RS
Data Sheet

Logic analyser LA-160

RS stock numbers 611-290 (10 MHz), 611-818 (20 MHz)

Introduction

The LA-160 logic analyser enables the activity of many digital signal points to be recorded simultaneously, and then examined in detail. The information is stored with respect to a 'clock' signal and the analyser records whether each signal point is 'high' or 'low' at each active edge of the clock signal. This information is stored in memory and is then available for detailed analysis via the logic analyser's display.

There are two basic forms of display. A 'timing diagram', where a series of successive logic levels for each channel is displayed from left to right on a screen. This is similar to the way that an oscilloscope displays information, since the trace represents the signals plotted against time. A 'state display' which is used to show the relationship between the various signals at each point in time (ie. each active edge of the clock signal). The analyser reads the logic levels for all the signals at each active clock edge and displays them as a 'word'. This word may be in binary, octal, decimal or hex formats. The display then becomes a list of successive words. This method is particularly relevant to bus organised digital systems such as microprocessor based equipment, parallel data transmission systems etc.

In order to define the section of data that is recorded, the logic analyser must be triggered. Triggering may be a simple change of level on a single line (as with triggering an oscilloscope) or it may be the simultaneous occurrence of a set of levels on a set of lines (eg. triggering on a 16-bit word from a microprocessor address bus). The LA-160 logic analyser stores data that occurred both before and after the trigger event.

There are two basic ways of recording data. These are synchronous acquisition and asynchronous acquisition. In the synchronous mode, the clock signal for the analyser is synchronised with a clock signal within the unit under test, and each piece of data is stored at a defined point; normally when the data is known to be stable. In the asynchronous mode, the clock signal for the analyser is independent of the unit under test and consequently data can be stored at any point on the data stream. If the analyser clock is set to be much faster than the data being stored, a timing diagram display will show a plot of the data against time, enabling the exact timing of level changes to be observed.

Features

● 16 data channels

● Internal or external clock, maximum speed 10MHz or 20MHz (A or B versions)

● 2,000 word data acquisition memory

● Timing diagram via an oscilloscope

● Built-in single word state display

● Binary, octal, decimal, hex or mixed display formats

● 20 bit trigger word recognition

● Non-volatile 200 word reference memory

● Word search capability

● Block compare facility, pass or fail against reference memory

● Automatic repeat acquisitions, dependent on a comparison result.

Data acquisition

The LA-160 logic analyser operates by sampling the logic levels at its 16 data inputs in synchronism with an internally or externally generated clock signal, and storing them in a memory prior to detailed examination.

The Sample Clock may be generated within the LA-160 or generated externally and supplied via the clock input. The state of the 16 data inputs and 7 other control inputs is latched on every positive going (or negative going) transition of the sample clock. If the two Clock Enable inputs are True at this point, a further clock signal is generated known as the Store Clock. (The Clock Enable inputs can be set to be True with either a high or a low signal level.) The Store Clock causes the latched state of the sixteen data inputs to be written into memory, it also enables the trigger latch circuitry.

When the LA-160 is instructed to start a data acquisition sequence, it writes data into the memory on every cycle of the store clock, overwriting the old data with new. If the sequence is then stopped with the 'Stop' key after at least 2,047 store clock cycles have occurred, the memory will contain the data present at the 2,047 store clock cycles prior to this. Normally,

however, the sequence will be terminated by a Trigger event. This causes the acquisition sequence to stop after a delay of 1,023 Store Clock cycles. The memory then contains the data present for the 1,024 Store Clock cycles before and the 1,023 Store Clock cycles after the Trigger event. This is a normal triggered acquisition.

The Trigger event is generated by the AND function of 6 signals; a Valid Trigger Word signal, 4 latched Trigger Enable inputs and the Trigger Armed signal. The Valid Trigger Word signal is generated by comparing the latched data inputs with a trigger word set via the keyboard. This can contain 'don't care' states and therefore can be made always valid if required. The Trigger Armed signal is generated by permanently latching the state of the Trigger Arm input with the Store Clock. Once latched, the Trigger Armed signal remains True for the duration of the acquisition sequence. The Trigger Enable and Trigger Arm inputs can be set to be True with either a high or a low signal level.

Figure 1 **LA-160 Acquisition section simplified block diagram**
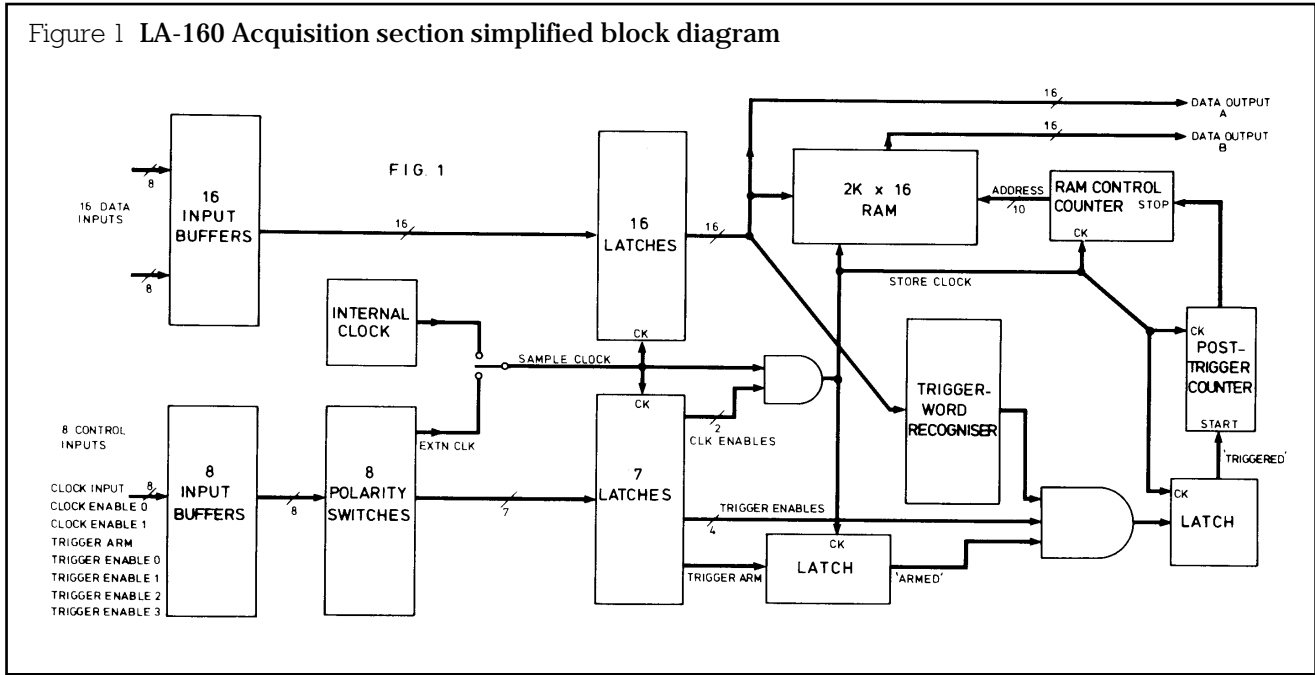
Data display

