), but for very accurate low level crosstalk measurement it is best to use segment C or J. Segment c measures crosstalk at 15kHz and 0dB.

Since crosstalk is a relative measurement it is important that the crosstalk segment is always preceded by a test level segment (T or V) otherwise a SEQ ERROR 13 will be generated.

Note for experienced users: The crosstalk result is the level of crosstalk relative to the measured level of the interfering tone. Since the interfering tone may not be connected to the other input channel the LA102 does not attempt to measure it. This means that meaningful crosstalk measurements can still be made when only a single channel is connected to the LA102 L input providing both output channels from the LA101 are connected to the device under test.

The LA102 must therefore calculate the level which the interfering tone on another channel would be measured at were it present. It assumes that this is equal to the crosstalk measurement level plus the gain of the system and it calculates the latter from the measured TL OUT result less the Test Level measurement level. For example, the sequence T0C6 is run and the TL OUT is +10dB. The absolute crosstalk level is -40dBu, so the relative crosstalk is -40 - (+6+10-0) = -56 since the LA102 assumes that the interfering tone would have been measured at +16dB.

The test level and crosstalk segments can therefore be run with any measurement level, although it is good practice to keep the test level segment at the test level.

4.10 Distortion Segments (D,E,F,G,I)

Segment D measures distortion at three frequencies (100Hz, 1kHz and 6.3kHz) in 6s at +8dB (by default), and is generally used for quick distortion measurement. Similarly segment E measures distortion at 100Hz +9dB, 1kHz +9dB and 1kHz -10dB in 6s. Segment I measures 100Hz and 1kHz distortion at +8dB and -10dB.

Where more frequencies are required, segment F can be used as it measures distortion at

six frequencies (40Hz, 100Hz, 315Hz, 1kHz, 6.3kHz and 10kHz) but it takes 18s. As usual, all measurements are THD (plus noise). Segment G is similar to segment F but it has 50µs de-emphasis to avoid overloading FM transmitter systems.

4.11 Wow & Flutter Segment (W)

Segment W measures the peak and mean weighted wow & flutter and speed error (on the 3125Hz tone) and makes use of essential settling time to take a mean phase reading at 3125Hz; useful as an azimuth check. Note that a speed of -99.9%, or a phase of -999° indicates that the measurement failed because the signal was too noisy.

4.12 Phase Segments (Y, Z, z)

Segment Z measures mean phase at 40Hz, 100Hz, 1kHz, 6.3kHz, 10kHz and 15kHz, and because of slow averaging it is more accurate than manual measurement. A result of '-999°' occurs if the phase for a particular tone could not be measured (typically because the system is very noisy). Segment Y is similar but has 50µs de-emphasis to avoid overload on FM transmitter systems. Segment z measures phase difference between channels at 40, 100, 315, 1k, 6.3k, 10k and 15kHz (the same as segment Z with 315Hz added).

Note: although phase can be measured at any frequency, the frequencies in this segment should not be changed (using the '!' segment) as the LA102 expects them and is optimised for them to give very accurate phase measurement.

4.13 User Level Segment (K)

Segment K is a general 6 tone level test which accurately records the level of six 1s tones (with autoranging and averaging). It can be used to test compression effects on compandors, tape machines, limiters and noise reduction systems, and to accurately test the frequency response of filters and equalisers over a large dynamic range (where the frequency sweep segments may not be as accurate because they cannot change range in mid-sweep).

The levels default to 0, -10, -20, -30, -40 and -50dB but any 6 levels can be specified by the user (with a resolution of 0.01dB). For example:

<p align="center">K +10,0,-30,-37,-47,-55</p>

If any levels are omitted they default to 10dB below the previous level (so K+20 would generate levels at +20, +10, 0, -10, -20 and -30dB). As with all segments these levels are relative to the LA101 test level - see sections 3.7, 3.10 and 4.21.

The first level is treated as the segment measurement level (see section 4.5) and is transmitted in the FSK segment header. The LA102 displays this in the segment title for reference, but the level at which the other tones are sent is not transmitted or displayed, so the user must know which levels were used in order to interpret the results. However, it is

possible to make the target levels appear on the printout by programming them into a tolerance definition, and this is explained in section 5.5. Typical results for the above example might look like this:

USER LEVELS (+10dB)

1.	+9.3	+9.5
2.	-0.2	0.0
3.	-30.1	-30.3
4.	-36.8	-37.7
5.	-47.6	-47.8
6.	-53.6	-54.1

Because of memory constraints within the LA102 this segment shares results space with the crosstalk segments. This means that LA102 configuration C must be set to at least 2 if segment K is being used in the same sequence as segments A, B, C or J, otherwise a Sequence Error 12 will occur and only one of the segments will be stored (see section 4.18 for a more detailed explanation).

The frequency defaults to 1kHz, but any 6 frequencies can be specified by using the ! tone segment (see section 4.16). This can be useful for accurately testing filters by using an inverse weighting curve. For example, a CCITT O.41 weighting filter could be tested by using six tones, corresponding to the filter's inverse: 200Hz at +21dB, 500Hz at +3.6dB, 1kHz at -1dB, 2kHz at +3dB, 3kHz at +5.6dB and 4kHz at +15dB. The result will show the deviation from the expected filter response and should be six levels all around 0dB. A suitable segment would be:

　　!K 200,1000,+21, 500,,+3.6, 1000,,-1, 2000,,+3, 3000,,+5.6, 4000,,+15

When using the ! tone segment in this way there must be six tones and each tone must last 1s (hence the 1000ms duration in the above example). If only three tones are required then dummy tones should be used to make the duration up to 6 seconds (otherwise the LA101 will start the next segment before the LA102 expects it, and a Sequence Error 8 will probably occur).

Like any other segment a tolerance can be specified for segment K and this can greatly simplify filter and equaliser testing. This is also useful because it allows target levels to be included on the printout.

4.14 Maximum Output Level (MOL) Segments (H, h)

A tape's maximum output level (ie the level at which 3% total harmonic distortion occurs) can be measured at 1kHz using segment H or 315Hz using segment h. These segments sweep the level in small steps over an 8dB range and record the level at which 3% THD occurred. Note that the MOL result is the absolute level out of the system and not the level into the system. For example if a tape machine has an overall gain of 4dB and the measured MOL is +7dBu then the input level which gives 3% distortion is

+3dBu.

To calculate the MOL in nWb/m it is necessary to establish a relationship between the machine output and a known tape flux level. For example, if a 320nWb/m test tape gives an output of -2dBu, and the LA102 indicates an MOL of +7.5dBu, then the MOL of the tape is:

$$320 \text{ x antilog}_{10} \left(\frac{7.5 - (-2)}{20} \right) = 955\text{nWb/m}$$

If the 3% distortion point does not occur in the 8dB covered by this segment the LA102 will not be able to measure the MOL and will indicate the failure by giving a result of +99.9dB if the distortion was below 3% at all levels in the range, or -99.9dB if the distortion exceeded 3% at the lowest level used. Should this occur the segment should be given a measurement level which will allow the 8dB range to include the 3% MOL point. If no measurement level is specified segment H will cover the range from 0dB to +8dB, while H4 will cover the range from +4dB to +12dB (as with all segments these levels are relative to the LA101 test level – see sections 3.7, 3.10 and 4.21).

When measuring MOL the LA101 holds the first level of the level sweep for ½s to allow the LA102 to accurately record the starting level. The sweep then progresses at a rate of 1dB/s over an 8dB range and the LA102 continuously measures the **absolute** level of THD until it is -30.45dB (3%) below the expected level of the signal. The LA102 then measures the actual absolute level of its input signal. Note that the expected level of the signal is based upon the initial level and the known rate of increase, but this may be different from the actual level if compression is occurring in the system. This means that the distortion may actually be greater than -30.45dB when the LA102 decides that it is -30.45dB below the expected signal level (ie if the actual signal level is less than expected). The LA102 attempts to correct for this by calculating the MOL from a weighted average of the expected level and the actual measured level.

In practice the result is usually accurate to within ±0.2dB of the manually measured MOL with reasonable quality tape and little compression. With poor quality tape the error may be as much as ±0.5dB. For best results the segment should be run at a level just below the anticipated 3% MOL level to minimise any errors due to compression effects. For example if the 3% MOL is known to be around +6.5dB best results will be obtained by running segment H6 whereas segment H will give less accurate results because of the output level error due to the compression effects over a 6dB range.

4.15 Difference Frequency Distortion (d)

Segment d measures second order difference frequency distortion with a double tone having a 1kHz centre frequency and 70Hz difference frequency (nominally), as explained in section 2.16. The level of each tone is -6dB relative to Test Level, so the rms level of

the double tone is -3dB, and the reference frequency to which the distortion is referred is 0dB.

4.16 Tone Burst/Tones Segment (!)

The tone burst segment ('!') is a very powerful facility for generating tones and tone bursts. It can also be used to design new segments similar to standard segments but using different frequencies or levels. Because this facility is so flexible it has been used for many different applications, including: meter testing, generating FSK and ASK test signals for testing decoders, generating morse code for identifying a transmitter source and even playing tunes.

The ! character is followed by frequency duration and (optional) level parameters:

!*f,d*	Generate *f* Hz for *d* ms (at 0dB), then silence.
!*f,d,l*	Generate *f* Hz for *d* ms at *l* dB, then silence.

It is also possible to specify the frequency, level and duration of up to 32 tones with a single ! segment:

!f_1,d_1,l_1,f_2,d_2...   Generate f_1 Hz for d_1 ms at l_1 dB, then f_2 Hz for d_2 ms at l_2 etc

The frequency *f* will be rounded to the nearest that can be generated.   0 is allowed and corresponds to the DC0 state (silence) which is useful before or after tone bursts. The output is not muted in this condition, because relay switching may produce undesirable transients.

The duration *d* in ms should be in the range 0ms to 1600000.0ms (ie 27 minutes) and may be specified to 1 decimal place (ie 100µs resolution). Timing is very accurate (±50µs or ±0.01%) when the level for a tone is not specified. If the level is specified the timing accuracy will be reduced slightly. A duration of 0 for the last tone in the list will cause the last tone to be held after the segment has terminated instead of silencing. This is only relevant in single segment mode (segment T behaves in this way) but can be useful for programming sets of presets on the number keys (see example 3 below).

The level *l* in dB (relative to Test Level) should be in the range -101.99 to +26.00 and may be specified to 2 decimal places. Transitions between tones where the absolute level of one is above -38dBu and the other is below -38dBu may result in a small click (lasting 2-3ms) as a relay is switched for levels below -38dBu.

The default value for any parameter is its previous value in the same segment if specified (default value for first occurrence is 0 for *f*, *d* and *l*). Note that this can considerably shorten definitions. There is no limit to the number of '!' segments in a sequence, but there is a limit of 32 tones per '!' segment. More than this will generate a 'TOO MANY TONES' error. In the unlikely event that you need to generate more than 32 tones, try

splitting into two separate '!' segments, but remember that there is a small delay before each segment is executed. To generate repeating patterns put a '<' character after the last parameter (section 4.17). To stop a '!' segment when it is running, hold the ⌷SEQ⌷ key until the display indicates that the sequence has stopped (typically up to 7 seconds).

The LA101 sequence editor describes the parameter of the ! tone segment at the cursor, to simplify entering and editing complicated tone definitions (eg TONE 7 DURATION/ms). If a very long series of tones is required it is possible that the sequence definition will exceed the 250 characters allowed by the LA101. In this case the sequence should be split into two or more sequences with the main sequence using the > segment to call sub-sequences as required (see section 4.23). This can also simplify any series of tones where a particular set of tones is repeated several times within the series.

It is possible to output an FSK header before the tones by simply placing a letter after the '!' character. Note that segments D, E, F, G, I, K, T, V, W, Y and Z can all be defined in this way using the '!' segment and this allows different levels or frequencies to be used, but remember that the LA102 will assume it has a standard Lindos segment so you will need to interpret the results intelligently. See section 4.27 for details of segment frequencies, levels and timings and equivalent '!' segment definitions.

Examples:

1. 1kHz at +12, +8, +4, 0, -4, -8 and -12dB for 2 seconds each, defined as a single segment:

        !1000,2000,12,,,8,,,4,,,0,,,-4,,,-8,,,-12

Note that the frequency and level are only specified for the first tone, and are left blank for subsequent tones. They will always default to their previous values, and therefore only need to be specified once in this example. The same results could be achieved using the much longer definition:

        !1000,2000,12,1000,2000,8,1000,2000,4,1000,2000,0,
        1000,2000,-4,1000,2000,-8,1000,2000,-12

Alternatively, each tone can be defined in its own segment giving 7 segments in total. This allows each segment to be run individually (see section 3.21):

        !1000,2000,12 !1000,2000,8 !1000,2000,4 !1000,2000,0
        !1000,2000,-4 !1000,2000,-8 !1000,2000,-12

2. To generate a 10ms 5kHz tone burst at +8dB followed by 5s silence:

        !5000,10,8,0,5000

Note that the frequency of 0 in the second 'tone' will select the DC0 state on the LA101. No level is specified for the second tone to avoid any transients caused by relay

switching.

3. A sequence containing 5 segments to be run manually to test a filter having a response of -5.7dB at 1kHz, 0dB at 2kHz, +3.0dB at 3kHz, +6.0dB at 5kHz, and +2.3dB at 10kHz:
                !1000,,+5.7 !2000,,0 !3000,,-3 !5000,,-6 !10000,,-2.3

Note that the duration defaults to 0 in each case so each segment will hold the tone after it has been run. To use this sequence press ✱ SEQ followed by the sequence number to obtain the SEG? prompt. Pressing 1-5 now will generate the appropriate frequency and level to give a 0dB output from the filter. Because all the tone durations are zero it does not make sense to run this as a whole sequence. If, however, the tones are defined with duration 1s, and made to hold after the segment has finished, the sequence could be run as a whole and would last 5s and still allow each segment to be run individually:
                !1000,1000,+5.7,,0 !2000,1000,0,,0 !3000,1000,-3,,0 etc

If more tones are required segments 6-10 can be defined or other sequences can be used.

4. A repeating segment to generate 'the Greenwich time signal' every 10 seconds:
                !1000,100,0,0,900,,1000,100,0,0,900,,1000,500,0,0,7500,,<

Two tone bursts of 0.1s followed by 0.9s of silence and then a long tone burst of 0.5s followed by 7.5s of silence. The '<' character causes the segment to repeat indefinitely (see section 4.17). Hold SEQ to stop it.

5. To generate 110 baud 7 bit FSK characters 'L' (binary 1001100) and 'C' (binary 0100011) by generating the tones for each bit. The actual bits (including start, stop and parity) are 1100011001111011000011:
                !1650,20,0,1850,27.3,,1650,18.2,,1850,,,1650,36.4,,
                1850,9,,1650,18.2,,1850,36.4,,1650,18.2,

This could be used to test FSK decoders operating at other baud rates, but would not normally be used to generate FSK within a Lindos sequence.

6. To simulate the W&F test segment with a -3.8% speed error. FSK 'W' followed by 3005Hz for 12.5s.
                !W3005,12500,0

7. A segment containing the 20 frequencies printed in the table for sweep segment U with compatible timing (ie a frequency sweep containing 20 frequencies instead of the usual 320):

                !U30,523.4,,40,168.7,,50,161.7,,63,182.8,,100,267.2,,125,218,,
                250,450,,500,450,,1000,450,,2000,450,,4000,411.3,,6300,260.2,,
                8000,147.7,,10000,137.1,,12500,144.1,,14000,63.3,,15000,42.2,,
                16000,45.7,,18000,98.3,,20000,328.3

This segment will produce a stepped graph but the levels will be correct at the listed frequencies on the printout. Note that the levels could be specified for the tones providing weighted sweeps. A simpler segment, using less frequencies is more manageable but remember that the printed levels will only be correct at the specified frequencies (30, 100, 500, 1k, 6.3k, 10k, 15k, 20kHz):

>!U30,1268.7,,100,1040.6,,500,112.5,,1000,1532.8,,6300,281.2,,
>10000,281.2,,15000,322.8,,20000,160,,

4.17 Repeating Segments and Sequences (<)

Segments can be made to repeat indefinitely by placing a < character after the segment (and its parameters). Normally this feature is used with frequency sweeps where the LA102 will continuously update the frequency response display as adjustments are made. The default sequences 15 and 20 are set up to provide repeating frequency sweeps at different speeds.

Whole sequences can be made to repeat by placing a << at the end of the sequence. This would normally be used for testing a communication link where the oscillator can be left at one end continuously generating the sequence. The measuring set can be connected at the receiving end and will automatically receive the next complete sequence and display the results. Alternatively, a test tape could be made containing several copies of the sequence, allowing the user to 'break-in' anywhere on the tape (see section 3.26).

'!' segments can also be made to repeat by following the whole segment with a '<' symbol. For example, to repeat a 100ms 1kHz tone burst every second:

>!1000,100,0,0,900 <

Accurate timing is maintained during repeating '!' segments. Unlike a normal '!' segment DC0 output will not be selected after the last tone unless it is specifically requested by using a frequency of 0 as in the above example. This allows two tones to alternate smoothly. For example, to alternate between 3125Hz and 3188.7Hz at 2Hz:

>!3125,500,3188.7 <

Any segment can be made to repeat by following the segment letter (O,P,Q,R,S,U or X) with a '<' symbol although only sweep segment results are displayed by current LA102 software. The fast sweep segment (X) is especially useful with repeating sweeps as it gives a very quick update of the frequency response allowing equipment to be adjusted easily.

4.18 Multiple Results Compartments

Normally the LA102 will only expect a single sweep segment, and a single distortion segment, etc., in each sequence. This can be overcome by re-configuring the way the LA102 uses its results memory.

The LA102 results memories are split into *compartments* where each compartment can hold one segment from each *segment group* listed below. Configuration C (in the LA102) must be set to determine the number of compartments per memory, and the number of memories. If insufficient compartments are available when a sequence is being received then some segments will be lost and the LA102 will generate a Sequence Error 12 (not enough compartments), followed by a Sequence Error 8 (missed segments).

The possible settings for configuration C are:
- C1 1 compartment per memory and 6 memories (0-5)
- C2 2 compartments per memory and 3 memories (0-2)
- C3 3 compartments per memory and 2 memories (0-1)
- C4 4 compartments per memory and 1 memory (0)
- C5 5 compartments per memory and 1 memory (0)

One compartment can hold one segment from each of the following groups:

GROUP	SEGMENTS
Frequency response:	O P Q R S U X o r u x
Test level:	T V
CCIR noise:	M N
A weighted & O.41 noise:	L n
Crosstalk and user levels:	A B C J K
Miscellaneous:	H c d h
Distortion:	D F G I
Distortion:	E
W&F and phase:	W z
Phase:	Y Z

Configuration C1 is the normal default setting with 1 compartment and 6 memories, the same as earlier software, and this is suitable for all of the default sequences. Allowing more compartments in each memory reduces the number of memories and the user must decide the best compromise. If results memories are not being used at all configuration C5 can be set to allow up to 5 segments from each group. Remember that memory 0 is the working memory used to receive sequences and that another memory will be lost if user tolerances are defined with configurations C1 to C3. Memory operations will show the range of available memory numbers or give a warning message if no memories are available. **Changing configuration C will clear all results memories as the LA102 must reorganize its memory usage.**

Only one source message segment (+) and one test level segment (T or V) is allowed in each sequence. To find the number of compartments needed for a particular sequence, examine the groups listed above and count the number of segments in each group (if the same segment letter is used twice within a sequence it must be counted twice). The maximum number of segments in any one group determines the minimum number of compartments required to store the results (and hence the minimum value for

configuration C). (When creating a sequence with the Lin4Win LA100 support software the number of results compartments required to run the sequence is automatically calculated.)

For example, these sequences will all require two compartments and will therefore need LA102 configuration C2, C3, C4 or C5 to be set before receiving them:

T D E0 G+4	2 segments from the distortion group (D and G)
T U0 U-8 D+8 D0	2 distortion and 2 sweep segments
T R C K N	2 segments from the crosstalk/user levels group

Segments with the same segment letter will be printed and displayed in the order received, while segments in the same group with different segment letters (for example F and G) will appear in alphabetical order.

4.19 Selecting a Tolerance (±)

By including a '±' character followed by a tolerance number in a LA101 sequence definition it is possible to select a tolerance to be applied before displaying sequence results. When the LA102 receives the '±' segment it temporarily selects the tolerance specified and displays PASSED or FAILED as soon as the sequence is complete. The Lindos Self Test sequence (sequence 16) makes use of this feature to select tolerance 16 (the Selftest tolerance) in the LA102:

> "LINDOS SELF TEST" T U C D N ±16

Note that the tolerance is only selected temporarily. The temporary tolerance selection will be cleared when another sequence is received or when the LA102 configurations are edited (since configuration T determines the tolerance to be applied). See chapter 5 for full details of tolerance testing.

4.20 Output Impedance Segment (%)

Output impedance can be selected from within a sequence definition using %*n,m* where *n* is the impedance in ohms (10, 75 or 600) and *m* is 0 for no level correction or 1 for 600Ω load impedance correction (ZC). This is equivalent to setting the impedance and correction in manual mode before running the sequence so, when ZC is selected, the test level the sequence runs at is also in dBm (ie segment T normally runs at 0dBu, but after %75,1 it will run at 0dBm assuming a 600Ω load). If *m* is omitted the level correction last used for that impedance is used. If *n* is omitted the current impedance is used. Use the sequence editor to insert these characters in the normal way (section 4.2). Example:

> "LINES TEST" "75OHM - 600OHM LOAD" %75,1 T O C E N Z

The LA102 input impedance is not affected by this segment.

4.21 Sequence Level Segment (/)

Test level can be set within a sequence using */n* before any test segments, where *n* is the level in dB (with 0.01dB resolution). This is equivalent to setting the test level in manual mode using ⁅✱⁆⁅1⁆ before running the sequence and makes all output relative to the test level, including the FSK. For example using the sequence:

<div align="center">/-17 %600,1 TrC+4ENz</div>

the FSK will be output at -17dBm (-10.98dBu into 600Ω matched load), segment T will be at -17dBm, segment C at -13dBm and distortion segment E will be at -8dBm and -27dBm (+9 and -10dB relative to test level).

When the sequence has finished the original test level will be restored as this segment only sets a temporary test level for the duration of the sequence.

4.22 Channel Segment (:)

The channel may be selected using :n,m which selects physical channel *n* and logical channel *m*. *n* should be 0 for MUTE, 1 for Left, 2 for Right or 3 for both channels (L+R) or omitted for no change. *m* should be 1 for Left, 2 for Right, 3 for both channels or omitted to make it default to the same setting as the physical channel.

The physical channel determines which output channel the signal will be on. Normally the signal is on both channels (except during noise or crosstalk segments) but it is possible to define a sequence with a tone on one channel only. For example, to generate a 1kHz test tone on the R channel only:

<div align="center">:2 !1000,0</div>

To generate the special ITV channel identification signal for Betacam/stereo recordings which consists of 1kHz steady tone on the right channel and 3s 1kHz pulses on the left channel separated by 250ms of silence:

<div align="center">!1000,3000,0,,0 :2 !1000,250,0,,0 :3 <<</div>

The logical channel determines which channel the LA101 will instruct the LA102 to make measurements on (via FSK) and also how many times the sequence will run. It is normally set by pressing the ⁅L/R⁆ key on the LA101 before running a sequence but this segment overrides any selection made with the ⁅L/R⁆ key. For example, a test sequence for a mono circuit can select single channel operation within the sequence:

<div align="center">:1,1 T O E N</div>

This sequence will only ever run on the left channel regardless of the L+R setting.

When measuring distortion on FM transmitter systems it is best to generate the test signal on one channel only to obtain the maximum difference signal and hence test the system at its limits. Generating the tone on both channels simultaneously (as Lindos sequences normally operate) results in a zero amplitude difference signal giving less valid results.

The channel selection segment (:) can be used to allow for this special case. If 16 is added to the physical channel number, before a distortion segment, then that distortion segment will only put the tone on the channel which is being measured and will MUTE the other channel. Sequence 17 (the FM transmitter test) makes use of this feature:

"FM TEST" "ONE CHAN MTD FOR THD" V R A :19,0 G N Y

4.23 Subroutine Segment (>)

Sequences can call other sequences using the > segment (like a computer subroutine). When >*n* is encountered in a sequence, sequence *n* is run as though it were a single segment and then the original sequence continues. The sub-sequence will only run on a single channel each time it is called, but will be called for each channel the main sequence runs on. For example:

        SEQ 1:   T>2NWZ
        SEQ 2:   RCI

Running sequence 1 will run segments +TRCINWZ on the left channel and TRCIN on the right. This facility is intended to allow complicated ! tone segments which require more than 250 characters, and is especially useful where a particular sequence of tones occurs at several places (tunes for example!). If the sequence consists entirely of ! tone segments with no letter segments, the sequence will run once only, as usual.

Sub-sequences may call other sub-sequences, but an error will occur if a sequence calls itself recursively.

4.24 Pause Segment (?)

A pause segment is available to wait for user input. A question mark (?) will cause the LA101 to stop and wait for a key to be pressed. Press ⬚1⬚ to continue running the sequence, or ⬚SEQ⬚ or ⬚✻⬚⬚SEQ⬚ to abort the sequence. The message "1=CONTINUE SEQ=STOP" will be displayed to indicate this unless the ? is preceded by a message segment. For example:

  "100, 1k AND 10kHz" !100,0 ? !1000,0 ? !10000,0 "PRESS 1 TO REPEAT"? <<

4.25 Sweep Headroom (^n)

When receiving a frequency sweep segment it is important that the LA102 uses a suitable level range. For most normal frequency responses the LA102 will do this automatically. However, problems can arise where a system has large peaks (eg steep filters, equalisers, loudspeaker crossovers etc). If the range chosen is too low then clipping will occur, causing part of the frequency response curve to be missed and producing RANGE? messages. If the range chosen is too high, accuracy and resolution will be reduced. This is explained in section 3.14, but a better solution is the ^n control segment.

4. User Defined Sequences

The headroom segment, ^*n*, indicates to the LA102 that a 0dB sweep may peak at anything up to *n*dB. This segment is normally placed immediately before the frequency sweep segment, and must be positioned after the test level segment (T or V). For example, if testing a filter which has 0dB gain at 1kHz and +12dB gain at 10kHz, the following sequence could be used:

<div align="center">T ^+12 U</div>

After receiving this segment the LA102 will ignore the measured test level when choosing the range to use. If it receives a 0dB sweep it will always choose a range suitable for measuring *n*dB, where *n* is the segment parameter. If the sweep has a measurement level which is not 0dB then this will be taken into account when choosing the level. For example consider the sequence:

<div align="center">T ^+12 U-20</div>

This runs a test level segment at 0dB and a frequency sweep at -20dB as well as warning the LA102 that the system may have a gain of up to 12dB. This means that the sweep at -20dB could peak at -8dB, so a range suitable for measuring -8dB will be chosen. Segments with extra headroom built in (eg segment R) will still have this extra headroom.

4.26 Subtract a Reference Curve (\n)

Some measurements will always require the subtraction of a reference curve, and this can be achieved by using the *n* control segment which instructs the LA102 to subtract the reference curve in memory *n*. The *n* segment must appear after the frequency response segment, otherwise the subtraction would occur before the frequency response had been measured (the LA101 only sends this segment once, and if sending a two channel sequence it will only send it when both frequency sweeps have been run). Some care should be taken when using this segment to ensure that the correct reference curve is stored in memory *n* before the sequence is received, and that LA102 configuration C1 is set.

4.27 Equivalent ! Segments

Most test segments can be defined using the ! segment to generate the FSK, followed by the necessary tones. The equivalent ! segment definitions are listed below, primarily because this format provides a concise way of describing the tones used in each segment. While it is possible to modify the frequencies in the ! segment, great care should be used, because the LA102 will expect certain frequencies and levels to be used. Refer to the relevant segment below for further details:

```
!A40,1000,0,100,,,315,,-.04,1000,,,-.41,6300,,-6.92,10000,,,-10.36
!B100,500,0,1000,,,6300,,,10000,,,
!C40,1000,0,100,,,315,,,1000,,,6300,,,10000,,
```

```
!D100,2000,8,1000,,,6300,,
!E100,+9,2000,1000,-10,,1000,+9,
!F10000,2000,+8,6300,,,1000,,,315,,,100,4000,,40,6000,
!G10000,2000,-2.36,6300,,1.08,1000,,7.59,315,,7.96,100,4000,8,40,6000,
!H1000,0,50,,0.05
!I1000,2000,+8,,,-10,100,,+8,,,-10
!J40,1000,-10,100,,,315,,,1000,,,6300,,,10000,,
!K 1000,1000,0,,,-10,,,-20,,,-30,,,-40,,,-50
!T1000,1000,0,,0
!V400,1000,0,,0
!W3125,12500,0,,,
!Y40,500,0,100,,,1000,,-.41,6300,,-6.92,10000,,-10.36,15000,,-13.66
!Z40,500,0,100,,,1000,,,6300,,,10000,,,15000,,
!c15000,3000,0
!z40,500,0,100,,,315,,,1000,,,6300,,,10000,,,15000,,
```

4.28 CCITT O.33 Sequences

Although the LA102 cannot make measurements from a CCITT O.33 sequence (see section 3.27), the LA101 can generate an O.33 sequence. This is achieved using the '–' segment which takes 7 characters in quotes:

–"BBC1A01"

The first four characters are the source identification, the next character is the special signalling character while the final two characters are the program identification (00-99). The LA101 will generate an FSK header complying with the CCITT O.33 specification: 110 baud, 1 start bit, 7 data bits, 1 even parity bit and 2 stop bits (as for Lindos FSK), with the following characters:

Start of header (SOH) character, ASCII 1
4 character source identification
Start of text (STX) character, ASCII 2
2 character programme identification
ETX (end of text) character, ASCII 3

Any CCITT O.33 sequence can be defined, by following this segment with tone (!) and channel selection (:) segments.

Although this header format is different from the Lindos header format, the LA102 will display the characters from an O.33 header as they are received, providing it is in sequence mode. This may be useful for identifying the source of an O.33 sequence, but the LA102 will not make any measurements.

4.29 Apply weighting (=n)

To automatically apply an LA101 weighting to a sequence definition, use the $=n$ control segment, where n is the weighting number. 1-5 are user weightings; 6 is RIAA inverse; 7 is CCIR 468-3 inverse; 8 is CCITT O.41 inverse and 9 is 50uS de-emphasis. Ensure the weighting is defined before running the sequence. $=n$ should come before any sweep segment in a sequence. The LA101 can only apply weightings to third octave frequencies, and consequently some segments cannot be used in a sequence which includes the $=n$ segment. In particular, segments O, S, X, Y, Z, !, c, d, o, r, u, x and z are not allowed and will generate an ERROR AT CHAR xx error message, where xx is the position of the offending segment in the sequence definition.

5.0 Tolerance Testing

For routine testing (production line testing, quality control checks etc) sequence operation allows fast simple measurement but still requires the user to ensure that each measurement is within its allowed range. By selecting one of the built-in tolerances listed in table 5.3, or by entering a user tolerance into the LA102 it is possible to perform PASS/FAIL tests, with every measurement being tested against its own tolerance specification. 'TOLERANCE PASSED' or 'TOLERANCE FAILED' will be displayed as soon as a sequence finishes (fig 5.1) and it will also be included in the printout header. The printout will also show the tolerance limits for each measurement in the form of a *tolerance string* (see fig. 5.4) and the format of this is explained in section 5.3. Measurements that are not within the specified range are marked on the display and on the printout with an asterisk (✱) as shown in figs. 5.2 and 5.4.
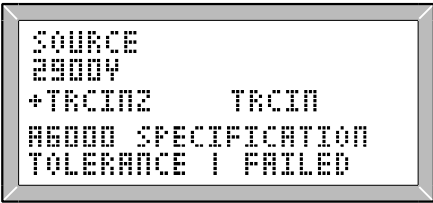
Fig. 5.1 Tolerance Failed

Fig. 5.2 Indication of Failed Values

For frequency response results the asterisk (✱) on the screen only indicates that the frequency response on the displayed channel has failed. It does not indicate which value has failed (because it is displayed regardless of the cursor position). To see which frequencies have failed it is necessary to print the results.

The tolerance testing system also provides some control over the format of the printout, and it can be used to add short comments or to suppress the printing of some results values to obtain a more concise printout (section 5.5)

The LA102 allows up to ten user tolerances to be stored in non-volatile memory using the built-in tolerance editor (section 5.6) or by using Lin4win, the Lindos Support Software for Windows® on a remote computer (section 5.7).

