Gould 1600 Series
Operators Manual

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1600 Operators Manual for the 1604 and 1602

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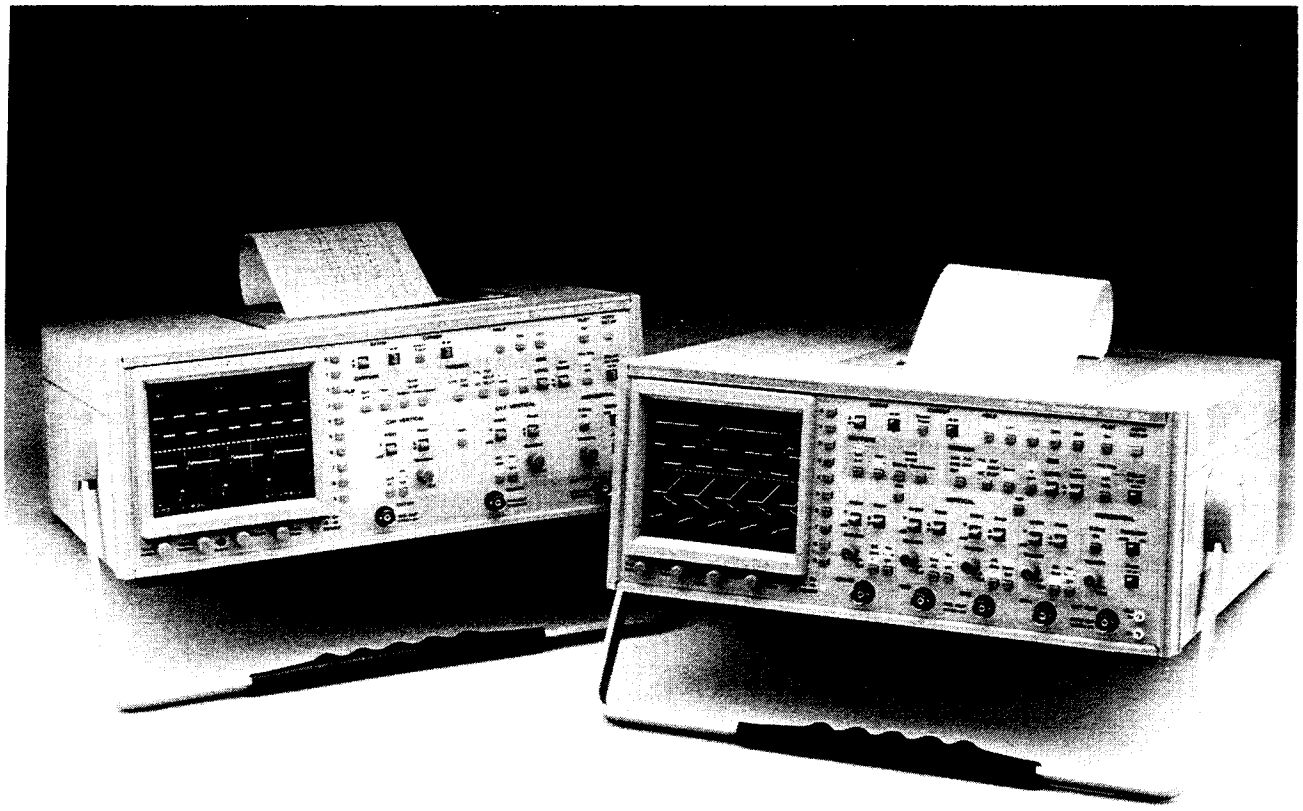
Introduction



The Gould 1600 digital storage oscilloscopes have been designed to provide a versatile range of instruments for use in a wide range of applications.

The 1600 can operate in storage or non-storage mode (digital or analogue mode) as required and includes all the features expected of an advanced modern oscilloscope at the same time retaining user-friendliness.

For the first time user, obtaining a trace is especially simple – just connect the signal and press the Auto Setup button – the 1600 does the rest. Having obtained a trace, three readily accessible cursors make it easy to take automatic time and voltage measurements directly from the display. The innovative use of five-position paddle controls instead of dials makes precise control of the instrument possible, the digital readout on the display constantly showing the current status where appropriate.

More advanced features of the 1600 include a comprehensive system of menu-controlled functions. For example, the Acquisition/Trigger menu operates features such as the glitch detection function and the trigger delay, division and pre-trigger display functions. The pre-trigger display function allows the signal immediately prior to the trigger point to be captured and displayed.

Another menu-controlled feature of the 1600 is its memory. Two complete traces can be stored for future use, and four complete front-panel control setups. With the optional battery backup facility, these can be retained even when the 1600 is switched off.

The 1600 comes complete with serial-channel and four-parallel channel analogue outputs for use with external plotters as standard. Optional extras include GPIB (IEEE488) & RS423 input/output ports for external control by a host computer, and Gould waveform processors to provide enchanced measurement and trace processing.

1.0 SAFETY AND POWER REQUIREMENTS

International Safety Warning
(as required for I.E.C. 348 Class I)

This manual contains information and warnings which must be observed by the user to ensure safe operation and retain the apparatus in a safe condition. The instrument has been designed for indoor use within the specified limits of temperature, i.e. 0 to 50 deg. C. It should not be switched on if there are obvious signs of mechanical damage and it should not be used under wet conditions.

Grounding

The instrument must be operated with a protective ground connected via the appropriate (yellow/green) conductor of the supply cable. This is connected to the instrument before the line and neutral supply connections when the supply plug is inserted into the socket on the back of the instrument. If the final connection between this and the supply is made elsewhere, the user must ensure the ground connection is made before line and neutral.

If any supply cable other than that supplied with the instrument is used, it must carry an adequate protective ground conductor.

Any interruption of the protective ground conductor inside or outside the instrument is likely to make the instrument dangerous. Intentional interruption is prohibited.

Signal connections into the instrument should be connected after and disconnected before the protective ground connection is made, i.e. the supply lead must be connected at all times that signal leads are connected.

Live Parts

The instrument is safe to operate with covers fitted and these must not be removed under normal usage. The covers protect the user from live parts and they should be removed only by suitably qualified personnel for maintenance and repair purposes.

WARNING: *Removing the covers may expose voltages in excess of 10000V on the PDA cap at the front of the tube on the left side. Also, voltages above 2000V can occur, in particular at the rear of the tube, even when the instrument has been disconnected from the power source for some time.*

Ventilation

The instrument relies on convection cooling and must not be operated in a position which restricts air flow through the ventilation slots in the sides of the instrument. The instrument should not therefore be used in a tightly fitting rack as this will limit ventilation. Adequate ventilation can usually be achieved by leaving a 3" gap around the top, rear and sides of the instrument.

Operating Temperatures

The instrument is designed to be operated in an environment having an ambient temperature of between 0 deg. C and 50 deg. C. The instrument is guaranteed to operate with full accuracy within a temperature range of 15 deg. C to 35 deg. C.

Note: *The use of the instrument in strong direct sunlight or next to radiators and other heat sources may markedly increase the temperature at the instrument and this should be taken into account when assessing the viability of using the instrument in a given environment.*

Power and Frequency Requirements

The instrument is designed to consume less than 100W and operate from supply voltages of between 95V and 265V, with mains tap switching.

It will operate at supply frequencies of between 48Hz minimum and 440Hz maximum.

Under the extreme conditions of 95V and 48Hz, the instrument will still operate properly even if there is a half cycle dropout in the mains supply.

Fuse Requirements

The following fuse arrangement must be followed:

* one 0.5A (at 240V) or 1A (at 120V) slow-blow fuse on the rear panel;
* one 3A fuse in the mains supply plug (UK).

1.1 GETTING STARTED

This section of the manual is aimed at the first-time user of the 1600 oscilloscopes. It describes how to set up the instrument and how to go about displaying a signal. Later sections of the manual will cover many of the features mentioned here in greater detail and at a more advanced level.

Power On

After connecting the oscilloscope to the supply, press the **POWER** (1) button situated below the lower-right corner of the display. A light will illuminate beside the button. The display will light up with something approximating that shown in Figure 1.1.1.

You may find that the display needs some adjustment. The following rotary controls can be used to adjust the display.

Trace Intens (2) This controls the brightness of the 'trace', i.e. the part of the display used to show waveforms. The trace will be visible as an approximately horizontal line across the display. The brightness of the cursors (see Section 1.6) and the trigger level indicator (Section 1.4.) are also adjusted by this control.

Alpha Intens (3) This is used to control the brightness of the characters displayed on the screen.

Trace Rotate (4) If the trace is not properly horizontal relative to the scale, then adjustment of this control with a small screwdriver will provide correction.

Focus (5) Controls the focus of the display.

Scale Illum (6) The graticule on the screen can be illuminated using this control.

The Power-On Display

Apart from the trace across the centre of the screen, other features are visible on the display. At the top will be the sensitivity of the four input channels and the timebase speed as shown. In this case, it is saying that Channel 1 is set to 1 Volt per vertical screen division (grid marking); i.e. an applied signal of 1V in Channel 1 will deflect the trace by one screen division. If any input is inactive, this will be indicated by 'OFF'.

At the bottom of the display is the name of the oscilloscope, i.e. '1604', and the version number of the internal software.

An example is shown in Figure 1.1.1

Viewing a Signal (Auto Setup)

On the 1600, obtaining a display of an input signal is particularly simple. Connect a signal (less than plus or minus 400V peak) to the oscilloscope via the **CH1** socket (or any of the other three input channel sockets) and press the **Auto Setup** button. Assuming you've applied a regular signal, say a 2kHz sine-wave with an amplitude of perhaps 5V peak to peak, it will almost immediately be represented on the display. An example is shown in Figure 1.1.2.

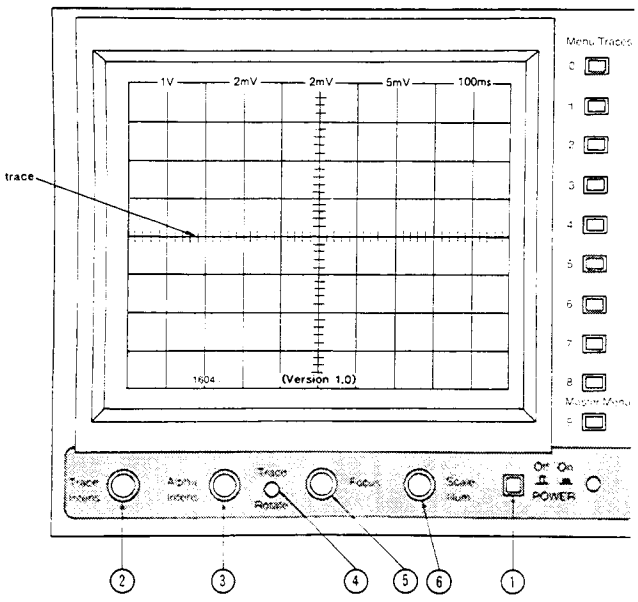


Figure 1.1.1 Power-on Display (1604)

CH1 (7) This is one of the channel signal input sockets, this one being for the connection of signals to Channel 1.

Auto Setup (8) will always attempt to arrange the display so that two to five complete cycles appear, with the amplitude set so that the height of the trace is two and five screen divisions. It also selects auto trigger to ensure that the screen is frequently updated and that a trace will be visible.

Note: *The maximum sampling rate of 20Msps is available when using CH1 and CH2 or CH2 and CH4 or single channel, (single channel only for 1602) when the maximum timebase range is 50us/div.*

Adjusting the Trace

The trace can be altered in two main ways: horizontally and vertically. Basic horizontal adjustments involve altering the sweep rate of the trace, so that the image on the screen stretches or contracts horizontally. The main vertical adjustment is the height of the displayed signal – i.e. the volts per screen division (as measured by the squares in the grid on the screen).

The behaviour of the trace varies slightly depending on whether the oscilloscope is in 'storage' mode or 'non-storage' mode, also known as 'digital' and 'realtime' or 'analogue' modes respectively. The required mode can be selected using the **Non/Store** button in the CAPTURE section of the front panel.