The single word display

The built-in 8 digit display shows the state of all 16 data inputs at the same moment in time using one of five display formats. These are binary, octal, decimal, hex or mixed (lines 15 to 8 in binary, lines 7 to 0 in hex). Data line 15 is the most significant bit and line 0 is the least significant bit.

8 indicator along the bottom of the display provide further information.

For example the same word can be displayed in five ways:

The data displayed comes from one of three locations, the Data Latches (Data Output A, Figure 1), the Acquisition Memory (Data Output B, Figure 1), or the Reference Memory.

In the 'Monitor' mode the display acts as a simple logic monitor and is updated continuously to show the state of the data inputs (subject to the presence of a Sample Clock waveform).

When recalling data from one of the memories the display shows the single 16-bit word at the cursor position. The cursor can be moved to any position in either memory and the position can be shown in decimal on the display (+999 to -999 for the Acquisition Memory, or +99 to -99 for the Reference Memory).

Memory cursor position
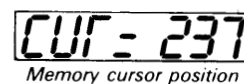
The oscilloscope display

The LA-160 can be connected to any conventional oscilloscope with variable timebase to obtain a timing diagram display of 8 or 16 channels from either of the memories.

The logic levels for the word at the memory cursor position are displayed at the centre of the oscilloscope screen, preceded by the levels for the 25 words before the cursor and followed by the levels of the 25 words after the cursor. Thus the oscilloscope displays a plot of the logic states for each channel during 51 cycles for the storage clock.

Connections

The LA-160 has 24 inputs. Sixteen of these are used for recording the data, while the other eight are used for controlling the recording process. The inputs are split into three groups each of which uses a 15-way female D connector.

Each input has a threshold level of about 1.4V and a load equivalent to one LSTTL gate input. This is suitable for use with most 5V logic families including TTL, DTL, NMOS, PMOS, and CMOS.

Great care must be taken to ensure that the inputs are not taken outside of the voltage range -0.5V to +5.5 V, as might occur when working on circuits which have auxiliary voltage rails in addition to +5V. To avoid any possibility of damage we recommend that connections are made via the optional LC-01 or LC-02 buffered input pods since these allow voltages up to ±15V to be applied to the inputs without damage.

Input Characteristics

The 24 inputs have characteristics as follows:

Data inputs:
$1 \times$ LSTTL Schmitt trigger gate load
typical positive going threshold +1.7V
typical negative going threshold +0.9V

Trigger Enable inputs:
$1 \times$ LSTTL standard gate load typical threshold +1.4V

Clock input
Clock Enable inputs $1 \times$ F series standard gate load
Trigger Arm input: typical threshold +1.5V

Typical input current for all inputs is $+20\mu A$ with the input level high and $-400\mu A$ with the input level low.

Note: An unconnected input will always be 'high'.

Important: The inputs must not be taken outside the voltage range -0.5V to +5.5V. In circumstances where overvoltage could occur accidentally we recommend the use of the optional LC-01 or LC-02 buffered data pods.

Set-up conditions

The 'set-up' conditions for the LA-160 can be inspected and modified using the key-pad. The 'set-up' parameters are marked in orange above the keys 1 to F. Depressing a key will cause the display to show the current state of that parameter, and allow it to be 'modified' if required.

The 'set-up' conditions are stored in permanent memory and are retained even when power is removed. As supplied the LA-160 is set-up as shown in Table 1.

The LA-160 can be returned to its original set-up conditions at any time by holding the Escape key depressed until the display shows '88888888'.

Table 1   **Set-up conditions**

Parameter	Initial set-up	Alternatives
Clock Source	Internal	External
Clock Polarity	Positive	Negative
Clock Period	100ns	Fifteen alternatives up to $800\mu s$
Clock Enables	Both 1s	0
Logic	Positive	Negative
Trigger Word	All don't cares	As required
Trigger Hold-off	Off	On
Trigger Enables	All 1s	0
Trigger Arm	1	0
Trigger Arm Delay	Off	On
Data Display Format	Hex	Binary, Octal, Decimal, Mixed
Acquisition Memory cursor position	000	-999 to +999
Reference Memory cursor position	00	-99 to +99
Reference Memory Limits	-99, +99	As required
Search Word	All don't cares	As required
Oscilloscope display mode	All 16 channels	Lo8, Hi8
Conditional Repeat mode	Stop on Fail	Pass

Setting the clock parameters

Clock Source

The Clock Source can be Internal (ie. generated within the LA-160) or External (ie. supplied via the clock input). When Internal Clock is selected the appropriate indicator is illuminated.

Clock Polarity

The analyser can be set to sample data on either the positive or negative going transition of the Sample Clock waveform.

Clock Period

The Internal clock can be set to any one of the sixteen frequencies between 1.25kHz and 10MHz (LA-160A) or 2.5kHz and 20MHz (LA-160B).

Clock Enables

Sampling only occurs when both clock enables are True. The Clock Enables use positive logic, ie. a high level at the input represents a 1. Each enable can be set to be True with the input high (1) or low (0).

Note: Unconnected inputs will always be high.

Setting the data display format

The 16 channels can be displayed in one of five formats; binary, octal, decimal, hex or mixed (upper lines binary, lower lines hex). The format set for the display of data is also used for the display of the Trigger Word and the Search Word.

The data is always displayed with the most significant digit on the left hand side and the least significant on the right hand side.

Binary format

Depress 'Binary', the data is shown in binary format (16 upper or lower segments).

In Binary format the data input line number corresponding to each bit displayed is marked above the display. The upper eight lines (8 to 15 inclusive) are also marked with the mnemonics for the control lines of the General Purpose Interface Bus.

Octal format

Depress 'Octal', the data is shown in octal format (6 digits, 0 to 7) with a letter 'o' on the right hand side.