0 None

1-10 User Tolerances

11 IBA Tape/General

TV	+-1
PQRSUX	+6,+2-2.5<3,,,,+-1<1.5,,,,,,,,,+2-2.5<3,,,?
CJ	-17,-25,-36,,,-32
B	-25,-36,,-32
I	-34,,-40
MN	-41,-45,-41
YZ	+-60,+-35,+-15,+-30,+-46,+-60
W	.12,,+-15,+-.3

12 IBA Tape/Restricted Use

TV	+-1.5
PQRSUX	+6,+3.5-2.5<3,,,,,+-1.5<2,,,,,,,,+3.5-2.5<3,,,?
CJ	-17,-25,-36,,,-32
B	-25,-36,,-32
I	-28,,-30
MN	-36,-40,-36
YZ	+-180,+-90,,,,+-180
W	.15,,+-90,+-.5

13 IBA Studio Path Standard

T	+-0.5
PQRSUX	+6,+-1<1,,,+-0.5<0.5,,,,,,,,,+-1,,,+6
MN	-60,-63,-60
I	-46,,-52,
CJ	-35,-43,-53,,,-49
B	-43,-53,,-49
YZ	+-20,+-16,+-10,+-14,+-17,+-20

14 Lindos Cassette

PQRSUX	?,+-3,,,+-2,,,,,,,,+-3,,,,,?
MN	-40
CJ	-20,,-30
B	-20,-30
I	-30,-28,-36,-40
W	0.12,,+-20,+-1
YZ	+-60,+-35,+-15,+-30,+-45,?

15 Studer A812 15ips

PQRSUX	+-2,+-1,,,,,,,,,,,,,,,,,+-2
MN	-50,-59,?
L	-63,?
D	?,-40,?
F	?,,,-40,?
C	?,,,-65,?
B	?,-65,?
W	0.04,,?,+-0.2

16 Lindos LA100 Self Test

!3	
U	+0-.15,,+-.1,,+-.05,,,,,,,,,,+-.10
T	+-.05
L	-107,-105
MN	-95,-98,-95
C	-90,,,-80
D	-80,-86,-76
Z	+-2

17 British Telecom EPS81 <40km

TV	+-1
O	?,+.75-1,,,+-.75,,,,,,,,,,,,,+.75-3,,?
E	-35,?,-40
MN	-45,-35,-45

18 British Telecom EPS84 <40km

TV	+-1
O	+.5-1<1,,,,+-.5<.5,,,,,,,,,,,,,,+.5-1<1,,,+.5-2<3,?
BCJ	-56
E	-50,?,-50
MN	-59,-44,-59
YZ	+-18,+-15,+-9,+-15,+-16,+-18

19 British Telecom EPS84 <320km

TV	+-1
O	+.5-2<1,,,,+-.5<.5,,,,,,,,,,,,,,+.5-2<1,,,+.5-2<3,?
BCJ	-56
E	-50,?,-50
MN	-52,-44,-52
YZ	+-18,+-15,+-9,+-15,+-16,+-18

20 British Telecom EPS98 <320km

TV	+-1.5
O	?,+.75-3.25,,,+.75-2.75,,,,,,,,,,,,,+.75-6.25,,?
E	-35,?,-40
MN	-44,-35,-44

Table 5.3 Pre-Defined Tolerances in the LA102 V6.5 Software

```
LINDOS AUDIO SEQUENCE TEST
SOURCE 3514C                    LA102 3514   V6.7    7 JAN 2000
SEGMENTS +TUCDN   TUCDN         TOLERANCE 16 SELF TEST PASSED

FREQUENCY RESPONSE [U] 0dB
     30Hz    -0.09     -0.09    +0-.15
     40Hz    -0.05     -0.06    +0-.15
     50Hz    -0.04     -0.04    +-.1
     63Hz    -0.02     -0.02    +-.1
    100Hz     0.00     -0.01    +-.05
    125Hz     0.00     -0.02    +-.05
    250Hz     0.00      0.00    +-.05
    500Hz     0.00      0.00    +-.05
     1kHz     0.00      0.00    +-.05
     2kHz     0.00      0.00    +-.05
     4kHz     0.00      0.00    +-.05
   6.3kHz     0.00     -0.01    +-.05
     8kHz     0.00      0.00    +-.05
    10kHz    +0.02     +0.02    +-.05
  12.5kHz     0.00      0.00    +-.10
    14kHz     0.00      0.00    +-.10
    15kHz     0.00      0.00    +-.10
    16kHz     0.00      0.00    +-.10
    18kHz    +0.02     +0.02    +-.10
    20kHz     0.00      0.00    +-.10


TEST LEVEL OUT [T] 0dB
           0.00      0.00dBu +-.05
NOISE CCIR 468-4 Q-Pk (rel) [N]
PK WTD     -96.5     -96.7    -95
PK UNW     -99.5    -100.7    -98
MN WTD     -96.7     -96.9    -95
CROSSTALK (rel) [C] 0dB
   40Hz   -106.9    -107.2    -90
  100Hz   -106.4    -104.6    -90
  315Hz   -109.9    -112.3    -90
   1kHz   -111.4    -108.8    -80
 6.3kHz    -99.7     -94.6    -80
  10kHz    -95.7     -90.9    -80
DISTORTION (2f-22k) [D] +8dB
  100Hz    -85.1     -84.0    -80
   1kHz    -89.8     -90.0    -86
 6.3kHz    -79.5     -79.4    -76
```
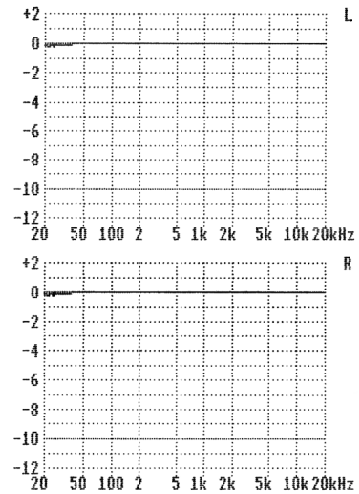

Fig. 5.4 A Typical Sequence Printout with Tolerance Testing (HP Deskjet)

5.1 Applying a Tolerance

Configuration T selects the tolerance to be applied, tolerances 1 to 10 being user tolerances, while tolerances 11 to 20 are fixed. Configuration T0 disables tolerance testing. Once configuration T has been set all sequence results will be automatically checked against the tolerance whenever they are displayed. If testing domestic cassette machines for example, it may be useful to set configuration T14 so that all results are automatically compared against the Lindos Domestic Cassette tolerance.

It is also possible to make a sequence select a particular tolerance to be applied. In this case the tolerance number is specified within the sequence definition, in a ± segment (see section 4.19), and this temporarily overrides the configuration T setting, until another sequence is received, or until the LA102 configurations are edited.

If the tolerance is pre-defined in the LA102 (tolerances 10-20) then nothing else need be done to check results against it. However, with user tolerances (1-10) the tolerance must be defined and entered into the LA102, using a tolerance editor.

Because the tolerance check is performed at the time of display or printout (rather than as the sequence is received) it is possible to change the tolerance number (configuration T) at any time to check the results in memory against any of the available tolerances. Similarly, it is possible to recall a results memory ([✳][3]) to check it against the current tolerance. Even examining a memory status ([✳][1]) will perform a tolerance check on the specified memory (see section 3.5 for details of memory operations).

5.2 Pre-Defined Tolerances

Tolerances 11-20 are pre-defined in the LA102 and cannot be changed. Tolerance 16 is the Lindos Selftest tolerance which is normally automatically selected by sequence 16, the Selftest sequence. The LA101 XLR outputs should be connected directly to the LA102 XLR inputs using good, screened cable. The front jack sockets should not be used because small errors in the output impedance can cause their own relatively large level errors which are not included in the level accuracy specification of the LA101. Sequence 16 will set the LA101 test level and output impedance automatically, but 10kΩ input impedance must be set on the LA102 before running the sequence.

Tolerances 17 to 20 are Engineering Performance Specifications (EPS) for programme circuits used by British Telecom: EPS81 amplified 10kHz programme (sound) circuit for mono transmission; EPS84 15kHz programme (sound) circuit suitable for mono transmission; EPS98 10kHz mono multi-terminal programme circuit to connect a central studio to a maximum of 12 outstations. Note that tolerance 18 applies to EPS84 circuits less than 40km long while tolerance 19 applies to EPS84 circuits from 40 to 320km long.

Tolerances 11-13 are IBA Code of Practice specifications for General Tape, Restricted Tape and Studio Paths respectively. Although the IBA is sadly no longer in existence the IBA Code of Practice is still considered by many to be the definitive standard for broadcast users and it is still in widespread use.

Tolerance 14 is a Lindos specification for a domestic cassette machines. Any good cassette machine should pass.

Tolerance 15 is the specification for stereo Studer A812 tape machines running at 15ips with IEC equalisation and 320nWb/m nominal level but it can easily be copied to a user tolerance and modified to suit other machines, speeds or equalisations etc. (See section 5.8).

5.3 Tolerance Strings

For every result value recorded by a test segment there can be a corresponding tolerance string. Each tolerance string can specify an upper value or a range and a maximum allowed difference between the two channels, in one of the following formats:

n	Value must be less than or equal to n
±n	Value must be 0±n
n m	Value must lie between n and m (space or sign separate n & m)
n±m	Value must be n±m

Any of these forms can be followed by a difference specifier:

<d	Channels (or registers) must match within difference d

Note that the first form would normally be used for distortion, noise or crosstalk results which must normally be below a certain limit (but there is usually no lower limit − they cannot be too good). The second form (±n) would normally be used for frequency response, speed error or phase results which should ideally be 0, although the third and fourth forms are often used for frequency response results as the upper and lower limits are often different (eg '+2-3').

n, m and d may be positive or negative, although the + sign is optional. Most tolerance limits tend to be whole numbers, although decimal places are allowed. In fact each value may be specified to a resolution of 0.0001 in the range -9999.9999 to +9999.99 (the decimal part can be omitted for whole numbers).

5.4 The Tolerance Definition

For each segment that requires a tolerance the segment letter is specified followed by a list of tolerance strings, one for each value measured in that segment each separated by a comma, as in table 5.3. A list of results values for each segment, together with the number of values produced by each segment, is shown in table 3.2 (on page 40).

The segments may be specified in any order, and any segments that have the same tolerance specification (eg R and S, or T and V) can be specified together by putting the segment letters together. If any tolerance for a particular value in a segment is omitted the tolerance for the previous value is assumed. For example, for distortion segment D, the specification should start with a 'D' and be followed by a tolerance for 100Hz distortion, 1kHz distortion and 6.3kHz distortion respectively. Space characters may be inserted to make the tolerance more readable (a space before each segment letter is strongly recommended). It is also possible to give the tolerance a title by putting a message in quotes at the start of the definition. For example:

> "DEMO" TV±.5<.1 D-60,-70,-65 YZ±20,,,±40

The tolerance title is 'DEMO' and this will appear on the printout and in the configuration menu. The measured test level (segment T or V) must be within ±0.5dB of 0dBu and the difference between channels less than 0.1dB. There is a -60dB upper limit for 100Hz distortion, -70dB for 1kHz and -65dB for 10kHz. Phase (segment Y or Z) must be within ±20° of 0° at 40, 100 and 1kHz and within ±40° at 6.3k, 10k and 15kHz (the missing tolerance strings default to the previous tolerance specification in the segment).

Before programming tolerance definitions into the LA102 it is a good idea to run a sequence on the system for which the tolerance is being produced and print the results. The proposed tolerance strings can then be written in beside each measurement and used to produce the tolerance definition. Once the full definition has been programmed into the LA102, the results can be printed again, with the tolerance applied, to ensure that the tolerance definition is correct and that it agrees with the proposed version.

Distortion tolerances must be specified in dB regardless of the printout setting, but users who prefer distortion results in % can put the equivalent percentage after the dB value, using an "=" symbol as a separator (see section 5.5). Only the dB value is used, as text following an "=" symbol is ignored up to the next comma, but it will appear on the printout. For example:

> D-50.5=0.3%, -60=0.1%, -80=0.01%

W&F and speed values must be in % and phase in degrees. All other values are specified in dB. Frequency response tolerances always refer to the normalised levels of the tabulated frequencies. Examine the built in tolerances for more examples.

A question mark (?) can be entered as a tolerance string to indicate that there is no tolerance for that value and the tolerance column is left blank on the printout, eg C-17,?,,-36,?,-32 will specify a tolerance for 40, 1k and 10kHz crosstalk, but will indicate a "Don't Care" condition for 100, 315 or 6.3kHz.

Some care is needed when using a tolerance to check the frequency response results

because the spot frequency levels that the tolerance is applied to are affected by the normalisation (ie the levels that are checked against the tolerance are always the same as the levels that are printed). A tolerance which has been defined assuming 1kHz normalisation might fail every value if given absolute levels instead of normalised levels. To cater for such possibilities the normalisation can be specified within the tolerance definition and this overrides the configuration J setting to ensure that the correct levels are compared with the tolerance. The ! character is used to force the normalisation to absolute (!0), 315Hz (!1), 400Hz (!2) or 1kHz (!3), regardless of the configuration J setting (and the V segment). This can be placed anywhere within the tolerance definition, but it is conventionally placed after the tolerance title (as shown in table 5.3).

5.5 Printout Format

In addition to the pass/fail features the tolerance strings can also be used to control the format of test printouts, albeit in a limited way.

Since the tolerance strings are free format, it is possible to include extra information (numbers and symbols only) which will appear on the results printout next to the relevant values. One use is to make the LA102 print distortion tolerances in % as well as dB, as explained in section 5.4. It is also useful to list the target or expected values for user level results (see segment K, section 4.13). For example, suppose segment K is being used to generate the levels -20,-25,-30,-35,-40 and -45dB, a tolerance could be defined to list these values without actually testing them by preceding each target value with an = sign. When the tolerance system encounters any invalid character (such as =) it will ignore the rest of the tolerance string, but still print it. For this example, the tolerance would be:

K =-20,=-25,=-30,=-35,=-40,=-45

Sometimes a much simpler printout is required than that normally provided, perhaps only listing one distortion value and one crosstalk value, and a reduced frequency response list. This may be to enable more results to be printed on a single sheet, or perhaps because the other values are not needed and an uncluttered printout is required. In some cases it may be possible to choose a more appropriate segment and this will also reduce the test time (segment F measures distortion at 6 frequencies whereas segment D only measures it at 3). Where there is no shorter segment it is possible to suppress particular results values by putting a slash character (/) in the corresponding tolerance string.

For example, the following tolerance definition:

N-40,/,/ C/,,,?,/,?

will apply a tolerance of -40dB to the CCIR peak weighted noise result, and suppress the printing of unweighted and mean noise. It will also suppress the 40Hz, 100Hz, 315Hz and 6.3kHz crosstalk results and only print the 1kHz and 10kHz values. Note that the ?

character is used to print a value without tolerance testing, and also that an empty field, after a / field will also cause the corresponding results line to be suppressed (since empty tolerance fields always default to the last field which had an entry). It is not possible to apply a tolerance to suppressed results values (because the printout would be very misleading if an invisible value failed). The simplified results printout would look like this:

```
NOISE  CCIR 468-3 Q-Pk (Rel) (N)
PK WTD    -39.7*  -41.6   -40
CROSSTALK (rel) (C) 0dB
  1kHz     -45.3   -46.9
 10kHz     -43.2   -42.7
```

If this facility is being used to suppress some results values without tolerance testing, the "TOLERANCE n PASSED" message printed at the top of the test sheet is redundant. In such cases, it can be suppressed by putting a slash character (/) at the start of the tolerance (as the first character, in place of the quoted title). Only printer output is affected, the results displayed on the LCD are always shown in full, and are never suppressed.

5.6 The LA102 Tolerance Editor

User tolerances are entered from the keyboard using a built in editor (or from a remote computer) and stored in non-volatile memory. Hold ON/OFF and press 1 to obtain the LA102 tolerance editor. User tolerances that are defined are indicated by a number (1-10), while undefined tolerances are represented by a dash ('−') as shown in fig 5.5.
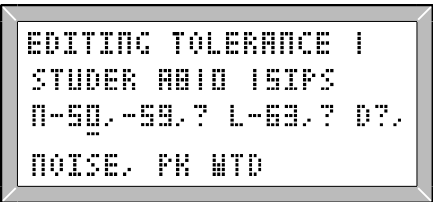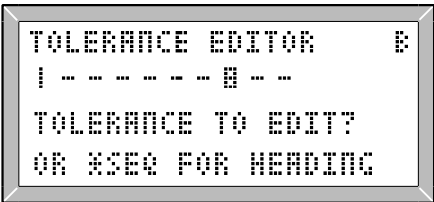
Fig. 5.5 The LA102 Tolerance Editor   **Fig. 5.6 Editing a Tolerance**

Enter the number of the tolerance to be edited by pressing 1 to ✳5. To view a pre-defined tolerance (11 to 20) use the < > buttons to select the tolerance number and then pressing PAGE. Pre-defined tolerances can be copied to a user tolerance - see later in this section.

The tolerance definition is a single line of text up to 250 characters in length (fig. 5.6).

The ⌈PAGE⌉ and ⌈OPTION⌉ keys move the cursor right and left by one character, while ⌈✳⌉⌈PAGE⌉ and ⌈✳⌉⌈OPTION⌉ move it 21 characters (a screen width), with the display scrolling sideways as necessary.

The ⌈<⌉ and ⌈>⌉ keys are used to change the character at the cursor, and they cycle through the available characters:

> <space> ABCDEFGHIJKLMNOPQRSTUVWXYZ
> bcdhkmnoruxz @!?%<>=±✳/+− . 0123456789 ,"

As in the sequence editor ⌈✳⌉⌈<⌉ and ⌈✳⌉⌈>⌉ give quick access to letters ('Z') and symbols respectively (see section 4.2). It is also possible to enter a number directly by pressing ⌈1⌉ to ⌈5⌉ or ⌈✳⌉⌈1⌉ to ⌈✳⌉⌈5⌉ (for 6 to 9 and 0). Pressing ⌈L/R⌉ inserts a space while ⌈✳⌉⌈Z⌉ (ZAP!) deletes a character, and all of the keys automatically repeat if held for a short while. ⌈✳⌉⌈SEQ⌉ returns to the 'TOLERANCE TO EDIT' prompt (fig. 5.5).

The LA102 tolerance editor gives a description of the tolerance entry at the cursor position, for example: FREQUENCY RESPONSE, 6.3kHz, or NOISE, WTD.

It is often convenient to copy a pre-defined tolerance to create a slightly different version without re-entering the entire tolerance - perhaps to modify the pre-defined Studer A812 tape tolerance to more accurately match a different machine, for example. This can be achieved by pressing ⌈>⌉ while the editor screen (Fig 5.5) is displayed, until the desired pre-defined tolerance title is displayed, then press ⌈PAGE⌉ to view the definition, ⌈L/R⌉ to enable copying, and finally the user tolerance number to which you wish to copy. Note that all pre-defined tolerances must be copied to a user tolerance before they can be changed.

Pressing ⌈SEQ⌉ (or resetting by tapping ⌈ON/OFF⌉) will leave the chosen tolerance in non-volatile memory ready to be selected by setting configuration option T to its tolerance number.

It is often useful to print tolerance definitions on a printer for future reference, and this is readily achieved by pressing ⌈✳⌉⌈PRINT⌉ from the tolerance editor menu to print all of the defined tolerances. When printed the '±' symbol will be expanded to '+-' characters as it is not a standard ASCII character and not available on all printers.

Each of the 10 user tolerances may be up to 255 characters in length. Because of the way RAM is shared in the LA102, sequence results memories 4&5 are lost (reducing the total number of memories from 6 to 4) when user tolerances are defined and any attempt to perform a memory operation with memories 4 or 5 will then be ignored. To reclaim sequence memories 4&5 all of the user tolerances must be cleared by using the reset menu (⌈ON/OFF⌉⌈3⌉ and then ⌈5⌉) or by deleting each tolerance in turn (using ⌈✳⌉⌈Z⌉).

5.7 Editing Tolerances on a Remote Computer

The Lindos Support Software (appendix A.2) provides a tolerance editor for editing tolerances on a remote computer. Tolerances can be saved to disk for later use, and transferred from the computer to the LA102.

If more than 10 tolerances are frequently used the Lindos Support Software should be used to store the tolerances on disk and transfer them to the LA102 as necessary. The Support Software also makes it easier to edit Tolerance definitions using a full-size keyboard so the LA102 tolerance editor can be ignored. Unlike sequence definitions, tolerances are often relatively large (typically 120 characters), so the support software is generally preferred if available.

5.8 Example Tolerance

To copy tolerance 'EPS81 <40km' (tolerance 17) into user tolerance 8, and add the specification that the channel difference at 1kHz must be less than 0.3dB (ie 'TV±1<.3')

Hold [ON/OFF] and press [1] to obtain the tolerance editor (fig 5.7)
Press [>] 7 times to select tolerance 17 (fig 5.8)
Press [PAGE] to enter viewing mode (fig 5.9)
Press [L/R] to enter copy mode (fig 5.10)
Press [✳][3] to select user tolerance 8 (fig 5.11)
Hold [PAGE] until cursor is at the space after 'TV±1'
Press [L/R][✳][>][<][<][<][<][<][<][<][<] to insert a '<' character
Press [PAGE][L/R][✳][>][>][>] to insert a '.'
Press [PAGE][L/R][3] to insert a '3' (fig. 5.12)
Press [SEQ] to exit from the editor
Hold [ON/OFF] and press [2] to obtain the configuration menu
Use [PAGE] and [OPTION] to position the cursor under the T (fig 5.13)
Press [✳][3] to ensure that tolerance 8 is applied to all sequence results

After entering a user tolerance it is wise to run a sequence, print the results and check the tolerance column to ensure it is as intended and that no commas or numbers have been omitted.
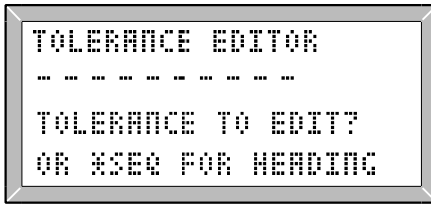
Fig. 5.7 Tolerance editor
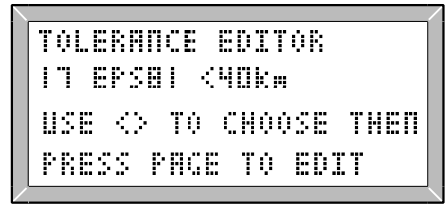
Fig. 5.8 Tolerance 17

Fig. 5.9 Viewing the Tolerance
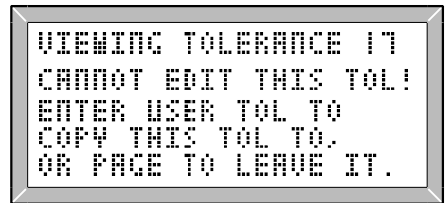
Fig. 5.10 Copying Mode
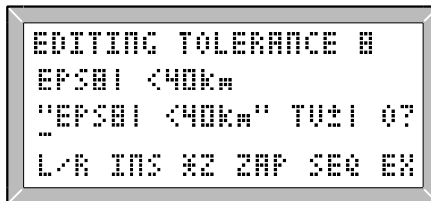
Fig. 5.11 The Opening Edit Screen
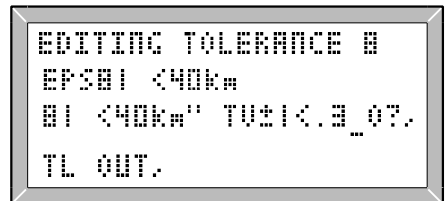
Fig. 5.12 The Final Version
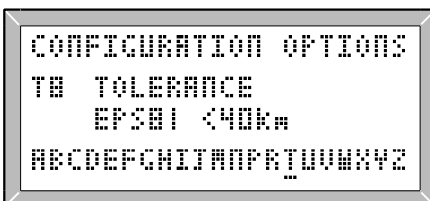
Fig. 5.13 Setting Configuration T

6.0 Using Test Tapes and Discs

The LA102 can automatically take measurements, without any special programming, from standard test tapes and discs (Compact Discs or gramophone discs) which do not contain FSK. A frequency response graph can be displayed on the screen, printed, tested against a tolerance or read into a computer just like a frequency sweep from the LA101.

Two modes are provided: *Test Tape* mode is intended for use with discrete tones, each lasting 2s or more, as found on most test tapes and cassettes, while *Frequency Sweep* mode is intended to be used with continuous frequency sweeps as found on most test CDs and gramophone discs. Either mode can of course be used with any other signal source such as a sweep oscillator.

```
SEQ OPTIONS
1 LINDOS FSK
2 TEST TAPE
3 FREQ SWEEP
```

```
SEQ 2 TEST TAPE   1 L
  1001Hz          .
    -5.02dBu -12.00dBu
  -15   -10    -5
▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓. . .
```
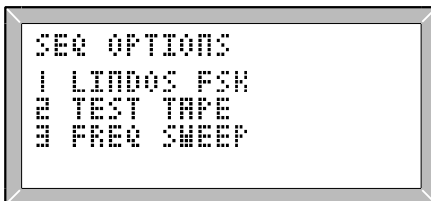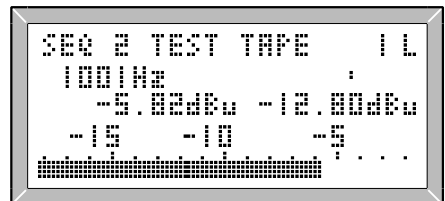
Fig. 6.1 Sequence Options   **Fig. 6.2 Test Tape Mode**

6.1 Test Tape Mode

Press SEQ OPTION 2 on the LA102 to enter Test Tape mode (see fig. 6.1). The LA102 will display SEQ 2 TEST TAPE and a level bar graph which indicates the level on the indicated channel (fig. 6.2). The frequency response section (consisting of discrete tones) should now be played from the test tape, CD or gramophone. When the LA102 finds a steady tone it will display the frequency and, after a short pause, the measured level. If the tone is present on both channels then both will be measured (one after the other) and two levels will be displayed (the L channel being displayed to the left of the R channel, as in fig. 6.2). Voice announcements, music and FSK will be ignored and will not affect measurements.   When the frequency response section has finished press the PAGE key to exit from test tape mode and display the frequency response graph. The level is averaged over 500ms periods and the average taken during the last period is the one actually used. Because of this some care is needed when using poor quality test tapes which may 'tail off' towards the end of the tone.

The LA102 will interpolate the frequency response samples that it recorded to produce the frequency response graph (fig. 6.3) so it is possible to move the frequency cursor (using the <RANGE and RANGE> keys) to any third octave between 20Hz and 20kHz to find the response at that frequency (see section 3.3). Obviously, the results must be interpreted sensibly if very few frequencies are used (interpolation over one octave is normally reasonable but any more than that is of dubious accuracy). The frequency response graphs will be normalised or absolute depending on the setting of configuration J (see section 3.16) and ✱TL may be used to set or clear the Test Level (see section 3.3).

Note that the display and printout formats always show their own set of frequencies which may not be the same as those measured by the LA102 although generally they will be similar.

Frequencies below 20Hz or above 20kHz are ignored and not measured. Moving the cursor to a frequency below the lowest frequency recorded, or above the highest will cause the error message RANGE? to be displayed to indicate that the response is not known at that frequency. The graph is not plotted in these regions and the printout will show a similar RANGE? message.

The LA102 should cope well in this mode with a wide variety of signal sources without any manual intervention. It will measure signals on either, or both, channels and will autorange as necessary. However in exceptional cases where the input signal is at a low level, or is noisy it may be necessary to set the input range or channel using the range and channel keys (after pressing SEQ OPTION 2). It is also possible to switch in the 22-22kHz filter by pressing ✱5 immediately after pressing SEQ. The current input channel is shown in the top right corner of the screen and normally toggles automatically between L and R. The bar graph will show the level on the displayed channel except when the level is being averaged when the bar graph is frozen (so use the digital value to obtain an accurate level measurement, rather than the bar graph). The number to the left of the channel indicator is for diagnostic purposes and shows how confident the LA102 is that it has a steady tone – it counts down from 3 when a tone is detected and the level is averaged when it reaches 1. Similarly some bars will appear below this number to indicate successful tone measurements (the 20 to 20kHz frequency range is actually mapped onto 32 display pixels horizontally). See section 6.3 below for more details.
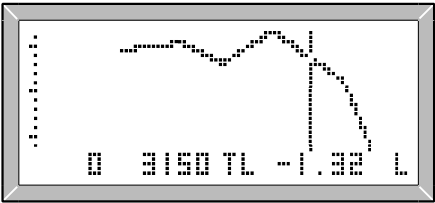
Fig. 6.3 Interpolated Graph   **Fig. 6.4 Frequency Sweep Mode**
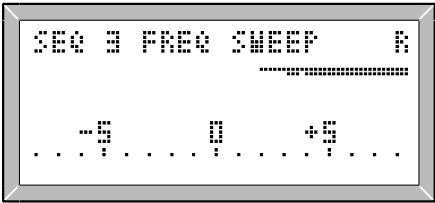
6.2 Frequency Sweep Mode

Press $\boxed{\text{SEQ}}$ $\boxed{\text{OPTION}}$ $\boxed{3}$ to enter frequency sweep mode (fig. 6.4). The LA102 will display SEQ 3 FREQ SWEEP and range and channel indicators. The frequency sweep should now be played from the test tape, CD, gramophone disc or other source. Press $\boxed{\text{PAGE}}$ to exit from this mode when the sweep has finished and the LA102 will display the frequency response graph.

The LA102 will measure and record the level whenever it thinks the input signal is valid, but note that it expects a continuous frequency sweep and will not reject speech, music or FSK which it will attempt to measure producing unpredictable results. Individual tones are best used with sequence option 2 (above) which will reject voice announcements and will also average for a longer period.

Only one channel is measured at a time but it is possible to record one sweep, change channel and then record the second. The current input channel is indicated by an L or an R in the top right corner of the display. If a tone is detected on one channel only then the LA102 will automatically select that channel; this is useful when using test CDs where a left channel sweep is often immediately followed by a right channel sweep. The $\boxed{\text{L/R}}$ key can be used to select the input channel explicitly and should be used when the LA102 cannot select the channel automatically (for example when the sweep is present on both input channels).

The level range must be set with the range keys as the LA102 does not autorange in this mode (it cannot know in advance how high the signal will be and cannot change range during a sweep because that will cause samples to be lost). Unfortunately the LA102 does not have enough time to produce a bar graph display and the scale is displayed simply to allow the user to set the range with the range keys. It is best to set the range too high (resulting in reduced accuracy) rather than too low (which may cause an overload).

Only frequencies within the range 20Hz to 20kHz will be recorded and a 32 pixel wide bar graph showing which samples in the 20Hz-20kHz frequency range have been received is displayed to show the progress. If the frequency sweep does not cover the 20Hz to 20kHz range only the received frequencies will be plotted on the displayed and printed graphs. Moving the cursor to a frequency which wasn't recorded will show RANGE? in place of the level as for the test tape mode described above.

Ideally the frequency sweep shouldn't be faster than about 3 octaves per second (ie 3.5s to sweep from 20Hz to 20kHz). The LA102 attempts to take 256 samples over the frequency range but will interpolate any missing samples before plotting the graph.

6.3 Frequency Response Results

The LA102 treats frequency response results obtained from the test tape and frequency sweep modes as segment U results and the segment list will actually show a dummy U segment in one or both registers. It is therefore possible to treat these results just like normal sequence results. They can be stored in a results memory using ⊛ 2 or ⊛ MEM , printed using ⊛ PRINT , read into a remote computer using the Lindos Support Software (see appendix A.2) or tolerance checked by defining a tolerance for segment U (see chapter 5).

The LA102 uses its zero-crossing detector to measure the input frequency and decide whether a tone is valid. If the signal source is very noisy (or at a very low level) the LA102 may not be able to measure the input frequency reliably and will produce a frequency response graph covering a smaller frequency range than expected.   High frequencies may be a problem, particularly on cassette where the bias frequency may produce intermodulation products.

Problems have also been experienced with gramophone discs which contained discrete tones on one channel only. If the crosstalk is very poor (and well above the noise level) the LA102 may detect the crosstalk breaking through from the other channel and mistake it for a valid tone. The best solution is to use a test disc which has tones on both channels simultaneously to avoid the crosstalk problem (note that unplugging one channel will not help since crosstalk will still be present on the channel being measured).