Non/Store (9) This button allows the user to select non-storage or storage (realtime or digital) mode. If storage mode is selected, a press of the button will select non-storage mode. Another press would re-select storage mode.

In storage mode, the oscilloscope digitises the input signal before displaying the trace, allowing various computational operations to be performed on the digitised information if desired. In non-storage mode, the oscilloscope produces a trace display directly from the input signal.

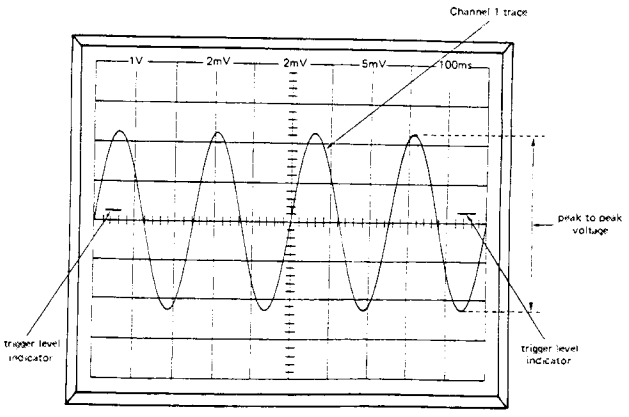


Figure 1.1.2 An Auto Setup Display (1604)

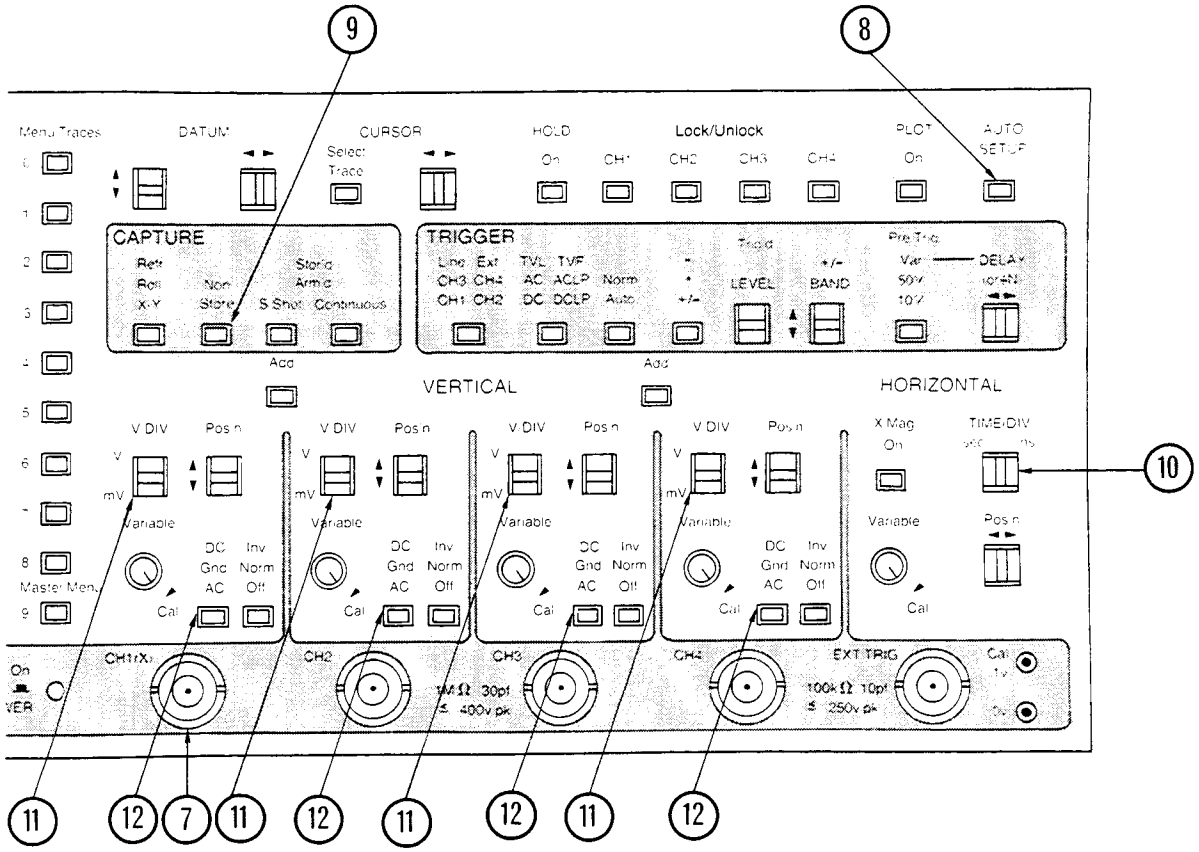


Figure 1.1.3 Horizontal & Vertical Controls.
(1604 illustrated, 1602 is similar with only two channels)

Horizontal Adjustment (TIME/DIV)

To alter the sweep rate of the trace, for example to look more closely at part of the image, the **TIME/DIV** paddle is used. With the 2kHz signal applied as discussed earlier, Auto Setup may have set the sweep rate to 200μs per screen division horizontally - i.e. each horizontal screen division represents 200μs worth of the input signal. This is shown by the '200μs' near the top of the display.

TIME/DIV ⑩ This is a five position paddle which controls the sweep rate of the trace. A gentle push causes a small change in the sweep rate, whilst a firmer push will cause a large change in the sweep rate.

Given that the current sweep rate is 200μs per screen division and that the Variable control (discussed in Section 1.3) is set to 'Cal', a gentle push of the paddle to the right will change the timebase from 200μs per division to 100μs per division. The displayed signal will stretch accordingly. A further gentle push to the right will change the timebase again, this time to 50μs, which is the fastest timebase in storage mode (100μs in dual mode).

If the paddle is pushed to the left the timebase will change in the opposite direction. The maximum time per division in storage mode is 200s; the 1600 will take over 33 minutes to acquire a full trace at this speed. In non-storage mode, the slowest timebase is 10ms per division and the fastest 200ns per division.

The timebase ranges are:

Non Store 10ms – 200ns

Store 200s – 100μs (50μs available with CH1 and CH3, or CH2 and CH4 or in single channel mode (single channel only for 1602).

Assuming that the oscilloscope is in storage mode and a 2kHz signal is applied as mentioned earlier, when the timebase reaches 500ms/div, an interesting phenomenon may appear: an 'alias'.

Aliases

An alias is a false image. The 1600 in storage mode is a digital oscilloscope and so takes frequent samples of the input signal in order to update the trace. Thus it may take one sample from one point on the input waveform and the next sample from a point slightly further along on the next cycle. It will then display the wave as being much slower than it really is.

The 1600 does however have a feature which will detect aliases, which is Display max-min. Display max-min selects the maximum data from the acquisition memory and displays it as an envelope. The max-min function is discussed further in Section 2.3.

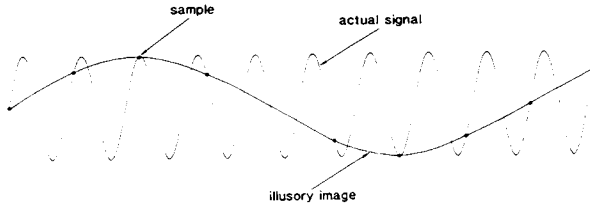


Figure 1.1.4 Alias Generation

Vertical Adjustment (V/DIV)

Each of the four channels has its own set of vertical controls. The main control in each case is the **V/DIV** (volts per division) paddle. Again this is a five-position switch. A gentle push either up or down will result in a slow single step change in the sensitivity of the instrument. A firmer push will cause a more rapid change.

V/DIV (11) This is a five-position paddle. It adjusts the volts per division. Pushing the paddle upwards will adjust the sensitivity as far as 10V/div and the height of the image will be seen to decrease in accordance with the changes. In the other direction, sensitivity can be increased as far as 2mV per division.

Note: *The 1600 is protected for input signals of up to ±400V. Larger signals can cause damage to the internal circuitry.*

AC/Gnd/DC (12)

This button controls the type of coupling between the input signal and the 1600. DC is the most generally applicable, and auto setup will normally set this control to DC, where possible. However, if when using the instrument you find that there is a permanent vertical offset in the display - i.e. the signal is consistently displayed too high or too low on the screen - you could try pressing this button once to set it to AC. This will cause the 1600 to remove any DC component which may be causing the offset. Repeated pressing of this button will cause it to cycle through the three settings AC, Ground and DC.

With this control set to DC, the 1600 can display signals in a frequency range of 0Hz(DC) to 20MHz in non-storage mode, or DC to 5MHz in storage mode. On AC, the range is 2Hz to 20MHz in non-storage mode or 2Hz to 5MHz in storage mode. With the setting on Gnd (ground) a 0V reference voltage is displayed (the input signal is not connected to ground or coupled to the trace in this case).

AC This is used to remove any DC component from input signals. Suitable input signals (i.e. the bandwidth) are from 2Hz to 20MHz in non-storage mode.

Gnd The input signal is internally disconnected from the inputs and the amplifier grounded. A 0V reference signal is displayed.

DC The input signal is directly coupled to the instrument so all frequency components of the input signal will be displayed. The bandwidth will be from 0Hz(DC) to 20MHz in non-storage mode or DC to 5MHz in storage mode.

This control is also discussed in Section 1.2. A summary of the effects of AC and DC coupling on the bandwidth is given below:

	DC	AC
Store	DC-5MHz	2Hz-5MHz
Non Store	DC-20MHz	2Hz-20MHz

Manually Obtaining a Trace

This subsection describes how to obtain a trace without using **Auto Setup,** whilst the oscilloscope is in non-storage mode.

You may need to consult later sections of the manual as not all of the operating features have been covered in this section.

1. Turn on the oscilloscope using the **POWER** button. The 1600 will go through its power-up sequence, checking the internal calibration.
2. Set the **Non/Store** button to Non; this places the oscilloscope in non-storage mode.
3. Decide to which channel you are going to apply the signal. CH1, CH2. (CH3 or CH4 for 1604).
4. Make sure the chosen channel is active by setting the **Off/Norm/Inv** button for that channel to Norm.
5. Set the **AC/Gnd/DC** button for the chosen channel to AC.
6. Turn that channel's **Variable** control fully clockwise to the Cal position.
7. Turn the HORIZONTAL **Variable** control fully clockwise to the Cal position.
8. Make sure the **X Mag** light is off.
9. Adjust the **Alpha Intens** control to give screen text of the desired brightness.
10. Adjust the **TIME/DIV** setting to give a timebase of 100μs.
11. Set the TRIGGER **Auto/Norm** button to Auto.
12. Adjust the **Trace Intens** control to give a trace of the desired brightness and if necessary adjust the position of the trace using the channel's VERTICAL Posn paddle and the HORIZONTAL **Posn** paddle in order to centralise it.
13. Adjust the **Focus** if necessary.
14. Adjust the **Trace Rotate** if the trace is not horizontal with respect to the screen graticule.

Displaying a Signal in Non-Storage Mode

This subsection assumes that the oscilloscope has been set up as described in the preceding subsection.

1. Connect the signal (less than 400V peak) using a BNC connector to the chosen input socket.
2. Set the **AC/Gnd/DC** button for the channel to either DC or AC. DC will couple signals having components from 0 to 20MHz. AC will couple signals of frequency from 2HZ up to 20MHz in non-storage mode, and is used for viewing AC components superimposed on DC voltages.
3. Adjust the gain of the chosen channel using the **V/DIV** paddle. For intermediate settings use that channel's **Variable** control.

4. Adjust the timebase using the **TIME/DIV** paddle. For intermediate settings use the horizontal **Variable** control.

Operating Hints

The following list gives some of the more commonly met problems in operating digital oscilloscopes, how to correct them, and a brief explanation of what was wrong.

You may need to consult later sections of the manual as not all the operating features have been discussed so far.

Problem: Trace off the top or bottom of the screen.

Too much vertical shift
- correct with that channel's vertical **Posn** paddle.

Input has large DC offset
- AC couple input signal.
- correct with **Posn** paddle.
- use a less sensitive range.

Problem: Trace not being acquired.

Instrument in single capture mode
- press **Continuous.**

Trigger level incorrect
- select AUTO and DC trigger, then adjust the level control until the trigger level 'indicator bars' are lined up with the centre of the trace.