Decimal format

Depress 'Decimal', the data is shown in decimal format (5 digits, 0 to 9) with a letter 'd' on the right hand side.

Hex format

Depress 'Hex', the data is shown in hexadecimal format (4 digits, 0 to F). In this mode the cursor position is simultaneously displayed to the right of the data whenever data is being recalled from either of the memories. When reviewing the trigger word or search word a letter 'h' is displayed on the right hand side.

Mixed format

Depress 'Mixed', the data is displayed in mixed format (8 upper or lower segments plus 2 digits, 0 to F).

Don't Care states

A Don't Care state is indicated by a ┆ symbol in binary mode, and a ≡ symbol in octal or hex modes. Don't Care states cannot be entered in decimal. If a word that contains Don't Care states is reviewed in a mode other than that in which it was set, those digits which partially contain Don't Care states will flash to indicate this.

Setting the trigger parameters

Trigger Word

The Trigger Word can be set in any of the five display formats (Binary, Octal, etc). If it is required to change the format depress the appropriate display format key prior to setting the Trigger Word. Don't Care states can be included within the trigger word in all display formats except decimal.

Trigger Word Hold-off

This facility prevents a Valid Trigger Word signal from being generated unless the trigger conditions have been satisfied for at least two clock periods. This pre-vents spurious triggering on glitches or transitory states when bus lines are changing and is useful when capturing data asynchronously. It should not be used during high speed synchronous acquisition (2MHz and above).

Trigger Enables

A Trigger Event only occurs when all four Trigger Enables are 'True'. The Trigger Enables use positive logic, ie. a high level at the input represents a 1. Each enable can be set to be True with the input high (1) or low (0).

Note: Unconnected inputs will always be high.

Trigger Arm

The Trigger Arm facility enables the triggering of the analyser to be delayed until after the occurrence of some external event. If a data acquisition is started with the Arm input false, the instrument will not trigger until after the input has been taken True. In order to be accepted, the arm input must be True during at least one active transition of the Store Clock waveform, its condition following this is then ignored. An LED on the display illuminates as soon as the Trigger Arm is accepted.

The Arm input uses positive logic and can be set to be true with the input high (1) or low (0).

Note: An unconnected input will always be high.

Trigger Arm Delay

When no external Trigger Arm signal is available, the Arm input will normally be set so as to be permanently True. In this circumstance the analyser may trigger before 1,000 Store Clock cycles have occurred, in which case the pre-trigger information in the Acquisition Memory will be only partially valid. To avoid this condition the operation of the Trigger Arm can be delayed by 1,024 Storage Clock cycles, ensuring that the memory always contains valid pre-trigger information.

Setting the data logic polarity

All the control inputs operate in positive logic only, ie. a high level on a control input always represents a logic level 1. The Data Inputs, however, can be set to operative or positive or negative logic.

Using the LA-160 as a logic monitor

By depressing 'Shift' followed by 'Monitor', the analyser operates as a simple logic monitor. In this mode the display shows the state of the Data Inputs updated in synchronism with the Sample Clock waveform, irrespective of the trigger conditions.

The data can be displayed in any of the display formats. No oscilloscope display is available in this mode.

The Monitor mode is useful as a means of continuously observing the state of the data lines.

Data acquisition

The analyser has three acquisition modes:

single shot, repeat, and conditional repeat. The following instructions assume that the Clock parameters

have been set up to achieve a valid Storage Clock signal and that the Trigger parameters have been set up to enable a Trigger Event to occur.

Single shot

Depress 'Single'. The analyser starts writing data into the acquisition memory synchronously with the Storage Clock waveform. As soon as the Trigger Arm is accepted the 'Armed' light will illuminate. Following this, as soon as a Trigger Event occurs the 'Triggered' light will illuminate and the analyser will stop writing data into its memory 1,023 clock pulses later. (**Note:** The total memory size is 2,048 words but only 1,999 are accessible). The display will then show the message 'Full' to show that the memory has been filled. The 'Data' and 'Cursor' keys may then be used to examine the memory contents.

Automatic Repeat

Depress 'Shift' followed by 'Repeat'. The analyser will then perform a data acquisition and, when completed, will display the data at the Acquisition Memory position indicated by cursor. It will display the data for just under two seconds before automatically performing another acquisition and so on until 'Stop' is depressed.

Conditional Repeat

The analyser can be set to perform acquisitions repeatedly with minimum delay and to stop automatically, either when the contents of a portion of the Reference Memory becomes identical with a portion of the Acquisition Memory (Stop on Pass) or not identical with it (Stop on Fail).

In this mode the analyser is repeatedly using the Memory Compare function described later.

Set the Acquisition Memory cursor position and the Reference Memory limits as required. Depress 'Shift' followed by 'Cond Rpt', the display will show 'Stop = P' or 'Stop = F' indicating whether the repeating acquisitions are to be stopped on a Pass or a Fail condition, use 'Modify' to change this if required. Depress 'Cond Rpt' again, the analyser will commence data acquisitions.

Using the Acquisition Memory

The Acquisition Memory has a total capacity of 2,048 sixteen bit words of which only 1,999 are accessible.

When the analyser is first switched on, the memory contents are entirely random. When a data acquisition is started the analyser starts to write data into the Acquisition memory in synchronism with the Storage Clock overwriting the existing data. When 2,048 words of data have been written in, this data starts to be overwritten with newer data and so on. This process can be stopped in one of two ways:

i) by a Trigger Event: the LA-160 defines the memory address to which data is being written when the Trigger Event occurs as 000, it then continues to write data into the memory for 1,023 cycles of the Storage Clock before stopping. Thus 1,023 words of post trigger data are stored, of which 999 are accessible. The amount of pre-trigger data is equal to the number of cycles of the Storage Clock that occurred between the start of the acquisition and the Trigger Event, the maxi-

mum being 1,024 words of which 999 are accessible. Trigger Arm Delay can be used to prevent triggering until at least 1,024 cycles have occurred thus ensuring the maximum amount of valid pre-trigger data.

ii) by depressing 'Stop': this stops the acquisition immediately and defines the memory address then being written to as 000. The display will show 'Not Trig' and the memory will contain pre-stop data equal to the number of cycles of the Storage Clock that had occurred, the maximum being 2,047 of which 999 are directly accessible.

If 'Stop' is depressed after a Trigger Event has occurred but before 1,023 further Storage Clock cycles have occurred, the display will show 'Not Full' and only a limited amount of valid post trigger data will then be available.