Many test tapes and discs have line up tones before the frequency response section and these may sometimes be at a different level to the response section itself. In such cases it is important that the LA102 does not receive these tones otherwise they will be incorporated into the frequency response graph.   Note that they may not always be overwritten if the same frequency occurs in the frequency sweep because a small speed or frequency error may result in one tone being measured, for example, as 398Hz and the other as 400Hz with different levels measured for each resulting in a discontinuity on the graph. If the levels are similar this will not matter. Indeed more accurate results may be obtained from very fast or very noisy frequency sweeps by playing the sweep several times to the LA102 to ensure that as many samples as possible have been measured.

6.4 Automatic W&F Measurement on Test Tapes

The smart test tape mode (option 2) will also measure W&F, speed and phase if a suitable tone is detected while measuring frequency response. When a 3150Hz (±5%) tone is detected, the level is recorded for the frequency response graph, and then the LA102 displays a W at the top of the display and attempts to measure W&F, speed (assuming a 3150Hz reference) and phase. The tone must last for at least 13s for this to be successful, and the LA102 will continue with the frequency response measurement when the tone changes. The results are presented in the same format as for W&F segment W, and may

be displayed (by pressing PAGE and W&F), printed, tolerance tested, or read into a computer in the usual way.

This facility must be used with care, as some test tapes contain a 3150Hz tone at a different level to the frequency response section. The LA102 cannot distinguish between a 3150Hz speed test and a 3150Hz tone in a frequency response section, so the frequency response graph can be corrupted by the different level of the speed test tone. In such cases it is best to measure W&F separately; ie only play the frequency response section to the LA102 when it is in sequence option 2 to obtain a frequency response graph which can be stored or printed. The W&F can then be measured, either manually, or automatically by pressing SEQ OPTION 2 again and playing the speed reference section (ie the smart test tape mode can be used to measure W&F on its own without measuring frequency response).

7.0 Applications Advice

7.1 Tape Machines

The LA100 is ideally suited for testing and aligning tape machines. Test tapes may be used to measure speed and wow & flutter with the LA102 although it is quite feasible to make record-replay measurements for the latter (see section 2.14). Test tapes can also be used to measure the replay frequency response automatically using the LA102 test tape mode (section 6.1).

Head azimuth adjustment is best performed using level option 4 which provides separate bar graphs showing left and right channel level and mean, instantaneous and peak phase together with mean phase and phase jitter figures (section 2.9) while record frequency response adjustment is best done using a repeating frequency sweep (sequence 15 or 20 – see section 3.9). Bias is best adjusted by peaking the output level (10kHz input), setting a test level on the LA102 and then overbiasing by the prescribed amount - reading the amount of overbias directly on the LA102 numeric scale.

Tape machines can be evaluated very quickly using one of the supplied sequences. Sequence 11 is a general/tape sequence with a -10dB frequency sweep but for speed of testing it does not include wow & flutter measurement (this can be added by putting segment W on the end of the sequence - see section 4.2). Sequence 3 is aimed at cassette and cartridge testing using a frequency sweep at -20dB and it also includes a wow & flutter test. On a three head machine the measurements may be taken at the same time as they are recorded although this is not recommended if measuring wow & flutter. On two head machines the sequence may be recorded on to tape and played back later. It is even possible to record a sequence on a machine which is known to be very good and use that to test other machines.

Compression effects and noise reduction systems can be tested using frequency sweeps at multiple levels (see example in section 4.18) or by using the user level segment to measure the output level against input level (see section 4.13). Maximum output level (MOL) can be measured at 1kHz or 315Hz using segment H or h respectively (section 4.14).

A few tolerances are provided for use with tape machines: tolerances 11 - 12 are IBA tape tolerances which are also used by many organisations outside of the IBA. Tolerance 14 is a Lindos domestic cassette tolerance which we consider to be a reasonable specification for a domestic machine. Tolerance 15 is a Studer A812, 15ips specification. Note that any of these tolerances may be copied to a user tolerance and modified (if testing a Studer A810 for example). See sections 5.4, 5.6 and 5.8 for details.

7.2 Loudspeakers

The LA100 can be used to measure level, frequency response, distortion and phase on a loudspeaker. Ideally an anechoic chamber should be used to reduce the effects that room reflections have on frequency response. Loudspeaker measurements have proved very successful, using a microphone and pre-amp and relying on the FSK passing through the system although careful microphone positioning may be required (see section 3.13). A better approach is to connect the L output from the LA101 directly to the L input of the LA102 for FSK communication and connect the right channel through the loudspeaker/ microphone system. The LA101 can then be instructed to run the sequence test on the R channel only, either by pressing the $\boxed{\text{L/R}}$ key to select the R channel once the LA101 is in sequence mode, or by putting a channel selection command (section 4.22) into the loudspeaker sequence, for example:

"LOUDSPEAKER TEST" :3,2 T U D

Note that the delay between the FSK signal reaching the LA102 and the sweep will be small and largely insignificant. A loudspeaker to microphone distance of 1m will result in a 3ms delay which corresponds to 0.5% error in frequency using a 5s sweep segment (ie the result for 1kHz will actually have been measured on 995Hz).

Frequency response measurements may also be performed by using a weighted frequency sweep corresponding to the inverse of a reference system. The frequency response results will then show the deviation from the reference system (see section 3.19).

Polarity can also be measured if one channel is connected directly from the LA101 to the LA102 by including a phase segment (Z) in the sequence. The phase difference between the loudspeaker system and the direct LA101-LA102 path can then be measured on a loudspeaker known to have the correct polarity. This expected phase can even be included in a tolerance to simplify pass/fail testing. For example if the expected phase at 1kHz is +38°, the tolerance could be:

Z ?,,+38±20,?

This will ensure that the phase is within ±20° of its expected value (a result of -142° would indicate a polarity reversal).

7.3 Microphones & Low Level Inputs

Microphone inputs must be tested at a low level, typically -50dB. This is easily achieved by setting the LA101 output level to -50dB and then pressing $\boxed{*}\boxed{1}$ to set the test level. All output, including test sequences, will now be relative to this test level. Alternatively the test level may be set within the sequence definition, as described in section 4.21.

To avoid overloading the input when the LA101 is turned on, configuration S (Start up level) should be set to a suitable value (see section 1.6), or the start-up preset (as

determined by configuration S, but usually 4) should be programmed to a low level, or muted (see section 2.5). A third solution is to hold the MUTE key when the unit is turned on.

7.4 Lines, Links & Networks

The LA100 is ideally suited for testing lines, links and networks. An automatic test sequence can be generated by the LA101 and received by the LA102 at the other end of the line. All the relevant control and timing data, together with a source identification message, is sent over the signal path as FSK data.

If the line is normally used for programme material the LA102 can still be left connected as it will only respond to sequences sent from the LA101 oscillator, and it will never mis-trigger on speech or music. Every measurement can be compared against tolerance limits giving an immediate PASS/FAIL message using the pre-programmed British Telecom specifications EPS81, EPS84 or EPS98 lines tolerances or one of 15 easily entered user tolerances.

A test sequence would normally measure level, frequency response, noise, distortion, crosstalk and phase on a stereo link within a minute. A single channel sequence would take typically 30s, but either can be made faster by omitting some tests. Compression effects due to noise reduction systems or compandors can also be measured (section 4.13).

If testing a line during a short break in programme material, or even if testing during a broadcast, it may be desirable to perform a very quick test. Faster testing is achieved by carefully choosing the test segments used. For example, segment X performs a 20Hz-20kHz frequency sweep in 1½s and segment B measures crosstalk in 2s.

Obviously there are physical limits to the accuracy of the faster tests; testing a NICAM anti-aliasing filter for example will require a 20s sweep to fully test the very steep roll-off which cannot be followed by the rms rectifier on fast sweeps. Bad echoes or group delay (time smearing) on the line can also affect fast measurements; in particular the fast sweep may produce inaccurate results due to the frequencies not appearing at the times the LA102 expects them to, again a slower sweep (5s or 20s) will avoid this problem.

If the receiving end is unmanned it is possible to retrieve the results via a modem connected to the remote LA102. The entire test could then be controlled by a computer which would run the test sequence on the LA101 and then retrieve the results by dialling the remote modem. If the results are not required immediately the LA102 may be configured to store up to 5 sets of results automatically (see section 3.20) for later examination or printing, or alternatively it may be connected to a printer and configured to print the results every time it receives a sequence (see configuration A, section 3.4).

If the oscillator is at a remote site it can be left repeating a sequence continuously (or hourly or daily etc) allowing a test to be performed by simply connecting an LA102 to the other end of the line and waiting until a complete sequence has been received. Alternatively it is possible to trigger a sequence by applying a DC signal to the LA101 serial input, allowing control from a simple switch or timer (see section 3.25).

7.5 Mixing Consoles

Testing a system with a large number of channels can be time-consuming despite the fast automatic test sequences. The LA100 can test two channels with a single sequence and can also hold up to 6 sets of sequence results in its non-volatile memory. This means that results for up to 12 channels can be held in memory for later printing (see section 3.5). To minimise the risk of storing the results in the wrong memory it is possible to make the LA102 automatically store the sequence results in the next available memory, repeatedly cycling through the memories (see section 3.20). A computer can be used for storing large numbers of results on disk (using Lindos Support Software).

7.6 Filters and Equalisers

Filters and equalisers can easily be tested using an automatic test sequence providing the filter passes the FSK frequencies (1650 and 1850Hz). If this is not the case then connect the left channel directly from the LA101 to the LA102 and connect the right channel through the system being tested, as described in section 3.13.

It may be necessary to change the printed graph format to ensure that the area of interest is printed. This is easily achieved by setting configuration options E, F, G and H to determine the graph width, fit, scale and height respectively, as described in section 8.4. Similarly if an equaliser is to be tested at several different settings then configuration F2 should be set to make the vertical scale the same for each graph.

Some care is needed when testing very steep filters where a slow sweep (segment S) may be needed to accurately measure the frequency response (see section 3.9 and 3.10).

Filters can also be tested by entering the inverse weighting of the filter into the LA101 and section 2.27 explains how to define a third octave user weighting curve. The frequency can then be changed manually on the LA101 and the deviation from the ideal filter response can be read directly from the LA102 display. Alternatively, a weighted frequency sweep may be used, see section 3.19. For a very accurate measurement of the filter's response over a large dynamic range the user level segment (K) may be used, see section 4.13.

Tolerances can be defined to test the filter's response whether it is measured using a flat sweep, a weighted sweep or the user level segment.

7.7 Compact Disc Players

Compact Disc players should be tested using a test CD. Level, phase, noise, THD, quantising distortion and difference frequency distortion can all be measured manually with the LA102 providing that suitable test tones are available on the CD. Quantising distortion should be measured on a 40Hz tone as described in section 2.17. Frequency response can be measured on a frequency sweep track using the LA102's smart frequency sweep mode (see section 6.2) which will work with any frequency sweep (ascending or descending).

There are several test CDs available from Denon, Sony and Philips. Some are aimed at testing CD specific features such as tracking accuracy, error correction, track number features, emphasis filters, DAC linearity and the ability to recognize CD-ROM discs. Other discs are more suited for measuring the audio performance of the CD player or of other audio equipment using the CD player as the signal source (for example, many test discs provide a 3.15kHz tone for W&F measurement on tape).

7.8 Amplifiers

Amplifiers are best tested with their output connected to their normal working load impedance. For loudspeaker amplifiers this would typically be 4Ω or 8Ω while for line amplifiers the LA102 can provide the 600Ω load which is typically required. High power measurements can be performed, using a divide by 10 voltage attenuator and setting configuration W if necessary, as described in section 2.22.

7.9 Production Testing

Many manufacturers use the LA100 for production line testing, either by using the automatic test sequences together with pass/fail tolerance testing, or by using the LA100 under computer control where the computer can log the results on disk and also control the device under test. The Lindos Support Software may be suitable providing the testing is not too specialized although some manufacturers prefer to write their own dedicated software. Note that such dedicated software need not be too complicated because it can still use all of the automatic testing facilities (including pass/fail tolerance testing) provided by the LA100 and it is often a simple matter to send a few commands to do the test and read the results back for logging on disk. A full description of all of the remote commands is given in chapter 9.

7.10 Meter Testing

Meters such as PPM and VU meters can be tested for level accuracy and for response to tone bursts. Sequence 19 provides a PPM test and is explained in section 3.15. Other meters can be tested in a similar way by defining suitable tone burst segments (see section 4.16).

7.11 FM Transmitter Systems

European FM transmitter systems use a 50µs pre-emphasis filter (-3dB at 3183Hz) to amplify the high frequencies before modulation, and the FM receiver has a corresponding 50µs de-emphasis filter to restore a flat frequency response. This is to obtain the best noise performance from the system (since FM systems have correspondingly higher noise at higher frequencies) and is possible since programme material generally has a lower level of high frequency components.

Applying a test signal with a flat frequency response at full amplitude will therefore cause the FM system to overmodulate at the higher frequencies, while applying a test signal at a lower level will not test the system at maximum deviation. The solution is to use a test signal with 50µs pre-emphasis such that the higher frequencies are attenuated. This will ensure that the tests are performed with full deviation after pre-emphasis at all frequencies.

Sequence 17 has therefore been provided for testing FM transmitters using 50µs pre-emphasised tones for measuring crosstalk, distortion and phase (segments A, G and Y). The LA102 applies a corresponding 50µs de-emphasis on the crosstalk measurements to obtain true crosstalk levels relative to the level of the tone on the other channel (which is not measured since the LA102 refers crosstalk measurements to the measured test level – in case the interfering channel is not connected). Note that the distortion is always referred to the level of the fundamental of each tone so no correction is needed. This sequence also uses segment V to measure the test level at 400Hz instead of 1kHz (this is common practice to ensure that it is not affected significantly by the 50µs pre-emphasis). Similarly, it is often desirable to normalise the frequency response results to 400Hz and this is readily achieved by setting configuration J2.

Note that the 50µs pre-emphasis filters used before modulation can also be tested by using a standard sequence (such as sequence 11) with the 50µs weighting curve available in the LA101 (on weighting 9). This should not be used for testing the entire system, since the LA102 will not apply a 50µs correction for the crosstalk measurement, but it can be used for testing the pre-emphasis filter on its own where a flat frequency response is expected.

Similarly the 50µs de-emphasis filter in an FM receiver can be tested by copying this weighting curve to a user weighting and inverting it to make it boost the high frequencies, as is explained in sections 2.26, 2.27 and 3.19).

75µs pre-emphasis (for American use) can be defined as a user weighting using the weighting editor. The definition is included in the Windows support software.

8.0 Using Printers

The LA102 can print test results directly using a suitable printer with a serial (RS232 compatible) input. Virtually any Epson, IBM, Apple or Hewlett Packard compatible printer will work except for Postscript-only printers (most Postscript printers usually provide Epson or HP emulation so they can still be used). Other printers, such as daisy wheels can be used by making the LA102 only use standard ASCII codes without any graphics or control information.

The main benefit which a printer gives is the ability to print sequence test results, including high resolution frequency response graphs (as shown in figs. 3.11 and 5.4), but it can also be used to print LA102 tolerance definitions, LA102 configurations settings and the manual mode frequency, level and phase measurements. The LA101 cannot print anything as it does not have serial output capability.

If a parallel only printer is available, printing is still possible, either by connecting it to a PC and using our support software, or by using our SLP lead, which has a serial to parallel convertor built into the plug.

Sections 8.1 and 8.2 explain how to make a printer work with the LA102. The later sections explain how to change the format of the print, how to choose a printer and details of particular printers.

8.1 Setting Up the Printer

The Lindos SL2 serial printer lead, supplied with the LA102, is suitable for most printers (but not the Epson LQ800, LQ850, LQ860, P40 or P80). Plug the 5 pin DIN plug into either of the LA102 serial interface sockets and the 25 way D connector into the printer's RS232 serial port (see appendix C for wiring details). Do not connect a computer (or any other serial device) to the LA102's serial port at the same time as this will result in a clash of handshake signals.

Some printers only provide a parallel port as standard in which case either a serial interface or our SLP lead will be needed. For Epson printers the MCS0K (available from Lindos) or the 8143 interface should be used. Some interfaces also provide buffers (typically 16K or 64K) which will hold the print data and free the LA102 more quickly.

The printer should be set up to receive serial data at 9600 baud using 1 start bit, 8 data bits, no parity and 1 stop bit. This is normally achieved by setting DIP switches on the printer, or on the serial interface board, using a small screwdriver or pencil although the cover may have to be removed on some printers. If obtained from Lindos the printer will already have been set up correctly and tested.

Other switches may be provided for handshake mode in which case DTR/CTS handshaking should be selected (this is usually the default, but some printers also have XON/XOFF handshaking which the LA102 cannot use). Other DIP switches might control draft/NLQ mode, character set (country), automatic line feed (LF) on (CR), condensed typeface etc, but these settings are not too important and may be set however is convenient. For example, if NLQ mode is always used for customer's printouts it may be desirable to make the printer default to NLQ mode by setting a DIP switch.

The LA102 must be told which type of printer it is using by setting configuration P to the appropriate value (see table 8.1 and section 8.4). Configuration P1 (the default) is suitable for all 9 pin dot matrix printers which are Epson (ESC/P) or IBM compatible. Configuration P2 or P3 should be used for Epson P40 and Epson P80 printers, but will in fact work with any Epson compatible. Configurations P4 and P6 are for the rather obscure HP Thinkjet and Apple Imagewriter respectively (not recommended). Configuration P5 is similar to P1 but sends a code to select NLQ printing to give better quality (but slower) printouts on printers which support this. Configuration P7 is for Epson LQ and other 24 pin printers. Configuration P8 or P9 are for HP Deskjet printers, giving a choice of graph size and resolution (P8 prints larger graphs, P9 prints slightly smaller ones). Note that the printer will probably print rubbish if the setting is not correct.

It is also worth ensuring that configuration B7 is set to make the LA102 operate at 9600 baud (occasionally it may be necessary to use other baud rates, perhaps with a printer which only works up to 4800 baud, but 9600 baud is used for most purposes and slower baud rates will normally reduce the printing speed).

8.2 Printing

To print the sequence results simply press ✻ PRINT when in manual or sequence mode (see section 3.4). This will print the results from the working memory (0). To print results from other memories they must first be recalled or exchanged with the working memory (see section 3.5). Multiple copies of the results can be printed by pressing ✻ PRINT and then, without releasing the ✻ key, pressing ✻ 1 to ✻ 5.

To print all of the tolerance definitions, enter the tolerance editor by pressing ON/OFF 1 and then press ✻ PRINT, as described in section 5.6. To print the current configuration settings, press ON/OFF 2 to enter the configuration editor and then press ✻ PRINT (see section 1.6). The measured frequency, level and phase from manual mode can be printed by pressing ✻ LISTEN, as explained in section 2.23

It is also possible to make the LA102 print the sequence results as soon as a sequence is received by setting configuration A (see section 3.4).

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A	Auto Print Seq	**A0 Off**, A1 On, A2 2 Copies, A3 3 Copies, A4 4 Copies
B	Printer baud rate	B1 75, B2 150, B3 300, B4 1200, B5 2400, B6 4800,
		B7 9600, B8 110, B9 19200
D	Distortion display	D1 %, **D2 dB**
E	Graph width	**E1 Normal (6cm)**, E2 Wide (12cm)
F	Graph fit	F0 0dB, **F1 Peak**, F2 Centre 0dB
G	Graph scale	G1 ¼dB/cm, G2 ½dB/cm, G3 1dB/cm, G4 2dB/cm,
		G5 4dB/cm, G6 8dB/cm
H	Graph height in cm	0, 1, 2, 3, **4**, 5, 6, 7, 8, 9, 10
I	Lines per inch	**6**, 7, 8, 9
J	Graph normalisation	J0 Absolute, J1 315Hz, J2 400Hz, **J3 1kHz**
M	Top margin in 1/6" lines	**0**, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
N	Page length in 1/6" lines	60-76 lines, default is **66** (ie 11")
P	Printer type	P0 ASCII text only. Lines terminated with LF.
		P1 Epson FX LX RX/IBM (9 pin printers using ESC/P)
		P2 P40 (40 column mode)
		P3 P40 (80 column mode)
		P4 HP Thinkjet
		P5 Epson FX/LX/RX. As for P1 but NLQ mode is set.
		P6 Apple Imagewriter
		P7 Epson LQ 24 pin and most other 24 pin printers
		P8 HP Deskjet using 100dpi resolution for graphs
		P9 HP Deskjet using 150dpi resolution for graphs
		P10 CSV - allows results to be directly loaded to most
		spreadsheets and word processors.
X	Date operation	**X0 Not printed**, X1 printed, X2 advanced at switch on

Table 8.1 LA102 Printer Configurations

8.3 Printout Format

When the sequence test results are printed, the format is similar to that used on the screen, but the headings are extended and tolerance details are added when tolerance testing is in use. Sequence results will usually fit onto a single test sheet, although the LA102 will start a second sheet if it needs to. It is often desirable to squeeze such printouts onto a single sheet by increasing the number of lines per inch (section 8.4, configuration I), reducing the graph height (section 8.4, configuration H) or by suppressing unwanted results values (section 5.5).

Frequency response graphs are always stored as 256 points with 1/256dB resolution, so the printed graph will be much higher resolution than that seen on the 84×32 pixel display.

8.4 Printers and the Configuration Menu

Various configuration options determine the printer type, baud rate and printout format. Hold ON/OFF and press 2 to obtain the configuration menu on the LA102, as described in section 1.6. Then move the cursor with the PAGE and OPTION keys until it is under

the appropriate configuration letter and use $\boxed{<}$ and $\boxed{>}$ to change the setting. The baud rates and printer types and other printer related configurations currently implemented are shown in Table 8.1. All configuration settings are retained in non-volatile RAM and many only need to be set once.

Configuration B sets the printer baud rate (which must match that of the printer) and configuration P sets the printer type (see section 8.1) Configuration P0 is for use with printers that are not otherwise supported (ie are not Epson, IBM or Apple compatible), and only outputs ASCII text with no control codes other than Line Feed (ASCII 10) and Form Feed (ASCII 12). All graphics and highlights will be lost, and configurations for page length and line spacing will be ignored, but this should enable printing on virtually any printer, including daisy-wheels! This mode can also be useful for transferring data to a computer without any programming by directing serial input to a file using a terminal emulator or a copy command and then pressing $\boxed{*}\boxed{\text{PRINT}}$.

Configuration N (50-99) sets the page length in units of 1/6" (the standard line spacing on most printers). For 11" fan-fold paper, or A4 paper in a sheet feeder, set N66 (this is the default value). For continuous A4 paper set N70.

Configuration M (0-12) determines the top margin and is useful when printing on headed paper. The number determine the number of 1/6" blank lines output at the top of each page (1/6" regardless of the line spacing setting). M0 is the default which doesn't leave a top margin.

Configuration I determines the number of lines per inch and defaults to 6. Setting I7, I8 or I9 gives 7.2, 8 or 9 lines per inch respectively and is useful when a printout will not fit on a single page at 6 lines per inch but will with more lines per inch (although 8 and 9 lines per inch look rather squashed)

Configuration D1 will change the distortion printout to read in % rather than dB (but can be overridden by pressing $\boxed{*}\boxed{>}$ when the distortion results are displayed) and configuration G and H allow the graph scaling and graph height to be set in dB/cm and cm respectively (note that these values are not exact and are generally rounded to the nearest cm to give an approximate indication). Setting configuration H0 will cause the graphs to be omitted while options H1 - H3 print a small graph reducing print time. Configuration X1 will cause the date heading to be printed in the heading (see section 3.21 &3.22 for details).

Configuration E determines the printed graph width. E1 (the default) prints a normal width graph while E2 prints an extended width graph with the frequency response table printed beneath it. The actual width depends on the type of printer, but Epson printers will print 6cm or 12cm graphs for configurations E1 and E2 respectively.

Configuration F determines graph fitting on the printout and can be set to ensure that the

important part of the graph is visible. Setting F0 always places the 0dB axis in the top half of the graph and loses the peak if necessary. Setting F1 (peak) always shows the peak even if this means not showing the 0dB axis. Setting F2 always centres the 0dB axis and this can be useful where several graphs are required all with the same scale.

8.5 Choosing a Printer

Printers have changed a lot over the last few years; they have become much cheaper and faster. Nine pin impact dot matrix printers have improved significantly but are still relatively noisy. 24 pin printers give better quality for a slightly higher cost.

Ink-jet or bubble-jet printers offer superb quality at a low price, without the noise. They are still slightly more expensive than most dot-matrix printers although the prices are falling rapidly and then can be highly recommended (this manual was typeset using a low cost Deskjet printer and then photo-reduced to 70%). Both Canon and Hewlett Packard offer portable models.

Laser printers also offer high quality, but are usually larger and more expensive.

Some printers have print 'buffers' or 'spoolers' which can hold a large amount of data freeing the LA102 before printing has finished. A typical Lindos printout to an Epson printer contains about 14Kbytes of data which can be held entirely in a 16K printer buffer (freeing the unit in 10 or 20 seconds). Even an 8K buffer can free the unit fairly quickly.

Even the cheapest printer will produce acceptable results, although if the test sheet is being issued with equipment to a customer, it is often worth paying slightly more for a better printer. It is also worth considering whether the printer is going to be used for other purposes, perhaps with a computer.

The times taken to print a typical printout for sequence 3 results using the default graph size settings are:

Epson FX850	37s	(draft mode)
HP Deskjet 500	45s	(standard mode – draft mode similar)
Epson LX850	55s	(draft mode)
Canon BJ200ex	38s	
Epson LX300	48s	

8.6 9 Pin Dot Matrix Printers

The cheapest kind of printer is the 9 pin impact dot matrix which uses 9 hammers to strike an inked ribbon to form an image on the paper. They are very noisy, and fairly slow, but they are cheap to run. Since each character is made up by a 7x9 array of pixels the quality

is fairly poor, although most 9 pin printers provide a Near Letter Quality (NLQ) mode which means they feed the paper slightly and print a second set of 9 dots interleaved with the first to double the vertical resolution. NLQ printing takes twice as long as 'draft' mode printing but does give much better results. The NLQ mode is usually selected by pressing a button on the front panel, or it can be selected by setting configuration P5 on the LA102.

Most 9 pin dot matrix printers are 'Epson compatible' which means they use the Epson Standard Codes for Printers (ESC/P) for text effects and graphics. The IBM standard is very similar to the Epson one but not quite the same. The LA102 actually uses a subset of Epson and IBM codes which will make it work on either of these, providing configuration P1 is set.

We have tried a wide range of 9 pin printers from several manufacturers, and all are suitable for use with the LA102 providing a serial interface is fitted to the printer where necessary (or the Lindos SLP lead is used). A typical printout from an Epson FX850 is shown in fig. 3.11 (reduced by 70% from the original).

8.7 Epson LQ and Other 24 Pin Printers

Epson LQ and other 24 pin Epson compatible printers give reasonably high quality print and can be used with the LA102. *Epson LQ* printers have a serial interface built in, but they use a 5 pin DIN connector so they need a Lindos SL7 printer lead instead of the more usual SL2. See appendix C.3. Set LA102 configuration P6. For simplicity in the LA102 only the 8 pin graphics modes are used and this results in taller graphs than Epson FX and other 9 pin printers.

8.8 Inkjet Printers

Early Hewlett Packard Deskjet printers were fitted with a serial interface as standard, but more recent ones are parallel only. For parallel only, obtain a SLP lead from Lindos; if your printer has a built in serial interface use the standard Lindos printer lead. Set configuration B7 for 9600 baud and configuration P8 for 100dpi graphics or P9 for 150dpi graphics. The printed graph contains the same number of pixels whichever setting is used, but setting P9 will print smaller graphs at a higher resolution. It is best to experiment and see which you prefer, but remember that configuration E2 can be set for double width graphs and configuration H can be used to increase the height (unfortunately configuration H does not represent the true height in cm as for Epson compatible printers because it actually determines the number of head passes used to print the graph). The printer's DIP switches B4, B5, B6 and B7 should all be down (9600 baud, 8 data bits, no parity).

HP Laserjet compatible printers should be suitable providing normal width graphs are used (configuration E1), but it will depend upon the built-in fonts and the range of control

codes implemented. Most *Laserjet II* compatible printers will not print the double width graphs which the LA102 sends in two halves (unfortunately this is necessary because the LA102 does not have enough free internal RAM to hold a full strip of the graph).

Most other types of inkjet printer (Canon, Epson, etc) can be configured to emulate either HP Deskjet or Epson. At the time of writing, the Canon BJ200 printer operating in its Epson emulation mode, and ishighly recommended. It produces high quality output, is fast, and is cheap to buy and run.

8.9 Portable Printers
The HP 340 or the Canon BJ30 are suitable. Set-up as described for deskto printers described in section 8.8

8.10 Printer Problems
In case of printer problems refer to the list of common symptoms and their likely causes below:

NOTHING PRINTED Does the LA102 display "NO HANDSHAKE"? If so, check the handshake line connections, otherwise check the data line connections and baud rate settings. Check printer's handshake and baud rate switch settings (see section 8.1)

GARBAGE PRINTED. If there is no recognisable (meaningful) print **at all** (ie no recognisable words) the printer's baud rate is probably set differently from the LA102's baud rate. If some words are recognisable amongst the rubbish then the baud rate must be correct. In which case it could be a handshake problem with the printer losing characters when its buffer becomes full, or it could be due to the printer expecting parity bits.

COLUMNS NOT ALIGNED. Proportional spacing may have been selected on a DIP switch or via the front panel controls. If so turn it off and reset the printer. Alternatively, the printer may not be performing carriage return upon receipt of line feed character. Check printer's DIP switch settings (in particular "AUTO-CR", if there is one, should be on).

GARBAGE BELOW THE 'FREQUENCY RESPONSE' HEADING. Does any of the graph appear? If not check that the printer supports the graphics codes used and that the mode switches are correct ("Alternate" mode for the HP Thinkjet etc). Try setting option H0 to suspend graph printing.

GRAPH RUNS OFF RIGHT OF PAPER. Check the LA102's configuration settings, especially printer type. Try setting configuration P3 or P2. Also ensure that the paper is loaded correctly.

LINE SPACING INCORRECT. Check that printer is in "Epson ESC/P mode" and not

in "IBM mode" (set by a DIP switch on the printer). Epson mode is recommended and is in more widespread usage although most IBM compatible printers should work. Does the printer support the ESC 2 and ESC A codes?

LA102 DISPLAYS 'REMOTE' when printing is started. The LA102 is going into remote mode because it is seeing data coming in via the serial port. This will never happen with Lindos SL2 printer leads, as the data input line is not connected, but some users who make their own leads sometimes connect this line (unnecessarily) to the printer's data output line. If the printer is generating XON/XOFF characters then this can cause the LA102 to go into remote mode. The solution is to disconnect the LA102 data-in line, and also ensure that the printer is set for DTR or CTS handshaking (most printers can be switched between DTR/CTS and XON/XOFF handshaking, but usually still generate DTR/CTS handshake when generating XON/XOFF handshake).

9.0 Remote Control

The Lindos LA101 and LA102 can be controlled remotely via their RS232 compatible serial data interfaces. A remote computer can set parameters, perform measurements, run test sequences and read results. For production testing the computer can be used to log the results on disk, and perhaps control other pieces of equipment at the same time, or prompt an operator to make adjustments. Lines and links to or from remote sites can be tested using a modem to control the LA101 or the LA102 over a telephone line. The LA101 can be commanded to run a test sequence, or the LA102 can be instructed to receive a sequence and return the results. Sequence test results can be stored on disk for later examination or printing, and this is especially useful where the LA102 results memories are insufficient. A small lap-top computer can be taken with the LA100 to a site, and hundreds of sequence results can be stored on disk. Remote control can also be useful in a studio or lab (perhaps where the LA100 is rack mounted and not easily accessible) as the computer provides a large high-resolution screen and full size keyboard.

The value of computer control then lies in its ability to present the results in a special way, make pass or fail decisions, control other special hardware or save results to disk for future reference.

Alternatively, the reason for using a computer may be to construct tests which are not already provided in sequences. Operator interaction may also be needed, for example the operator may be required to adjust the bias on a tape recorder for a specified result before the program proceeds to its next test. A wide range of commands are provided which enable both test signals and measurements to be fully determined. These require a little thought with regard to timing, and in some cases settling delays will have to be determined and programmed in. In other cases, where a known result is expected, very fast results may be achieved by fixing the measurement range in advance. Lin4WinXP provides this fascility in the form of procedure testing. The user sets up a series of measurements in a table and clicks run to log the results. Special purpose commands are provided to extend settling delays, disable auto ranging or pause the procedure until a key is pressed. Consult the Lin4WinXP manual for full details.

Note that it is also possible to trigger sequence operation from a simple switch and this is explained in section 3.25.