Trigger source on the wrong input
- change trigger source.

Trigger coupling on an unsuitable setting
- change trigger coupling.

Hold or Lock on
- release Hold or Lock.

Timebase on very slow acquisition
- adjust timebase speed.

Problem: Trace is unstable even when triggered.

Alias
- check for alias using glitch detection which is a menu selection and select a faster timebase range, or switch to non-storage mode.

Noisy input
- select DCLP or ACLP trigger coupling.
- adjust trigger level.

Trigger on Auto
- With low frequency inputs, below 30Hz, Auto trigger will initiate triggers overriding the input triggers. Select Normal trigger.

Input has many trigger points and an irregular sequence
- use divide by N.

Problem: Trace has a very flat top or bottom.

Trace captured when in limit and **Posn** shift has been used
- use less sensitive range.

1.2 VERTICAL POSITION AND ATTENUATORS

Each of the channels has its own complete set of controls. these adjust its sensitivity to input signals and the vertical position of its trace on the display. The controls are shown in Figure 1.2.1. for the 1604.

The channels are identical in all respects except when used in 'X-Y mode'. Here, Channel 1 is used to control the X (horizontal) component of the trace. Channels 2, 3 or 4 control the Y (vertical) component. For further discussion of this, see Section 2.2.

Channel Selection (1)

A channel may be switched on or off with its **Off/Norm/Inv** button. If the channel is on, its trace can be displayed in either normal or inverted mode. The channel status is shown by the illuminated letters above the button.

The three options **Off/Norm/Inv** are selected by sequentially pressing this button.

Off The channel is deactivated, indicated with a red Led:

Norm The trace is a true representation of the input signal.

Inv The input signal is inverted before being displayed. If there is any DC component in the signal this will also be inverted and could cause the trace to disappear from the screen. If DC coupling is in use, see below.

Input Coupling (AC/Gnd/DC) (2)

The coupling of the signal to the 1600's is chosen using the **AC/Gnd/DC** button, the current setting being shown by the illuminated letters above the button. The three options AC/Gnd/DC are selected by sequentially pressing this button.

AC This is used for rapidly varying input signals superimposed on DC. Low frequency and DC components will be removed. Suitable input signals (i.e. the bandwidth) are from 2Hz to 20MHz in non-storage mode (2Hz to 5MHz in storage mode)

Gnd The input signal is not coupled to the instrument. A 0V reference signal is displayed.

DC The input signal is directly coupled to the instrument so all frequency components of the input signal will be displayed. The bandwidth will normally be from 0Hz(DC) to 20MHz in non-storage mode or DC to 5MHz in storage mode.

The input impedance is 1MOhm in parallel with a capacitance of 30pF for all 3 selections. The effect of coupling on bandwidth is summarised below:

	DC	AC
Store	DC-5MHz	2Hz-5MHz
Non Store	DC-20MHz	2Hz-20MHz

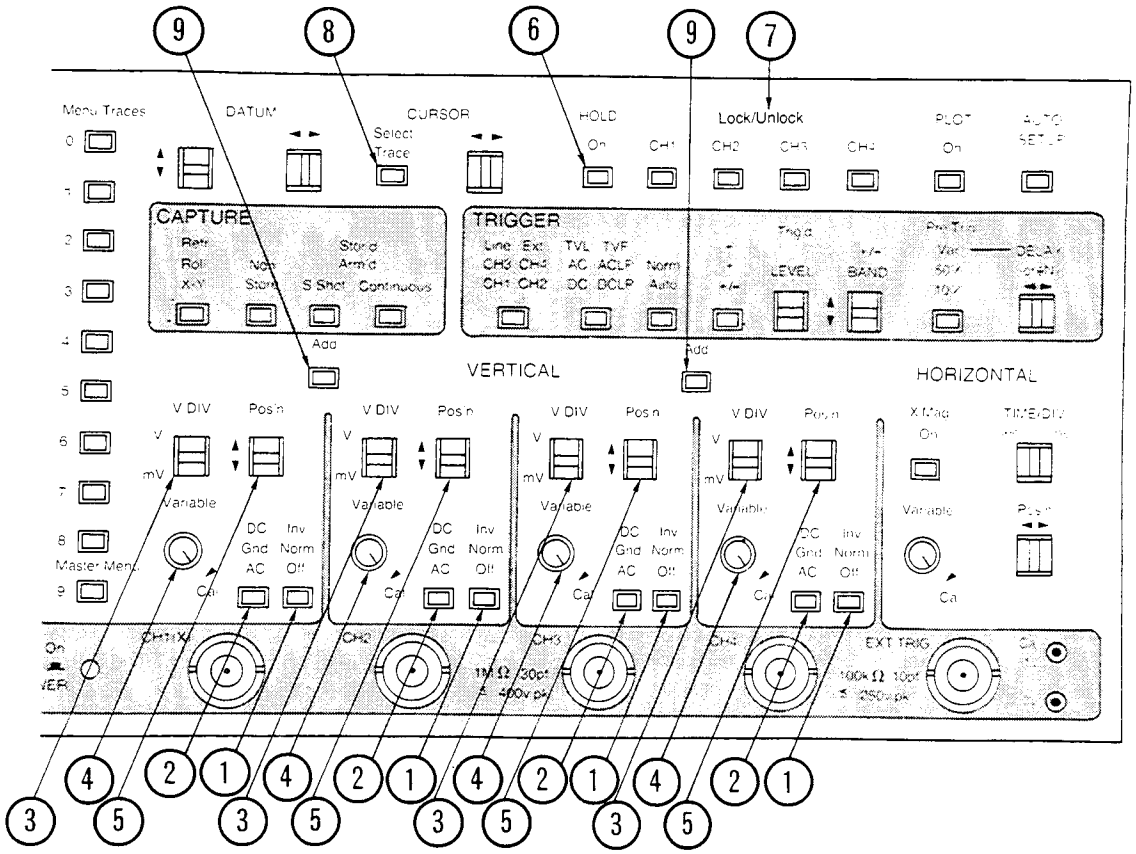


Figure 1.2.1 The Vertical Controls

Sensitivity (V/DIV ③ , Variable ④)

The **V/DIV** paddles control the sensitivity of the channel attenuators - i.e. they control the amount by which the trace is deflected for a given input signal, the sensitivity being adjusted in discrete steps. The **Variable** controls allow intermediate attenuator settings to be used. The current sensitivity is shown in the top line of the display. The "›" symbol is shown in front of the attenuator setting when **Variable** is used (not set to 'Cal').

Example screen display:

5V Channel 1 is set to a sensitivity of 5 volts per screen division.

›20mV Channel 2 is uncalibrated and the attenuator is set to a sensitivity greater than or equal to 20mV per screen division.

V/DIV This paddle steps the attenuator through the discrete calibrated ranges from 2mV to 10V per screen division in 1, 2 5 steps. With a x 10 probe the ranges are 20mV to 100V per division at the probe input tip. With x100 the ranges are 200mV to 1000V. The V voltage symbol is shown in inverse video when x10 or x 100 is used.

Variable When this is not set to 'Cal', the step setting of the attenuator remains unchanged, but a variable gain is applied to the input signal. This control applies attenuation in the range of 1 to 0.4. Thus, with an initial setting of 1V, the actual sensitivity of the channel can be set by this control to anywhere between 1V and 2.5V per division.

Posn ⑤

The VERTICAL **Posn** paddles control the vertical position of the trace for their respective channels.

Posn These move their respective traces up and down the display. They have the following settings: fast up, slow up, no shift, slow down and fast down. In addition, after a few moments in the fast modes the moving trace will accelerate.

If the oscilloscope is in storage mode and the HOLD is operated, or the channel is locked, or a single shot capture has been made, any part of the trace which was captured off the top or bottom of screen will be shown by a horizontal line indicating that the acquistion has reached its limit.

Add ⑨

The two **Add** buttons allow channel inputs to be added together so that a new trace appears, displaying either the sum, or if one channel is inverted the difference, of the input signals. The original channel traces do not remain on display. The left-hand **Add** button is for Channels 1 and 2, the right-hand button being for Channels 3 and 4 on the 1604.

Add Displays the sum/difference of Channels 1 and 2 (left button) or Channels 3 and 4 (right button for 1604). The original traces disappear and the resultant traces are displayed as Channel 1 or Channel 3 for 1604.

HOLD (6) and LOCK (7)

The HOLD button is used to freeze the display:

HOLD This button freezes the display as soon as it is pressed. A further press releases the display.

It is associated with the **LOCK** buttons as follows:

LOCK The four channel buttons, labelled **CH1, CH2 (CH3 and CH4 for 1604)** are used to lock the relevant trace when **HOLD** is selected so that when **HOLD** is released the locked trace(s) remain frozen.

Cursors

The cursors may be called onto any channel in storage mode by pressing the **Select Trace** button. If only one channel is in use then the cursors will go onto the only displayed trace. If more than one channel is in use, then successive presses of this button will switch the cursors from one trace to the next. A final press will switch the cursors off.

Select Trace (8) Calls the cursors onto the active traces in succession. A final press switches the cursors off.

For a full description of cursor operation, see Section 1.6.

1.3 HORIZONTAL POSITION AND TIMEBASE

The controls discussed in this section allow the trace to be moved sideways, magnified (i.e. stretched), and observed at widely varying sweep rates, allowing signals of greatly differing characteristics to be examined with equal ease.

Timebase Settings

The timebase is set using the **'TIME/DIV'** paddle. As with all the paddles, this is a five-position switch.

Moving the paddle to the left reduces the sweep speed (acquisition rate) for the traces. When 200 seconds per division is reached in storage mode, further leftward presses will be ignored (the limit is 10ms/div in non-storage mode). Moving the paddle to the right, the limit is 50μs/div in storage mode (unless the machine is in dual mode when the limit is 100μs/div); in non-storage mode the limit is 200ns/div. This timebase information is summarised below:

	Single	Dual
Store	200s-50μs	200s-100μs
Non Store	10ms-200ns	10ms-200ns

In addition to the **TIME/DIV** paddle, a **Variable** control allows intermediate, uncalibrated, timebases to be chosen in the real-time (non-storage) mode. With **Variable** set to 'Cal', defined, calibrated timebases are chosen by the **TIME/DIV** paddle. Changing the setting of Variable imposes a reduction of the timebase from 1 down to 0.4. Thus with **TIME/DIV** set to 1ms/div and **Variable** turned fully anti-clockwise, the actual timebase will be approximately 2.5ms/div.

TIME/DIV This is a five-position paddle which controls the sweep rate of the trace. A gentle push causes a small change in the sweep rate, whilst a firmer push will cause a large change in the sweep rate.

Variable When not set to 'Cal', this control imposes a reduction of the timebase from 1 down to 0.4. This control, unlike the vertical **Variable** controls, is only effective in non-storage mode.

X Magnification

The **X Mag** button is used to switch on the X or horizontal magnification facility. When selected, the initial expansion in storage mode applies the setting as defined in the Display menu (Section 2.4), and in realtime mode always to x5. If the feature has not been used since power-up, the last selected expansion before power down is selected. The timebase display is adjusted to reflect the amount of expansion set.

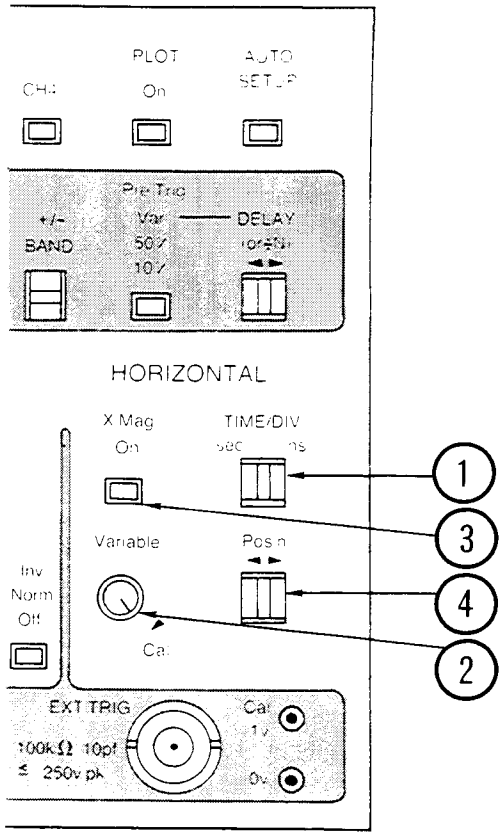


Figure 1.3.1 The Horizontal Controls

When magnification is applied, the trace expands around the present centre of the screen. With the Display menu, X magnification may be set to 2, 5, 10, 20, 50, 100, or 200 in storage mode. In non-storage mode a single step of x5 is available.