Displaying the contents of the Acquisition Memory

The keys marked 'Aqu Mem' and 'Ref Mem' select between a display of the Acquisition Memory contents and the Reference Memory contents. Having selected the Acquisition Memory, depressing the key marked 'Cursor' will cause the display to show the current position of the acquisition memory cursor in decimal. Depressing the key marked 'Data' will cause the display to show the data stored at the cursor position. (In hex mode the cursor position will be displayed simultaneously with the data.)

Displaying and moving the cursor position

By depressing the key marked 'Cursor', the single line display will show the position of the cursor in decimal. This can be anywhere between +999 and -999 if the acquisition memory is being recalled, or +99 or -99 if the reference memory is being recalled. To return to a display of the data at the memory position indicated by the cursor, depress the key marked 'Data'.

Simultaneous display of cursor position and data

In hex mode only, depressing 'Data' will cause the display to show the data in hex on the left hand side and cursor position on the right hand side.

Moving the cursor position

The two keys marked with arrows are used to shift the cursor position. The key with the arrow pointing right moves the cursor towards more recently stored data (a more positive value) whilst the key with the arrow pointing left moves the cursor the other way.

A single depression of these keys moves the cursor one memory location, if the keys are held depressed they will autorepeat.

Alternatively the cursor position can be moved using 'Modify'. With the cursor position displayed, depress 'Modify', the existing position will start to flash, enter the required position (changing the sign with the +/- key first if required), the cursor position is moved as the final digit is entered.

Returning the cursor position to zero

If the 'Cursor' key is held depressed the cursor position will be automatically reset to 000 or 00.
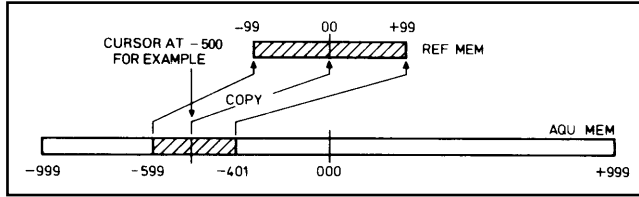
Using the Reference Memory

The Reference Memory has a capacity of 199 sixteen bit words. This memory can be loaded from the Acquisition Memory and can be modified via the keyboard.

The Reference Memory is non-volatile and therefore its data is retained when the analyser is switched off.

Loading the Reference Memory

The Reference Memory can be loaded automatically with a block of 199 words from the Acquisition Memory. The position of the block which is copied is defined by the position of the acquisition memory cursor, see below.

Position the Acquisition Memory cursor at the centre of the block of data which is to be copied into the reference memory. Depress 'Shift' followed by 'AÆR'.

Displaying the contents of the Reference Memory

Depressing 'Ref Mem' causes the display to show either the Reference memory cursor position or the data at that cursor position in exactly the same way as for the Acquisition Memory.

When in this mode the 'Ref Mem' indicator on the display flashes. To return to displaying the Acquisition Memory depress 'Aqu Mem'.

Modifying the contents of the Reference Memory

The contents of the Reference Memory may be modified using the 'Modify' key in the same way as a Trigger Word or a Search Word is modified. Don't Care states can be included.

Limiting the size of the Reference Memory

When using the Automatic Memory compare facilities (Compare or Conditional Repeat), it may be desirable to limit the size of the block of data which is used for the comparison. This can be achieved by limiting the effective size of the Reference Memory.
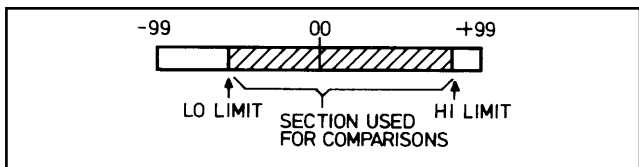
Using the Oscilloscope Display

Depress either 'Data' or Cursor'. The logic levels for the word at the memory cursor position are then displayed at the centre of the oscilloscope graticule preceded by the levels for the 25 words before the cursor and followed by the levels for the 25 words after the cursor. Each word appears on one of the major or minor divisions of the graticule. Thus the logic waveforms of each of the sixteen input channels covering 51 cycles of the Storage Clock are displayed. Line 15 is at the top and line 0 is at the bottom, the lines are arranged in blocks of four to make identification easier.

The oscilloscope can display data from either the Acquisition or the Reference Memory. When the cursor is moved the display will scroll left or right.

As an alternative to displaying sixteen channels, the oscilloscope can be set to display the upper or lower eight channels only. This enables the waveforms to be examined in more detail and increases the trace brightness.

Depress 'Scope 8/16' until the display reads 'Lo 8' or 'Hi 8' as required and change the oscilloscope's vertical sensitivity to 100mV/div.

Depressing 'Scope Ref' causes the set-up waveform to be displayed for as long as the key is held depressed. This enables the graticule centring to be quickly checked and the low state of all the lines to be observed. Alternatively the analyser can be put permanently into this state by depressing 'Escape'.

Holding 'Compress' depressed when viewing the Acquisition Memory causes the display to show 51 words at 10 word intervals, thus giving an overview of 510 words. This can be useful in locating the position of a particular event such as a line changing polarity.

Making time measurements

When the clock speed is known (eg. when using the internal clock), the oscilloscope display can be used for timing measurements.

As an example, the diagram below shows two pulses sampled with a 100 ns clock period. They appear with coincident leading edges, but non-coincident trailing edges; thus demonstrating that the leading edge positions are within 100 ns of one another, whilst the trailing edge positions differ by 16×100 ns (ie. $1.6\mu s \pm 0.1\mu s$).
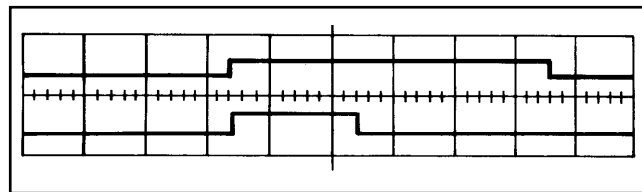
Where a timing measurement across more than 50 clock periods is required, this can be done by moving the cursor until each point falls on the graticule centre, and then subtracting the two cursor location values.

Using the Word Search facility

The LA-160 can be made to automatically search through its Acquisition memory in order to find a specified word. This facility is very useful during software analysis for locating specific sections of code.

Depress 'Shift' followed by 'Search'. The display will show the existing state of the search word. This can be modified using the 'Modify' key in the same way as setting the Trigger Word. Don't Care states can be included.