The Lin4WinXP support software will be sufficient for many applications, and is available for computers runnings Windows. See the Lin4WinXP documentation accompanying the unit for more information. Users who prefer to write their own software to control the units will find a full description in sections 9.3 to 9.22.

9.1 Connecting the LA100 to a Computer

Most computers have a suitable RS232 (or RS423) compatible serial port and connection is extremely simple using the relevant Lindos leads (see appendix C for order codes and wiring details). Only one serial port is needed in the computer, even when connecting both the LA101 and the LA102, although a second serial port may be useful for connecting a mouse, serial printer or other serial device.

Two serial interface sockets are provided on each LA10X unit, connected in parallel. The units are normally connected together, using one socket on each, and then one unit is connected to the computer serial port, as shown in fig. 9.1. Such 'daisy-chaining' is possible because the two units share a common command set, and the LA101 has no output or handshakes; only an optically isolated remote input; so there is no danger of both units trying to drive the same line.

A printer should not be connected at the same time as the computer as this will result in a clash of handshake signals. It is much better to connect the printer directly to the computer. The Lindos Support Software can be used to print results files using the PC's printer driver.
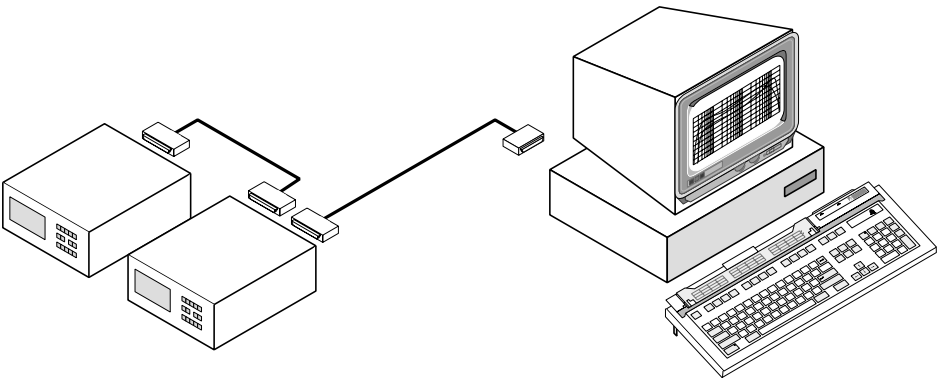
Fig. 9.1 Connecting the LA100 to a Computer

The LA102 has a full bi-directional serial port so it can receive commands from the remote computer and also return results and status information to the computer. The LA101, however, only has a serial input port, and cannot therefore send data back to the remote computer. As well as avoiding bus contention, this also means that the oscillator remains floating when connected via a serial lead since the serial input is optically-isolated, and there is no common ground connection between the internal LA101 ground

and the computer ground. The lack of serial output is not a problem since there is usually no need to read data from the LA101.

If an LA101 is connected for remote control without an LA102 then the computer will probably require a handshake signal before it will output anything. This is easily arranged by inserting a 'dummy handshake plug', with pins 2 and 5 wired together, into the spare serial interface socket on the LA101. This returns the computer's handshake output to its handshake input.

When connecting the LA100 to an Acorn BBC computer it is important to insert the plug into the BBC's socket with the correct orientation. The BBC computers use sockets with two polarising slots and it is essential that the plug is inserted with its key in the left hand slot as viewed from the rear of the computer. We recommend blanking off the redundant slot with a small piece of plastic and adhesive!

9.2 The RS232 Serial Data Format

The remote computer should be configured to use the same serial data format as the LA100: 1 start bit, 8 data bits, no parity and 1 (or more) stop bits. The CTS and DTR lines are used for hardware handshaking - see Appendix C for wiring diagram. XON/XOFF or software handshaking is not supported. Fig 9.2 shows the voltage levels and timing of the serial interface. Note that the handshake out of the LA102 is generated during the MSB of a character, ie ahead of the stop bit, minimising problems with equipment that is slow to respond, and it is important that no data is sent when the LA102 handshake line indicates that the unit is busy. It is possible to communicate with the LA100 without handshaking providing sufficient time is allowed after sending every command to allow the unit to complete it.

Note that the serial input port (but not output) is in fact TTL level compatible (since the threshold is +2V) and can therefore be driven directly from a TTL output providing the necessary serial data driver software is written (this is useful if the controlling computer doesn't have a serial port).

The LA100 will work at various baud rates from 75 baud up to 9600 baud, determined by configuration R. The default is 300 baud which is available on virtually all computers and modems, and it is therefore recommended that the LA100 configuration is never changed from this. Indeed the Lindos Support Software always expects the LA100 to be set for 300 baud when it initially establishes communication and it will automatically switch to a higher baud rate (if possible) when communication is established.

9.3 Entering Remote Mode

To put the units into remote mode, the computer should send a BREAK (logic 0) pulse lasting between 120 and 250ms and then wait 200ms before sending any characters.

Data in/out

| | start | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | stop |

+5V 0
-5V 1

LA102 Handshake Out

+5V 0   **Ready to receive**   **Not ready**

-5V 1

Input threshold:	+2V	Output levels:	±5V (RS232/423 compatible)
Input range max:	±15V	Output current:	5ma (short circuit protected)
Input current at 5V:	3.5mA	Inputs will accept RS232/423 or 5V TTL signals	
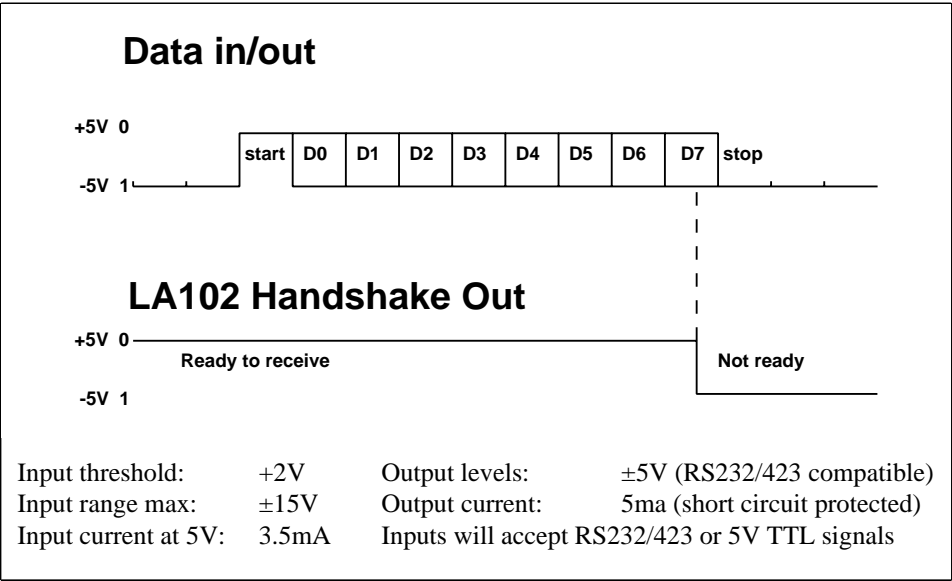
Fig. 9.2 LA100 Serial Interface Specification

Alternatively, send a NULL character (ASCII 0) at 75 baud instead of the break (this is equivalent to a 120ms break). This is necessary to gain the units' attention since all serial communication is handled in software. The LA101 and LA102 will both display REMOTE on the screen together with the configured baud rate (usually 300). All keys are disabled, except [LISTEN] which may be used to change the monitor volume and [ON/OFF] which may be tapped to reset the unit to manual operation. These keys must not be pressed when serial communication is in progress as even changing the volume may cause the unit to miss data.

Some care may be needed when changing the computer's baud rate as it is necessary to ensure that the output buffer is empty before selecting a new baud rate to prevent data being corrupted or lost. Note that most serial chips will have at least a two byte buffer, so it is not always good enough to ensure that the computer's output buffer (implemented in software) is empty, because the serial chip may still be transmitting data. It may therefore be necessary to wait a short while after sending a character before changing baud rate.

It is also a good idea to send a Carriage Return (CR) character after changing the baud rate, to flush the LA100 line input buffer and ensure that it is ready for a command. This is not strictly necessary, but it will make the system recover if it was left in a peculiar state (perhaps by unplugging or resetting the computer during a previous communication).

To summarise the procedure for entering remote mode:

> Send a BREAK (or set 75 baud and send a null character)
> Wait 250ms
> Set 300 baud
> Send a Carriage Return (CR, ASCII 13)
> Send a 'BR7' command terminated with a CR
> Wait 200ms
> Set 9600 baud

A few very old computers can only operate at a single baud rate and cannot generate break signals. In such cases it is still possible to use them with the LA100 by setting the LA100 configuration R baud rate (see section 1.6) to match that on the computer. The LA100 can be put into remote mode by sending a character (Carriage Return or Null are preferred), but several attempts may be needed before the LA102 responds, especially at higher baud rates, because its processor only checks the remote input for activity at intervals between updating the display. In such cases the LA102 will respond better if it is in PAGE mode, where it does not have to monitor the input and update the display continuously.

9.4 Command Format

Commands are sent as a single line of text, terminated with a CR character (ASCII 13), using the ASCII character set (American Standard Codes for Information Interchange). Most commands are two upper-case letters often followed by numeric or text parameters separated by commas. Most parameters are optional with sensible defaults, and may be omitted by simply leaving the field blank but still sending the separating commas, to indicate which values have been omitted. Trailing commas do not need to be sent. For example, SQ0,1,3,3 could be sent as SQ0,1,,3 or simply SQ,1. Table 9.3 lists the available commands which are described fully in the remainder of this chapter.

Commands are executed on receipt of the CR which should appear at the end of every command line. No spaces are allowed (even at the end of the line) except in headings. Line feed characters (ASCII 10) should not be sent. When operating at or below 300 baud the LA101 and LA102 will display incoming characters on the LCD as they are received and this can often help isolate communication faults. Above 300 baud the received characters are displayed when the whole line has been received (terminated by a CR).

When a command has been sent to the LA102 the handshake line from the unit will be set to prevent further characters being sent while the unit processes the command, so it is quite acceptable for the controlling program to send the next command immediately (since the operating system should hold it up while waiting for the handshake to clear). However, when sending commands to the LA101 (or if communicating without hardware

handshaking), the computer should allow a small time delay after every line to give the unit time to execute the command (typically 80ms). Some commands will obviously take longer than this, and this is explained with the relevant commands descriptions below. Running a 20s sweep, for example, will take an additional 20s, and this must therefore be allowed for.

Most values returned by the LA102 are in ASCII form with a single value per line and each line terminated with a CR character. Sweep data, however, is sent as 2 byte 16-bit binary numbers, in order to minimise the time spent transferring data, and this is explained fully in section 9.16. The characters in the text parameters (sequence, tolerance, and heading definitions) should generally be limited to the characters available in the unit's built in editor (see sections 4.2 and 5.6) as other characters (including many lower case letters) may not be displayed correctly on the LA100 display (which has a limited character set). However, if the built in editors are not being used it is possible to use any ASCII character, and characters will of course be printed correctly on the printout.

Some remote commands are unique to one unit, others are recognized by both units. To send a command to one unit only, prefix it with a '1' (for the LA101) or a '2' (for the LA102). If this is not done and one of the units does not recognize the command then it will generate a 'BAD COMMAND' error. This does no harm, and can be safely ignored, but it is good practice to avoid it by using the relevant prefix. For example '1KB' will cause the LA101 to return to keyboard mode leaving the LA102 in remote mode.

9. 5 Some Examples

Before writing any software to control the LA100 it is a good idea to become familiar with some remote commands by using either the 'Remote Commander' provided with the Lindos Support software or a suitable terminal emulator program. Once the unit is in remote mode (see section 9.3), try typing the following commands, shown in bold (the text in italics indicates example text returned from the LA102):

Command	Returned text	Comment
RS		reset the LA100
VL6		set volume 6 (in the range 0-16)
1FR6300		set the frequency to 6.3kHz
1LV+8		set +8dBu
2L?	*+8.01*	measure the level in dBu
2P?	*-2*	measure the phase in degrees
2IC2		input channel=2 (right)
2FN4,4		Set function 6.3kHz distortion
2L?	*-85.59*	read (normalised) 6.3kHz distortion
2E?	*0*	read error number (see appendix E)

Note that commands with a question mark return data. Sequences can also be used from remote mode. For example:

Command	Returned text	Comment
1DS0,TUDW		Define sequence 0
2MC0		Clear results memory
SQ0		Run sequence 0
E?	*0*	Ensure no error occurred (0=OK)
2R?		Read segment lists
	+TUDW	Left channel segment list
	TUD	Right channel segment list
2R?,D		Read distortion results
	-87.3	100Hz left channel
	-87.5	100Hz right channel
	-90.2	1kHz left channel
	-90.7	1kHz right channel
	-85.6	6.3kHz left channel
	-84.3	6.3Hz right channel
2R?1,W	*0.0039*	Weighted W&F
	0.0015	Unweighted W&F
	-1.2	Phase in degrees
	+0.3	Speed error in %

All of these commands are fully described below.

9.6 Hints on Writing Programs

Before writing a program to control the LA100 it is recommended that the programmer is familiar with at least the basics of manual or sequence modes, as described in chapters 2 and 3.

It is recommended that all programs assume the LA100 to be set to 300 baud and enter remote mode as described in section 9.3, selecting a higher baud rate once communication is established. For most applications 9600 baud will be used, but note that the LA102 can actually output data at 19200 and will support split baud rate operation. Providing the computer supports it, it is therefore possible to send commands to the LA100 at 9600 and receive returned data at 19200. Acorn BBC computers can do this, but most PC compatibles cannot.

All LA100 communication should be through a handful of procedures: one to enter remote mode; one to leave remote mode and return the units to keyboard control; one to send a line of text to the LA100 (with the necessary handshake and timing built-in); and one to read a line of text from the LA102. If frequency response graphs are being read

General Purpose Commands   **(section 9.8)**

RS	Reset (frequency, level, channel, measurement etc)
TR	Total reset and return to manual mode (equivalent to tapping $\boxed{\text{ON/OFF}}$)
KB	Return to manual mode (keyboard control)
DT	Display test. Display goes all black and then all white on next char.
ID	Identify. Unit display serial and version numbers.
ID?	Read unit identity. LA102 returns serial and version numbers.
BR$n,m$	Set remote baud rate. Input baud rate code n, output code m (7=9600)
SCxn...	Set configurations (eg SC P0,R3)
RC?	Read configurations
VLn	Set monitor volume (0-16)
E?	Read last error number (see appendix E)

LA101 Output Commands   **(section 9.9)**

OCn	Set output channel. $n=0$ both off, $n=1$ L only, $n=2$ R only, $n=3$ L+R
FRn	Set frequency in Hz (4.7 to 37878).
LVn	Set level in dB
TLn	Set test level in dB
WFn	Set output waveform ($n=0$ sine, $n=1$ square etc)
OZn	Set output impedance in ohms
ZCn	Set impedance correction ($n=0$ off, $n=1$ on, $n=2$ MC, $n=3$ HC)
F:n	Set frequency by code (see appendix F.2)

LA101 Preset Commands   **(section 9.10)**

FP$f1,f2,f3$...	Program frequency presets for use in manual mode
LP$v1,v2,v3$...	Program level presets for use in manual mode

LA101 Frequency Sweeps & Tone Burst Commands   **(section 9.11)**

SW$f1,f2,d$	Generate a frequency sweep (see appendix F.2 for frequency codes)
TS$t1,t2,d$	Generate third octave frequency sweep
TB$f,d$	Generate tone burst, frequency f Hz, duration d ms.

LA101 Weighting Curves   **(section 9.12)**

WCn	Apply weighting curve
DWn...	Define weighting curve n

LA102 Measurement Commands   **(section 9.13)**

ICn	Set input channel ($n=1$ left, $n=2$ right)
FN$n,m,g$	Set Measurement Function n ($n=1$ Level, $n=2$ Noise etc.) and option m
F?n	Read input frequency in Hz
L?n	Read input level (measurement function determined by last FN)
P?n	Read phase in degrees
RNg	Set level range g

Table 9.3 Remote Command Summary

RN?	Read the level range
AR	Enable autoranging
IZ*n*	Set input impedance
M?*p,n*	Rapid level measurement: *n* samples with sampling period *p* ms.

Running a Sequence (section 9.14)
| SQ*n,m,c,r* | Run and receive test sequence *n*, segment *m*, channel *c*, register *r* |
| SP*n,m* | Set sequence parameters. *n* is measurement code, *m* is timeout period |

Defining a Sequence (section 9.15)
| DS*n,xxx...* | Define sequence *n* to be *xxx...* |
| DI*n,id* | Define source identity |

Reading Sequence Results (section 9.16)
SR?*r*	Read results as a single block of ASCII text
S?*r*	Read frequency sweep graph results for register *r*
R?*r,xxx...*	Read results for register r
RR?*r,xxx...*	Read results with measurement level
PR	Print results (ie return data as if to printer)

LA102 Heading and Date (section 9.17)
DH,*xxx...*	Define printout heading
RH?	Read printout heading
SD*d,m,y,h,n,s*	Set date and time
RD?	Read date and time (*d,m,y,h,n,s*)

Tolerance Testing (section 9.18)
CT*n*	Check tolerance *n* and return list of failed segments
ST*n,xxx...*	Set tolerance definition (*n*=1 to 5) to *xxx...*
RT*n*	Read tolerance *n* (as a single line)

Memory Operations (section 9.19)
MC*n...*	Memory clear
MR*n*	Memory recall
MS*n...*	Memory store
MX*n...*	Memory exchange

Using the Smart Sequence Modes (section 9.20)
| SM*n* | Smart sequence mode (n=2 Test tape, n=3 Frequency Sweep mode) |
| IN | Interpolate smart sequence results |

User Sweeps (section 9.21)
| US*s,f1,f2,d,l* | Define User Sweep Segment |

then another procedure will be needed to read a binary byte from the LA100, and it is important to ensure that all bytes can be read (some communications libraries particularly on Unix or MSDOS systems may interpret ASCII 4 or ASCII 26 as an end-of-file character and terminate, so it is important that a raw-binary mode is used for this, where relevant).

It is good practice to allow for communications failures, perhaps caused by the LA100 being disconnected, turned off, or interrupted (by a user reset). If during the initial communication the handshake line is always set, preventing data from being set then it is reasonable to assume that the LA100 is not connected (or perhaps the LA101 is connected without a dummy handshake plug). Similarly, if the handshake line is set during normal communication, or if the LA102 does not return data when it is expected, it is reasonable to time-out and generate an error. Note however that a few operations can take a long time. In particular, running a sequence can take up to 4 minutes (in extreme cases), or if waiting for a sequence with the LA102 timeout disabled, it could be several hours!

If measurements are being made under computer control it is good practice to start by sending an RS command to reset both units. If sequences are being used this is not too important since the LA100 will automatically set the necessary parameters.

Though not essential it is good practice to check that all segments in a sequence have been correctly received by following the SQ command with E? or R?. This command will be held back by the LA102 handshake line until the sequence has finished (or timed out). It is good practice to specify measurement functions in full (function and option) to avoid confusion. When using the L? command to read levels remember that the first reading may not have settled fully, especially on slow rectifiers like PPM or if range changing has occurred. Send L? to autorange followed by L?n to return an averaged value, with a short time delay in between if necessary.

9.7 Errors

The LA101 or LA102 can generate errors and display error messages on their LCD. The error number for the last LA102 error can be read using the E? command and this also clears the error message (on both units), but note that it is not possible to read the error status from an LA101 (see section 9.1). An error number of 0 indicates that no error has occurred since entering remote mode or last reading the error number (ie reading the error number also clears it to 0). Errors are not fatal in themselves, although it is important that the remote computer takes the appropriate action.

Typical events which can cause errors include bad commands, FSK failure, serial communication failure, out of range parameters etc. A full list of errors is shown in appendix E, but note that only the errors which have a number beside are relevant to remote mode.

9.8 General Purpose Commands

These commands control various LA100 settings, but are not related to audio measurement in any way. Most commands are common to both units, but remember that commands can be prefixed with a '1' or a '2' to make them only affect the LA101 or LA102 respectively.

Reset: RS

Performs a reset to default values equivalent to manual reset but without leaving remote mode. Output frequency and level are set to values determined by configurations S and T. This command does not reset parameters set by the SP command.

Total Reset: TR

Perform a total reset and return to manual operation. The serial number and version are briefly displayed.

Return to Keyboard Control: KB

Return unit to manual keyboard operation but leave all settings for examination. Adding a 1 (KB1) will restore the frequency, level, channel selection and test level to the state before remote mode was entered.

Display Test: DT

Display goes all black. On next character received it goes all white. A further character returns normal remote mode ready for next command.

Identify: ID

Unit displays its serial number and version number, together with its special initialisation message (if it has one) on the bottom two lines of its display.

Read Unit Identity: 2ID?

Read LA102's serial number and version number (separated by one or more spaces) followed by a Carriage Return (CR). eg V6.5 software might return: '6643 V6.5'. This command can also generate an error (128 or 129) indicating a unit failure, so it is wise to read the error number with E? and report any problems to the user. Error number 128 indicates that the EPROM has failed (ie it gave a bad checksum), while error 129 indicates that the memory has been cleared since the last ID? command, perhaps because the battery is faulty or because the battery has been removed. This will detect a RAM failure even if the unit has been switched off and on since the last ID? command. If any non-volatile RAM settings are being depended upon then it is important that they are reset after such a failure.

Set Remote Baud Rate: BR*n,m*

Sets input and output baud rate to values determined by baud rate codes *n* and *m* respectively: 1=75, 2=150, 3=300, 4=1200, 5=2400, 6=4800, 7=9600, 8=110, (9=19200

output only). LA102 displays input baud rate to left of output baud rate if different. Note that the computer's output baud rate must be set to match the LA100 input baud rate after this command (and vice versa). If *m* is omitted then the input and output baud rates are both set to a value determined by *n*.

Set Configuration Option: SCxn...

Set configuration x (a letter A-Z) to value n. Multiple options may be set at the same time by separating them with commas, but it is not necessary to set all of the configurations. If an option number is omitted the configuration is set to its default value. For example:

> SC B7,P,G3

will set baud rate configuration B7, printer type P1 (by default) and graph scale G3. To restore all configurations to their default value use:

> SC A,B,C,D,E,F,G,H,I,J,K,L,M,N,O,P,Q,R,S,T,U,V,W,X,Y,Z

Unknown configuration letters are ignored. Note that some configurations only determine the start-up or default setting which are used after a reset or RS command, and will not come into effect immediately. For example setting configuration R will not affect the remote baud rate in use, and setting configuration Z will not change the current impedance. Note that most configuration letters mean different things on the LA101 to the LA102, so prefix the command with a '1' or a '2' to set the configurations on one unit only.

Read Configurations: 2RC?

This command returns all of the LA102 configuration options as a single line string terminated with CR. Each configuration letter is followed by the current option number and the configurations are separated by commas. For example, the default configurations would be returned as:

> A0,B7,C1,D2,E4,F1,G5,H4,I6,J3,M0,N66,P1,R3,T1,U1,V8,W1,X0,Y0,Z2

The remote computer must not assume that the list of configuration letters will not change as future software may add new configuration options. Note that the same text can be returned to the LA102 in a SC command to restore the configuration settings to the same state as when they were read. The LA101 configurations cannot be read.

Volume: VL*n*

Sets monitor speaker volume on the LA102 (and on the LA101 if a speaker has been fitted), *n*=0 to 16. VL0 turns the speaker off, and the last non-zero volume setting will be used if LISTEN is pressed to turn the speaker on.

Read Last Error Number: E?

The last error number is returned by the LA102 (terminated with a CR character), and any displayed error message is cleared (on both the LA101 and the LA102). See section 9.8 for further details and appendix E for a full list of error messages and numbers. An error number of 0 indicates that no error has occurred since the last E? command (or since entering remote mode). Errors 1-31 indicate sequence failure, errors 32-63 indicate operational errors, 64-91 indicate remote command or serial interface failure, and 128-159 indicate system failures, although only a few of these numbers are currently allocated (1-12, 32-33, 64-68 and 128-129). If a second error occurs before the first error number has been read the original error number is overwritten, and the E? command will always return the last error number.

9.9 LA101 Output Commands

These commands provide control over the LA101 output, including frequency, level, impedance etc. They provide functionality similar to that provided by the LA101 in manual mode (see chapter 2).

Output Channel: 1OC*n*

Set the output channel state: *n*=0 MUTEs both channels, n=1 Left only, *n*=2 Right only, *n*=3 Both on. This is equivalent to using the $\boxed{\text{L/R}}$ button in manual mode, and muted channels are terminated with the selected output impedance via relays. An alternative way to turn the output off is to use the WF2 command (see below) which will set the DC0 output state (quicker but noisier, see section 2.24).

Frequency: 1FR*n*

Set the output frequency to *n* Hz, in the range 4.77 to 37878. (For square waves only the frequency may be up to 151500Hz). The LA101 will generate the nearest frequency it is able to synthesise. The actual frequency can be calculated by reference to the 'F:' command (below), measured or found from appendix F. For example: 1FR1000, 1FR1009 and 1FR997 will all set 1001.6Hz. Note that the frequency can be set even when the waveform is set to DC, but it will not have any effect until a suitable waveform (sine, square, triangular or sawtooth) is selected.

Level: 1LV*n*

Set output level to *n* dB, relative to test level (if set). *n* may be in the range -127.99 to +127.99dB, but the resulting output level, after adding test level, impedance corrections and weightings must be in the range -101.99 to +26.00dBu. Examples: 1LV-60 sets -60dB, 1LV1.234 sets +1.23dB (only the first two decimal places are used).

Test Level: 1TL*n*

Set the LA101 Test Level to *n* dBu, with *n* in the range -101.99 to +26.00dBu. This overrides any previous test level setting, and 1TL0 should be used to clear the Test Level. It is equivalent to setting Test Level in manual mode (see section 2.6), but it will not

affect the output level until the next 1LV command. The test level is also used by sequences, so it is often useful before an SQ command. Most programs will not use this facility as it is often simpler to calculate the absolute output level and set it directly using the 1LV command.

Set Waveform: 1WFn

Set output waveform n: 0 sine waves, 1 square waves, 2 DC0 output, 3 DC positive voltage (DC+), 4   DC negative voltage (DC-), 5 triangular, 6 Sawtooth (SW+), 7 Sawtooth (SW-), 8 Double tone (1011±35Hz).   Note that the selecting waveform 8 will automatically generate a double tone of 976Hz & 1046Hz which cannot be changed with the frequency command. See section 2.24 for an explanation of these waveforms. WF2 can be used to quieten the output without switching the mute relays, and is therefore useful before generating a tone burst, or sequence, for example. For noise measurements, it is best to use the mute setting available via the OC command.

Output Impedance: 1OZn

Set output impedance n where n is the output impedance in ohms: 10, 75 or 600 (some special units may have other values instead, eg 10, 40, 600). Alternatively, n can be an impedance code in the range 0, 1 or 2 for the three available impedances, 10 75 and 600Ω respectively. The latter form is provided primarily for testing LA101 units where the available impedances may not be known, but can be measured. The rules concerning front and rear sockets are as for manual selection (see section 2.21).

Impedance Correction : 1ZCn

Turn impedance correction (ZC) on or off for the current impedance. n=1 for on, n=0 for off. Should normally be used AFTER 1OZ. Again this corresponds directly with the ZC function available in manual mode (see section 2.21)

Set Frequency by Code: 1F:n

This command sets the frequency using the internal LA101 frequency code. The 1FR command described above is usually preferred, but this command may be useful where the LA101 frequencies are being stepped through in order, or where the exact LA101 frequency must be known. The frequency code n (0-415) can be found from appendix F, or it can be calculated from the following equations:

$$x = \frac{f}{302.154}$$

$$r = 6 + \text{int}\left(\frac{\log x}{\log 2}\right)$$

$$c = \text{int}\left(64 - \frac{2^r}{x}\right)$$

$$n = 32r + c$$

where f is the frequency in Hertz, and c, x and r are temporary variables. Since the LA101 can only generate certain frequencies the above equation will give a frequency code to set the nearest frequency possible. The actual frequency generated, a, can be calculated from the following, and will always be within 1.5% of f:

$$r = \text{int}\left(\frac{n}{32}\right)$$

$$c = n - 32r$$

$$a = \frac{10^7 \times 2^{(r-15)}}{64 - c}$$

For sine, sawtooth and triangular waveforms f should be in the range 4.768 to 37878Hz ($n=0$ to 415). Squarewaves can be generated to 151.5kHz ($n=0$ to 479) in remote mode.

For example, to set 1001.6Hz, the command 1F:249 would be used, and to set the next highest LA101 frequency (1027.9Hz), the command 1F:250 would be used. A few other frequencies can also be generated using this command with codes of 1024 and higher (see appendix F for details).

Some obsolete commands are also available for backwards compatibility with very early LA100 units: CH, A:*n*, L:*n*, R:*n*, WT*n*, D0, D+, D- set input channel, attenuation, left channel, right channel, weighting, DC0, DC+ and DC- respectively, but they have now been superseded by the IC, LV, OC, WC and WF commands.

9.10 LA101 Preset Commands
These commands have no immediate effect in remote mode, but they can be used to set up the LA101 frequency and level presets remotely for use in manual mode (see section 2.5).

Frequency Presets: 1FP*f1,f2,f3,f4,f5*
Set frequency presets 1 to 5 to the specified frequencies, *f1* to *f5*. To set a third octave

frequency and ensure that it is displayed rounded, precede the frequency with a minus sign ('-'). Omitting any value leaves the previous value set. Example: 1FP-100,-315,-1000,-6300,-10000.

Level Presets: 1LP*v1,v2,v3,v4,v5*
Set level presets 1 to 5 to the specified levels, *v1* to *v5*.. Omitting any value leaves the previous value set. Example: 1LP-80,-60,-40,-20,0

9.11 LA101 Frequency Sweeps & Tone Burst Commands
Frequency sweeps and tone bursts and normally generated by defining a suitable sequence (using the 1DS command) and then running it (with the SQ command). The frequency sweep commands have the advantage that the precise start and stop frequencies can be specified, but they do not generate FSK so the LA102 will not respond automatically.

Frequency Sweep: 1SW*f1,f2,d*
Perform frequency sweep, without FSK header. *f1* and *f2* are the start and finish *frequency codes* (not actual frequencies), and *d* is the duration of each frequency in ms (0.1-6553.5). Note that the LA101 uses 32 frequencies per octave, so a 3 octave sweep lasting 20s will use a duration of 208.3ms per tone. *f1* and *f2* may be calculated as for the F:*n* command or taken from appendix F. Descending sweeps are not allowed, so *f2* must be greater than *f1*. Weightings will not be applied, even if selected. This command is really for use with other measuring equipment, as it is generally simpler to use a test sequence for making frequency response measurements on the LA102. However, the LA102 can receive frequency sweeps which do not have an FSK header using its frequency sweep mode (see section 6.2 and section 9.22).

Third Octave Frequency Sweep: 1TS*t1,t2,d*
Perform third octave frequency sweep, without FSK header. *t1* is the starting third octave code, *t2* is the finishing third octave code and *d* is the duration of each frequency in ms (0.1-6553). Note that *t1* is the first frequency to be output, but *t2* will not itself be output as *t2*-1 will be the last frequency. Also *t2* must be larger than *t1*. See appendix F for third octave frequency codes. If selected, weightings will be added to each level to give a weighted frequency sweep, and this is the main reason for using this command over the SW command described above. Like the SW command, this feature is really for use with other measuring equipment.

Tone Burst: 1TB*f,d*
Generate a tone burst at frequency *f* Hz lasting *d* ms (0.1-6553.5ms) with amplitude determined by the last LV*n* command. Note that his command should normally be preceded by a WF2 command to silence the output by setting the DC0 condition before the tone burst, and this condition will be restored after the tone burst. Tone bursts always begin at a zero-crossing for minimal sidebands. Tone bursts can also be defined as sequences (see section 4.15) and this allows multiple tone bursts/tone sets to be run.

Examples: TB1000,20 will generate 20 cycles of 1001.6Hz; TB10000,0.1 will generate 1 cycle of 10080Hz.

9.12 LA101 Weighting Curves

The LA101 has 4 pre-defined and 5 user definable weighting curves which can be used to adjust the output level depending on the output frequency. A full description is given in sections 2.26-2.27.