X Mag This button activates or deactivates X or horizontal trace magnification. In storage mode, the amount of magnification is determined by the Display menu. In non-storage mode, only x5 is available. The timebase range displayed reflects the amount of expansion selected when **X Mag** is on.

The 1600 normally displays 100 dots (samples) per screen division. At an expansion of x20, there are only 50 dots per division, at x50 there are 20, etc. up to x200 when only 5 sample dots per division will be displayed.

Trace Position (Posn)

The horizontal Posn paddle is used to move the trace to the right and left. The paddle as usual has five settings: fast right, slow right, no shift, slow left, and fast left. In addition after a few moments on the fast settings, the rate of shift accelerates.

Posn (Horizontal) This paddle moves the trace right or left. It is a five-position paddle, having the settings fast right, slow right, no shift, slow left and fast left.

The position of the cursors (see Section 1.6 for more about these) is fixed in relation to the trace and they will move with the applied shift. With X magnified traces, the cursors can be off the part of the trace displayed on the screen. To bring them back into view it is necessary to use the **CURSOR** position paddles.

XMAG and POSITION OPERATION in storage mode

When using Refresh with pre-trigger the X Magnification and X position controls will not operate while the 1604 is armed or acquiring a waveform. This becomes more apparent with slow timebase ranges or with infrequent triggers. A warning message will be displayed until the end of acquisition when changes can be made.

1.4 BASIC TRIGGER CONTROL

The trigger facilities offered by the 1600 are very comprehensive; those discussed here are controllable directly from the front panel. For the more advanced menu-controlled facilities see Section 2.3.

The power-down trigger setting will be retained on future power-up.

Selecting Source (1) and Coupling (2)

The left-most button in the TRIGGER section of the front panel controls from where the triggering takes its source. When Ext is selected, the source is the 'EXT TRIG' socket in the lower right corner of the front panel - inputs to this should not exceed plus or minus 250V peak.

TRIGGER The left button steps through the available options of trigger source. These are CH1, CH2, (CH3, CH4 1604) Ext and Line. After Line has been selected, a further press of the button returns the selection to CH1.

The button next to this is for selecting the trigger coupling. It steps through the available options: DC, DCLP (DC Low Pass filter), AC, ACLP (AC Low Pass filter), TVL (TV Line) and TVF (TV Frame). After TVF has been selected, a further press of the button returns the selection to DC. All the couplings can be used with any source except Line. On LINE, the input coupling is not selectable.

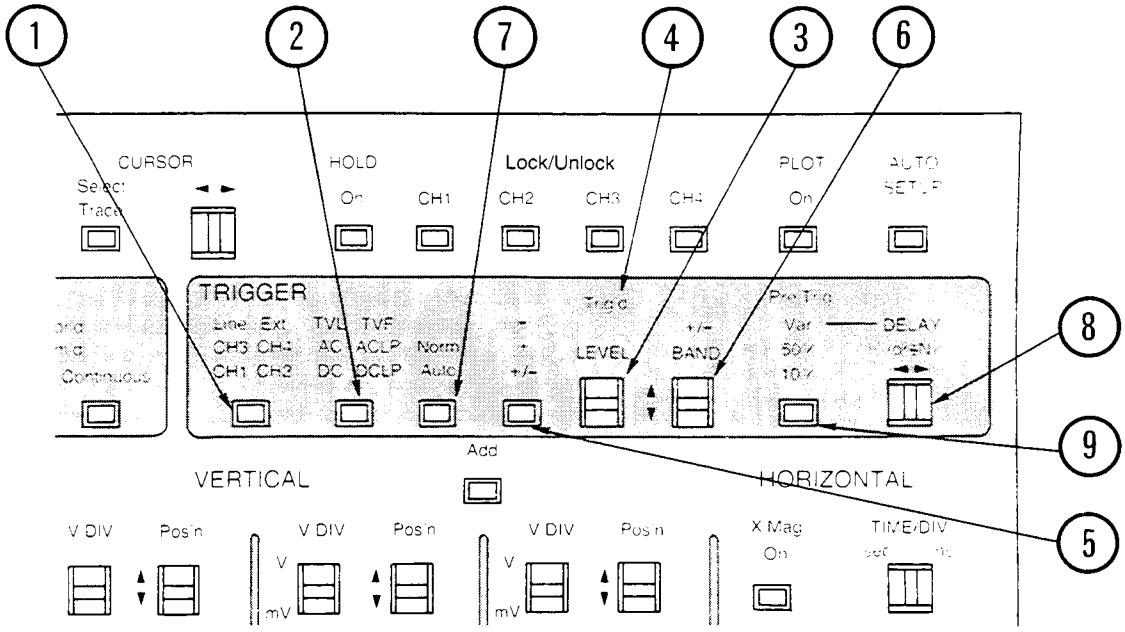


Figure 1.4.1 Trigger Controls

Table 1.4.1 Choices of Source and Coupling

Source	Coupling
CH1, CH2, (CH3, CH4, 1604) EXT	AC, ACLP, DC, DCLP, TVL, TVF
LINE	None

Table 1.4.2 Useful Frequency Ranges of Coupling Types

Coupling	Input Frequencies
AC	4Hz to 20MHz
ACLP	4Hz to 50kHz
DC	DC(0Hz) to 20MHz
DCLP	DC(0Hz) to 50kHz
TVF	Composite video: PAL, NTSC or SECAM
TVL	Composite video: PAL, NTSC or SECAM

Trigger Level (3)

The trigger level is set by the **LEVEL** paddle. This has five positions: fast up; slow up; no change; slow down; fast down. The trigger level is indicated at a vertical point on the screen by two bars, one on the left and one on the right-hand side of the screen. These show the trigger level relative to the screen trace.

Note: *This feature is a level indication only, for an accurate level use the Pretrigger bright up.*

LEVEL This paddle adjusts the trigger level, the trigger bars on the screen showing a representation of the level set relative to the trace.

Trig'd (4) This lights up when the 1600 is receiving valid trigger signals.

Trigger Slope (5)

A trigger is generated when the selected source signal passes through the chosen trigger level. This transition may be either on a rising or a falling edge. The rising edge is considered to be a positive slope and the falling edge a negative slope.

+/− + − This button selects positive (+), negative (−), or either (+/−) slope triggers. The current selection is indicated by the light above the button and is changed by successive presses of the button.

Trigger Band (6)

Rather than just having a specific trigger level as set by the **LEVEL** paddle, a trigger band is available. The width of the band is set using the **BAND** paddle. As soon as the signal leaves the region chosen, in either direction, a valid trigger is registered. The '+/-' symbol indicates that **BAND** trigger is chosen. The range of the band is from 0.5 divisions to 8 divisions and is indicated on the display while the level is being adjusted.

BAND This paddle allows a range of adjacent trigger levels to be selected, the paddle controlling the extent of the range.

Auto Trigger

There are two modes in which the trigger system can operate: Auto and Normal. In Normal mode, display sweeps/captures can only occur when a valid trigger input has been received. When Auto is selected, if no valid trigger has been received for some time the instrument will generate its own trigger and initiate a capture. This ensures that the screen is constantly updated irrespective of the input signal. However, if valid input triggers are received at a rate of 30Hz or more, the instrument will start all captures with these and not generate its own triggers.

Auto/Norm (7) This button selects which trigger mode the instrument is operating in. The selected mode is indicated by the light above the button. If Auto is selected then one push will select Normal and a further push will re-select Auto.

External Trigger Input

The 1600's have on external trigger input, labelled 'EXT TRIG', selected by setting the trigger source (see above) to 'Ext'.

Note: *Signals presented at the EXT TRIG input should not be more than ±250V peak. Larger signals could cause damage to the sensitive internal circuitry.*

Trigger Delay (8)

This option allows the user to set two types of delay: delay by time and delay by events. The initiation of a capture will not then take place until the delay conditions, as described below, have been met. The two types of delay are not independent and it is not possible to combine the two. A trigger event as discussed below is a valid trigger as set by the source, coupling, **LEVEL, BAND** and slope controls.

Delay by Time

This is set by the **DELAY** paddle when the trigger mode set in the Acquisition/Trigger menu is 'Trig Delay' with units of time (see Section 2.3). As usual, this has five settings: decrease time fast, decrease time slow, no change, increase time slow and increase time fast. The delay time may be set to an accuracy of 50ns, but the step size is dependent on the chosen timebase setting.

DELAY If the trigger mode (see Section 2.3) is set to 'Trig Delay', a gentle push of the **DELAY** paddle to the left decreases the time delay; a firmer push causes the delay to decrease at a faster rate. A gentle push to the right increases the time delay; a firmer press increases it at a faster rate. Delay may not be reduced

below zero with this paddle (but see Pre Trig below). In non-storage mode, delay may not be set for sweep speeds greater than 5μs/div.

If the time delay is zero, the trigger point will be at the left-hand edge of the screen. When the delay increases from zero, the display shows events after the trigger point; i.e. the trigger point moves to the left and disappears from the screen altogether. The maximum delay is dependent upon the timebase setting and is equivalent to 100 screens.

The current trigger delay setting is shown on the screen while the paddle is adjusted. The amount set can also be viewed on the Status menu (Section 2.2 and altered on the Acquisition/Trigger Menu (Section 2.3).

Delay by Events

This option allows the user to control the number of trigger events to be detected before a trace is to be acquired. The delay is set by the DELAY paddle when the trigger mode is set to 'Trig Delay' and the units are set to 'events' (see Section 2.3). The paddle has five settings: fast decrease; slow decrease; no change; slow increase and fast increase.

DELAY When 'Trig Delay' by 'events' is selected from the Acquisition/Trigger menu, a gentle push of this paddle to the left decreases the number of events, a firmer push decreases the number of events at a faster rate. A gentle push to the right increases the number of events, a firmer push increases the number more quickly.

The number of events currently selected is shown on the screen while being adjusted; e.g. if events=3, the trace will be captured after three valid trigger events were detected.

The minimum number of events delay is 2, whereby the trace will be captured following the second trigger event. The maximum number of events by which capture can be delayed is 16383.

Divide by N

When 'Div by N' is set in the Acquisition/Trigger menu (Section 2.3), the **DELAY** paddle can be used to set the value of N (or the current TV line or 'phase' - see Section 2.3). When this option is set, the instrument will acquire a trace every N triggers provided the current CAPTURE mode is **Continuous** (see Section 1.5). The range of N is 2 to 16383 inclusive.

DELAY Sets the number **'N'** of valid triggers which must be received before the instrument will acquire a trace. The instrument will acquire a trace every N triggers if set to **Continuous.** This function is active when the trigger mode as set in the Acquisition/Trigger menu (Section 2.3) is set to 'Div by N'.

Pre-Trigger (Pre Trig) (9)

Specific amounts of pre-trigger can be set in storage mode with the **Pre Trig** button. Pre-trigger is the name given to the 1600's ability to capture and display waveforms prior to the trigger point. This is only possible in storage mode. If 'Pretrig' is selected in the Acquisition/Trigger menu (Section 2.3) using the 10% or 50% host panel selection, then the **Delay** paddle is used to set the amount of pre-trigger instead. Pre-trigger is given as a percentage: with 0% pre-trigger, the trigger point would be on the left-hand edge of the screen. With 100% it would be on the right-hand edge. 50% is when the trigger point is in the middle of the screen.