Depress either of the cursor shift keys ($\rightarrow$ or $\leftarrow$) and the analyser will automatically move the cursor backwards or forwards from its present position until an occurrence of the search word is found. The analyser then stops with the display showing the cursor position. Depress one of these keys again and the cursor will move on to the next occurrent of the search word.

If the cursor gets to either end of the acquisition memory, the display will show the message Fail 999 or Fail -999.

Using the Memory Compare facility

The LA-160 can be made to automatically compare the contents of the Reference Memory with the contents of the block of the Acquisition Memory of the same size.
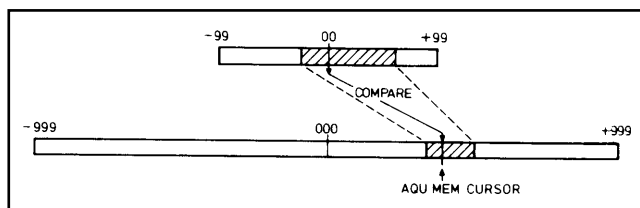
The portion of the Reference Memory used is as defined by the Reference Memory limits facility, whilst the portion of the Acquisition Memory used is defined by the current position of the Acquisition Memory cursor. The current position of the Reference Memory cursor is ignored.

Depress the 'Shift' key followed by the key marked 'Compare'. The LA-160 will automatically move both cursors from one end of each memory block to the other, continuously comparing the data at each point. If all the data matches, the cursors will be returned to the Reference Memory 00 position and the display will show the message PASS. If a mismatch is found, the cursors will be returned to the Reference Memory 00 position and the display will show the message FAIL.

The analyser can be made to perform a Memory Compare automatically every acquisition.

Using the Word Compare facility

The LA-160 can be made to automatically compare the contents of the Reference Memory one word at a time.

The section of the Acquisition Memory used is defined by the current position of the Acquisition Memory cursor. The current position of the Reference Memory cursor is ignored.

Depress 'Shift' twice followed by 'Word Comp'. The display will show the current Acquisition Memory cursor position, or 00 for the Reference Memory cursor position along with the message PASS if the two words of data match, or FAIL if they mismatch.

Depressing either of the cursor shift keys will step the comparison words forwards or backwards. Holding either key depressed will cause them to autorepeat. Whenever a change from PASS to FAIL or from FAIL to PASS occurs, a short bleep will be produced.

The memory contents 'Send' facility

The LA-160 can be made to output the entire content of its acquisition memory as serial ASCII data at RS423 levels.

128 strings of 73 eight bit ASCII characters are transmitted with a baud rate of 9,600 and a character repetition rate of 1.25 msecs.

CR	Carriage Return
LF	Line Feed
Null Null	Two Nulls
S	Letter S
XXXX	Address of 1st data word in Hex
XXXX XXXX XXXX etc	} 16 sequential data words in Hex

Thus the first string contains the address 0000, the second string 0010 etc. All 2048 data words are sent starting with the earliest pre-trigger word and ending with the last post-trigger word. The trigger word is sent in the 65th string as the first data word after the address 0400.

The 'Send' facility is intended for use with a computer, where the data can be written directly into memory and then analysed further (eg. disassembled). It can also be used to drive a printer which has a suitable serial interface.

Depress 'Shift' twice followed by 'Send'. The analyser will start to output data, and will return to 'ready' when this is completed.

The rear panel connector signals

Five output signals and one input signal are available on the nine pin D connector mounted on the rear panel.

The connections are as follows:

Pin No.	Function
1	Trigger Word Recognition output
2	RS423 Data output
3	'Clear to Send' input
4	Internal Clock output
5	Internal Clock 10 output
6	'Triggered' output
7	Ground
8	Ground
9	Ground

Internal Clock output

When the internal clock is selected, a TTL level signal at the same frequency is available on pin 4. This can be used to drive the circuit under test for synchronous acquisition using the internal clock.

Internal Clock 10 output

When the internal clock is selected a TTL level signal at one tenth of this frequency is available on pin 5. If this is used to drive the circuit under test then synchronous acquisition will be achieved with the analyser taking ten samples for every clock period of the circuit under test. This can be very useful for locating hardware faults.

'Triggered' Output

The 'Triggered' Output is a TTL level signal available on pin 6. This signal goes low at the start of a data acquisition and is then latched high by the occurrence of a trigger event. This signal may be useful for driving external equipment eg. generating a hardware break for a microprocessor system.

Trigger Word Recognition output

The Trigger Word Recognition output is a TTL level signal with an open collector output and $1k\Omega$ pull-up impedance. It is available on pin 1. The output goes high whenever the data word matches the trigger word, at all other times it is low.

This signal can be useful for such things as qualifying the point at which the LA-160 responds to a trigger event. For example if the signal is fed to a counter whose output is connected to the Trigger Arm input of

the LA-160, triggering can be prevented until the nth occurrence of the trigger word as set by the counter.

Note: This signal must not be loaded by more than 50pF if correct operation is to be maintained.

RS-423 Serial output

This is a bipolar output available on pin 2. The typical output level is $\pm4V$ (8V pk-pk) at ZOUT = $1/2\Omega$. The idle state is low. The signal is used for sending data to a computer or printer which has a serial data input at RS-423 or RS-232 levels. Operation of the RS-423 output is controlled by the 'Send' or 'Print' routines.

'Clear to Send' input

This input has a threshold of about $+1.4V$ and will accept bipolar signals up to the RS-232 maximum of $\pm25V$. It is available on pin 3.

When the input is taken high, the RS-423 output is enabled to output data as controlled by the 'Send' or 'Print' routines. The RS-423 output is disabled during periods when 'Clear to Send' input is taken low or left unconnected.

LC-01 Buffered input pod (**RS** stock no. 611-307)

The LC-01 provides a convenient means of connecting the LA-160 to the circuit under test whilst at the same time providing protection against accidental overvoltage of the inputs. One LC-01 is required per input connector, so that three will normally be needed.

The LC-01 consists of a 15-way D connector linked to a pod by 0.6 metres of ribbon cable. The pod is automatically powered from the analyser and contains eight high impedance buffers along with protection components which enable voltages up to $\pm15V$ to be applied without damage. The input impedance is $100k\Omega$, and the threshold is $+1.4V$, as per standard TTL.

At the end of the pod is a standard 10-way 0.1in pitch header providing 8 signal inputs plus two grounds. This header mates with either the ten way wireable socket provided or with the optional LG-09 logic grabber set which consists of nine colour coded logic grabbers wired to a ten way socket.