Weighting: 1WC*n*

Select output weighting curve *n*: 0 No weighting curve (flat output), 1-5 user weightings, 6 RIAA inverse, 7 CCIR 468-3 inverse, 8 CCITT O.41 inverse, 9 50uS de-emphasis. When using a weighting curve (ie *n* is non-zero) only third octave frequencies may be used, the FR command will generate the nearest third octave frequency and segments using non third-octave frequencies (eg phase 15kHz) cannot be used. Use 1WC0 to clear the weighting curve. The weighting operates as soon as the WC command is received, and the output frequency will be immediately rounded to the nearest third octave frequency (if it isn't already) and the output level modified according to the weighting for that frequency.

Define Weighting Curve: 1DW*n*,*name*, *f1*, *f2*,*w1*,*w2*,*w3*,*w4*,*w5*...

n is the weighting curve number 1 to 5. The name of the weighting curve is optional and can be up to 21 characters long. *f1* and *f2* are the first and last third octave frequencies to be defined (5 and 31500 to cover all 39 third octave frequencies) and the weighting curve outside of this frequency range is not changed. See appendix F for a full list of third octave frequencies. *w1* is the weight for frequency *f1*, *w2* is the weight for the next third octave frequency etc. If there are not enough weights for all of the third octave frequencies up to *f2*, the last weight will be used, for example:

<p align="center">1DW 1,FLAT,5,31500,0</p>

This will clear user weighting 1 by setting all weights from 5Hz to 31.5kHz to 0dB. Weights are all in dB in the range -127 to +127dB, and are assumed positive if no sign is given. They may be integer or have any number of decimal places, but the LA101 will only use the first 2. Some care is needed to ensure that the DW command is not too long for the input buffer (250 characters), and if necessary it must be split into two parts covering different frequency ranges.

For example, to define weighting curve 1 to give 0dB at 1kHz, +0.2dB at 1.25kHz, +0.5dB at 1.6kHz, -1dB at 2kHz, -6dB at 2.5kHz, -18dB at 3.15kHz and -60dB at 4kHz and above: 1DW1,EXAMPLE,1000,31500,0,0.2,0.5,-1,-6,-18,-60

9.13 LA102 Measurement Commands

These commands provide control over the LA102 measurements, input range and input channel. They provide functionality similar to that provided by the LA102 in manual

mode (see chapter 2), but note that it is often possible to increase the accuracy by instructing the LA102 to perform several measurements over a short period of time and return an average value. Unlike manual mode, the LA102 will not take any measurements, or perform any autoranging while it is waiting for a command, but only when a relevant measurement command is received.

Set Input Channel: 2IC*n*

This command selects the input channel for future level, noise, crosstalk and distortion measurements: $n=1$ for Left, or $n=2$ for Right. It does not affect phase measurement which is between L and R channels, or W&F measurements which are always made on the L channel. Sequence measurements are also unaffected, as the channel is determined by the parameters of the SQ command.

Set Measurement Function: 2FN*n*,*m*,*g*

Set measurement function *n*, option *m*, range *g* as in manual mode. Functions are 1 level, 2 noise, 3 crosstalk, 4 distortion, 5 W&F and misc, and the option number should be in the range 1-15 , as shown in table 2.6. The range code *g* is as for the RN command (see below). If *n* is omitted, the last option used for this function will be used. If *g* is omitted, autoranging will be enabled (but it will not occur until the level is read using the L? command), otherwise the specified range will be set.

For example: FN2,1 sets CCIR weighted noise. As in manual mode, setting a distortion function will cause the level of the fundamental to be measured and used as a reference for future distortion measurements, so this command should be used in the presence of the tone, and should be sent again if the level of the tone changes.

Read Frequency: 2F?*n*

The frequency in Hz (to 6 decimal places) is returned (terminated with a CR character). The frequency is measured after the filters, so if distortion is selected, the frequency measured will be that of the residual distortion (generally harmonic plus noise and not especially useful). On W&F the frequency measured is that of the flutter components, not the input frequency. To ensure that the true input frequency is measured, ensure that a level function is set (FN1) before using this command. If specified, *n* (1-255) determines the number of frequency measurements to make before returning an average. It is optional, and usually omitted, but the larger the value the more accurate the reading will be. The default (if *n* is absent) is 4 which is roughly equivalent to the frequency measurement accuracy available in manual mode. The time taken to measure the frequency will depend on the input frequency as well as *n*, but the larger *n* is, the longer it will take.

The F? command does not change the range setting, and assumes that the range is suitable for frequency measurement (same rules as for manual mode apply, ie frequency can only be measured if signal is within ±30dB or so of current range setting). The range

may be set directly using the RN command, or if unsure of the level, use L? to read the level with autoranging enabled. See section 2.8 for further details.

Read Level: 2L?*n*

The level is returned in dB as a decimal number with 2 decimal places, terminated with a CR character. The measurement function and option would normally be set before reading this command to determine the actual measurement (level, noise, distortion etc). The LA102 will autorange if necessary before taking the measurement, providing autoranging has been enabled with the FN or AR commands, but the range will be fixed after an RN command (or after an FN command with a range parameter). If specified, *n* (1-255) determines the number of readings to take (at 20ms intervals), before returning a mean value. It is usually omitted and the LA102 then defaults to *n*=5 (100ms total). For example, to measure the mean level over a 1s period, use the command: 2L?50.

Although this command returns a fairly accurate measurement quickly, it may not have fully settled if a range change is involved (particularly if a slow rectifier is in use). Where time permits use one L? command to autorange and a second (L?n) to return an accurate reading.

Read Phase: 2P?*n*

The phase between channels is measured and returned in degrees in the range ±180°, terminated with a CR character. A positive value indicates that the R channel leads the L channel. If the phase could not be measured (because no coherent tone was present) then an asterisk (*) is returned (still terminated with a CR character). If specified, *n* (1-255) determines the number of readings to take, before returning a mean value. It is usually omitted and the LA102 then defaults to *n*=8. The time taken to measure the phase will be approximately proportional to the product of the number of readings and the period of the input signal.

Unlike frequency, phase is measured at the front end (before the filters) and so is only reliable for inputs +28 to -30dBu. However, there are two alternative front end gains, so set the range or use an L? command first to ensure that the optimum one is in use (as for the F? command described above). See section 2.9 for further details.

Set Range: 2RN*g*

Set and lock the level range. Autoranging will be disabled until restored by a 2FN*n,m* or a 2AR command. If *g* is omitted then the current measurement range is locked, otherwise the range is set to a value suitable for measuring a level of *g* dBu. The range number, *g*, would normally be a multiple of 10dB, indicating the centre scale value of a range, but if it isn't then the next higher range above *g* is set, thus ensuring that the level is well within the measuring range. On each range it is possible to measure the level up to +8dB above the centre scale value, or down to -40dBu below it, although accuracy is reduced the lower the level, so it is best to use the next lower range if measuring a level which is 4dB

or more below the centre scale value. Where the level is not known in advance it is best to use the autoranging facility. See section 2.3 for more details.

For example, 2RN+10 will set the +10dBu range suitable for measuring tones up to +18dBu, while 2RN-23 will set the -20dBu range, suitable for measuring tones up to -12dBu.

Read the Level Range: 2RN?

The current level range is returned, and can be useful after autoranging has been used. The range is returned in dB in ASCII decimal, terminated with a CR character and will be a multiple of 10 in the range -100 to +20 (equivalent to the centre value shown on the bar graph in manual mode). See the description of the RN command for details.

Enable Autoranging: 2AR

This command enables autoranging after it has been locked with an RN or FN$n,m,g$ command, but the autoranging will not actually occur until the next L? command.

Set Input Impedance: 2IZn

Set input impedance: n=0 10kΩ, n=1 600Ω.   Both channels present this load regardless of channel selection.

Rapid Level Measurement: 2M?p,n

This command measures and returns several level samples using the currently selected measurement option (set with 2FN) and range (set with 2RN). n samples are measured with one sample being read and returned every p milliseconds (each sample is averaged over a 2ms period regardless of the value of p, ie using a sampling period of 250ms will not make the LA102 average the level over 250ms). n must be in the range 1-256 samples while p must be in the range 5-255ms. To allow high speed sampling the level samples are returned in two's complement binary, integer byte first, followed by the fraction byte (as for the remote S? command – see section 9.17). The sampling rate is limited by the LA102's output baud rate and the shortest allowed sampling period is 5, 6 and 70ms for 19200, 9600 and 300 baud respectively. The sampling rate is accurate to ±1ms providing the computer can accept the data as fast as the LA102 can generate it. Obviously this accuracy will be reduced if the computer uses its handshake line to block incoming data. Note that this command can be used to monitor wow & flutter levels of tape over a period of time (with a sampling rate of 50Hz say) - the results can then be processed using a Fourier transform and a suitable window to find the frequency of the flutter components. This will give an indication of the source of the flutter.

Set Gain Code: 2G!n

Set internal gain code n (0-19) for Lindos use only during calibration. This is similar to the RN command, but allows independent specification of front-end gain and main gain.

9.14 Running a Sequence

As for keyboard operation, sequences provide a quick and convenient way of performing a lot of complex measurements, and this can greatly simplify remote programming, as well as providing all of the usual benefits of using sequence mode (see chapters 3 and 4 for details). To avoid changing any of the 10 user sequences (numbered 1-10), an extra sequence (number 0) is provided for remote mode use only and it is recommended that remote software should always use sequence number 0 when defining a special sequence. Even when using a standard sequence, it is good practice to define it as sequence 0 in case the one in the unit has been changed.

Run and Receive Sequence: SQn,m,c,r

This command instructs the LA101 to send a sequence, and the LA102 to receive one. The parameters are sequence number (n), segment number (m), channel number (c) and register (r), but they are all optional, and this command will normally be used with no parameters, to run sequence 0 on both channels (for example: SQ).

The sequence runs relative to Test Level if one is set (see TLn above), and the source ID segment is added automatically where necessary (see chapter 3 and section 4.3). The LA101 ignores further commands until the sequence is complete, and the LA102 handshake holds back further commands during this time.

The sequence number n should be in the range 0-10, but future LA100 software may provide more sequences. The segment number m specifies which segment to run (with segment 1 being the first – see section 3.21), but it is usually omitted in which case the entire sequence runs. The channel number c should be 1, 2 or 3 for left, right or both channels respectively, and it will default to 3 if omitted (see section 3.11). The final parameter, r, specifies the register number, 1 or 2, to hold the incoming sequence, and would normally only be used when two mono sequences are to be received independently and the results shown side by side (see section 3.12).

Some examples:

SQ	Run sequence 0 on both channels
SQ1	Run sequence 1 on both channels
SQ1,1	Run segment T (sequence 1, segment 1) on both channels
SQ2,,1	Run sequence 2 on the left channel only
SQ,,1,2	Run sequence 0 on the left channel and store results in register 2

Any sequence can be run using this command, but it is important to note that the LA102 will not respond to a sequence which does not contain FSK (sequence 19, the PPM test for example). If running such as a sequence the command should be sent to the LA101 only (1SQ19,,1 to run sequence 9 on the L channel without making the LA102 wait for a sequence). Similarly, repeating sequences will never finish (until a key is pressed on the LA100) so they are best avoided. It makes more sense to run a sequence, read the results

and then run another sequence while processing the last set of results, perhaps to produce a quick update from a repeating sweep, similar to that provided by sequence 15.

If the LA102 does not receive a sequence within a fixed time (typically 10s) then it will time out and generate sequence error 10. This prevents the system locking up completely if the audio path is not connected. After sending an SQ command the computer should check the error number (using E?) and take corrective action if error 10 occurred (typically, this will mean prompting the user to plug the audio leads in). The time out period can be adjusted or disabled using the SP command (see below). It is useful to disable it where the LA102 is monitoring a programme circuit which perhaps only carries one sequence per day. The computer can instruct the LA102 to listen indefinitely and then read the results when a sequence has been received. Alternatively, the SQ command can be repeated every time the LA102 times out, but this is more clumsy and possibly error-prone.

The LA102 will abort and accept further commands if a sequence error occurs, and again this can be detected by reading the error number with the E? command. If a sequence error is detected it is possible to continue receiving the sequence by repeating the SQ command immediately (the command will be ignored by the LA101 while it is generating a sequence).

Normally both units will be connected to the computer and to the equipment under test and both units will respond to the command simultaneously. Note that they do not rely on the command for synchronisation, so it does not matter if there is a small delay (perhaps when testing a 3-head tape machine), as the LA102 will always synchronise on the FSK. The command may be sent to one unit only by prefixing it with a '1' or a '2' to make the LA101 send a sequence or to make the LA102 receive one. This would normally be done when testing lines and links, where only one unit is available at a particular site, or perhaps when recording or replaying a sequence from a 2-head tape machine which does not provide off-tape monitoring. In such cases, it is important that the LA102 is ready to receive a sequence, so if the two units are under computer control the SQ command should be sent to the LA102 first and then the identical command should be sent to the LA101. Alternatively one unit may be under manual control, but again the LA102 must be in sequence mode when it receives the sequence.

Notes for advanced users:

1. If the sequence was run from remote mode the handshake line of the LA102 will prevent further remote commands interrupting the sequence, so it is permissible to send an E? or R? command without waiting for the sequence to finish (since it will be held up by the handshake line). However, sequences which are run from the LA100 front panel (using the ⃞SEQ key) can be interrupted by sending a command (since the handshake line will not indicate that the unit is busy). In such cases the units should be left to finish the

sequence before sending any commands if the results are wanted.

2. Although the parameters sent to each unit are identical, the LA102 ignores the sequence number and the LA101 ignores the register number, since they are both irrelevant. Similarly, the LA102 only uses the channel number to determine whether the sequence is being run on one or two channels (it does not take any notice of which channel is specified, since this is determined by the FSK sent from the LA101).

Set Sequence Parameters: SP*n,m*

This command sets two miscellaneous parameters which affect sequence reception. The first is the filter code (n) which specifies which rectifier and filter should be used for level measurements (test level and sweep segments): 1 is the default (2-100kHz) while 2 selects the audio band filter (22Hz-22kHz bandwidth), equivalent to pressing ✻ LPF in sequence mode (see section 3.1).

The second parameter m is the time-out period (0-255) in units of 0.1s (VERY approximately – the actual time depends upon the input signal). If no FSK is received within the time-out period then the LA102 aborts and generates error 10, as explained above. m=0 (no time-out) is permitted, but the default setting is 100. SP without parameters restores the default settings (1 and 100).

Note for advanced users: Other filters can also be used by setting n to $16f+p$ where f is the function (1 to 5) and p is the option number (1-15). This is similar to using ✻ FIX, as explained in section 3.22, and is really for very specialist use (and for testing the internal filters in the LA102).

9.15 Defining a Sequence

The sequence definition takes the form of a single line of text (up to 250 characters), as explained in section 4.1. Any of the 11 sequences can be defined, but it is usual to only modify sequence number 0, as this is reserved for remote use and is not accessible from the keyboard. Another use of this command is to set up the 10 sequence definitions ready for a particular application, in which case all 10 can be defined using 10 separate commands.

Define Sequence: 1DS*n,xxx*...

Defines sequence n (0 to 10) to be the sequence definition *xxx*. If n is omitted sequence 0 is defined. The sequence definition *xxx*... can contain any of characters from the LA101 character set (as shown in section 4.2), and may contain text for screen display. For example:

```
1DS1,"GENERAL/TAPE TEST"TRCINZ
1DS2,"TONE BURST""5kHz 0.1s +6dB"!5000,100,+6,0,900
1DS3,"TOLERANCE DEMO"TUD|14
```

Note that the ± character used for specifying a tolerance number within a sequence (see section 4.19) is not a standard ASCII character, so the | character (ASCII 124) should be used instead, as in the last example above. Extremely long sequences should be split into two or more sequences and linked with the sub-sequence segment > (see section 4.23).

Define Source Identity: DI*n,id*
The source ID is a common message transmitted in FSK at the start of every sequence which does not have its own source ID (see section 4.3). If $n=0$ the source ID will be set to the string *id*. If $n=1$ the source ID will be set to the units serial number followed by the string *id*. the first character of which will be treated as the cyclic character and advanced each time a sequence is run. If $n=2$ the source ID will be set to the serial number, followed by the cyclic character which initialises to 'A', followed by the string *id*. The source ID length should not exceed 21 characters including serial number and cycle character. Use DI2 (with no text) to restore the default value of serial number followed by cycle character 'A'. For example, to set the cycle letter to A and the source ID message to "TJC-FM" use: DI2,A TJC-FM.

9.16 Reading Sequence Results
Sequence results may be transferred to a computer for remote processing, or simply for storage on disk. It takes typically 3s to transfer the results for a typical stereo sequence at 9600 baud. The results may be from a sequence which has just been run under computer control, or they may have been received some time ago, under keyboard control. The results can only be read from memory 0, but it is a simple matter to use the memory commands described in section 9.19 to swap the appropriate memory into memory 0 before reading.

Read Sequence Results: 2SR?*r*
This command 2SR? reads the sequence results as a single block of ASCII text terminated with a CTRL-Z character (ASCII code 26). By default, every line is terminated with a Line Feed character (ASCII 10), and no other control characters are included. The format resembles the sequence results printout which the LA102 can produce and is intended to be both machine and human readable.

An extended form of this command, 2SR?*n* allows an option number to be specified to control the precise format of the returned data. Each bit in the option number controls a particular feature and by default all bits are 0. The bits are described in fig. 9.4.

Bit	Value	Action
0	1	If this bit is set then page breaks and margins are suppressed making the text suitable for processing and storage on disk. If this bit is clear the text is formatted as though it was being sent to a printer, leading spaces are included at the start of every line and the text is divided into formatted pages using configuration N to determine the page length and configuration M for the top margin. Formatting would normally only be used when passing the text directly to a printer.
1	2	If this bit is set then embedded *graph handles* are included in the text (see below).
2	4	If set the data fields are separated with a comma to produce a CSV file (see CSV Format below)
3	8	If set terminate text lines with CR and LF (the PC/MSDOS convention). If clear terminate text lines with LF (the Unix and RISC OS convention).
4	16	If set force the distortion and level results to be given in dB (as though LA102 configurations D2 and U0 were set), otherwise use configurations D and U to determine the units. The former would be used when the computer software knows about converting from dB to percent, and when tolerance testing is going to be applied to the results.
5	32	If set suppress tolerance testing, and don't include any tolerance information.
6-7		Not allocated (must be zero).
8-15		Include printer control codes and graphics bit map data for frequency response graphs. These bits represent the printer type, as for configuration P, but will normally be zero. Some care is needed as the control codes may include an ASCII 26 byte (either in an escape sequence, or as part of the bit map graphics data) before the true end of file character, so the only way to be sure that the end of file has been reached is to timeout if no data is sent for 2 seconds. If control codes are included the resulting data cannot be processed easily and the only real use is if it is being send directly to a printer.

Fig 9.4 Bit allocation for option Number *n* (in Remote Command SR?n)

The command `SR?3` would normally be used when reading the results text for storage in a file. This will suppress the margins and pagination and include the embedded graph handles. `SR?11` might be used on a PC to make the LA102 terminate the lines with CR and LF (the MSDOS standard). For example, if the LA102 has just received the sequence TDZ, an `SR?3` or an `SR?7` command will return results similar to those in fig. 9.5.

```
LINDOS AUDIO SEQUENCE TEST          LINDOS AUDIO SEQUENCE TEST
SOURCE 0518E              LA102 0518  V6.0   SOURCE 0518E              LA102 0518  V6.0
SEGMENTS +TDZ  TD                   SEGMENTS +TDZ  TD

TEST LEVEL OUT [T] 0dB              TEST LEVEL OUT [T] 0dB
        +0.01    -6.65dBu                , +0.01 , -6.65dBu
DISTORTION (2f-22k) [D] +8dB        DISTORTION (2f-22k) [D] +8dB
 100Hz   -87.9    -89.0              100Hz , -87.9 , -89.0
  1kHz   -89.5    -91.4               1kHz , -89.5 , -91.4
6.3kHz   -84.4    -88.3             6.3kHz , -84.4 , -88.3
PHASE (mean) [Z] 0dB               PHASE (mean) [Z] 0dB
  40Hz       -4d                     40Hz ,   -4d
 100Hz       -5d                    100Hz ,   -5d
  1kHz      -11d                     1kHz ,  -11d
6.3kHz      -42d                   6.3kHz ,  -42d
 10kHz      -58d                    10kHz ,  -58d
```

Fig. 9.5 Results text read by SR?3 (left) and same results text in CSV form read by SR?7 (right)

Graph Handles

When reading textual results using the SR? command, described above, it is possible to include embedded *graph handles* in the results text by setting bit 1 in the option number. This adds a ^ symbol and a graph handle, for each channel, to the end of each frequency response segment title. For example:

```
FREQUENCY RESPONSE [X] 0dB^1^2
     30Hz    -1.11      -1.11
     40Hz    +0.55      +0.55
     50Hz    +0.55      +0.55
```

In this example, there are frequency response results for two channels, so two handles are given. The handle number should be quoted in the S?*n* command (see below), where *n* represents the graph handle. Extending the S? command in this way allows multiple sets of frequency response results to be read from an LA102 (note that the results may contain up to 10 graphs if configuration C5 has been set in the LA102 – see section 4.18).

Read Frequency Sweep Results: 2S?*r*

Although the results text returned by 2SR? includes frequency response results, only a few frequencies are included because the full list would be very long. These frequencies are the same as for normal printouts and Table 3.2 on page 40 lists the frequencies for each frequency response segment. Attempting to use these few values to plot a frequency response graph would produce very crude results.

The S? command returns all of the 256 point frequency response results for register *r* (normally 1 for L channel, or 2 for R channel). The actual samples are returned in binary to minimise the data transfer. At 9600 baud, the data for two frequency response graphs takes 1s to transfer using this binary format, compared to the 6s it would take using ASCII decimal.

A 3 line header is returned first giving the start frequency f_1, the finish frequency f_2 and the number of samples *n* with each value in ASCII decimal being terminated with a CR character (in current software *n* is always 256, but this should not be assumed). This is followed by *n* samples of binary data, with each sample taking 2 bytes. Note that this binary data may contain any 8 bit number (0-255) so it is important that the operating system or communications library treats it as raw data without processing end-of-line, or end-of-file characters.

For each sample pair, the first byte is the integer part (in dB), while the next byte is the fractional part (1/256dB) using two's complement. For example, the bytes $FF,$C0 would represent -0.25, while $05,$80 represents +5.5dB ('$' indicates hexadecimal). The levels are all absolute levels in dBu (not normalised) and the remote program should subtract the appropriate value to normalise the results as required (sample number 145 for 1kHz or 112 for 400Hz normalisation with sweep segments P,Q,R,S,U and X).

The frequency at which the *i*th sample was measured, can be assumed to be:

$$f_1 \times \left(\frac{f_2}{f_1}\right)^{\frac{i}{n-1}}$$

where *i* is in the range 0 to *n*-1. ie the frequency is exponential with time.

Note for advanced users: The LA101 does not generate truly exponential sweeps, as it in fact generates each frequency for a constant time, and the 32 frequencies per octave which the LA101 uses are not spaced exponentially (although the error is small). The LA102 corrects for this by using and displaying the actual frequency generated by the 101 at the time of that sample. Refer to SW command for further details.

Example
To read all of the results from an LA102 a program should perform the following steps:
1. Put the LA102 into remote mode.
2. Send an ID? command to read the identity of the LA102.
3. Read the identity into a string (terminated by a CR character).
4. Ensure that the LA102 has V6.0 or later software. Do this by scanning the identity string until a capital 'V' is found, and read the following digits (one or two digits will precede the decimal point). If this number is less than 6, the LA102 does not support this format and the results cannot be read, so generate an error and go to step 9.
5. Send an SR?n command (n is usually 51 or 59, but could be 1 or 9 when reading simple results).
6. Read characters into text buffer up to and including the terminating ASCII 26 character.
7. Scan the text buffer for ^ characters. For each one that is found, read the following graph handle (note that the graph handle may be over 9, so all subsequent digits should be

read up to the next non-numeric character).

8. Read the graph results (if any) using the S?n command where n is the graph handle. Repeat for each graph handle that was found. Note that the S?n command returns three lines of text, representing the start and finish frequencies and the number of samples. This is followed by 2 bytes per sample for every sample (this is always 256 in current software). This binary data should be held in a buffer, as it is, without processing.

9. Send a KB1 command to return the LA100 to manual mode.

Read Segment List: 2R?*n* (retained for backward compatibility - 2SR? preferred)

The segment list for register *n* is returned, or for both registers if *n* is omitted. The segment list is simply the list of segments received and each list is terminated with a CR character. Register 1 normally holds the results for the left channel, while register 2 holds the results for the right channel (but see single register operation in sections 3.12 and 9.14). After running the default sequence 1 for example, the R? command would return two lines: +TRCINZ and TRCIN. If a register contains no segments then a blank line is returned.

Read Results: 2R?*r,xxx...*(retained for backward compatibility - 2SR? preferred)

This command reads the results for the specified segments (*xxx...*) in register *r*. The segment letters should all be in the segment list (as read using R? without a segment list, see above) for the register(s) being read. All results are returned in ASCII decimal (typically with 2 decimal places) and every value is terminated with a CR character (ie one result value per line). The register number *r* should be 1 or 2 to read the results from a particular register and this usually corresponds to the L and R channels respectively (but see sections 3.12 and 9.15). Alternatively *r* can be omitted to read pairs of results for the two registers (register 1 value, then register 2 value, with every value terminated with a CR). This latter form should only be used where the segment appears in both segment lists (ie it is not generally suitable for reading phase results which are usually only in one register).

Every segment has a fixed number of results value, as shown in table 3.2, and the results values for each segment are returned in the same order as they are printed (not the order in which the measurements are performed). The source ID text can also be read by putting a + character in the list of segments – it will be returned as a single line of text (up to 21 characters long) terminated with a CR character.

Some examples should clarify this:

R?1,T	Read Test Level for L channel (register 1)
R?2,D	Read distortion results for R channel (100Hz, 1kHz and 6.3kHz)
R?,D	Read 6 distortion measurements:
	100Hz L, 100Hz R, 1kHz L, 1kHz R, 6.3kHz L, 6.3kHz R

R?1,W   Read W&F weighted, W&F unweighted, speed and phase
R?1,+   Read source ID text (up to 21 characters sent via FSK)

To avoid any risk of the remote computer mis-interpreting the results, the format is always fixed: distortion results are always returned in dB relative to the level of the fundamental (never in percent, regardless of the configuration setting) and Test Level results are always in absolute dBu. Other results are as for normal sequence operation: noise and crosstalk results in dB relative to the measured Test Level (see section 3.10); speed errors (as measured by segment W) in %; phase results in degrees; user level and MOL results (segments K and H) are in absolute dBu. See section 9.6 for another example. If necessary the distortion results can be converted to a percentage using the following equation:

$$p = 10^{d/20} \times 100\%$$

where *d* is the level of distortion in dB and *p* is the level as a percentage (ie -20dB=10%).

Normalised frequency response results can be read using this command and the corresponding levels for the frequencies shown in table 3.2 will be returned (with the normalisation operating as described in section 3.16). These are the same as the values which are printed and used for tolerance testing. The full 256 point frequency response data can be read using the S? command (see below), and this is essential if high-resolution graphs are to be plotted.

Read Results with Measurement Level: 2RR?*r,xxx...*
This command is the same as the 2R? command described above but it also returns the segment measurement level before the segment results (on a single line terminated with a CR character). This measurement level is transmitted in the FSK segment header from the LA101, and is printed in the header line of each segment (see fig. 3.9). A full explanation of measurement levels is given in section 4.4.

Print Results: 2PR
This command will cause the LA102 to output the sequence results in a format suitable for printing. This will include printer control codes (and graphics data) so this command is normally used when the data is to be passed on to a printer by the controlling computer. Configuration P will be used to determine which printer control codes should be used and setting P0 will cause printer control codes and graphics data to be omitted providing a simple way of obtaining sequence results from the unit. Lines will be terminated with Line Feed characters (ASCII 10), and pages will be terminated with Form Feed (ASCII 12) characters. Note that LF and FF characters may also appear within the binary graphics data which is used to print graphs. There is no specific end-of-printout code, but the busy line will indicate that the LA102 is ready for data when it has finished. (Alternatively, if no data is sent for 1s, it may be assumed that the LA102 has finished).

9.17 LA102 Heading and Date

The LA102 has a printout heading and a date setting, as explained in sections 3.21 and 3.22 which can both be set or read remotely.

Define Heading: 2DH,*xxx*...

This command defines the heading *xxx* to be used at the top of the printout. It may be up to 40 characters long (longer headings will be truncated). The comma is important as future software may allow 2DH2,*xxx* to define the second line of the heading. Use DH on its own to clear the heading. See section 9.15 for details of the equivalent LA101 command (DI).

Read Heading: 2RH?

Read the printout heading (a single line terminated with CR).

Set Date and Time: SD*d,m,y,h,n,s*

Sets the date and time to date *d* (1-31), month *m* (1-12), year *y* (1987-2155), hour *h* (0-23), minute *n* (0-59), second *s* (0-59). All values are optional and omitted values will be left unchanged. Current hardware and software do not use the time, but store the date in non-volatile memory for use on the printout. The date can be made to advance at switch on by setting configuration option X2. For example, to set the date to 14 June 1998:

SD14,6,1998

Read Date and Time: 2RD?

Read the date and time *d,m,y,h,n,s* as described above. The 6 numbers are separated by commas, but the current LA102 hardware will always return 0 for h, n and s (ie midnight).

9.18 Tolerance Testing

Tolerances can be transferred to and from the LA102, and this facility is used by the Lindos Support Software to allow remote editing of tolerances on a computer. It is also possible to run a sequence and test the results against a tolerance without actually reading or processing the results themselves. See chapter 5 for further details of tolerance testing.

Check Tolerance: CT*n*

The sequence results (in memory 0) are checked against tolerance *n* and three lines are returned: the tolerance number, the tolerance name and a list of failed segments. If *n* is omitted (or is out of range) then the current tolerance number is used and this will usually be determined by configuration T unless a ± segment or a previous CT command has changed it. For example, after running the Selftest sequence (sequence 16), a CT16 command might return:

> 16
> Self Test
> N

indicating that segment N (noise) has failed. If the sequence passes the tolerance check then an empty line will be returned in place of the failed segment list.

Set Tolerance: 2ST*n,xxx*...

Set tolerance *n* (1 to 10) to be the tolerance definition *xxx*. The tolerance definition *xxx*... should be as specified in section 5.4 and can contain any of characters from the LA102 character set (as shown in section 5.6), but it must not contain a CR character. For example:

> 2ST1,"PXR5 SPECIFICATION" T+-0.5<0.2 U+1-2 D-50,-55,-52
> 2ST2,"DEMONSTRATION" T|1 X+1-2,,,|1,,,|0.5,,,,,,,,|1,,|2

Note that the ± character is not a standard ASCII character, so the | character (ASCII 124) should be used instead, as in the last example above. Alternatively, a '+-' character pair can be used. Note that one results memories will be lost when user tolerances are defined but it becomes available again when all user tolerances are cleared. To clear a tolerance send an ST*n* command without a tolerance string (to clear all of them, repeat this command 5 times).

As with keyboard operation, defining the tolerance does not automatically cause it to be used, and it is necessary to apply it (as described in section 5.1) or by using a CT or SC command to check the results against a tolerance, or set configuration T respectively.

Read Tolerance: RT*n*

The specified tolerance *n* is returned as a single line (up to 256 characters), terminated with a CR character. '±' characters are returned as ASCII character 124 (vertical bar) since ± is not an ASCII character. If the tolerance number *n* is out of the allowed range then tolerance 0 (the empty tolerance) is used, and error 66 (Out of range) is generated. This means that the system will not lock up if an out of range value is used. In current software the tolerance number may be 0-20, but this may be changed in future versions.

9.19 Memory Operations

All of the commands described above for reading sequence results only operate on the current, or working, memory (0) and access to the other memories is provided via the remote commands listed below. These memory operations correspond to the operations available from the LA102 keyboard, described in section 3.5. Note that results from any memory (1-5) can be read by first sending an MX command to swap the specified memory with the working memory, reading the results, and then sending the same MX command to swap the memories back to their original state. This technique is used by the Lindos Support Software to read results from other memories without losing the current results in memory 0.

Memory Clear: 2MC*n...*

Clear the results from memory *n*. It is possible to specify more than one memory, by separating the memory numbers with commas. For example: MC0,1,2,3,4,5 will clear all memories.

Note for advanced users: Strictly, this command only clears the segment lists, as read by the R? command, and does not actually clear the results from memory, so it is possible to still read them. This can be confusing if a badly written program keeps showing the same results when in fact the sequence is not being received at all, and the old results are being left untouched. However, since it is recommended that all programs always check the segment list to find which results are available this is largely irrelevant. The LA100 itself, and the Lindos Support software behave correctly, and will not access results for a segment which is not in the segment list.