Pre Trig Used when 'Pretrig' is selected in the Acquisition/Trigger menu to set 10% or 50% pre-trigger by successive presses of the button. If 10% or 50% is selected then the **DELAY** paddle can be used to set a variable amount of pre-trigger in 0.1% steps and the VAR Indicator will light to indicate variable pre-trigger is selected. A further press of the button will switch off pre-trigger and select delay by time or events as previously selected.

Note: *A bright sample dot displays the precise trigger point.*

1.5 ACQUISITION FACILITIES

The acquisition facilities on the 1600 allow the user to freeze the trace on the display. This section discusses the three forms of display which are selectable from the front panel, namely 'Refreshed', 'Roll' and 'X-Y'. Firstly, however, it is important to be aware of the oscilloscope's two main modes of operation, also discussed in Section 1.1, i.e. the 'storage' and 'non-storage' modes.

The behaviour of the trace varies slightly depending on whether the oscilloscope is in 'storage' mode or 'non-storage' mode, also known as 'digital' and 'realtime' modes respectively. The required mode can be selected using the **Non/Store** button in the CAPTURE section of the front panel.

Non/Store (1) This button allows the user to select non-age or storage (realtime or digital) mode.

In storage mode, the oscilloscope digitises the input signal before displaying the trace, allowing various computational operations to be performed on the digitised information if desired. In non-storage mode, the oscilloscope behaves like a conventional analogue instrument, the input signal directly producing a trace display. The single-shot and hold facilities discussed below are only available when the oscilloscope is operating in storage mode.

Freezing the Display

There are two ways to do this: a single-shot capture whereby a full screen is acquired then frozen, or by pressing the button labelled **HOLD.** Using the **HOLD** button freezes the display the moment it is pressed. This can cause discontinuities in the trace as the displayed waveform may contain data from more than one capture. When in **HOLD** mode, it is possible to selectively lock the channels using one of the buttons **CH1** to **CH2, (CH1 to CH4 for 1604) so that when HOLD** is released the selected channels remain held.

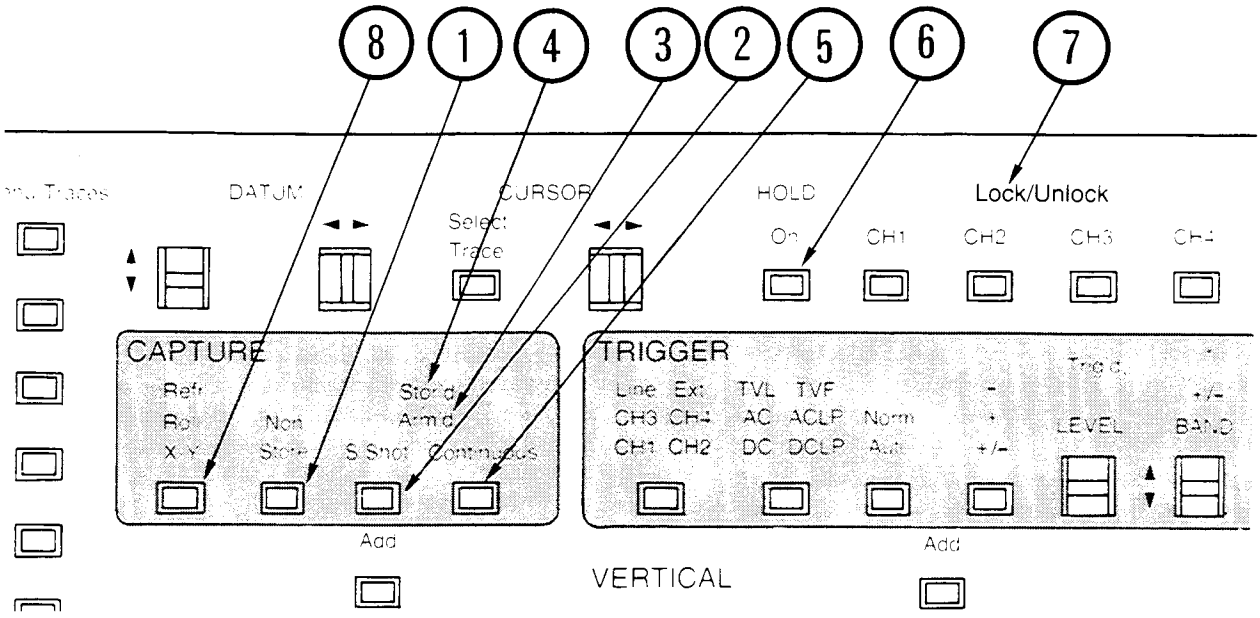


Figure 1.5.1 The Capture Controls

The **S/Shot** and **HOLD** buttons only operate in storage mode.

S/Shot (2) This button arms the instrument for a single-shot triggered acquisition sweep (capture). The Arm'd light will be illuminated to show that the button has been pressed.

Arm'd (3) This light illuminates after the **S/Shot** button has been pressed; it will stay lit until either a valid trigger has been received or until the Continuous button is pressed.

Stor'd (4) This light illuminates on completion of a single-shot acquisition. This is after the instrument has been Arm'd, triggered and a complete trace acquired. The light will stay illuminated until the instrument is rearmed or **Continuous** is pressed.

Continuous (5) This button puts the 1600 in continuous capture mode (i.e. its default state). The instrument will automatically re-arm itself after each capture is completed; this enables the displayed traces to be updated with each triggered sweep.

On the 1600 there are four buttons labelled **LOCK**, namely the **CH1**, **CH2** **CH3** and **CH4** buttons near the top right of the front panel on the 1602 there are two buttons **CH1** and **CH2**. These are used to lock the particular channels when the display is held. **LOCK** will not work unless **HOLD** is operated first.

HOLD (6) This button freezes the display immediately irrespective of the stage any ongoing acquisition may have reached. To release hold on all channels, simply press the relevant **HOLD** button.

LOCK (7) These buttons are used to lock the data displayed on the channel(s) selected once **HOLD** has been operated. To unlock the channel(s), **HOLD** must be operated and then the relevant button(s) pressed to unlock the required channel(s) so that when **HOLD** is pressed again the unlocked channel(s) will update.

Display Modes (8)

The following three display modes are directly selectable from the front panel. They are discussed in more detail in Section 2.2.

Refreshed This is the usual oscilloscope mode, whereby even if the 1600 is in storage (i.e. digital) mode, it will imitate the style of a conventional realtime 'scope: the display is plotted from left to right as it is acquired.

Roll This mode is like a chart recorder: the display scrolls from right to left until a trace has been acquired. The scrolling effect is most noticable on the slower timebase ranges; on the faster ranges there is no discernable difference between Roll and Refreshed. Roll is only available in storage mode and is particularly useful for viewing slowly changing signals.

X-Y This mode allows the **CH1** socket input to control the X (horizontal) component of the trace, and any or all of the **CH2, CH3** and **CH4** sockets for the Y (vertical) component, CH2 for the 1602.

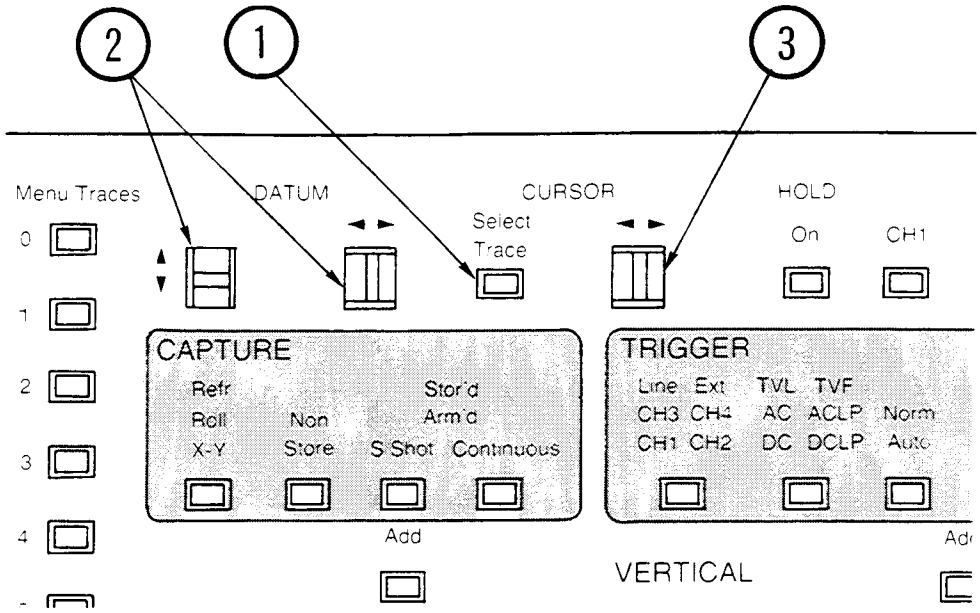


Figure 1.6.1 The Cursor Controls

1.6 CURSOR MEASUREMENTS

The 1600 allows you to take direct measurements from the screen display automatically, using inbuilt cursors. These are movable reference lines which the oscilloscope can display. It takes the measurements between these lines. The cursors are only available in storage mode.

Cursor Selection

The cursors are switched on or off using the **Select Trace** button. If X magnification (see Section 1.3) is in use, the cursors may not be visible on the screen, but this is easily remedied using the paddles described below. The measurement cursor can be assigned to any of the active traces, selected by successive presses of the button.

Select Trace ① One press of this button activates the cursors and places them on the trace of the lowest numbered active channel. Successive presses move the cursors onto successive active channels, until a final press deactivates the cursors.

The Cursors

Once activated by a press of the **Select Trace** button, three cursors will appear, as indicated in Figure 1.6.2. The large dashed vertical line is the 'time' datum and the short vertical line is the measurement 'cursor'. The dashed horizontal line is known as the 'voltage' datum. Movement of the datums and cursor is achieved using the **DATUM** and **CURSOR** paddles.

Movement

The three cursor movement paddles are each five-position switches. The left-hand **DATUM** paddle moves the voltage datum vertically, and the right-hand **DATUM** paddle moves the time datum horizontally. The **CURSOR** paddle moves the measurement cursor along the trace - i.e. the cursor, when moved horizontally, automatically follows the trace up and down.

DATUM ② These five-position paddles move the two datums. The left-hand paddle moves the voltage datum up and down, and the left-hand paddle moves the vertical datum to the right and left.

CURSOR ③ This paddle moves the measurement cursor to the right and left along the trace. It is a five-position paddle, with the settings fast left, slow left, no movement, slow right and fast right.

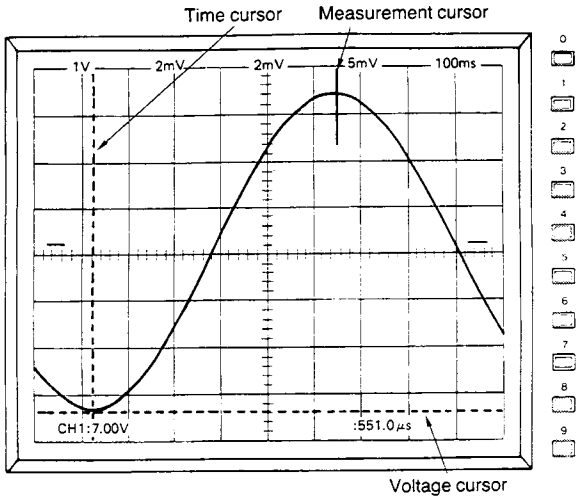


Figure 1.6.2 The Cursors

1.7 INPUT/OUTPUT

The 1600 is equipped with a Miscellaneous I/O connector, which is used for the analogue plot outputs. Two other sockets are also provided, for expansion options such as GPIB (IEEE488), RS423 and Waveform Processor interfaces. These options are discussed briefly in Section 3. The built-in plotter 104 is also discussed in Section 3. See also Section 2.6, which discusses the Plot menu.

Miscellaneous Input/Output

This connector is fitted to the rear panel and allows connection to the analogue plot outputs.

The connections are as below.