LC-02 Variable threshold input pod (**RS** stock no. 612-467)

The LC-02 input pod acts in a similar way to the LC-01, but the input threshold voltage may be varied between -3V and +10V or set to a TTL threshold of +1.4V.

LR-64 Extended facilities ROM (**RS** stock no. 611-408)

The LR-64 is an additional ROM which extends the software facilities of the LA-160. It is easily retro-fitted by the user.

The additional facilities are those marked in brackets on the keyboard. If these facilities are selected on an LA-160 which is not fitted with the LR-64, a brief "error" message will be displayed.

The additional facilities are as follows:

Signature

This function enables a section of data within the acquisition memory to be compressed into a 4 digit hex 'signature'. The purpose of this is to enable the user to immediately identify a block of data as being correct or incorrect by means of its unique signature.

The signature facility is a very fast way of comparing suspect data with known good data, and allows go, no-go testing to be performed by unskilled operators by comparing signatures against prepared documentation.

The LA-160 calculates 17 signatures simultaneously, a signature for all 16 data channels together and a signature for each individual data channel. Thus the data can first be verified for all 16 channels and then, if incorrect, each data channel can be checked separately.

The user can select the size and position of the acquisition memory block used for signatures by specifying a low and high address limit.
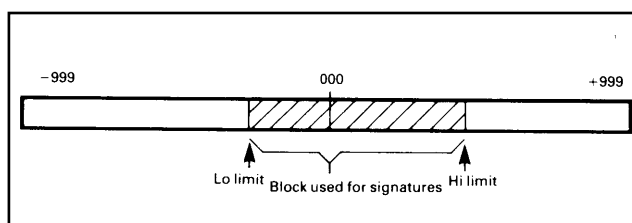

As supplied these limits are pre-set to -099 and +099. The length of time taken to calculate signatures varies between 300msec for 50 words or less, and 10 seconds for 1,999 words.

Timing

This function enables the built-in single line display to show a timing diagram for any one channel. This is intended primarily for applications where no oscilloscope is available.

The display shows the state of the channel at the cursor position plus the states for the 15 store clock cycles prior to this.
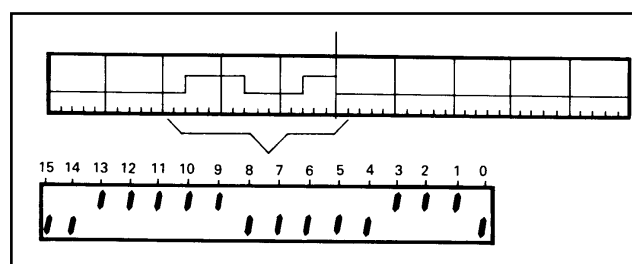
The cursor can be moved using the cursor shift keys, with the Timing display scrolling left or right accordingly. The display can be rapidly switched between channels enabling Timing comparisons to be made. Both the acquisition and reference memories can be displayed in this mode.

Trigger Count Delay

There may be occasions when it is desirable to prevent the analyser from triggering on the first occurrence of a trigger event, but to trigger on some later occurrence instead. For example the user might require to trigger on the third call of a subroutine within a nested loop.

The Trigger Count Delay facility enables the point at which the analyser triggers to be delayed by up to 9,999 occurrences of the trigger event. The trigger count delay number represents the number of occurrences of the trigger event which must occur between the analyser being 'armed' and the analyser being enabled to respond to a trigger event. This can be set anywhere between 0 and 9,999. Thus if it is set to 0002 the analyser will trigger on the third occurrence of the trigger event.

Once set, the Trigger Count Delay will operate in all three of the acquisition modes ie. Single, Repeat and Conditional Repeat. During the periods when the delay is operating the display will be blanked apart from a letter C on the left-hand side. This letter will be brighter than normal because the display multiplexing is disabled. During these periods the 'Stop' key will not operate and the acquisition can only be terminated by depressing 'Escape'.

The trigger counting system has a minimum repetition period of 50μsecs and therefore if any trigger events occur less than 50μsecs apart the analyser will ignore them.

Note: With the Trigger Count Delay set to 0000, the facility is completely inoperative. This is the condition set when supplied.

Print

This function enables a data print-out to be obtained using any printer which has an RS-232 serial input. Four print-out formats are available: state listing for sixteen data channels, signature listing, combined timing diagram and state listing, and a state listing for thirty-two data channels. All the formats, except the combined timing diagram and state listing, are available with any type of printer. The combined timing diagram and state listing format will only operate with an **RS** printer, Epson printer or a printer with Epson emulation.

The RS-232 printer input should be connected to the RS-423 logic analyser output as follows:

LA-160 RS-423 output		Printer RS-232 input
Data output (pin 2)	to	Data input (RCD) (pin 3)
Clear to send input (pin 3)	to	Request to send (RTS) (pin 4)
Ground (pins 7, 8 & 9)	to	Ground (pin 7) link (pin 6 to pin 20)

A cable with the above connections is supplied with the LR-64 extended facilities ROM.

The printer interface must be set-up as follows:

9,600 baud: 8 bits: no parity: 1 start bit: 1 or 2 stop bits.

Print formats

Four format numbers are available. Formats 0, 1 and 3 will operate with any printer. Format 2 will only operate with an **RS** printer, an Epson printer or a printer with Epson emulation. Format 3 will only operate when the LE-32 thirty two channel extender is fitted.

All the formats include a statement of the analyser set-up parameters (ie, trigger word, clock sources etc.)

Format 0 is a 16 channel state listing of whichever memory was almost recently selected (acquisition or reference). When printing the acquisition memory the printout will list all the data between the two limits set-up using the 'signature' function (see 'Signature' section) which can be anywhere between -999 and +999 but which are factory initialised to -099 and +099. When printing the reference memory, the print-out will list all the data between the two limits set-up using the 'RM limits' function which are factory initialised to -99 and +99.

The data at each memory location is printed simultaneously in three formats: binary plus ASCII plus octal, decimal, hex or mixed. The last format is selected by the LA-160 display format-keys.

Format 1 is a listing of the signatures as would be calculated using the 'signature' function. In this format depressing 'Shift', 'Print' causes all 17 signatures to be calculated (using the present signature limits) and then printed out.

Format 2 is a combined timing diagram and state listing. It uses Epson graphics-mode control codes.