Memory Recall: 2MR*n*

Recall results from specified memory to memory 0, the working memory. This is normally done in order to read the contents of a memory other than memory 0. Note that the original results in memory 0 will be overwritten, and this can be avoided by using the MX command instead.

Memory Store: 2MS*n...*

Store results from memory 0, in memory *n*. The results will be copied and the results will still remain in memory 0 after this command. Note that multiple memory numbers can be specified to store the results in more than one memory, although this is of limited use. For example: 2MS1,2 will stores the results from memory 0 in memories 1 and 2.

Memory Exchange: 2MX*n...*

The results in memory 0 are swapped with the results in memory *n*. If several memory numbers are given, then each memory will be exchanged with memory 0 in turn. For example: MX2,4,2 will exchange memories 2 and 4, leaving memory 0 unchanged, while MX1,2,3 will rotate memories 0 to 1, 1 to 2, 2 to 3, and 3 to 0.

9.20 Using the Smart Sequence Modes

The smart sequences modes, described in chapter 6, for working with external sweep generators, test tapes and discs can be used from remote mode, although the procedure is slightly more complicated than with most commands: The frequency sweep or test tape measurement is started using the SM command, but this also restores the unit to manual keyboard operation, so it is necessary to use the usual procedure to enter remote mode before sending any further commands. (It was necessary to implement this feature in this way because the LA102 cannot receive serial input while performing the high-speed sampling needed for these measurements). The results are normally interpolated using the 2IN command before reading them with the SR? command.

Smart Sequence Mode: **2SM***n*
The SM command selects a smart sequence mode (*n=2* for test tape mode or 3 for frequency sweep mode) and puts the LA102 back under keyboard control. Note that the LA102 cannot decide when it has received all of the tones or sweeps and the remote computer should determine this (by reading the tape counter, by asking the user or by waiting the correct length of time, for example).

Interpolate Smart Sequence Results: **2IN**
The IN command interpolates the raw frequency response data measured by the 2SM command, and also puts a dummy U segment into the left and/or right segment lists to indicate that the frequency response data is valid for that channel (ie that samples were taken).   The 2IN command should always be used when discrete tones have been measured by the smart test tape mode and is recommended after a sweep has been measured in case any of the 256 frequency samples were missed.

If the raw data is not interpolated it is still possible to read it using 2S? or 2R?,U commands and invalid samples will be returned with a level of -128dB. Note that a frequency response graph of the raw data will only show the measured values, and in the case of test tapes this may only be 10 points out of the full 256.

9.21 User Sweeps
User sweeps allow frequency sweeps to be run as test segments with any start and end frequency (ie not restricted to the four existing ranges 20-20kHz, 10-30kHz, 30-8kHz, 30-4kHz and 300-18kHz provided by the existing sweep segments). The disadvantage is that the LA102 cannot sensibly interpret the results which must be read and processed remotely and the procedure for doing this is rather complex.

Define User Sweep Segment: **US***s*,*f1*,*f2*,*d*,*l*
s is a sweep segment letter (OPQRSU or X). *f1*, *f2*, *d* are start frequency code, end frequency code, and duration per frequency, as for the SW command, and *l* is the (integer) level to output the sweep at, in dB, relative to Test Level. This command does not run the sweep, it merely defines parameters for a segment labelled '@'. To run it, define a sequence containing the @ segment (using the DS command), and run it (using SQ). The @ character is not transmitted, but is replaced by the character *s* in the FSK header, so that the segment will be interpreted by the LA102 as a standard 1.5s, 5s or 20s sweep.

It is the users responsibility to ensure that the sweep timing is correct. The LA102 will assume the sweep to be a 20Hz to 20kHz sweep, and will display and print it as such, so for a meaningful graph the sweep data must be read from the LA102 (using S?) and processed remotely.

The start frequency must not be in the vicinity of the FSK frequencies (1650-1850Hz) as

the LA102 starts its sweep timing when the FSK sync. tone finishes. The duration of the sweep will be *(f2-f1)×d* milliseconds. For 5s sweep segments (OPQR and U), the LA102 timing is as follows:

TIME	
0s	FSK sync tone ends, sweep begins
0.25s	sweep sample 0 taken (allows for settling)
4.74s	sweep sample 254 taken (56.75Hz sampling rate)
4.84s	sweep sample 255 taken (ignore for user sweeps)

For 20s sweep segments (segment S):

TIME	
0s	FSK sync tone ends, sweep begins
0.25s	sweep sample 0 taken (allows for settling)
20.17s	sweep sample 255 taken (12.8Hz sampling rate)
20.67s	sweep sample 255 taken (ignore for user sweeps)

For example, to run a 5s sweep from 10kHz to 20kHz at +4dB to be measured on the 0dB range setting (segment U), send the following commands:

1USU,353,386,140.3,+4	Define user sweep
1DS0,@	Define seq containing seg @
2MC	Clear 102 results memory
SQ0	Run seq 0, seg 1, R channel

10kHz is code 354, 20kHz is code 386, 386-354=32 frequency changes in 4.49s, ie 140.3ms per frequency. Therefore *d* is 140.3. Now the sweep should start lower than 10kHz so that it will be at 10kHz at 250ms. 250/140.3=1, so start frequency code is 354-1=353. Code 386 will be reached after 33×140.3=4.6299s ready for sample 255, and will finish at 4.770s. The sweep can optionally be made to run on by adding one or two to the final frequency code, and this may have some merit if tape speed errors are to be tolerated. The Lindos sweep segments actually remain on the last frequency of the sweep for extra time, with the slight advantage that sample 256 (delayed) remains correct over a range of speed errors.

Read the sweep results from the 102 using the S? command, ignoring the start and finish frequencies it returns. The LA101 sweep is approximately exponential with time and the equation given under S? may be used to calculate the frequency of any sample, but for greater accuracy you may calculate the actual frequency being measured at any time in the sweep. Note that sample 256 will be invalid with this segment as it is taken late. This is intended to provide tolerance to speed errors in normal sweep segments, which hold the finish frequency for some time at the end of the sweep.

9.22 Using Sequences

Using sequences from remote mode is very simple and the basic steps are outlined below.

Start by sending an MC to clear the results memory. It can be a good idea to download the sequence to the LA101 before running it to be sure of what you are running, and it is best downloaded as sequence 0 using a 1DS0,*xxx*... command to leave the manual mode sequences (1-10) alone. The SP command can be used to select the LPF or change the timeout although most programs will probably leave the default values in use. Send SQ to both units to run the sequence (or SQ,*m* to run a single segment or SQ,,*c* to run on a single channel etc). It is good practice to check the error state (using E?) after running the sequence to ensure that all of the segments were received correctly and that the unit did not time out. Use SR? to read the sequence results, and then 2S? to retrieve the full frequency response data if required (see section 9.16).

10.0 Service Information

The information given here is intended to assist users in identifying simple faults, replacing printed circuit boards (PCBs), and fitting exchange EPROMs when software updates are supplied, but users are advised not to undertake detailed fault finding. Circuit diagrams showing the power supply, microprocessor, interfaces and input and output stages are shown in appendix D, but full circuit diagrams are not supplied at present - justified by the fact that it is very difficult to fault find efficiently without a full knowledge of the very complex way in which software and hardware are closely integrated. It is also impossible to recalibrate the units without a special computer test system as the error corrections have to be stored in the program EPROM: there are no calibration trimmers in the units. In any case, the testing of meter tone burst responses, flutter response, and filter weighting curves is both difficult and impractically time consuming without automated testing. Most resistors are contained in thick film packs which are laser trimmed to 0.1%, and the capacitors are selected to 1% or better and in some cases pre-aged, making replacement with everyday components inadvisable. All TL072 and 34182 chips are selected for low input offset voltage, and noisy chips are rejected.

Probably the most likely faults on these units are battery or DC-DC converter failure, reed relay failure, or failure of microprocessor components, and a competent engineer can tackle these without returning the units. It is also quite practical to exchange one of four major items (top PCB, bottom PCB, LCD display, panel with keys) as these have plug and socket connections. Detailed advice can usually be given quickly by telephone or fax, and spares supplied where required.

CAUTION – BOARDS AND CHIPS CAN BE DAMAGED BY STATIC.

10.1 EPROM Replacement
A single EPROM contains the program, error correction data, and sequence data for the unit. It can be found on the top PCB (IC2) by removing the top cover, and is labelled with a software version number and serial number. The version number is incremented (V6.5, V6.6 etc) each time a new software version is issued with changes or new facilities. If upgrading from a software version below V6.5 refer to appendix I.3 for a list of the new features which the upgrade will provide.

TAKE STATIC PRECAUTIONS, the EPROMs are CMOS devices. We recommend sitting down with the units and EPROMS in their protective tube to minimise further static generation, touching an earthed metal object, and then proceeding. This is normally adequate in our experience.

Disconnect the units from the mains and ensure that they are turned off. The battery can be left connected. Remove the rack mount angles where fitted, and remove the top covers. Because of the error corrections it contains, each EPROM is programmed for a specific unit; or more correctly a specific bottom PCB. Check that the serial numbers on the chassis (above the keyboard) match those on the new EPROMs and do not use them if they are different. If a replacement bottom PCB is fitted then its corresponding EPROM must also be fitted.

DO NOT USE EPROMS WITH THE WRONG SERIAL NUMBER!

Carefully prise out the old EPROM (IC2) a bit at a time using a small screwdriver under each end in turn. Insert the new EPROMS carefully with the notch on the left (viewed from the front) and switch on. The unit should display 'MEMORY CLEARED' and clear its non-volatile memory, so configuration options, sequence definitions and other user settings must be re-entered. If the display operates normally, link XLR sockets and check that the two units read the same (to within ±0.05dB) at 0, -20 and +20dB. If the errors are larger than this check the serial number on the EPROM to ensure that the correct one is fitted.

PLEASE RETURN OLD EPROMS TO LINDOS.

10.2 Recalibration

Experience shows that the LA100 is very stable over time and units returned for recalibration are very rarely out of specification. A simple test is to check various levels with the LA101 and the LA102 connected directly together (using XLR sockets, 10Ω output impedance and 10kΩ input impedance). If the generated and measured levels agree to within ±0.05dB over a wide range (eg -60dB, -40dB, -20dB, 0dB, +20dB) then it is reasonable to assume that both units are probably within calibration. The Selftest sequence also gives a good indication that the units are operating correctly: connect the LA101 to the LA102 (via XLR leads) and run sequence 16. This measures level, frequency response, distortion, noise and phase and applies the Selftest tolerance. After about a minute the LA102 should display SELFTEST TOLERANCE 6 PASSED. See section 10.6 if it fails.

It is also possible to check the calibration of the LA100 using an accurate AC milli-voltmeter which is traceable to a national or international voltage standard, and many calibration laboratories will perform such a test for a moderate fee although they will not be able to recalibrate the unit if it fails. It is therefore much more sensible to return the unit to Lindos wherever possible.

Lindos offer a comprehensive low-cost recalibration service which includes a free software upgrade (if necessary) and typically takes 2-3 days. Minor repairs are often performed free of charge and batteries and other components are tested and replaced

where they are found to be defective. The Lindos calibration reference is routinely checked in a test house approved by the UK National Physics Laboratory and traceable to national standards.

10.3 Power Supply Voltage

The LA100 is normally factory set for 220-240V, or 110-120V if requested, and the voltage is marked on the rear panel. It can be changed by removing the bottom cover and disconnecting and removing the bottom PCB. Removal of the plastic cover over the mains transformer connections will expose eight pads with a PCB track linking the inner two pads for 240V operation. For 110-120V operation this link should be cut and the outer two pairs of pads linked together, as shown in fig. 10.1. It will probably be necessary to unscrew the mains inlet filter for better access. 100V operation is available as an option - contact Lindos for details.

240V   **120V**

Fig. 10.1 Links to Select Power Supply Voltage

10.4 System Overview

The LA101 and LA102 have a common top printed circuit board which can be accessed by removing the top cover. This board contains the microprocessor, software EPROM, RAM, display and keyboard latches, serial input interface and power supply. The LA102 also has monitor amplifier, loudspeaker and serial output interface but these components are not fitted on the LA101. The bottom board contains the audio oscillator in the LA101, or the audio measuring circuits in the LA102, and can be accessed by removing the bottom cover. The two boards are connected via a short ribbon cable (PL2 on the top board) which carries the Lindos System Bus, power to the bottom board and a monitor signal for the loudspeaker from the bottom board (see appendix D.2).

If the bottom board is disconnected, the top board will still function and generate a display on the LCD. The LA102 will show its normal manual mode display (but the keyboard will not function), while the LA101 will run a keyboard test showing 14 squares which can be toggled by pressing the corresponding key on the front panel. The LA101 keyboard test can also be entered by holding [1] and [2] and pressing [ON/OFF]. Press [✳][ON/OFF] to exit from this test mode and enter manual mode but note that the LA101 may 'lock-up' without a bottom board. The LA101 EPROM can also be used in the LA102 to test the LA102 keyboard.

The ±15V supply is derived from the +5V supply via the DC-DC converter fitted at TR2. The microprocessor, keyboard and display will all function even if the ±15V supply fails, but the audio output, level measurement, loudspeaker and RS232 interfaces will not work without it.

10.5 Fault Diagnosis

A quick visual inspection can often reveal simple faults: check that all connectors are pushed fully home, that no leads are trapped or broken and that all chips are fully seated. If no obvious fault is found look through the list of common faults below:

1. **Unit will not turn off:** It is possible for a fault to make the processor lock-up (crash) with the battery power selected making it impossible to turn the unit off (but remember that the unit will always operate when a mains supply is connected). In such cases the top cover should be removed and the battery connector (PL4) disconnected for a second to turn the unit off. Re-connect the battery and turn the unit on. If it still doesn't work, disconnect the battery and connect the mains. If the unit works without the battery then proceed to section 10.9 for battery testing, if not then proceed as in step 2:

2. **Display shows random pattern or nothing at all when mains power connected**: Does it stay completely white and not change **AT ALL**? If so it is likely that the +5V power supply has failed (see section 10.7). If it shows a random or all black pattern it is probably battery fault (section 10.9), or possibly a microprocessor fault (section 10.13).

3. **Display shows EPROM FAILED**: The software EPROM has failed and should be replaced with a new one from Lindos (in such cases the unit may still be usable – press the SEQ key to attempt to continue).

4. **Output or displayed level is incorrect:** see section 10.11.

5. **Selftest sequence failed:** see section 10.6.

6. **Output is noisy when muted:** suspect a relay fault and refer to section 10.12.

7. **Poor noise, distortion or W&F:** run a Selftest sequence and refer to section 10.6. These faults are often caused by noisy DC-DC converters which can be exchanged between units, or by relay faults (section 10.12).

8. **MEMORY CLEARED message when unit turned on:** This will occur normally if the battery has been disconnected, or if new software has been installed. If it occurs at other times then it may be the result of a flat or faulty battery (see section 10.9).

If the problem cannot be located contact Lindos Electronics for further advice before returning the unit.

10.6 Selftest Failed

Because of the low residual levels and the very stringent tolerance specification it is important that good quality screened leads are used (with the screen connected to the LA102 XLR ground, pin 1) and that the 10kΩ input impedance is selected for this test.

The cause of the failure can be found by printing the results (section 3.4) or examining them on the LCD (section 3.2) to find the failed measurement marked with an asterisk (section 5.1).

Distortion and noise failure can be caused by a noisy DC-DC converter and it is often worth swapping the converters between the two units to see if it affects the results. Level errors should be check manually as explained in section 10.11.   Poor noise and low frequency (40Hz and 100Hz) crosstalk and distortion can result from mains interference and it is often worth repeating the test with the mains, oscilloscope and RS232 leads disconnected to ensure that there are no earth-loops picking up the mains power frequency.

10.7 5V Power Supply Check

Power supply voltages may be checked using the negative side of C12 (2200μF) on the top board as a 0V ground reference (see circuit diagram, appendix D.2). The main +5V supply can be picked up on pin 20 of any 74HC373 chip, and should be within ±5%. If within tolerance, measure the voltage on pin 28 of IC1 (using the same ground reference). This is the non-volatile RAM +5V supply which should also be 5V ±5% If it isn't then the processor will not operate and the LM2931 5V regulator fitted at IC20 has almost certainly failed.

If the main +5V supply is not working disconnect each of the following in turn and measure it again: battery connector (PL4), bottom board connector (PL2), DC-DC converter (TR2). It is possible that one of these systems is loading the 5V supply to such an extent that it is preventing the unit from operating. If the the 5V supply works without the battery proceed to section 10.9.   If it works without the bottom board or DC-DC converter proceed to section 10.8.

If there is still no +5V supply check the voltage across the C12 capacitor. It should be at least 12V.   If it is, suspect the 7805 IC18 regulator and the diode D3. If not remove the fuse F1 and test it. With the fuse removed and **with the mains disconnected** measure the resistance of the transformer primary and secondary by removing the bottom board and removing the plastic plate covering the mains connection to the top board.   The two primaries in series should measure around 720Ω (cold) - 840Ω (hot)and the two secondaries in series should be around 2.8±1Ω.

10.8 ±15V Power Supply Check

If the display works perfectly but the oscillator output is at a very low level, or if the measuring set is measuring an incorrect level then the ±15V should be suspected.

Using the 0v reference point on the top board as a 0V reference, check that the ±15V at the two labelled test points/links (to the left of the DC-DC convertor on the top board) is within ±5%. Low voltage may be the result of a faulty DC-DC convertor or excessive load from the bottom board. If in doubt, check the current by opening one of the 15V links and inserting an ammeter in its place. Normal current should be around 35mA (LA101) and 38mA (LA102), 40mA maximum. Try a good DC-DC converter from a different unit and repeat the tests.

If the 15V current consumption is high turn the unit off, disconnect the ribbon cable to the bottom board (PL2) and repeat the tests. If it is still very high the fault is on the top board, otherwise it is probably on the bottom board. In either case it is often possible to locate the fault by feeling the ICs on the suspect board to see if any feel hot (the DC-DC converter, IC18 5V regulator and the AC-DC convertor all run hot, but all other components should be quite cool).

10.9 Battery Testing

This section refers to lithium-ion batteries as used in the LA100 MK3, if you have an earlier unit with NiCAD batteries please refer to section 10.9 of the fifth edition manaul, which is available from the downloads section of our website www.lindos.co.uk.

If the unit only works when the battery is disconnected try charging the battery (ie plug the battery in and connect a mains power supply to the unit). After 20 minutes, turn the unit off, by temporarily disconnecting the battery if necessary, and turn it back on again.

If the unit still doesn't work the battery has almost certainly failed. In either case it is worth testing the battery as described below, but remember that a full charge takes 16 hours. Replacement battery packs are available from Lindos, and unwanted faulty packs should be returned to Lindos for safe disposal.

Note that non-volatile memory contents may be lost if the battery and the mains supply are both disconnected for more than a second.

With the mains connected and the battery unplugged measure the voltage V_{oc} across pins 1 and 3 of the PL4 connector (fig. 10.2). If it is not within the range 8.35-8.4V then the switchmode power supply (AC to DC convertor) may be faulty.

Push the battery connector back on half-way to allow for the probes (fig. 10.3) and measure the battery voltage on charge, V_{ch} which should be 6.4-8.4V. If it is lower than this after 1 minute the battery has probably failed.
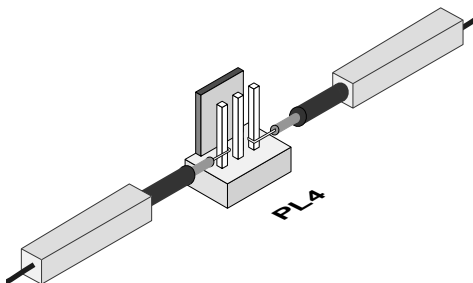
Fig. 10.2 Measuring V$_{OC}$ **Fig. 10.3 Measuring V$_{ch}$**
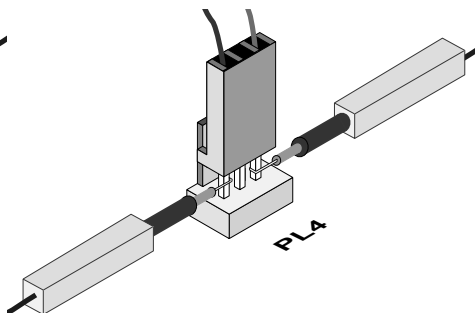
Battery current can be checked by plugging the battery connector on to the positive pin only and connecting a meter in series with the negative pin (fig. 10.4). Use a 10A range to minimise the voltage drop – most meters drop 200-600mV on a 400mA range.
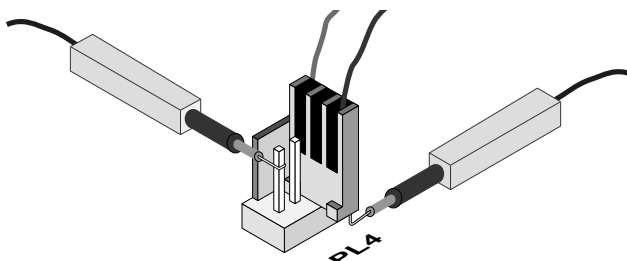
Fig. 10.4 Measuring the Battery Current (I$_{ch}$, I$_{dis}$ and I$_{mem}$)

Measure the battery consumption I$_{dis}$ with the unit running on batteries and the mains disconnected. This should be 480-520mA. If higher than this check the ±15V consumption as explained in section 10.8.

The charging current I$_{ch}$ with the mains connected should be typically 150mA with a cold, discharged battery, 40mA with a warm, charged battery). If the current is higher the battery probably has a short-circuit cell. If lower the charging circuit may be faulty.

The memory consumption I$_{mem}$ with the unit turned off should be 0.2-0.3mA. If not this indicates a fault with the IC20 LM2931 regulator or the IC1 RAM chip.

If all measurements are within limits connect the mains and leave on charge for at least 24 hours. Then disconnect the mains, press ✱ ON/OFF to leave on battery lock, checking hourly to see if the unit is still working. The LA101 has a built-in discharge timer to do

this for you: hold ⟨1⟩ and ⟨3⟩ and tap ⟨ON/OFF⟩ and leave on for several hours. When the unit has turned off, hold the ⟨1⟩ and ⟨3⟩ keys and connect the mains and the LAST TIME display will indicate how long the battery lasted before the unit switched off. To test an LA102 battery, either put it into the LA101, or use the LA101 EPROM in the LA102. 4-5 hours operation can be expected with a good battery.

10.10 No LA101 Output

Remove the bottom cover and check the fuses F1 and F2 on the bottom PCB. These protect the outputs from connection to large voltages, and may be blown by inadvertent connection to power rails, incorrectly wired phantom power inputs etc. Sometimes they fail for no reason – fuses are not very reliable components! The other possible fault is relay failure – see section 10.12

10.11 Level Errors

A common cause of level errors is incorrect setting by the user. For example, if the LA101 shows an unexpected level when it is turned on or after a preset is used, then it is likely that the presets have been re-programmed (see section 2.5). Test the system using XLR leads to link the LA101 directly to the LA102, select 10Ω output impedance, 10kΩ input impedance, level option 1 and ensure that neither unit is displaying TL (Test Level – section 2.6) or ZC (Impedance correction – section 2.21) and that no weighting curve name is shown next to SIN (section 2.26). The displays should appear exactly as in figs. 10.5 & 10.6 with **nothing else** displayed. If unsure how to obtain this display, reset both units by pressing ⟨ON/OFF⟩⟨3⟩ and then ⟨1⟩ on both keyboards (see section 1.4):
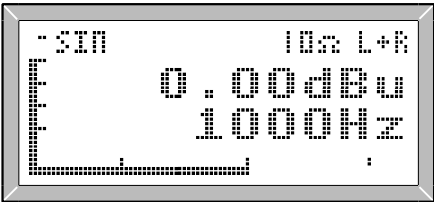
Fig. 10.5 LA101 Display   **Fig. 10.6 LA102 Display**
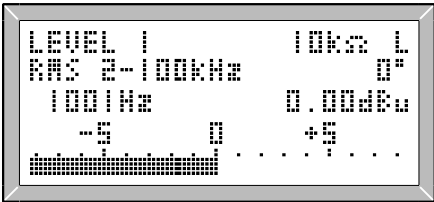
If the level is still incorrect, proceed as follows. If the fault is on one channel only, swap the L & R leads at the LA102 input and see if the fault changes channel too. If it does then the fault is on the LA101 otherwise it is on the LA102.

If still unsure of which unit is faulty test the LA101 or the LA102 against a different measuring set or oscillator to isolate the fault to one of the units. An alternative signal

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source such as a test CD can be used with the LA102, while the LA101 output can be checked on an oscilloscope or DVM.

Some common level errors have obvious causes: a small error of 0.2dB or less can be caused by fitting an EPROM with the wrong serial number and hence the wrong calibration data (ensure that the serial number on the EPROM matches that on the chassis above the keyboard). An output level or a displayed level of -40dBu or lower (instead of 0dBu) can be caused by the ±15V power supply failing, and this can be checked as explained in section 10.8.

All other level faults are invariably caused by output fuse failure (section 10.10) or relay failure (section 10.12).

10.12 Reed Relay Faults

Faulty relays may fail to switch, may only switch one way, or may go high impedance (to a few ohms instead of 0.1Ω), or they may short to both contacts. These faults usually result in erroneous levels, sometimes only under 600Ω loading. To avoid unnecessary relay removal it is usually possible to deduce which relay is to blame from the output circuit diagram, and a relay which has gone high impedance can easily be confirmed by linking appropriate pins and looking for a change in loaded output level. Note that the circuit diagrams (appendix D.3 and D.4) all show the relays in their 'off' or deactivated position with a logic 0 input. Both output and input impedances can be measured easily using a multimeter as no coupling capacitors are included. The units should be switched on for this test, and the LA101 can be set to -99dB to eliminate DC offsets for greater accuracy. Measurements from one pin to chassis can also be useful.   A figure of around $10\text{-}20k\Omega$ is normal.

The LA101 uses reed relays to switch output impedances, for output channel selection, and to select the final (64dB) attenuator stage (see appendix D.4). Monitor the output signal on all four outputs (left and right, jack and XLR sockets), and measure the output impedance on all four sockets with -99dB set (remember that the rear XLR sockets should always be 10Ω while the front jack sockets should switch between 75Ω and 600Ω). If the fault is on both channels RL1 is probably faulty, and a -64dB error is invariably caused by RL1 failing. If the fault is only on the jack sockets and not on the XLR sockets the cause is RL4 (left channel faulty) or RL5 (right channel faulty). If it is present on the LA101 XLR sockets too then it is most probably RL2 (left channel only) or RL3 (right channel only).

The LA102 uses a reed relay to select front-end gain of either plus or minus 10dB, and another to switch in 600Ω loading (see appendix D.3). Failures commonly result in one or both channel reading erroneously above +6dB (the change-over point for front-end gain). Occasionally a failure can result in one channel having an input impedance of $5k\Omega$ instead of $10k\Omega$. Measure the input impedance on both channels and monitor a 0dBu and

a +20dBu tone on both channels. If the fault is only present with a particular input impedance setting then RL3, the impedance switching relay is probably the cause. If the fault is independent of input impedance then the fault is probably RL1 (left channel faulty) or RL2 (right channel faulty). Figure 10.7 is useful if diagnosing relay problems.
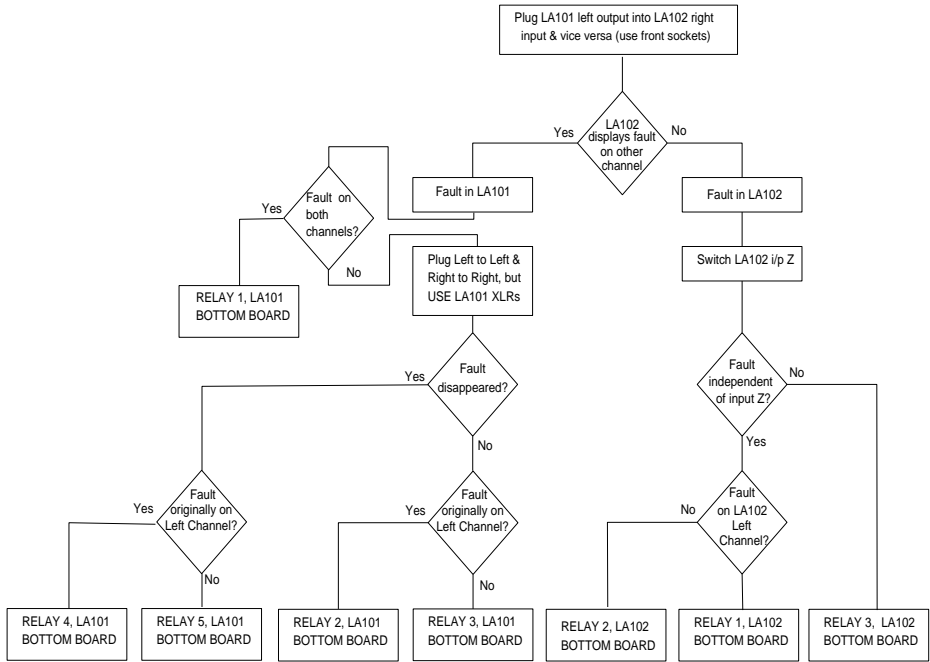
Fig. 10.7 Reed Relay Fault Finding Flow Diagram

10.13 Microprocessor Faults

If the display shows a random or black pattern when turned on check the +5V supplies as explained in section 10.7. If both 5V power supplies are operating correctly then the fault may be with the processor, EPROM, RAM, processor clock, reset circuit, data lines or address line. Such faults can be difficult to locate but fortunately they are very rare.

Refer to the circuit in appendix D.1 and examine the waveforms on all of the 16 address and 8 data lines. Most of them should be changing cleanly between the two logic levels, but if a line is stuck at a particular logic level it suggests that there is a short on the board, perhaps caused by a faulty component. Similarly a line stuck at a level between 1V and 4V indicates a fault. Disconnect the bottom board and try again, and try removing latch ICs (40373 chips) until the fault disappears.

10.14 Display Faults

A preset control (RV1) on the top PCB sets the display contrast, and can be adjusted for optimum results.   Incorrect setting can result in a dark or streaky background. Anomalies such as a double image, or any sort of doubling up of lines or columns are likely to be caused by the top PCB. Problems of contrast or pulsating backgrounds are likely to be caused by the display which contains its own multiplexing chips. Missing lines or columns of pixels usually mean a faulty display. Test by substituting a new display – it is possible to plug in the display module from another unit by removing all of the covers and standing the good unit above the faulty unit (the ribbon cable to the display is long enough to allow this without dismantling the display module). **Backlit and non-backlit displays are incompatible.**

10.15 Replacing Boards

When a fault appears to relate to the bottom (analogue) board in a unit, an exchange board may be supplied, especially for overseas units where return of the complete unit may be undesirable. Where a problem exists on both channels it may be advisable to check the ±15V supply rails (links on top PCB) before fitting a new board. To replace the bottom board switch off, disconnect the battery, and remove both covers. Unplug the various connections to the bottom board (the IDC connectors can be eased out with a screwdriver under the ribbon cable, they do not lock) and remove the self tapping screws fixing the board at its edge. Refit the new board and then swap the EPROM (top board) for the new one supplied, as this will have the correct calibration factors stored in it. Replacement boards are fully tested and guarantee correct calibrated operation without any adjustment. If problems still persist it is probably advisable to return the whole unit to us.

PLEASE RETURN FAILED BOARDS AND EPROMS TO US FOLLOWING REPLACEMENT.

CAUTION – BOARDS AND CHIPS CAN BE DAMAGED BY STATIC.

10.16 Spares

A Lindos Spares Price List is available upon request. Individually itemised parts lists are not issued as in many cases small parts are sent free of charge on telephone advice to avoid invoicing. Our aim is to keep your unit working when necessary, not to operate as a component supplier!

10.17 LA101 Loudspeaker

It is possible to fit a loudspeaker into the LA101 to monitor the generated signal, and this may be useful when using an oscillator without a measuring set (perhaps for line testing). However, it is important to note that the loudspeaker will not change level as the LA101 output level is adjusted (since it cannot possibly cope with the extremely large dynamic range of the LA101).

The monitor volume can be controlled as on the LA102, by holding MUTE and pressing the the <Hz and Hz> buttons (the same buttons as on the LA102), and the initial volume is determined by configuration V. Plug a DAC0832 into IC6 and an LM386 into IC7, fit a 64Ω (0.3W) loudspeaker at LS1 and remove the protective tape from the loudspeaker grill on the top cover. A loudspeaker upgrade kit is available from Lindos.