Table 1.7.1 The Miscellaneous Input/Output Connector

Pin No.	Name	Description
1	Plot X out	Plot X ramp
2	Y1 Plot out	Y1 output channel
3	Y4 Plot out	Y4 output channel (1604)
4	PL2	Pen Lift 2
5	0VA	0V analogue
6	not used	
7	0VL	0V Logic
8	not used	
9	Plot Y2 out	Y2 output channel
10	Plot Y3 out	Y3 output channel (1604)
11	PL1	Pen Lift 1
12	0VA	0V analogue
13	+5V	+5V, 100mA max.
14	0VL	0V Logic
15	0VL	0V Logic

Note: *The +5V output on this socket is for test purposes only. If it is used for any reason then the total current must not exceed 100mA.*

Plotting

There are five methods of plotting captured traces from the 1600. These are: internal plotter, RS423, GPIB, single-channel analogue and quad-channel analogue (four channel). All five types are initiated by pressing the **PLOT** button. Normally, the 1600 will default to plotting with single channel analogue plot unless the internal plotter is fitted. To change to any other type, see Section 2.6. Once another type has been selected this will be the default setting on power-up but if IEEE or RS423 is selected, and the option is not fitted on power up, the selection will no longer be valid.

PLOT Pressing this button causes the chosen plotter to make a copy of the screen display. A further press aborts the plot.

Single-Channel Analogue Plot

Single-channel plot is for use with single-pen plotters. This uses the analogue outputs from the Miscellaneous I/O connector. Pen lift is available from this connector with PL1 and PL2, these two outputs being connected together to lift the pen.

The two signals 'X plot out' and 'Y plot out' have a sensitivity of 100mV/Div on screen. When no plots are in progress the outputs will be 0V. The format of the output will be limited to traces only: there will be no grid, border or alphanumerics. Only displayed traces will be plotted and these in numerical order.

Dual Channel Analogue Plot (1602)

Two channel plot is for use with recorders having two pens or to plot an X-Y display.

Four Channel Analogue Plot (1604)

Four channel plot is for use with recorders having four or more pens. It uses the analogue outputs from the Miscellaneous I/O connector. The format is the same as single channel plot, i.e. traces only. Displayed traces will be plotted simultaneously. Further Y outputs, 'Y2 plot out', 'Y3 plot out' and 'Y4 plot out' are also on the Misc. I/O connector.

2. ADVANCED FEATURES

The main body of this section covers the menu system, its structure and how to select the features controllable through it. In addition, all the remaining buttons not covered in Section 1 are described here.

2.0 ADDITIONAL BUTTONS

The Numeric Buttons

The buttons **0** to **9** are used in conjunction with the menu system to provide a large number of extra functions not otherwise available directly from the front panel. The menu system is activated with the two buttons **9** and **0**, labelled **Master Menu** and **Menu/Trace** respectively:

Master Menu Pressing this button replaces the trace display with the Master Menu.

Menu/Trace This button toggles the display between the traces and the last used menu.

2.1 MASTER MENU

Although the menu system controls a considerable number of functions, it is designed to be simple to use. There is one master menu from which other menus can be obtained with a single button push.

Each entry on the master menu is a menu, covering one aspect of the 1600. The text is lined up with the numeric buttons **0-9** on the side of the display. To obtain any secondary menu simply press the relevant button.

Status This menu displays information about the present setup and backup memory setups of the instrument.

Acquisition/Trigger This menu controls probe selection and the glitch detect function. Also, trigger delay, divN and Pre-trigger features can be selected.

Display This menu controls the format in which the traces are displayed.

Save/Recall Control Settings The front panel and menu settings can be stored or retrieved.

Plot The various methods of plotting captured traces can be set using this menu. Once set up, simply press the **PLOT** button on the front panel to produce a hard copy.

Special Functions This menu allows the desired TV standard to be set. Also, it controls trace arithmetic.

2.2 STATUS MENU

This menu allows the horizontal, vertical and trigger settings of the instrument to be viewed but not changed. A change is made via the front panel controls and the other menus. A typical display is shown in Figure 2.2.1.

VIEW SETUP There are five possible setups on the 1600: the four held in the backup store and the current setup obtained from the front panel buttons and paddles. The setup presently being displayed is indicated by the inverse video characters after the words 'VIEW SETUP'.

Examples:

VIEW SETUP CURRENT	The status menu is showing the present instrument setup.
VIEW SETUP 4	The setup in memory number 4 is being displayed. The words 'Not current status' appear as a reminder.

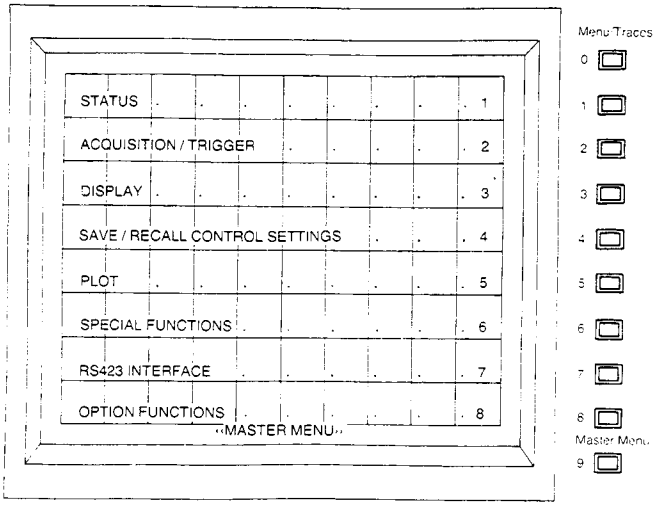


Figure 2.1.1 The Master Menu

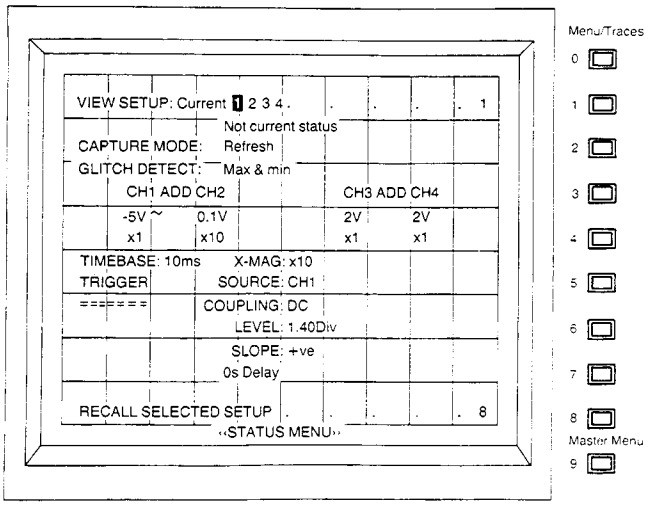


Figure 2.2.1 A Status Menu 1604

To view a different setup simply press button number 1. Each press steps through the five options: CURRENT, 1, 2, 3, and 4. After 4 has been selected a further press will return the choice to CURRENT. The selection is shown on the display by inverse video.

CAPTURE MODE: There are three display modes: Refresh, Roll, X-Y. Roll is available in Non storage only.

Refresh This is the usual oscilloscope mode, whereby even if the 1604 is in storage (i.e. digital) mode, it will imitate the style of a conventional realtime 'scope: the display is drawn from left to right as it is acquired.

Roll This mode is like a chart recorder: the display scrolls from right to left until a trace has been acquired. The scrolling effect is most noticable on the slower timebase ranges; on the faster ranges there is no discernable difference between Roll and Refresh. This mode is available in Non storage.

X-Y This realtime mode allows you to use the CH1 socket input to control the X (horizontal) component of the trace, and any or all of the CH2, CH3 and CH4 sockets for the Y (vertical) component(s). (CH2 for 1602).

The various choices of capture mode are made with the front panel **CAPTURE** and **Non/Store** buttons, the current setting being indicated by the menu and the front panel LEDs.

GLITCH DETECT: The various options are Max & Min, Max only, Min only and Off. They are selected using the Acquisition/Trigger Menu (Section 2.3).

Channel Sensitivity and Coupling

The input sensitivity of the channels is shown in volts per division. The range is 2mV to 10V per division. If Add mode is selected, as in the example in Fig 2.2.1, the word 'ADD' is shown between the channels being added.

Along with the input sensitivity of the channels, other information is also shown. The symbols used are as follows:

- – Trace invert
- ‹ Uncalibrated
- ~ AC coupled
- Ground

Below the sensitivities, the probe gain settings are shown as x1, x10 or x100. These may be set using the Acquisition/Trigger Menu (Section 2.3).

TIMEBASE: The sweep rate of the timebase is shown in s, ms, μs or ns per division.

X-MAG: Next to the display of the timebase, the current X magnification is shown. This is set from the Display menu for storage mode (Section 2.4).

Triggering

This section of the display shows the selected trigger options. The choices of source are CH1, CH2. (CH3, CH4, on 1604), Line and Ext. The available couplings are DC, DCLP, AC, ACLP, TVL & TVF. These are discussed in Section 1.4.

The trigger level is shown in terms of the number of screen divisions. In the case of a trigger band, the width of the band in divisions is shown.

The trigger slope is shown as either +ve (positive), –ve (negative), or BAND +ve/–ve.

Following this is the trigger delay by time setting. If the time delay is positive this is given in s, ms, μs or ns or events as appropriate. With negative time delays (pre-trigger is selected from the Acquisition/Trigger menu - Section 2.3) the figure is given as a percentage of pre-trigger: 0% places the trigger point at the left-hand edge of the screen and 100% on the right-hand edge.

Recalling the Selected Setup

As discussed above, button 1 is used to select which setup to view with this menu. If you wish this setup to be imposed on the instrument's control settings, just press button **8.** This option is only applicable when a setup other than the current one is being viewed.

2.3 THE ACQUISITION/TRIGGER MENU

This menu controls on the one hand probe ratios and glitch detection and on the other hand special trigger functions.

PROBE RATIO: An independent probe amplification ratio can be set for each of the four input channels using buttons 1 and 2. The ratios available are x1, x10 and x100. After selecting which channel's input ratio to alter by successive presses of the number 1 button, the ratio itself can be set with successive presses of button 2. Thereafter, probes of the chosen ratios may be attached to the appropriate inputs and the correct adjusted sensitivities will be displayed by the oscilloscope.

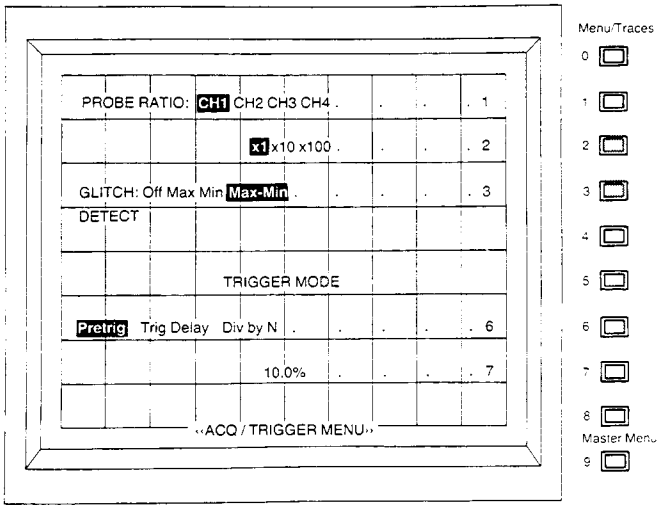


Figure 2.3.1 An Acq/Trigger Menu with Pre-trigger Selected.

GLITCH DETECT: Using the number 3 key, glitch detection can be switched on or off. If it is to be switched on, the options are Max, Min, or Max-Min. These operate as described below.

The glitch detect function is distinguished from the Max-Min function of the Display menu (Section 2.4) in that glitch detection operates on acquisition and the Max-Min function of the Display menu operates on the acquisition memory. One consequence of this is that glitch detection can detect very narrow glitches, down to 50ns wide. When set to Max, the maximum of each cycle is acquired. When set to Min, the minimum of each cycle is acquired. When set to Max-Min, both will be acquired from each cycle.

TRIGGER MODE: This option allows the user to select one of the special trigger functions. These are Pretrig, Trig Delay, and Div by N. They are selected using the 6 key. These options are described below. See also Section 1.4.