A sixteen channel timing diagram covering 51 words centred about the cursor is printed out. This can come from either memory and is identical to the timing diagram that would appear on the oscilloscope display. A state listing for these 51 words in binary plus ASCII plus octal, decimal, hex or mixed is also printed out.

Format 3 this can only be used when the LE-32 thirty two channel extender is fitted. It is similar to Format 0 but prints the state listing for all 32 channels.

LE-32 thirty-two channel extender module (**RS** stock no. 612-350)

The LE-32 enables the analyser to acquire thirty-two channels of data simultaneously. The analyser's memory depth is modified to 1000×32 bit words, and the maximum acquisition speed is reduced to 5MHz when using an LA-160A or 10MHz when using an LA-160B.

The LE-32 mounts directly below the LA160 using two extended screws and is powered from the analyser which must be fitted with an LR-64 extended facilities ROM. All data inputs and the main control inputs are brought out on a single 40-way connector (32 data +6 control) and two single sockets are provided for further control inputs. Each input has a TTL threshold (+1.4V) and a leading equivalent to one LSTTL gate input. Once the LE-32 has been connected, the LA160 must be put into the LE-32 mode. This is carried out as follows:

Depress 'Shift' followed by 'Modify', the displays will show 'Select'

Depress 'O', the display will show 'LE32 = OFF'.

Use 'Modify' to change this to ON, the display will then change to 'READY' and the analyser will be in the LE-32 mode.

To return to normal mode this same procedure should be used to set 'LE32=OFF'.

When put into LE32-mode, the logic analyser automatically sets up its parameters as follows:

Parameter	Initial Set-Up	Alternatives
Clock Source A	External	None
Clock Source B	External	None
Clock Polarity	Both positive	Negative
Clock Enables	Both don't cares	1 or 0
Logic Polarity A	Positive	Negative
Logic Polarity B	Positive	Negative
Trigger Word A	All don't cares	As required
Trigger Word B	All don't cares	As required
Trigger Hold-Off	Off	None
Trigger Enables	Both don't cares	1 or 0
Trigger Arm	Don't care	1 or 0
Trigger Arm Delay	Off	On
Trigger Count Delay	0000	As required
Channel Group Display	A	B
Data Display Formats	Both hex	Binary, Octal Decimal, Mixed
Acq. Mem. Cursor	000	-499 to +499
Ref. Mem. Cursor	00	-99 to +99
Ref. Mem. Limits	-99, +99	As required
Signature Limits	-099, +099	As required
Search Word	All don't cares	As required
Scope Display Mode	All 16 channels	Lo 8, Hi 8
Cond. Rpt. Mode	Stop on Fail	Pass
No of Channels	32	16

In order to make connection to the circuit under test, the user may wire-up his own connector or use an LC-05 'personality' module. Neither the LC-01, LC-02 data pods or LC-04 modules may be used with the LE-32.

## LC-04 buffered 'personality' modules
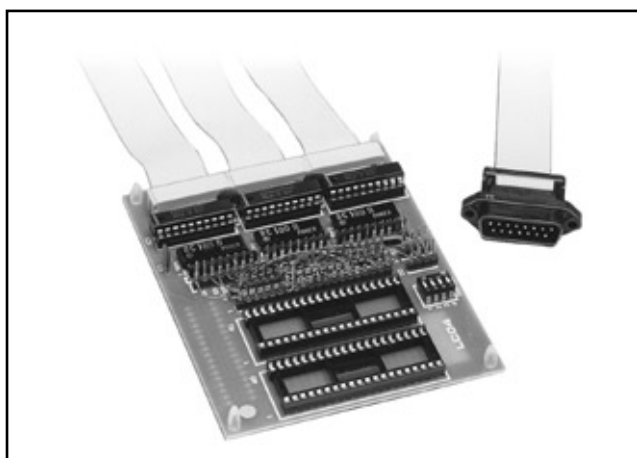
Where there is a requirement to connect to 5V systems such as standard microprocessors, the LC-04 series of 16 channel buffered 'personality' modules may be utilised. Each module connects to the LA-160 via three 15-way D connector cables. The circuit under test is connected via a 40-pin DIL socket. A set of wire-wrap pins enables the user to set any order of data inputs, clock, qualifiers, etc. to suit a particular processor or system. A microprocessor may be installed in one of the module's sockets, allowing a simple interconnecting cable, based on 40-pin headers, to be used for connection to the target system. Alternatively the LC-06 cable assembly may be used.

The modules are supplied in four versions - one non-wrapped, for users to configure, and three pre-wrapped for use with three of the most popular processors (Z80, 8085, 6502).

LC-05 buffered 'personality' modules
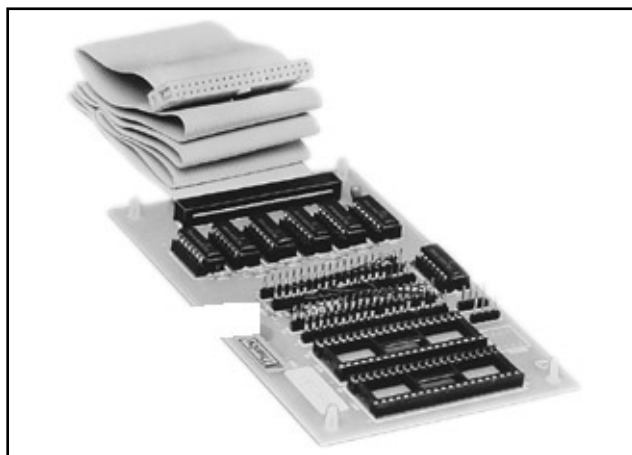
In a similar way to the LC-04 'personality' modules, the LC-05 units may be used to connect a 5V microprocessor system to the L-32 extender module. The Z80 and 6502 modules are wired to capture the data, address and control signals whilst a non-wrapped module is also available for other configuration. The modules are connected to the LE-32 via a single 40 way DIL connector. As with the LC-04 modules, the processor under test may either be inserted into the LC-05 or an LC-06 cable assembly may be utilised.

LC-06 test clip cable assembly

A length of ribbon cable, terminated at one end with a 40-way DIL header plug, and at the other end with a sprung 40-way IC test clip. This assembly is designed to plug into an LC-04 module at the header end, and to clip onto a microprocessor IC at the test clip end.

LA-PC link (**RS** stock no. 614-750)

General

Advanced features such as data state listings, timing diagrams, data annotation etc, normally associated with only very expensive logic analysers, are made available to the user of the LA-160 by the addition of an LA-PC link.