Appendix A Accessories

A.1 Items Supplied with the LA100

The LA100 Audio Analyser is supplied with :

> This LA100 Manual
> LA100 Quick Reference Card
> Registration card to be completed and returned to Lindos Electronics
> Dual mains lead
> A selftest printout
> 2 x RS232 leads (2m D type to D type)

A.2 Computer Support Software

Lindos computer support software is provided will all LA100 units:

Lin4WinXP support software running under all versions of Windows from 98 to XP.

Lin4WinXP comes with appropriate connecting leads (see appendix C) and manual.

A.3 Conversion Kits (Rack Mount/Separate)

The LA100 comprises the LA101 Audio Oscillator and the LA102 Audio Measuring set, which are normally supplied as two separate units, while the LA100R consists of the same two units bolted together with double width covers and end plates for 19" rack mounting (2U high).

An LA101 and LA102 pair can easily be converted to a single LA100R unit using a CV1 Conversion Kit, available from Lindos. Similarly, an LA100R can be converted to two separate LA101/LA102 units using a CV2 Conversion Kit.

It is also possible to rack mount a single LA101 or LA102 unit using a DU1 dummy unit which includes an empty chassis, double width covers and end-plates.
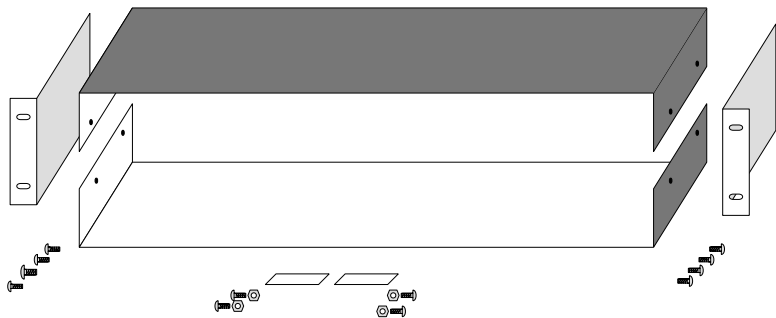
Fig. A.2 The CV1 Rack Mount Conversion Kit

Appendix B Audio Sockets

Both the Oscillator and the Measuring Set have a pair of XLR sockets at the rear and a pair of Post Office, B-gauge (small tip) jack sockets at the front of the unit for two channel (usually Left and Right) audio testing. The rear XLR sockets should normally be used in a studio environment, while the jack sockets should be used for telecommunications and line testing. On the measuring set the front and rear sockets are connected in parallel, but on the oscillator the impedances are different, with a low 10Ω impedance available at the XLR sockets and a 75Ω or 600Ω (switchable) impedance available at the front jack sockets. For greatest accuracy the rear low impedance output should be used. The LA101 output is fully floating and electronically balanced, but the two channels are connected in parallel when they are both are enabled, so they are not independently floating. The LA102 input is balanced (but not floating).

B.1 Rear XLR Connectors

The rear XLR connectors on the LA101 and the LA102 are 3 pin XLR connectors which conform to the following standards: IEC268-12 (1987), SMPTE RP-134-1986, EBU R50-1988, ANSI S4.48-1992 and AES14-1992 (*J. Audio Eng. Soc., Vol. 40 No.1/2, 1992 January/February)*. In accordance with these specifications, pin 2 is designated as live (positive polarity), while pin 3 is designated as return, as shown in fig. B.1. In an unbalanced system pins 1 and 3 should normally be connected together. Some care is needed here as some manufacturers (particularly in the USA) have used a system based on pin 3 being positive, although this is less common now that the above standards have been published.

The **LA101 output impedance at the XLR connector is always 10Ω**, regardless of the displayed impedance, while the LA102 input impedance can be switched between 600Ω and $10k\Omega$ (see section 2.21).
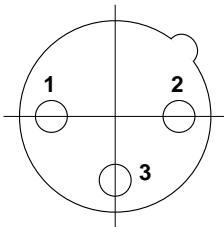
XLR pin connector (male), as seen looking into the rear of the LA101 Audio Oscillator.

Pins are designated:
1 Screen (shield)
2 Live (positive polarity)
3 Return

Fig. B.1 Male XLR Pin Connector

B.2 Front Jack Sockets

The front sockets are PO316, B-gauge (small-tip) jack sockets, and a suitable plug (fig. B.2) is available from RS components (tel: +44 1536 201201; part number 477-618)

The **LA101 output impedance at the jack connector can be switched between 75Ω and 600Ω** (but not 10Ω), while the LA102 input impedance can be switched between 600Ω and 10kΩ (see section 2.21).

Connections are:

Sleeve	Shield (ground)
Ring	Return
Tip	Live (positive polarity)
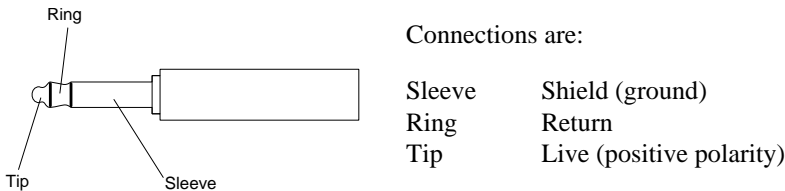
Fig. B.2 B-Gauge Jack Plug

B.3 BNC Sockets

The rear BNC sockets on the LA102 provide separate oscilloscope and sync. outputs. The SCOPE output carries the input signal after the channel selection, filter and gain stages and can therefore be used to monitor distortion residue and other filtered signals. An output level of 1V rms (2.8V peak to peak) corresponds to centre scale on the bar graph, so an input level of -24dBu measured on the -30dB range will give 2V rms output.

The SYNC output is for connection to the trigger input of an oscilloscope and carries a 0/+5V signal corresponding to the polarity of the L input signal. Fig. B.3 shows some typical waveforms as they would be seen on an oscilloscope.
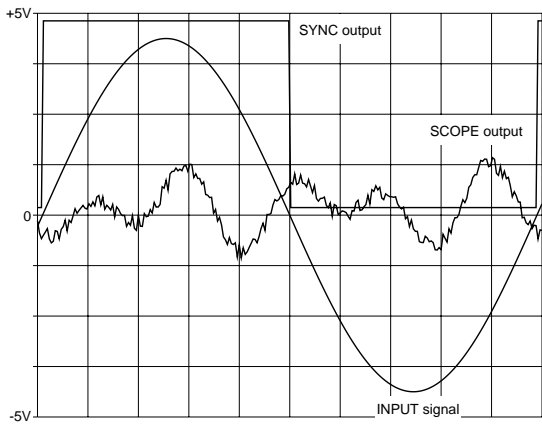
Fig. B.3 Typical Oscilloscope Display (measuring distortion)

Appendix C RS232 Connections

The LA101 and LA102 both have a 9 pin D type socket and a 9-pin D type plug, connected in parallel, for connecting RS232 compatible devices such as printers, computers or modems. The computer connecting leads are supplied with the LA100. These are standard RS232 leads with direct connections between all pins and sockets. Spare or replacement leads are available from Lindos. The available leads are:

SLP3   Serial interface cable suitable for serial printers
            (2m, 9 pin D type to 25 pin D type)

SLP2   PC compatible or lap-top computer lead
            (2m, 9 pin D type to 9 pin D type)

RS232USB RS232 to USB convertor for use with USB only computers

SLP   Printer lead suitable for most parallel printers (2m, 9 pin D type to Centronics.

The pin connections of the LA102 socket, together with Lindos recommended colours, are shown in fig. C.1. The LA101 sockets are similar, but the data out and handshake out pins are not connected internally. Connectors for printers being connected to the LA100 should be wired as shown in figs. C.1 to C.3 (using the same colour system as in fig. C.1 for the LA100 end of the lead). LA101 to LA102 and LA102 to computer leads (for daisy-chaining) should be wired pin to pin.

RXD (green)   TXD (orange)   DTR (blue)

Ground (black)

1 2 3 4 5

6 7 8 9

CTS (red)
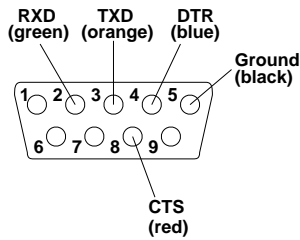
Viewed looking into solder side of 9 way D line socket

Fig. C.1 LA102 Socket

Ground (black)   RXD (green)

7   3

20

DTR (blue)
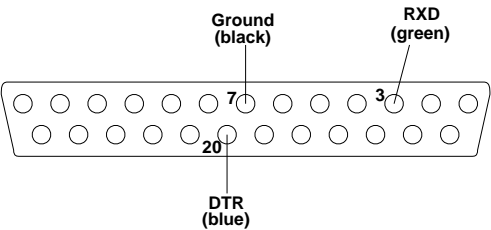
Viewed looking into solder side of 25 pin D plug

Fig. C.2 Printer Plug

TXD (orange)   RXD (green)   CTS (red)   Ground (black)

Link   Link   Link

2 3 4 5 6 7 8

20

Link pins 4, 6 & 8   DTR (blue)
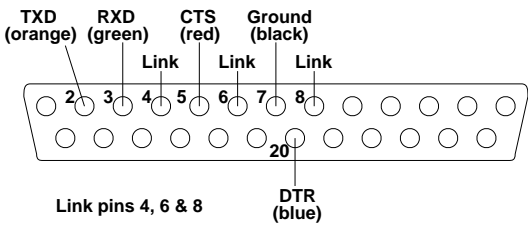
Viewed looking into solder side of 25 way D line socket

Fig. C.3 IBM PC XT

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Appendix D Circuit Diagrams
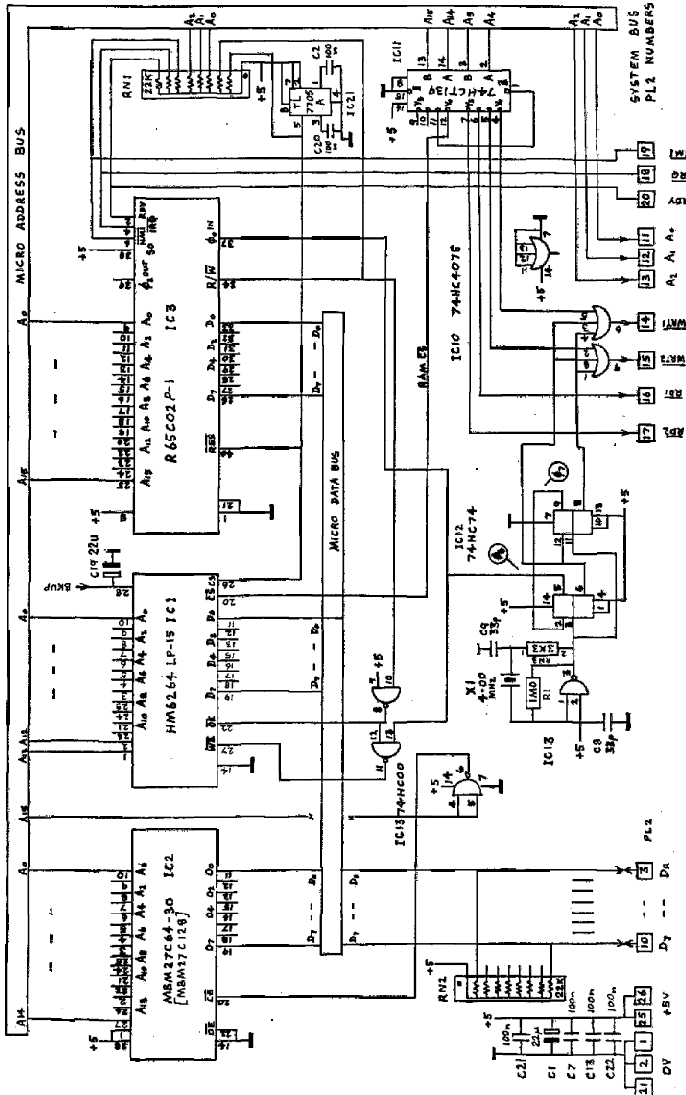
Lindos PJS840621G.

LA101 BLOCK 1 - MICROPROCESSOR H4.6

D.1 LA100 Microprocessor
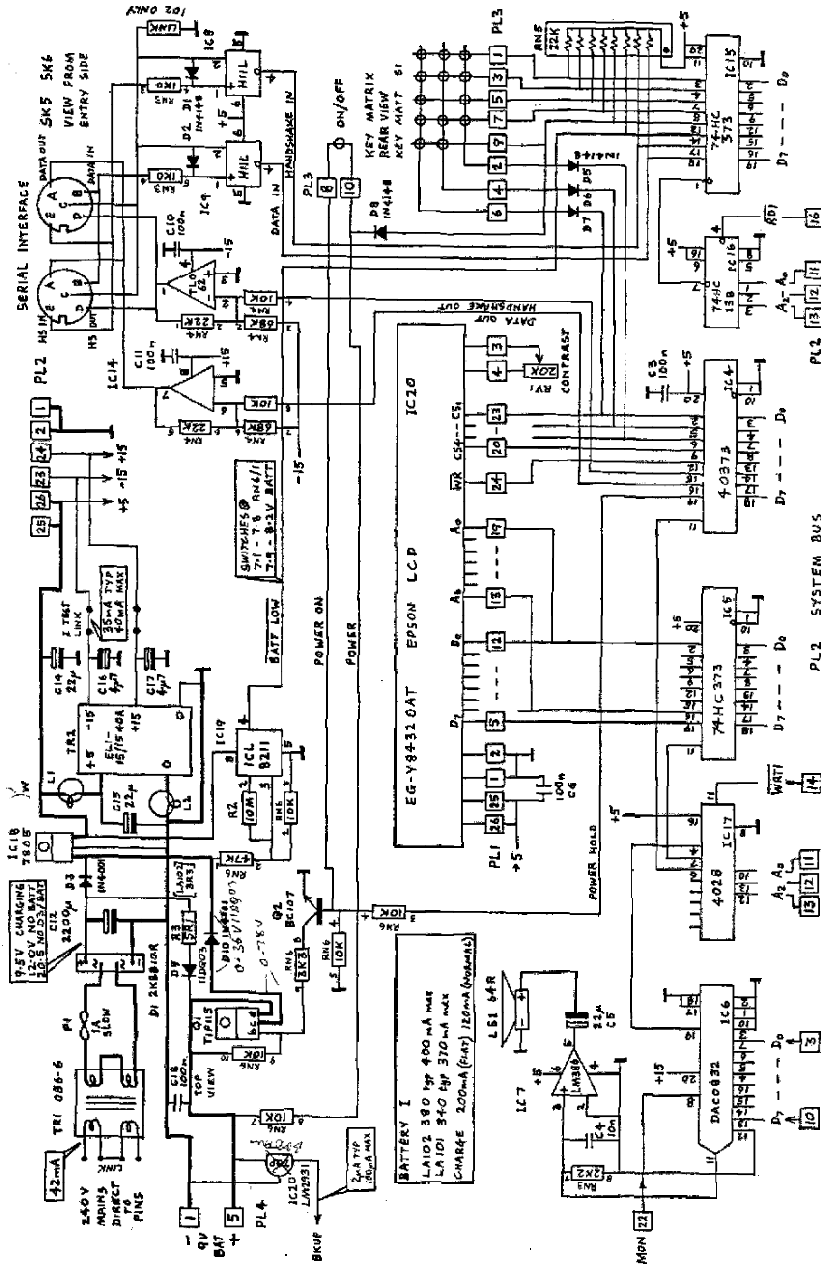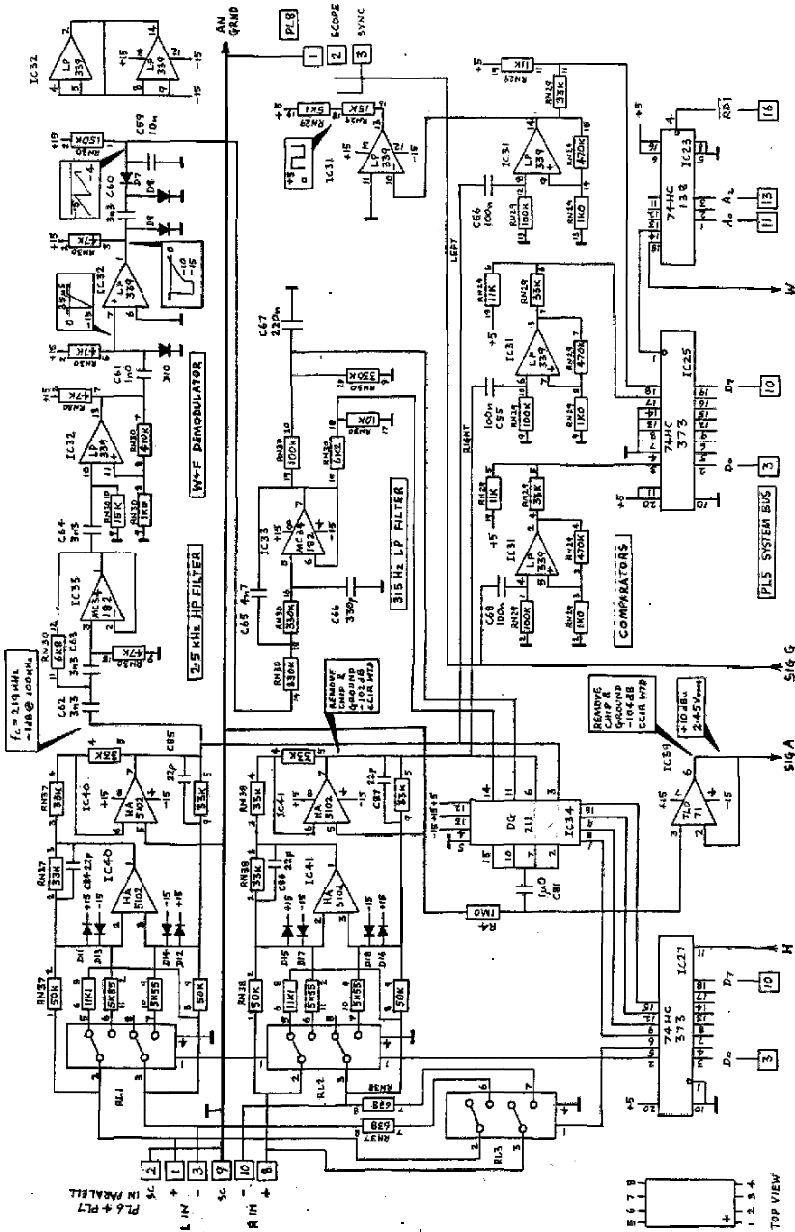
D.2 LA100 Power Supply & Interfaces

Lindos PJS850514E

D.3 LA102 Front End

D.4 LA101 Attenuator & Output Amplifier
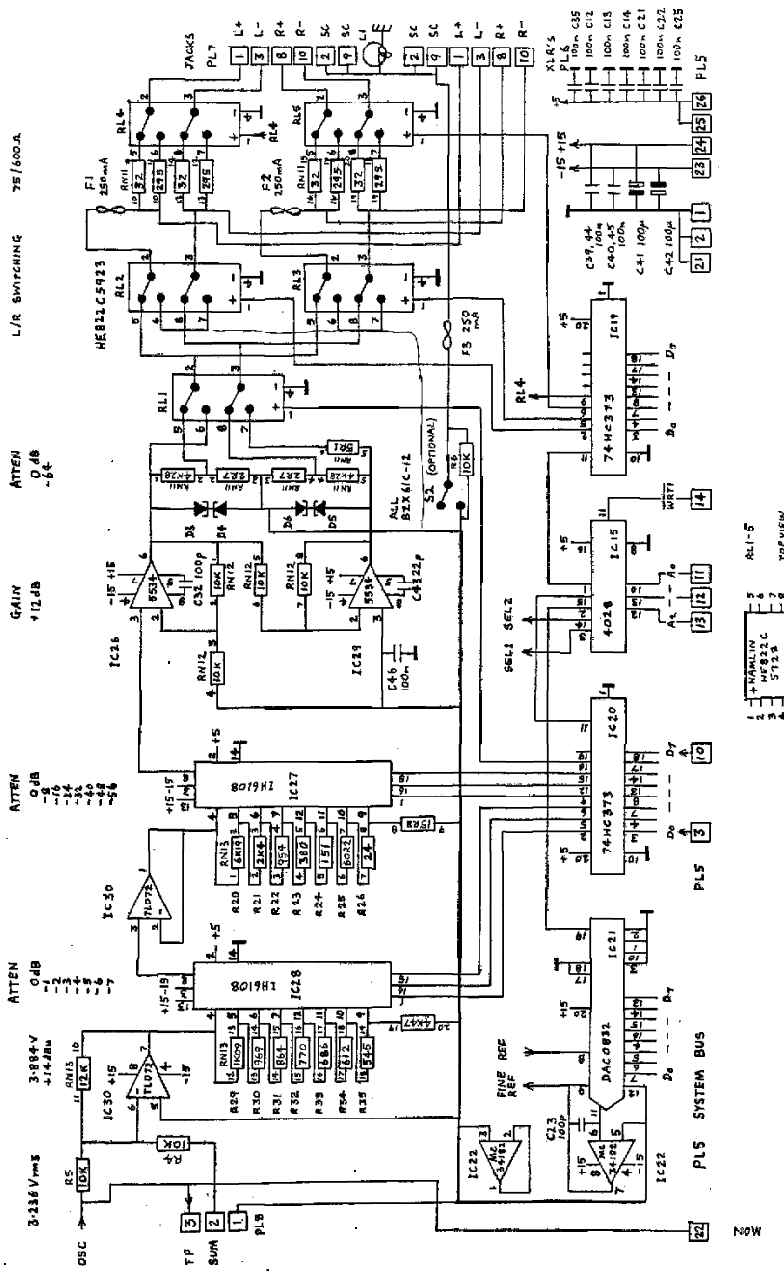
Appendix E Error Messages

This is a list of all the error messages and warnings which the LA101 and LA102 can generate in their various modes. When using the LA102 in remote mode it is possible to read an error number from the LA102 to determine whether an error has occurred. Where this is relevant the error number is given below after the error message (see section 9.8, E? command). Note that error numbers cannot be read from the LA101 and also that many of the errors listed below can only be generated manually and therefore do not have a remote error number.

ERROR MESSAGE	EXPLANATION
< (flashing)	Level too low – accuracy is being lost (see section 2.3)
> (flashing)	Level too high – ADC is being overloaded (see section 2.3)
B (flashing)	Low battery (unit will switch off automatically within 30 seconds)
BAD COMMAND (65)	Remote command not recognized (see section 9.7)
BAD IMPEDANCE	An impedance was specified in a % segment which is not available (see section 4.20)
BAD MEMORY (32)	Bad memory number (for MC, MS, MR or MX command)
BAD NUMBER (67)	Bad number - illegal character in numeric parameter
BAD TOLERANCE (33)	Bad tolerance definition
BAD TONE	W&F measurement needs 2.9-3.4kHz tone (see section 2.14)
CAN'T	Cannot select 400Hz high pass filter on current measurement (see section 2.20) or cannot select right channel for W&F measurement (see section 2.14)
CAN'T EXTEND	The sequence or tolerance definition has reached 250 characters. Note that sequences can be split into multiple sub-sequences (see section 4.23). Both sequences and tolerances can usually be shortened by leaving some parameter fields blank so they will default to the previous value – see sections 4.16 and 5.3 (eg tolerance U±2,±2,±2,±1,±1,±2 can be reduced to U±2,,,±1,,±2).
CANNOT EDIT TOLERANCE	Only tolerances 1-10 can be edited by the user. (see section 5.6)
CANNOT EDIT WEIGHTING	Only weightings 1-5 can be edited by the user. Press 1-5 to copy the fixed weighting to one of the 5 user weightings where it can be modified (see section 2.27).
CANNOT USE WEIGHTING	The segment cannot be used with a weighting curve in use (see section 3.19).
EPROM FAIL (128)	An EPROM failure has been detected. Contact Lindos for a replacement EPROM (and quote your serial and version number). Note that if you press the SEQ key it may be possible to continue using the unit if a bit has failed in an area of EPROM which provides features that you do not use.
HDR MUST BE 7 CHARS	The CCITT O.33 header string must be exactly 7 characters long (see section 4.28).
MAX LEVEL EXCEEDED	This output level would have exceeded +26dBu. Note that some

	segments use levels above the test level.
MEMORY CLEARED (129)	The RAM was in an inconsistent state (usually at power-up) and was therefore cleared completely. May be due to a battery failure, or to new software having just been installed.
MEMORY OPERATIONS NOT ALLOWED (32)	No memories available, reduce configuration C - see section 4.18.
NEED OSC13 OSCILLATOR EPROMs	This message indicates that you need new waveform EPROMs to use a particular feature, such as the 22.5kHz frequency or double tones.
NO HANDSHAKE	The printer is not ready for data, either because it is turned off, not connected or it is off-line. This error may also occur if the printer lead is wired incorrectly, or if the wrong handshake mode is selected on the printer (the LA102 needs DTR/CTS handshaking and will not work with XON/XOFF).
NOT ALLOWED WITH REMDISP	Remote display is not allowed with repeating frequency sweeps (because the processor cannot handle that many tasks).
NOT AVAILABLE	No results are available for the selected measurement because no suitable segments were included in the sequence test (or the source message was not received).
OUT OF RANGE (66)	Numeric parameter was out of range (in remote command or in sequence definition)
RANGE?	The level at the sweep cursor frequency was not be measured because it overloaded the LA102 (see section 3.14) or because it was out of the frequency range covered by the test tape or disc (see sections 6.1 and 6.2).
SEQ ERROR 1	FSK Parity error (signal noisy, or bad dropouts)
SEQ ERROR 2	FSK carrier (sync) tone lost (dropouts?)
SEQ ERROR 3	FSK frequency too low (period too long)
SEQ ERROR 4	FSK frequency too high (period too short), may be noisy
SEQ ERROR 5	FSK frequency went out of range (check speed is within ±5%)
SEQ ERROR 6	FSK decode failed
SEQ ERROR 7	FSK Segment code not known or corrupted
SEQ ERROR 8	Missed segments (not all received), possibly because the LA102 did not receive the start of the sequence (ensure that the LA102 is put into sequence mode before the sequence is run on the LA101 or played from a recording). This error may also occur if another sequence error has already occurred, resulting in segments being lost (watch the LA102 display for sequence errors before this one). Another likely cause is insufficient compartments being available to hold the results (see sequence error 12 and section 4.18).
SEQ ERROR 9	Source ID (+ segment) message too long or corrupted.
SEQ ERROR 10	Timed out waiting for sequence (see remote SP command, section 9.14).
SEQ ERROR 11	Serial port busy or no handshake.
SEQ ERROR 12	Not enough compartments to hold sequence results (increase configuration C - compartments per memory - see sections 4.18 and 3.23).
SEQ ERROR 13	A noise or crosstalk segment has been received when no Test

	Level results are available. Since noise and crosstalk measurements are relative to the measured test level these segments must be preceded by a test level segment (eg the sequences RCIN or RCINT will generate this error. They should read TRCIN).
TOO LONG (64)	Remote command line too long (over 250 characters).
TOO MANY	Too many tolerance strings have been entered into the tolerance editor for a segment which does not produce that many results values.
TOO MANY > CALLS	Sequence may call other sequences up to 10 levels deep (see section 4.23). Sequences should not call themselves recursively, otherwise this error will occur (use << instead to repeat the entire sequence).
TOO MANY TONES	Only 32 tones (96 parameters) are allowed in a ! tone burst segment. More can be accommodated by using two ! segments one after the other (using different sequences if necessary – see sections 4.16 and 4.23).
TOO QUICK (68)	Missed start bit of remote data (baud rate may be incorrect, or there may not have been enough time allowed to execute the previous command).
UNUSED	The measurement option is not defined and should not be used.

Appendix F Frequency Lists

F.1 IEC Third Octave Frequencies (and remote codes)

Table F.1 shows the nominal third octave frequencies which are used by the LA101 in manual mode when the frequency is changed with the $\boxed{<\text{Hz}}$ $\boxed{\text{Hz}>}$ keys. These frequencies are also used for third octave frequency sweeps and the code refers to the third octave frequency code which is used from remote mode when running third octave sweeps with the TS command.

The actual frequencies which the LA101 generates are shown below in table. F.2.

Code	Freq	Code	Freq	Code	Freq	Code	Freq
1	5.0	11	50	25	500	31	5000
2	6.3	12	63	22	630	32	6300
3	8.0	13	80	23	800	33	8000
4	10.0	14	100	24	1000	34	10000
5	12.5	15	125	25	1250	35	12500
6	16.0	16	160	26	1600	36	16000
7	20.0	17	200	27	2000	37	20000
8	25.0	18	250	28	2500	38	25000
9	31.5	19	315	29	3150	39	31500
10	40.0	20	400	30	4000		

Table. F.1 Third Octave Frequencies and Remote Frequency Codes

F.2 LA101 Frequencies and Remote Codes

The actual frequencies which can be synthesised by the LA101 oscillator are shown below in fig. F.2. These frequencies will be displayed in manual mode after a fine frequency change is made by pressing $\boxed{*}\boxed{<\text{Hz}}$ or $\boxed{*}\boxed{\text{Hz}>}$. When using the normal third octave frequency buttons $\boxed{<\text{Hz}}$ and $\boxed{\text{Hz}>}$ the displayed frequency is normally rounded to the nearest third octave. The LA101 can be forced to always display the true frequency which is being generated by setting configuration F2. See section 2.2.

The code listed beside each frequency is the frequency code which should be used in the remote F: and SW commands. See sections 9.9 & 9.11.