Pretrig This allows points before the trigger point to be displayed. The amount of pre-trigger visible can be set either with the front panel **Pre Trig** button or using this menu with button **7.** The options in both cases are 10% or 50% pre-trigger, or variable pre-trigger controllable with the front panel **DELAY** paddle and with the numeric keys. Variable pre-trigger can be set anywhere between 0% pre-trigger and 100% pre-trigger in 0.1% steps. 0% corresponds to the trigger point being displayed on the left hand edge of the screen, 50% the middle of the screen, and 100% the right hand edge of the screen.

Trig Delay With this set, the oscilloscope will acquire a trace following specified delay after the trigger. The amount of delay is shown beside the 7 key. The units (μs, ms, s or events) are controlled with the **8** key. If events are chosen, the delay will be that number of extra trigger events (i.e. if events=0 then the trace will be acquired after the first valid trigger). Delay can be controlled by the **DELAY** paddle, or by entering a number via the numeric keys.

Div by N An acquisition will be performed every N trigger events. The current value of N is shown beside the 7 key. It can be set either with the **DELAY** paddle or by entering a number with the numeric keys. Div by N is particularly useful for observing digital signals, TV signals and similar periodic functions. When Div by N is selected, the **8** key allows a choice of front panel control: the **DELAY** paddle can be used either to vary **N**, or to alter the phase – e.g. to allow the next or previous TV line to be acquired instead of the current one.

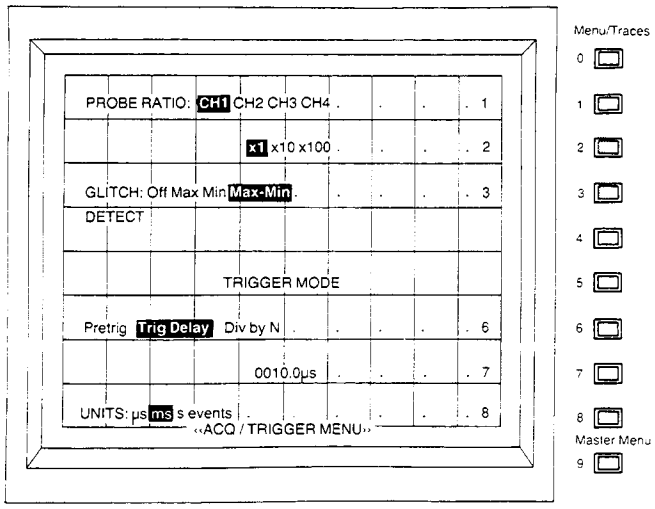


Figure 2.3.2 An Acq/Trigger Menu with Trig Delay Selected.

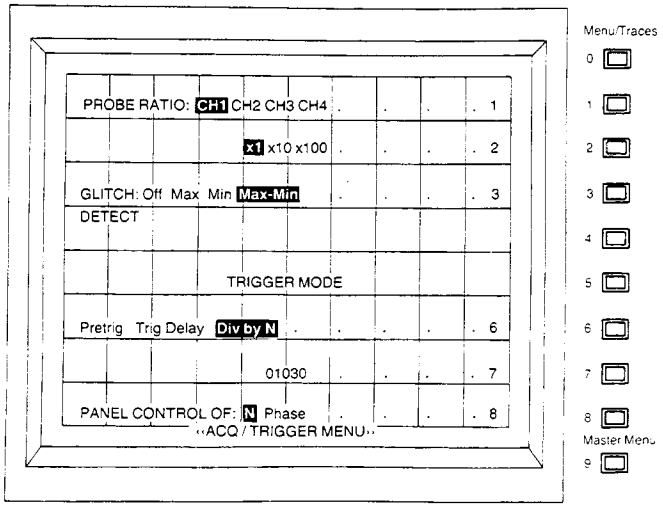


Figure 2.3.3 An Acq/Trigger Menu with Div by N Selected.

2.4 THE DISPLAY MENU

The Display menu is used to control some of the display defaults, and to operate the reference traces.

DISPLAY: This option is used to determine whether or not Max-Min is to be the normal default. The determination may be made with the number **1** key.

Off No Max-Min. Every tenth sample point is displayed.

Max-Min If the Magnification is off, the 1600 will look for the maxima and minima of successive groups of 20 samples, displaying the maximum and minimum in the order in which they occurred. If there is an alias being displayed, see Section 1.1, it will probably be displayed as a wave envelope formed from the maxima and minima. The envelope is formed alternately one dot high and one low, i.e. maxima then minima.

X-MAG: When the front-panel **X Mag** button is set to 'On', the trace is expanded horizontally by the amount set with this menu option using the number **2** key. When Mag is on the block changes, eg. x2 gives blocks of 10. At magnifications of 10 or more all samples are displayed.

DOT JOIN: The number **3** key allows the oscilloscope to be set as follows:

Off No dot joining will be performed.

On Dot joining is switched on so that real sample points will be joined by a straight line. This is most visible on traces expanded by more than 10 times.

Using the Reference Traces

The last five menu options are concerned with using the two reference traces. These provide the option of storing traces for comparison. These will be lost when the instrument is powered down. There is an optional battery back-up facility which allows them to be retained even after power-down.

To copy a currently displayed and held trace into one of the reference traces, carry out the following procedure:

* first of all select the source channel with the number **5** key;
* choose which reference trace to copy into with the number **6** key;
* press the number **4** key.

The next two options on the menu are to allow the recall and display of the reference traces. The number **7** key toggles the display of reference trace 1 and the number **8** key toggles the display of reference trace 2. They are displayed as well as the normal four traces (if those are switched on) in exactly the state they were in when saved.

2.5 SAVE & RECALL SETUPS MENU

This menu allows the front-panel control setup of the instrument to be saved into any of four memories and to be recalled for future use, even after power-down and subsequent power-up as they are battery backed up. The Status menu (see Section 2.2) allows the various setups to be examined.

On pressing one of the buttons **1** to **4**, the current setup will be saved to the appropriate memory. The word 'SAVING' will appear briefly below the words 'Save setup'.

To recall a setup, press one of the buttons **5** to **8**. The bottom line of the display will show the words 'PRESS AGAIN TO RECALL SETUP'. This is a safety measure as the new setup will replace the current front panel setup. Press the same number again, and the new setup will be recalled and imposed. Press any other number key and the recall will be abandoned; the front panel setup will be left unchanged.

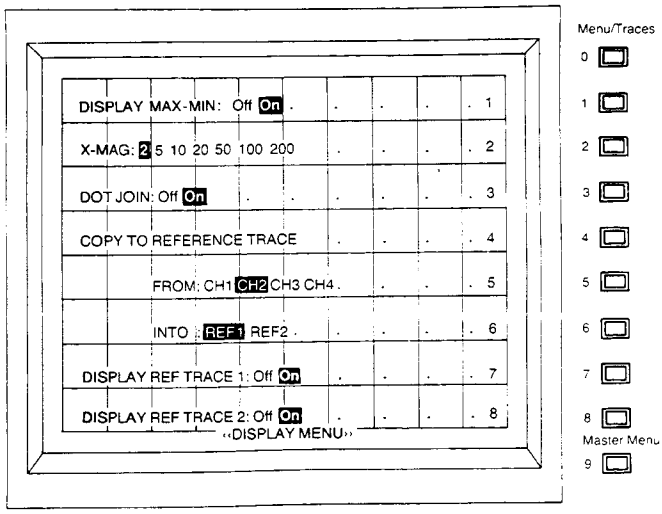


Figure 2.4.1 The Display Menu

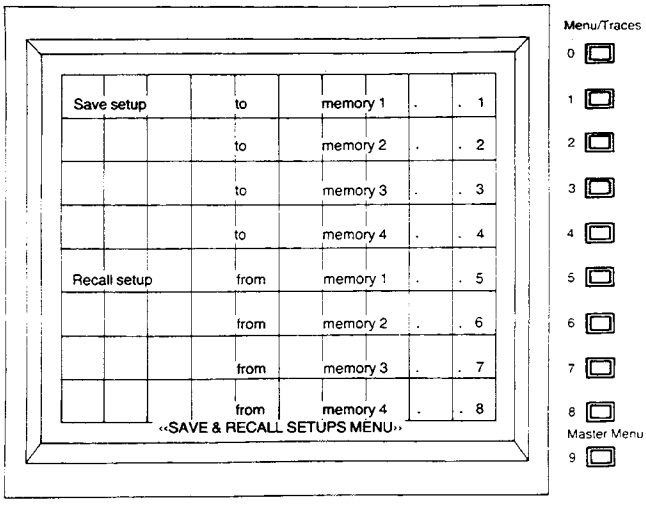


Figure 2.5.1 The Save & Recall Setups Menu

2.6 THE PLOT MENU

This menu allows the user to set the default plotter option, as follows:

PLOT MODE: This can be set to either Single or Auto with successive presses of the number **1** button. In Single plot mode one press of the **Plot** button will produce one plot output. In Auto mode, the plotter will instead do successive plots, performing a fresh acquisition between each one.

PLOT OUTPUT: Pressing the number **2** button allows the user to set the default plotter. The options are:

1. Single channel analogue plot (default if no internal plotter);
2. Four channel analogue plot; (dual on 1602)
3. Internal plotter if fitted;
4. Digital plotter with IEEE488 or RS423 interface if one of these I/O interfaces is fitted.

Four channel analogue plot is referred to in the menu as 'Analog-Quad'. It allows plots to involve up to four different pens, one for each trace.

OUTPUT RATE: The user can set the speed of the analogue plots: it can be 0.05, 0.5 or 5 divisions per second. Selection is made with successive presses of the number **3** key.

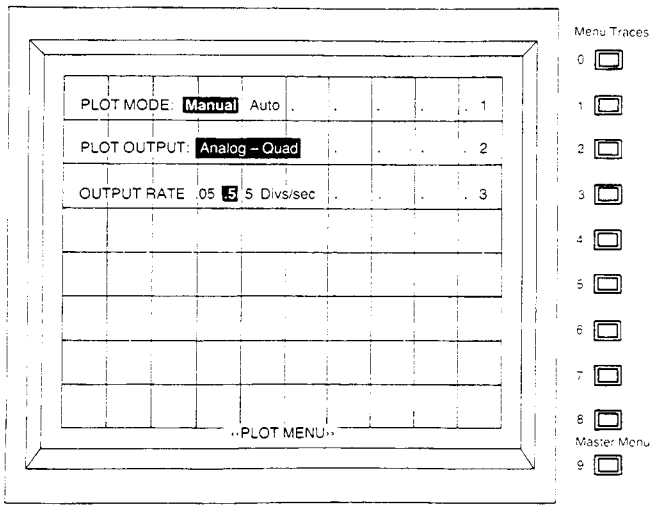


Figure 2.6.1 The Plot Menu

104 PLOTTER

PAPER LOADING Please use only Gould paper (Part No: – 04101165 for a pack of 8 rolls).

When loading the internal plotter please follow these steps:

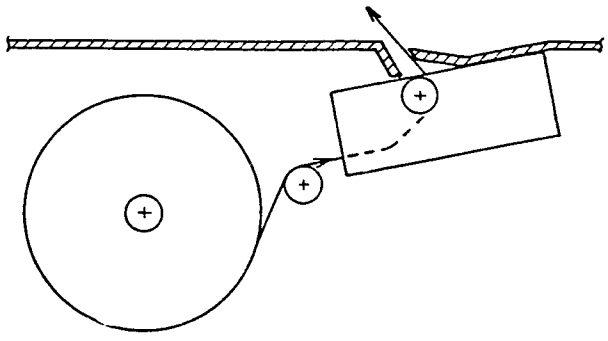
1. With scissors, cut the end of the paper square.
2. Open the printer cover by depressing the catch and lifting the cover until it is fully open.
3. Remove the cardboard roll from the shaft (if the plotter has been used previously).
4. Insert the end of the paper into the slot in the bottom of the plotter feeding the paper from the underside of the roll, as shown below.
5. Insert the shaft into the roll and place the roll of paper into paper compartment.
6. Press the paper feed button (blue) to get the paper through the slot in the top cover.
7. Close the printer cover – the catch is self-locking.

Pen Installation/Removal Please use only Gould pens (Part No: – 04101175 for a pack of 1 of each color).