This LA-PC link, which is a software package, enables the LA160 to be interfaced to an IBM PC or compatible and hence acts as a powerful extension to the LA-160.

The main features of LA-PC Link can be summarised as follows:

Sophisticated data state listings

Up to 32 words per screen in multiple data formats. Scrolling by line or by page plus random page access. Word search and screen compare facilities.

High resolution timing diagram

Sixteen channels of 64,256 or 1,024 samples per screen. Rapid pan and zoom, movable channel positions. A and B group channels can be mixed in 32 channel mode. Dual cursors with automatic difference measurement.

Full disc storage facilities

Save data to disk to reference and comparisons. Saved data includes details of the analyser's set-up state.

Comprehensive data annotation

Each data channel can be allocated a user-defined label. Disc storage files can be annotated and date and time stamped.

Versatile printing facilities

State listings and timing diagrams with full annotation can be printed using a standard dot matrix printer.

16 channel or 32 channel operation

Operates with both 16 and 32 channel versions of the LA-160.

Computer requirements

Before an attempt is made to load this software the user is advised to check that the computer, which should be an IBM* PC/XT/AT or a close compatible features the following:

At least one 51/4 in floppy disc drive

At least 192K of RAM

PC-DOS or MS-DOS operating system V.2.0 or above

Serial communications port (RS-232C)

Display adaptor capable of emulating the IBM CGA

(Colour graphics adaptor) standard**

* IBM is a registered trademark of International Business Machines Inc.

**This type of display adaptor is desirable but not essential. The software can operate in either of two modes. Mode 1 is for a colour graphics adaptor with a colour monitor or a monochrome monitor. Mode 2 is for text-only adaptors or graphics adaptors which do not meet the IBM CGA standard. Mode 2 cannot display timing diagrams on the screen, although timing diagrams can still be produced using a printer.

Initial operations

a) Setting up the LA-160

In order to correctly send data to the computer the LA-160 must be put into 'PC Mode'.

To change the mode press the following keys on the LA-160: 'Shift', 'Modify', '4', the display will show 'PC=OFF' or 'PC=ON'. Press 'Modify' following by either 'on' or 'off' the display will return to 'ready'.

In 'PC Mode' the LA-160 automatically sends data to the computer every time a data acquisition is completed.

b) Loading the disc software

'Boot' the computer and place the LA-PC Link working disc into the default drive.

Type LA (return)

An opening screen will appear showing the software issue number and the license and copyright information. Wait for the prompt and then press any key to continue. The program will progress to the system menu.

Operating the program

a) General overview

The serial interface linking the LA-160 logic analyser to the computer is unidirectional ie. the LA-160 can send data to the computer but cannot receive data from it.

The LA-160 is set up and operated from its own keypad in exactly the same way as when it is used as a stand alone instrument. See the standard LA-160 operating manual for instructions as to how to operate it.

Whenever the LA-160 completes a data acquisition it transmits the total contents of its acquisition memory ($2K \times 16$ bit words or $1K \times 32$ bit words) to the computer. It also sends information which identifies the type of data (16 or 32 channel and all the current set-up states of the logic analyser.

The computer writes the incoming data to a data buffer within its working memory. There are two such data buffers labelled DX and DY. Thus two complete acquisitions can be held in the computer's memory at any time.

The program enables the computer to manipulate, display, store or print the contents of these data buffers.

Note: It is not possible to send the contents of the LA-160s reference memory to the computer.

b) The system menu

The system menu provides access to all the main facilities of the program via the function keys F1 to F10.

F1 calls a help screen which gives some basic information regarding the operation of the program. Note that F1 can be used at any time to call a help screen appropriate to the current function.

F2 enables the program to be terminated. Note that at any other time F2 will return the program to the system menu.

F3 provides access to the timing diagram displays.

F4 provides access to the state display.

F5 provides access to the annotation screen which shows the logic analyser's set-up states and allows text comments to be added to the data both for display and for disc storage.

F6 provides access to the disc directory for storing and recalling data to disc.

F7 provides access to a 'terminal' mode whereby the standard print routines of the LA-160 can be sent either to the screen or to a printer connected to the computer.

F8 toggles between normal intensity colour, high intensity colour, and monochrome for all text display screens.

F9 not used.

F10 toggles between using the DX data buffer or the DY data buffer as the current data buffer. Note that the F10 key has the same function on the screens.

c) **Using the timing display**

The timing display is accessed via the F3 key from the system menu.

Upon entry the display shows a timing diagram representing 256 samples from sixteen channels.

The timing display can be 'panned' to show any section of the memory, 'zoomed in' to show increased details (64 samples) or 'zoomed out' to show a wider overview (1,024 samples).

These actions are performed using the pointer which appears initially in the middle of the screen. The pointer is moved about by using the cursor keys on the numeric keypad of the computer keyboard, (or by using a 'mouse' if fitted).

The '+' key and '-' key on the numeric keypad are used to perform control operations using the pointer. (When using a mouse the LH and RH mouse buttons are equivalent to the '+' key and '-' key respectively.)

The cursor keys move the pointer fairly slowly. To move the pointer more quickly depress the shift key then use the cursor keys whilst holding the shift key down.

The section of memory being displayed is shown graphically by the bar at the top of the screen, this is known as the 'data window bar'. The position in memory of the word at the pointer position is shown at the bottom of the screen.

d) **Using the state display**

The state display is accessed via the F4 key from the system menu.

Upon entry the state display shows a page of either 32 sixteen channel words or 16 thirty-two channel words depending upon the format of the data within the current buffer.

Each word is displayed in three formats, the first is binary, the second is Hex and the third is ASCII. The latter two formats can be changed by pressing the F5 and F6 keys which cycle through Octal, Decimal, Hex and ASCII formats.

The position within the memory of the page being displayed is shown graphically within the data window bar. The data can be scrolled by line or by half page or a new page can be selected from any position within the memory.

A word find facility enables the page to be scrolled by occurrence of a specified data word.

A screen comparison facility enables the state listing screen to be compared with a reference screen in order to rapidly identify differences.

e) **Printing data**

Timing and state data can be sent to a printer connected to the computer by pressing F4 key.

Supplied in the LA-PC Link package are:

- A comprehensive instruction manual showing how to operate the program step by step.
- one 5$\frac{1}{4}$in 360 DSDD 48tpi floppy disc containing the software.
- two 28 pin ROM ICs containing software for the LA-160.
- one cable linking the LA-160 to the computer.