Code	Freq Hz	Code	Freq Hz	Code	Freq Hz	Code	Freq Hz
0	4.7683	52	13.871	104	43.596	156	135.63
1	4.8440	53	14.194	105	44.389	157	139.50
2	4.9221	54	14.532	106	45.211	158	143.61
3	5.0028	55	14.886	107	46.064	159	147.96
4	5.0862	56	15.258	108	46.950	160	152.58
5	5.1724	57	15.650	109	47.870	161	155.00
6	5.2616	58	16.061	110	48.828	162	157.51
7	5.3539	59	16.495	111	49.824	163	160.09
8	5.4495	60	16.954	112	50.862	164	162.76
9	5.5486	61	17.438	113	51.944	165	165.51
10	5.6514	62	17.951	114	53.074	166	168.37
11	5.7580	63	18.495	115	54.253	167	171.32
12	5.8687	64	19.073	116	55.486	168	174.38
13	5.9838	65	19.376	117	56.776	169	177.55
14	6.1035	66	19.688	118	58.128	170	180.84
15	6.2280	67	20.011	119	59.546	171	184.25
16	6.3578	68	20.345	120	61.035	172	187.80
17	6.4931	69	20.689	121	62.600	173	191.48
18	6.6342	70	21.046	122	64.247	174	195.31
19	6.7816	71	21.415	123	65.983	175	199.29
20	6.9358	72	21.798	124	67.816	176	203.45
21	7.0971	73	22.194	125	69.754	177	207.77
22	7.2660	74	22.605	126	71.806	178	212.29
23	7.4433	75	23.032	127	73.982	179	217.01
24	7.6293	76	23.475	128	76.293	180	221.94
25	7.8250	77	23.935	129	77.504	181	227.10
26	8.0309	78	24.414	130	78.755	182	232.51
27	8.2479	79	24.912	131	80.046	183	238.18
28	8.4771	80	25.431	132	81.380	184	244.14
29	8.7193	81	25.972	133	82.759	185	250.40
30	8.9757	82	26.537	134	84.186	186	256.99
31	9.2477	83	27.126	135	85.663	187	263.93
32	9.5367	84	27.743	136	87.193	188	271.26
33	9.6881	85	28.388	137	88.778	189	279.01
34	9.8443	86	29.064	138	90.422	190	287.22
35	10.005	87	29.773	139	92.128	191	295.92
36	10.172	88	30.517	140	93.900	192	305.17
37	10.344	89	31.300	141	95.741	193	310.01
38	10.523	90	32.123	142	97.656	194	315.02
39	10.707	91	32.991	143	99.649	195	320.18
40	10.899	92	33.908	144	101.72	196	325.52
41	11.097	93	34.877	145	103.88	197	331.03
42	11.302	94	35.903	146	106.14	198	336.74
43	11.516	95	36.991	147	108.50	199	342.65
44	11.737	96	38.146	148	110.97	200	348.77
45	11.967	97	38.752	149	113.55	201	355.11
46	12.207	98	39.377	150	116.25	202	361.68
47	12.456	99	40.023	151	119.09	203	368.51
48	12.715	100	40.690	152	122.07	204	375.60
49	12.986	101	41.379	153	125.20	205	382.96
50	13.268	102	42.093	154	128.49	206	390.62
51	13.563	103	42.831	155	131.96	207	398.59

Table F.2 LA101 Frequencies (and Remote Frequency Codes)

Code	Freq Hz	Code	Freq Hz	Code	Freq Hz	Code	Freq Hz
208	406.90	260	1302.0	312	3906.2	364	12019
209	415.55	261	1324.1	313	4006.4	365	12254
210	424.59	262	1346.9	314	4111.8	366	12499
211	434.02	263	1370.6	315	4222.9	367	12755
212	443.89	264	1395.0	316	4340.2	368	13020
213	454.21	265	1420.4	317	4464.2	369	13297
214	465.02	266	1446.7	318	4595.5	370	13586
215	476.37	267	1474.0	319	4734.8	371	13888
216	488.28	268	1502.4	320	4882.8	372	14204
217	500.80	269	1531.8	321	4960.3	373	14534
218	513.98	270	1562.4	322	5040.3	374	14880
219	527.87	271	1594.3	323	5122.9	375	15243
220	542.53	272	1627.6	324	5208.3	376	15624
221	558.03	273	1662.2	325	5296.6	377	16025
222	574.44	274	1698.3	326	5387.9	378	16447
223	591.85	275	1736.1	327	5482.4	379	16891
224	610.35	276	1775.5	328	5580.3	380	17361
225	620.03	277	1816.8	329	5681.8	381	17857
226	630.04	278	1860.1	330	5787.0	382	18382
227	640.36	279	1905.4	331	5896.2	383	18939
228	651.04	280	1953.1	332	6009.6	384	19531
229	662.07	281	2003.2	333	6127.4	385	19841
230	673.49	282	2055.9	334	6250.0	386	20161
231	685.30	283	2111.4	335	6377.5	387	20491
232	697.54	284	2170.1	336	6510.4	388	20833
233	710.22	285	2232.1	337	6648.9	389	21186
234	723.37	286	2297.7	338	6793.4	390	21551
235	737.02	287	2367.4	339	6944.4	391	21929
236	751.20	288	2441.4	340	7102.2	392	22321
237	765.93	289	2480.1	341	7267.4	393	22727
238	781.24	290	2520.1	342	7440.4	394	23148
239	797.19	291	2561.4	343	7621.9	395	23584
240	813.80	292	2604.1	344	7812.9	396	24038
241	831.11	293	2648.3	345	8012.8	397	24509
242	849.18	294	2693.9	346	8223.6	398	25000
243	868.05	295	2741.2	347	8445.9	399	25510
244	887.78	296	2790.1	348	8680.5	400	26041
245	908.43	297	2840.9	349	8928.5	401	26595
246	930.05	298	2893.5	350	9191.1	402	27173
247	952.74	299	2948.1	351	9469.6	403	27777
248	976.56	300	3004.8	352	9765.6	404	28409
249	1001.6	301	3063.7	353	9920.6	405	29069
250	1027.9	302	3124.9	354	10080	406	29761
251	1055.7	303	3188.7	355	10245	407	30487
252	1085.0	304	3255.2	356	10416	408	31249
253	1116.0	305	3324.4	357	10593	409	32051
254	1148.8	306	3396.7	358	10775	410	32894
255	1183.7	307	3472.2	359	10964	411	33783
256	1220.7	308	3551.1	360	11160	412	34722
257	1240.0	309	3633.7	361	11363	413	35714
258	1260.0	310	3720.2	362	11574	414	36764
259	1280.7	311	3810.9	363	11792	415	37878
						1055	22490

Appendix G LA102 Filter Graphs
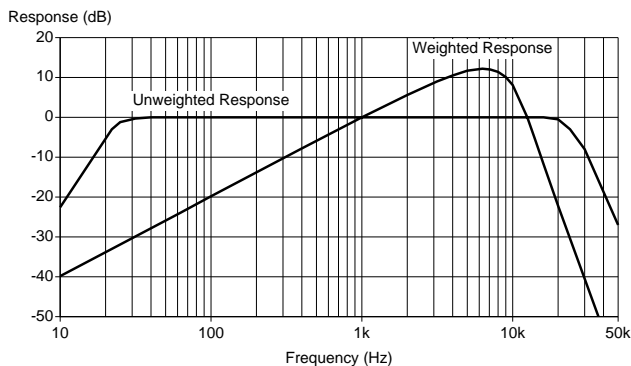
Hz	dB	Tolerance
31.5	-29.9	±2
63	-23.9	±1.4
100	-19.8	±1.0
200	-13.8	±0.85
400	-7.8	±0.7
800	-1.9	±0.35
1k	0	±0.2
2k	+5.6	±0.5
3.15k	+9.0	±0.5
4k	+10.5	±0.5
5k	+11.7	±0.5
6.3k	+12.2	0
7.1k	+12.0	±0.2
8k	+11.4	±0.4
9k	+10.1	±0.6
10k	+8.1	±0.8
12.5k	0	±1.2
14k	-5.3	±1.4
16k	-11.7	±1.6
20k	-22.2	±2.0
31.5k	-42.7	+2.8 -∞

Fig. G.1 CCIR 468-4 Noise Weighting Curve (Noise options 1 & 2)
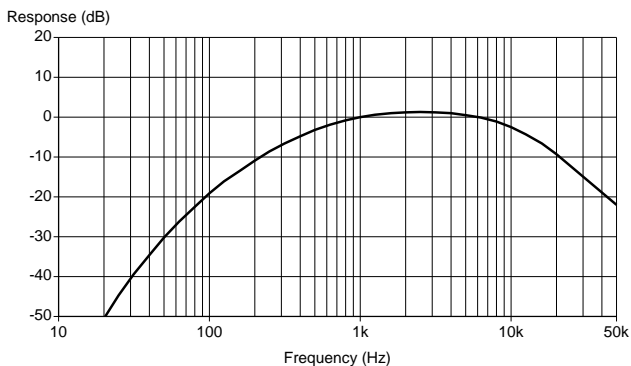
Hz	dB	Tolerance
20	-50.5	±2.0
40	-34.6	±1.0
80	-22.5	±1.0
100	-19.1	±0.5
200	-10.9	±0.5
400	-4.8	±0.5
800	-0.8	±0.5
1k	0	0
1.6k	+1.0	±0.5
2.5k	+1.3	±0.5
4k	+1.0	±0.5
8k	-1.1	±0.5
10k	-2.5	±0.5
12.5k	-4.3	±1.0
20k	-9.3	±1.0
50k	-22.0	±1.0

Fig. G.2 IEC179 'A' Weighting Curve (Noise option 7)
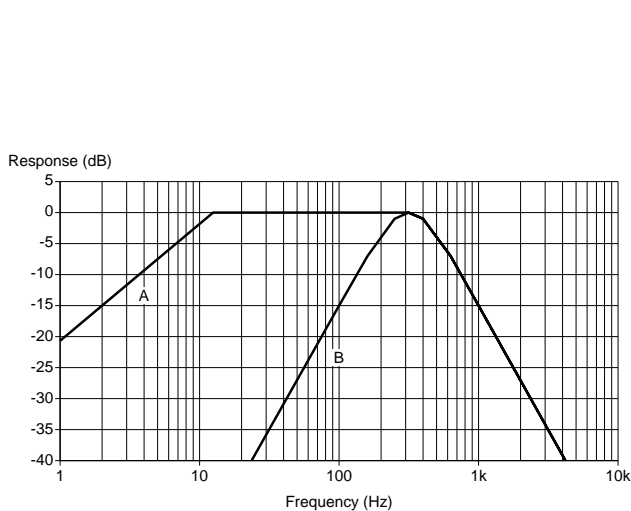
IEC98 Rumble Curve A

Hz	dB	Tolerance
2	-15	±1.5
10	-0.5	±0.5
20	0	±0.5
315	0	0
400	-1	±1
630	-7	±1
1k	-15	±1
3.15k	-35	±1

IEC98 Rumble Curve B

Hz	dB	Tolerance
31.5	-35	±1
100	-15	±1
160	-7	±1
250	-1	±1
315	0	0
400	-1	±1
630	-7	±1
1k	-15	±1
3.15k	-35	±1

Fig. G.3 IEC98 Rumble Weighting Curves (Noise options 4 & 5)
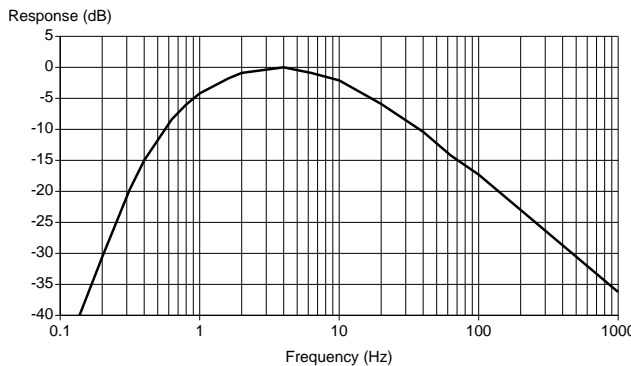
IEC386 Wow & Flutter Weighting

Hz	dB	Tolerance
0.2	-30.6	+10-4
0.315	-19.7	±4
0.4	-15.0	±4
0.63	-8.4	±2
0.8	-6.0	±2
1	-4.2	±2
2	-0.9	±2
4	0	0
6.3	-0.9	±0.2
10	-2.1	±2
20	-5.9	±2
40	-10.4	±2
63	-14.2	±4
100	-17.3	±4
200	-23.0	±4

Fig. G.4 IEC386 Wow & Flutter Weighting Curve (W&F option 1)

Appendix H FSK Header Format

The LA100 FSK (Frequency Shift Keying) uses 110 baud with a mark frequency of 1650Hz and a space frequency of 1850Hz. The data is transmitted using 1 start bit, 7 data bits, 1 even parity bit and 2 stop bits, as shown below:

Space (0) 1850Hz

| start | D0 | D1 | D2 | D3 | D4 | D5 | D6 | parity | stop | stop |

Mark (1) 1550Hz
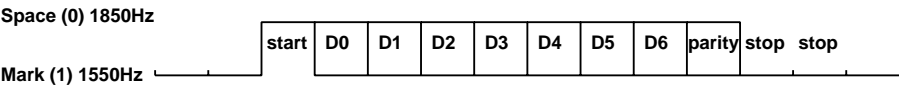
The mark frequency is transmitted for at least two bits before the first character.

All test segments are preceded by an FSK header. There are two different header formats in use. The old format, used by all units prior to V4.1 software transmitted an 'L' or 'R' channel character followed by the segment character ('A'-'Z' or '+'). This format is recognized by every LA102 and will be sent by every LA101 except where a segment level or repeat segment is specified (ie to be compatible with early units do not use segment levels or repeat segments). The new format is only recognized by LA102 V4.1 and later software (and can only be generated by LA101 V4.1 and later). The second byte is still the segment character, but the first byte uses different bits to specify various attributes:

bit 0	0 for L channel, 1 for R channel
bit 1	reserved for channels 3/4 (0 now)
bit 2	1 if level byte follows, otherwise 0
bit 3	immediate display requested
bit 4	always 1
bit 5	always 0
bit 6	always 0

If bit 2 is set a third byte is transmitted in the header, and this is the measurement level byte, a (7 bit) two's complement number in the range -63 to +31dB. Bit 3 is set if the segment is going to be repeated and causes the LA102 to display the result immediately if possible (currently this only operates with frequency sweep segments). Timing for the actual measurements starts when the FSK carrier tone stops (ie after the last stop bit).

To terminate the sequence, a '.' segment is sent, followed by a segment count (0-15) which is used to ensure that all of the segments have been received. Single channel sequences transmit a count of zero on the unused channel. Text segments send a segment character of '+' followed by up to 21 characters of message, terminated with an ETX character (ASCII 3).

Appendix I LA100 Versions

I.1 LA100 History

The Lindos LA100 was launched in 1985 with V1.0 software, but our policy of continuous development while always ensuring backwards compatibility means that the latest software will operate in all LA100 units. Software updates are normally free upon request.

Some special versions of the LA100 are available, indicated by a letter suffix. For example, the LA100R is a rack mount version, while the LA100RP is a rack mount version with power supply monitoring. Apart from the rack mount version the other versions are for specialist applications and we strongly discourage customers from ordering them except where there really is a genuine need. In particular, the LA100C and LA100T need a different software version so we cannot issue free software updates for them.

I.2 Upgrading Early Units

Very early units with serial number below 400 cannot use software later than V3.5 without a hardware upgrade. A UPG1 upgrade is recommended and this involves returning the LA100 to Lindos. As part of the upgrade both the LA101 and the LA102 will be fully repaired, tested, refurbished and recalibrated. The processor and power-supply board in each unit is replaced allowing larger EPROMS to be used and providing 8K of non-volatile RAM for storing up to 6 sets of sequence results, tolerances, configurations, sequence definitions etc. The audio board in each unit is modified and the calibration process has been extended to improve the accuracy of many measurements. The mains input filter is also replaced with one providing better protection against mains transients and lightning damage and enhancing the EMC performance. A full one year guarantee is included in the price.

Alternatively, a UPG2 upgrade is available for units with serial number 100-399, and this involves the user cutting a couple of tracks and making links on two of the PCBs to enable the larger software EPROMs to be used. Both upgrades include the latest software.

I.3 Software Changes

Users who are upgrading from earlier software should refer to the following list to see which features have been introduced. For example, a user upgrading from V4.6 should refer to sections V4.7 onwards to see what changes have been made. More details about a new feature can be found by looking up the appropriate section in this manual. Only the major changes are described as the minor changes are far too numerous to describe here.

V3.4   User programmable tone bursts (section 4.16); FSK decoding improved.

V3.5   LA101 keyboard test (section 10.4).

V4.0   Tolerance testing (chapter 5): All sequence test results may be automatically tested against a tolerance or limit, with an immediate PASS or FAIL result displayed on the LA102 LCD. A variety of standard (BT, IBA, Studer etc) and popular (Lindos cassette etc) tolerances are defined in EPROM, and up to 5 complete tolerances may be entered and stored in non-volatile memory. All tolerance information and whether the test passed or failed may be printed with the test results.

Measurement levels: every test segment may be given its own measurement level. For example D+6 will measure distortion at +6dB. Measurement levels are displayed and printed with the test results (section 4.5).

IBM printer compatible; new configuration options; faster frequency and phase measurement.

V4.1   Repeating sweeps provide a real-time display of frequency response using 1.5s, 5s or 20s frequency sweeps. Fully interactive cursor movement is possible during the sweep. Repeating sequences (section 4.17) and repeating tone bursts (section 4.16) are also provided.

Improved tone burst accuracy; FM sequence; new tolerances (section 5.2).

V4.2   Automatic selection of tolerance by LA101 using ± segment (section 4.19)

V4.3   New RR? remote command to read results (section 9.16)

V4.4   Tape alignment: A new display is provided giving a real-time display of phase, phase jitter, and stereo level in both digital and bar graph form. This display is designed to provide everything needed for tape head alignment (section 2.9).

New FP and LP remote commands to set presets (section 9.10); sequence editor provides more helpful messages; new configuration options (section 1.6); triangular and sawtooth waveforms (section 2.24); 22.5kHz frequency (section 2.25); configuration and tolerance printing (section 8.2); phase measurement improved.

V4.5   Wide frequency response graphs can be printed (section 8.4); new remote commands (RN?, VL); faster graph updating; tolerances 13 & 14 for IBA Studio Path & domestic cassette; EPROM checked at power-up.

V4.6   DC+ and DC- polarity reversed (see appendix B).

V4.7   New frequency ranges for sweeps (30Hz-4kHz, 10Hz-30kHz); weighted sweeps (section 3.19); sequences can call other sequences (section 4.23).

V4.8   User weightings (section 2.27 & 3.19): Weighting curves may be entered into the LA101 and will be applied to all tones generated. This is ideal for simple visual

testing of filters and other frequency-dependent systems; just enter an inverse curve for the device under test and check to see that the output is flat. Inverse curves are supplied for RIAA, CCIR 468-3, O.41 and 50us.

Segment to set output impedance (section 4.20); remote command to define weighting curve (section 9.12).

V4.9   Multiple similar tests: A test sequence may now contain multiple similar tests, such as frequency response sweeps at different levels. All the tests may be displayed, printed and tolerance-checked as usual (section 4.18).

New frequency ranges for sweeps (300Hz-18kHz, 300Hz-8kHz); pause segment (section 4.24); remote error beep; dBm units; segment to set test level (section 4.20); 400Hz high pass filter (section 2.20); flashing overflow and underflow indicators (section 2.3).

V4.10   Minor changes.

V4.11   Test tape operation: As well as responding to recorded or transmitted Lindos sequence tests, the LA102 can measure, display, print and tolerance-check frequency response, W&F and speed errors using a standard test tape. Voice announcements are ignored and all levels and frequencies are logged and interpolated to produce a frequency response graph (chapter 6).

Up to 15 test segments allowed per sequence; software de-glitching for low frequency measurement; automatic results storage (section 3.20); slow averaging for rumble measurement.

V4.12   Automatic option selection on crosstalk (section 2.12); tolerance failure indicated on LCD for sweep graphs; configuration J selects normalisation (section 3.16); Studer tape tolerance.

V5.0   New features in V4.7-V4.12 software tidied up and rationalised; improved help in tolerance editor; 15kHz crosstalk segment; improved range selection on two channel repeating sweeps. Breakout: $\boxed{1}\boxed{2}\boxed{4}\boxed{\text{ON/OFF}}$.

V5.1   Segment to select output channel (section 4.22).

V5.2   Provisional HP Deskjet printer support (section 8.8).

V5.3   MOL (section 4.14) and user level segments (section 4.13); weighting curves can be copied; frequency sweep mode automatically selects input channel (section 6.2); Epson LQ printer support (section 8.7); full HP Deskjet printer support; expanded bar graph scale (section 2.2).

V5.4   Channel, impedance and test level set within a sequence are local to sequence and do not affect subsequent sequences; sequence message strings now stay until cleared (section 4.1); slow averaging on level measurement (section 2.25); new remote command for rapid level sampling (section 9.13).

V5.5   Speed measurement (section 2.15); faster autoranging; distortion tone can be on one channel only for FM tests;; results value suppression for simpler printout formats (section 5.5); manual mode printing of displayed frequency and level (section 2.23); LA101 output level can be displayed in V or dBV (section 2.22).

V5.6   New waveforms for negative going sawtooths & double tones (providing OSC13 EPROMs or later are fitted); difference frequency distortion measurement (see below); support for LA103 Insertion Test Unit if detected; double width printing problem fixed (introduced in V5.5); automatic distortion option selection improved; limited support for CCITT O.33 FSK headers in both LA101 and LA102 (section 4.28); remote keyboard support added; minor bug fixes.

Segment V (400Hz test level) no longer forces 400Hz normalisation of the frequency response graph, since this can now be achieved by using LA102 configuration J, or by using a tolerance definition to force the normalisation frequency (section 5.4), and it was felt to be confusing having three different ways of doing it. For users who still want a sequence to force 400Hz normalisation it is possible to add a '±21' to the end of the sequence, to make it select tolerance 21 which in turn forces 400Hz normalisation.

IMD measurement replaced by Difference Frequency Distortion measurement (section 2.16), which gives a result 3dB lower. This is in accordance with the IEC268-3 specification which uses a different reference level.

The NA? remote command provisionally introduced in V5.0 software has been dropped. Similarly, the Softstrip results printout which was in earlier software is no longer available, as we know of nobody still using this feature.

V5.6 software can generate a 1kHz double tone with 70Hz separation (section 2.24) for difference frequency distortion measurement (section 2.16), and a new segment (d) has been provided to measure this. However, the LA101 also requires the latest (OSC13) waveform EPROMs in order to generate the double tone. New units supplied with V5.6 or later software will be fitted with these waveform EPROMs, but users upgrading older units who wish to use this feature should request new waveform EPROMs from Lindos. To find whether a unit has OSC13 EPROMs, press ✳4 to step through the waveforms and look for DOUBLE (or remove the bottom cover and check the label on the EPROMs).

V5.7   Test tape mode is now more tolerant of noise and glitches. FSK decoding can now operate on the R channel (section 3.11). Screen updates are now much faster during fast repeating sweeps. Crosstalk segments with measurement levels are now allowed. Sequence error 13 is generated if a noise or crosstalk segment is received without a test level segment. Input impedance is no longer printed with sequence results since it made the printout look cluttered. A Test Level result in dBu indicates that 10kΩ was used, while dBm indicates that 600Ω was used.

MC and HC impedance corrections have been removed from manual mode because they were too confusing and of very limited use, although they are still available via remote mode (section 9.8) and sequence mode (section 4.20). Matched Correction at 600Ω is the same as 600Ω ZC, and is of little use with 10Ω or 75Ω output impedances since the LA101 cannot drive a 10Ω or 75Ω load at a very high level.

V6.0 Sequence banks. LA101 Configurations T6 and S6. Printing channel difference graphs. User tolerances increased from 5 to 10. CSV results files. SR? remote command.

V6.1 Phase measurement at 15kHz more tolerant of noise, glitches etc. ASCII ROMAN 8 character set is selected on EPSON and HP printers to ensure that square brackets are printed correctly even if the printer's DIP switches are set for non-English alphabet.

V6.2 Remote results format tidied up. Heading correctly positioned. MOL segment causing LA102 to time out when remotely controlled now fixed

V6.3 Subtract reference curves, \n control segment, Memory clear command replaced by memory subtract command.

V6.5 V6.3 did not permit the use of weighted frequency sweeps. This is corrected.

As far as possible software updates are upwards compatible; adding new features while maintaining compatibility. However, some features have recently been dropped because they were of little use and were confusing to most users. These include the MC and HC impedance correction modes (see V5.7 above); 400Hz normalisation on segment V (see V5.6 above) and IMD measurement (replaced by Difference Frequency Distortion in V5.6). Please contact Lindos if any of these changes cause any problems.

I.4 Rack Mounted Unit (LA100R)

The LA100R is a 2U rack mount version of the LA100, comprising the LA101 and the LA102 bolted side by side to make up the 19" width. Conversion kits to convert to and from single units are also available (see section A.3).

I.5 CCITT O.41 Filter Version (LA100C)

A version of the LA102 with a CCITT O.41 psophometric weighting filter for noise measurement on telephone systems has been produced. This filter replaces the standard A weighting filter in the LA102 and allows O.41 psophometric noise to be measured either manually, or automatically within a sequence.

I.6 Power Supply Monitoring (LA100P)

When the LA100 is being used to test critical transmission paths for live broadcast material it is often desirable to be able to detect failures within the LA100 itself. The power supply monitoring circuit provides a jack socket on the rear panel connected to an internal relay. This provides a closed circuit when the unit is operating correctly, or an open circuit if the power supply fails. This will detect all of the common faults which can occur, including mains supply failure, fuse failure, transformer and DC-DC converter failure and battery failure (when the unit is not connected to the mains). It will not detect relay faults or processor faults but these are quite rare.

I.7 Telecom Australia Version (LA100T)

These units are very similar to the standard LA100 Audio Analyser, but have different sequence definitions, 400Hz distortion and crosstalk filters in place of the 315Hz filters present in standard units and 40Ω output impedance in place of 75Ω. This means that distortion options 2 and 12 and crosstalk option 2 will select a 400Hz measurement; segments C, J, F, and G all use 400Hz in place of 315Hz; and segment h (315Hz MOL) is not available in the Telecom version.

Note that this does cause a small incompatibility between different LA100 units. A standard LA101 generating segment F will produce 315Hz which a Telecom LA102 will attempt to measure using its 400Hz distortion filter, giving an incorrect result for 400Hz distortion (typically -24dB will be obtained regardless of the equipment being tested). A similar problem will arise if a standard LA102 is used to measure a sequence from a Telecom LA101. Note that the problem only affects the 315Hz or 400Hz measurement in the segments listed above. All of the other frequencies in these segments, and other segments will operate correctly.

Crosstalk measurement will be more tolerant, as it is possible to measure 315Hz crosstalk using a 400Hz bandpass filter (or vice-versa) and the result will be about 1.7dB lower than a correct crosstalk measurement.

It would have been possible to use new segment letters for the 400Hz distortion segments in place of segment F and G, but that would have made it difficult to obtain distortion results at other frequencies, so it was decided to allow this small incompatibility.

LA100T units run V5.7T software which does not offer all the features described in this manual. In particular, the sequences are not arranged in banks, the latest Windows support software will not communicate correctly with the LA100 and the SLP serial to parallel convertor for printing directly to parallel printers will not operate,

Appendix J Specification

J.1 LA101 Audio Oscillator

Frequency range 5Hz to 38kHz, 3 or 32 steps per octave.

Frequency accuracy Correct to 0.02% (200 ppm).

Frequency stability ±30ppm over specified temperature range (quartz synthesised).

Frequency resolution 32 spot frequencies synthesised over one octave, repeating, multiplied by 2,4,8 etc.

Level accuracy ±0.03dB +26 to -60dBu, ±0.2 -60 to -80dBu. Laser-trimmed resistors and software error corrections stored in EPROM.

Impedance accuracy ±2% or ±2Ω (whichever is the greater).

Amplitude range -100 to +26dBu in 1dB or 0.01dB steps.

Amplitude flatness ±0.05dB, 5Hz - 31.5kHz.

Waveforms Sine, square, triangular, sawtooth (positive and negative going), DC+, and DC-. A double tone with 70Hz separation is available at 1kHz.

Distortion (THD+N) -86dB 1kHz, -86dB 400Hz, -80dB 100Hz, -76dB 6.3kHz (all maximum, measured rms, with 22kHz bandwidth). Combined LA101/102 measurement.

Output selection L/R/L+R or Mute. Muted channel is terminated with selected impedance.

Output impedance 10Ω at rear XLRs. 75Ω or 600Ω selectable on front jack sockets. Balanced and floating, separate resistors. Other output impedances available. 40Ω replaces 75Ω in Telecom Australia version.

Minimum load 600Ω at +20dBu one channel, or +18dB both channels loaded.

Weighting curves RIAA, CCIR 468, O41, 50µs de-emphasis. In addition, up to 5 user programmable weighting curves may be entered.

Sequences 10 programmable sequences, with Lindos defaults.

Segments 47 selectable test segments for user assembly.

FSK Frequency Shift Keyed data transmitted over signal path, 110 baud.

Presets	5 frequency and 5 level presets.
Relative levels	Current level can be stored as a working level for testing microphone inputs etc.
Tone bursts	100μs to 27 minutes, programmable frequency, level and duration (specified to a resolution of 100μs). Sequences of tones or tone bursts can be easily programmed, and can be made to repeat.
Z-correction	Automatic level corrections for 600Ω loading selectable.

J.2 LA102 Audio Measuring Set

Inputs	10kΩ and 600Ω selectable. Differential inputs, with L/R selection.
Overload protection	Withstands 100V rms, diode limited.
Level measurement	-95 to +28dBu in 10dB ranges (autoranging/manual).
Default	RMS 2Hz-100kHz -3dB, 20Hz-40kHz -0.2dB.
Options 2-5	RMS 22Hz-22kHz, VU 22Hz-22kHz, RMS A Wtd, PPM, VU A Wtd.
High pass filter	400Hz with12dB/octave selectable.
Audio band filter	selectable with 22Hz 12dB/octave, 22kHz 36dB/octave.
Level resolution	Digital: 0.01dB steps. Bar graph: 0.2dB/pixel or 0.04dB/pixel.
Level accuracy	±0.05dB +28 to -60dBu, ±0.2dB -60 to -80dBu
Frequency	Reciprocal counting 20Hz-20kHz, 4-5 digit readout
Phase	±180 degrees, 20Hz to 20kHz with ±2° accuracy (up to 40kHz with reduced resolution).
Noise measurement	-105 to +8dBu in 10dB ranges.
Default	CCIR468-4 weighted quasi-peak.
Options 2,3,6,7	CCIR468-4 unweighted, RMS 22-22k, CCIR/ARM, CCIR RMS.
Residual Noise	-97dBu CCIR468 wtd, -107dBu RMS 22kHz.
Rumble measurement	Weighted slow (IEC98) (on noise option 5). Unweighted slow (IEC98) (on noise option 4).
Crosstalk	-117 to +8dBu, narrow band measurement, automatic freq. selection. Measured with a two stage 12dB/oct bandpass filter. -1dB at 20% frequency error, -10dB at one octave.
Options1-6	100Hz, 315Hz, 1kHz, 6.3kHz, 10kHz, 40Hz. Telecom Australia version has 400Hz in place of 315Hz.

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Options 7-9	80Hz-400Hz, 1.8kHz-21kHz and 12-21kHz bandpass.
Residual Noise	-117dBu at 1kHz, -111dBu at 6.3kHz typical.

Distortion THD+Noise, relative, with automatic fundamental measurement and filter frequency selection. Measured with a combined multi-stage notch and high-pass filter. Frequency tolerance is ±1% for a 70dB notch. No nulling occurs and the broad notch rejects flutter sidebands effectively. (-60dB @ +2%)

Options 1-6	100Hz, 315Hz (3rd harmonic), 1kHz, 6.3kHz, 10kHz, 40Hz.
Level Range	-60dBu to +28dBu, noise limits readings below 0dBu.
Residual reading	Combined specification as for LA101 above.
Response	-0.5dB at 2nd harmonic, 22kHz 36dB/octave band-limited.

Wow & flutter -80dB to -20dB (0.01% to 10%).

Default	weighted quasi-peak to IEC386, DIN45507.
Options 2,6,7	Unweighted quasi-peak, weighted RMS, Unweighted RMS.

Quantising distortion 40Hz notch, 400Hz HP, Wtd CCIR & Unwtd rms.

Difference frequency dist. 70Hz bandpass filter for 2nd order difference frequency distortion measurement on double tone with 70Hz separation (1kHz-20kHz).

FIM (Frequency Intermod.) To DIN45411 (3KHz/300Hz) to -60dB, 0.1%

Sequences Responds automatically to all LA101 sequences.

FSK speed tolerance ±4% speed error allowed.

Monitor loudspeaker With volume setting and listen switch.

Scope/headphones output BNC 1V RMS output mid-scale and 0/+5V BNC sync. pulse.

22Hz-22kHz filter Elliptic design with 60dB rejection at 44kHz. This permits valid distortion measurement on Compact Disc players despite sampling residue.

Sequence results Sweeps produce a graph on the display with cursor readout, automatic scrolling and scaling facilities. Sequences produce a graph plus several pages of data with quick access.

Printout Sequence results can be printed directly on an Epson ESC/P, IBM or HP Deskjet compatible printer fitted with serial interface. Printout includes high resolution frequency response graphs.

Sequence results memories	5 sequence memories allow later printout or analysis.
Tolerance testing	10 user programmable tolerances in addition to 10 pre-programmed tolerances (Selftest, IBA, EPS81, EPS84, EPS98, Studer A812 etc)
Test tape mode	LA102 can automatically measure frequency response, W&F and speed from a test tape, ignoring voice announcements and plotting an interpolated graph between the spot frequencies it finds. External frequency sweeps can also be used.

J.3 Common to Both Units

Standards	All measurements meet quoted standards regarding weighting curves, accuracy, and meter ballistics.
Serial interface	Inputs: Opto-isolated, +2V threshold. Outputs ±5V. Compatible with most RS232 and RS423 equipment. 8 data bits, 1 start bit, 1 stop bit, no parity.
Baud rate	75, 110, 150, 300 (default), 1200, 2400, 4800 and 9600 (19200 baud also available on output only). Split baud rates supported.
Size	216mm(W) $\times$ 88mm(H) $\times$ 258mm(D). Weight: 3kg (LA101 or LA102). Display 71mm $\times$ 27mm.
Power requirement	Mains 220-250V, 50-60Hz, 9VA, (110V option).
Battery life	4 hours (lithium-ion). Automatic mains recharge in 16 hours.
Remote control	The RS232 compatible serial interface provides complete control of measurements and access to results using a comprehensive set of ASCII commands. Sockets are 5 pin domino DIN (as on Acorn BBC computer).
Safety	Meets IEC348 class 1 and BBC requirement for internal insulation.IEC mains socket has filter plus transient protection.
Temperature range	10-40°C operating, 10-30°C for full distortion specification.
Connectors	PO Jacks (B gauge, small tip) & XLR-3s at rear.
Guarantee	1 year. Fast repair/software recalibration service available.
Technical support	Lifetime technical support from Lindos via telephone +44 1394 380307 (usually 24 hours), fax +44 1394 385156 or mail.

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