The normal pen sequence is:-

Pen No.	Color
1	Black
2	Blue
3	Green
4	Red

Each pen holder is color coded for this sequence.



2.7 THE SPECIAL FUNCTIONS MENU

This menu allows the setting of the TV standard and the time and date for plot output on the optional internal plotter. Also, it allows trace arithmetic to be performed.

TV STANDARD: Successive presses of the number **6** key allow a choice of television system: either NTSC, PAL, or SECAM. With each choice, the number of raster-scan lines appropriate to that system is shown below the selection. For different numbers of lines, the Acquisition/Trigger menu should be used instead (Section 2.3).

Autocal: Enables, disables the autocalibration function which balances the offsets in the amplifiers removing gain errors in the amplifiers. The function will operate at power on and then after 10 minutes allowing for the warm-up time. It will then operate once an hour except when key functions have been selected. Divide by N, Roll mode, <50ns/div, Menu mode, 'armed' and waiting for trigger. It is advisable not to switch off the Autocal until 10 minute autocal has operated.

Time: To set the time, press the number **8** key. Then use the numeric keys to enter the time in the order hours, minutes then seconds, two digits each. Leading zeros must be entered if appropriate.

Date: Pressing the **7** key once allows the date to be set. The date is entered with the numeric keys in the order month, day, year, with two digits each. Leading zeros must be entered if appropriate.

Trace Arithmetic

Arithmetic can be performed with the traces using the numeric keys **1** to **4.** The operations available are addition, subtraction and multiplication. They function by using the values of one trace to operate on the values of a second trace (which may be the same trace as the first one). The procedure is as follows:

1) place the cursors on the trace with which the result of the operation is to be displayed;
2) select the Special Functions menu;
3) using the number **1** key, select the first operand trace:
4) with the **2** key, select the operator;
5) select the second operand with the number **3** key;
6) if you are satisfied that the correct arithmetic operation has been selected, press the number **4** key to place the result in the trace you selected with the cursors. There may be a short pause while the arithmetic is performed.

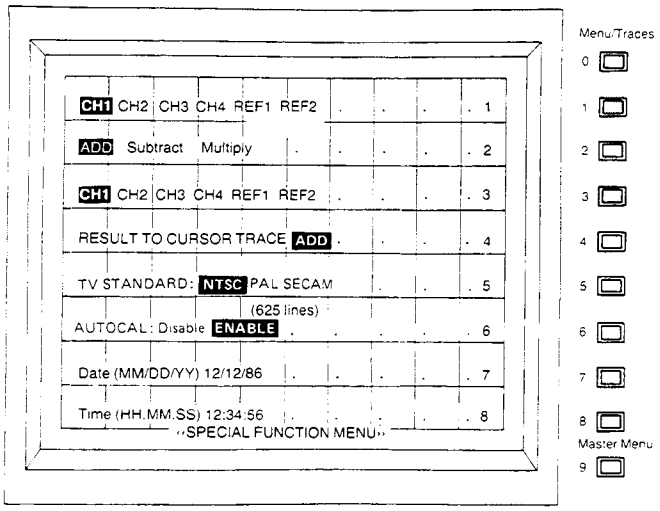


Figure 2.7.1 The Special Functions Menu

3. 1600 OPTIONS

This section of the manual looks at the options available for the 1600 series.

Waveform Processor

The waveform processor keypad and controller provide a variety of waveform processing functions such as automatic measurement of risetime, overshoot, frequency, period, etc. They also allow TV frame/line capture to be performed with greater ease than on the basic instrument. In addition to the waveform processing option is a real-time clock and a choice of 50x1k reference waveform memories or 5x10k reference waveform memories.

The interface sockets are for Gould interfaces only.

GPIB & RS423 Interfaces

GPIB and RS423 are very versatile interfaces allowing fast communication between a host computer and its peripherals. They are discussed in more detail in Sections 3.1 and 3.2. Note that only one of these two interfaces may be fitted at any one time.

The Internal Plotter

The optional internal plotter of the 1600enables the user to take copies of the screen display. The plot output includes the graticule (screen grid), a border, all displayed traces, alphanumerics and channel identification.

The plotter is supplied with four pens: black; blue; green and red. The grid, border and on-screen alphanumerics are plotted in black. You may of course change these pens & the choice of colours.

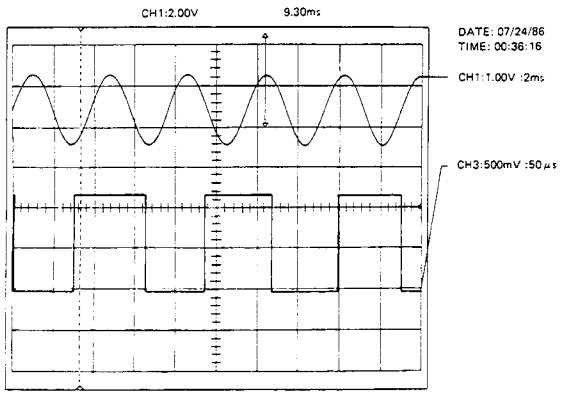


Figure 3.3.1 Example of Plot Output.

GPIB/RS423 Plots

The 1600 can operate in stand-alone mode to drive a digital GPIB or RS423 plotter. The output will be of the same form as the internal plotter, shown in Figure 3.3.1. The choice of colours is dependent on the pens used and the number available. Some plotters are able to detect missing pens: in these cases another pen will be selected.

Data output from the 1600 to the plotter is compatible with HPGL, Hewlett-Packard Graphics Language.

3.1 GPIB(IEEE488) Input/Output Interface

As most of what follows is equally applicable to RS423, any differences between the two systems will be noted below rather than in Section 3.2. Note that the systems can only be used whilst the oscilloscope is in storage mode. Also, the two systems are alternatives: the 1600 will not operate either system if both are fitted.

GPIB is a very versatile interface allowing communication between a host computer and its peripherals. There are three main modes possible when using GPIB.

Local The operator has full control of the instrument via the front panel. The 1600 may be interrogated but not manipulated in any way by the host computer.

Remote The operator has little control of the instrument, only the **S/Shot** and **Continuous** buttons will still operate. All of the 1600 GPIB commands can be used when in this mode.

Local Lock Out This is an extension of Remote mode. When the instrument is placed in this state the operator has no control of it from the front panel.

One main difference in how RS423 and GPIB operate is in how the connections are made. In RS423 separate input and output wires are used. On GPIB all data, whether input or output, is transferred over the same wires.

RS423 There is one output and one input on the host computer dedicated to each peripheral.

GPIB There is one common set of connections on the host computer; these are used for both input and output and connect to all the peripherals, which are wired in parallel.

In a system using several GPIB controlled instruments the host computer needs some method of controlling which instrument will respond when a command is sent over the bus wires. This differentiation is performed by addressing, where each instrument has a unique GPIB address (not required on RS423). The address of the 1600 is set through the menu system.

GPIB Menu

This menu allows the user to set the GPIB address of the 1600.

GPIB Address The addressing system used by the 1600 is single primary addressing; pressing button 1 enables the address to be entered.

Number entry is as follows:

1. Press button **1**.
2. Enter the new address number using the numeric keys. Both digits must be entered, most significant digit first. The digit to be entered flashes in inverse video.
3. After both digits have been entered the numeric buttons return to their usual menu control function.

GPIB and RS423 Command Syntax

The commands of the 1600 are simple and English-like. Where necessary, mnemonics have been used to replace large words or text. To enable the user to send more readable commands, spaces may be inserted freely within the commands. All spaces will be ignored except with the TXT command.

Strings

A string is the smallest complete message that can be sent over the bus.

e.g. "HSA=5E-3"

Commas may be used as separators within a string and semi-colons can be used to separate strings from each other.

e.g. "HSA=5E-3;ST1=1,2,3....."

A string may contain only ASCII characters, except binary blocks (see later). The space, character codes above 127 (decimal) and control codes other than line feed will be ignored. Upper and lower case are distinct and upper case should be used for all commands.

Numbers

Numbers that appear in commands must conform to certain conditions:

1. the number must contain less than 20 characters;
2. the mantissa must be an integer, i.e. it must not contain a decimal point;
3. the mantissa may contain a sign (+/−). + will be assumed if none is specified;
4. the exponent is optional, if included it must be preceeded by an 'E';
5. the exponent may contain a sign, if omitted + is assumed

Blocks

The buffer of the 1600 is of limited size: when large data transfers are being carried out is is necessary to break them into smaller groups, or blocks. Blocks can be terminated in one of four ways:

1. ‹cr›‹lf› EOI asserted with lf.
2. ‹cr›‹lf›
3. ‹lf› with EOI.
4. ‹lf› without EOI.

EOI stands for End Or Identify. When this is asserted with ‹lf› it indicates the end the present data transfer.

Methods 2 and 4 are used as separators between blocks. Methods 1 and 3 are used to terminate the final block.

Records

A record is a group of one or more command strings. The strings will be separated by semi-colons within the record. Records are separated in the same way as blocks and therefore the final record must be terminated by methods 1 or 3 above.

If a record (or a block) becomes too long, i.e. greater than 256 characters, this will exceed the size of the 1600 buffer. The record will be ignored and a service request will be issued by the instrument (see later).

The simplest form of record has a single string and is terminated by a ‹lf› with EOI.

e.g. "HSA=5E-3 ‹lf›" EOI asserted with lf

The 1604 will accept characters from the bus until a correctly terminated record is received or until the buffer overflows (see above). Each command string within the record will be executed before any further characters are accepted.

Command Types

There are three types of command:

Interrogative This is a request for information about instrument status or for the contents of a memory to be transmitted.

Assertive These commands request a change in one of the settings or memory of the instrument. They are only valid when in Remote or Local Lock Out mode. They have the form 'parameter=setting'.

Direct Action Assertive These commands have a direct action rather than changing a setting. They are only valid in Remote and Local Lock Out modes.

Service Requests

Service requests are generated by the 1600 to inform the bus controller that some event or problem has occurred. These have no effect upon the instrument and may be ignored. In response to a serial poll or the **SRQV** command the 1600 will supply a number. This has the meaning given in Table 3.1.1.

Table 3.1.1 Service Requests.

SRQ	Meaning
0	Ok
74	Completed
96	Invalid command
98	SRQ stack overflow
99	Command buffer overflow
100	Selection failure
101	Not allowed when Local
102	Syntax error (parameter field)
103	Number out of range
104	Length error (bulk transmissions)
105	Checksum error

If service requests are generated but not serviced the 1600 will save them up in an internal stack. When ten successive requests have been ignored this will generate a further request (98). The result of this will be that the stack is cleared, except for SRQ 98.

Sending and Receiving Stores

The contents of the display trace memories and the reference memory stores present a few problems for bus transfers. They may be too large to fit into the bus controller's buffer, and they also require a considerable amount of time to transfer.

The first problem is handled by breaking the data into BLOCKS (with the exception of binary - see later). The 1604 will transmit blocks of no more than BLL characters, each terminated by ‹cr›‹lf› with EOI marking the last block. The breaks must occur between data points and EOI must not be asserted. The data points are separated by commas. To terminate a block it is merely necessary to replace a comma with ‹cr›‹lf›. When mass data is sent to the instrument, the size of the block is not important and BLL need not correspond to the actual block length being transmitted.

The second problem is handled by the facility to specify the Numeric Base (NB):

Decimal - for simple entry into BASIC machines.
Binary - for maximum transfer speed.
Octal and Hexidecimal - to minimise conversion time on machines using these bases.

When mass data is sent to the 1600, the numeric base is deduced from the header (see later) and need not correspond to the current setting of NB.

If EOI is sent with any character, the instrument will interpret this as meaning the transfer is terminated (unless the command EOI=OFF has been received).

The format of the transmitted data is the same as that of the received data; thus the store can be read, saved and returned at some later date.

Mass Data Format

Mass data transfers have three parts:

1. A header which is specific to the command, e.g. 'TRC1A='.
2. A numeric base specifier:
   #B - Binary
   #O - Octal
   #H - Hexadecimal
   None required - Decimal
3. The data points themselves.

Binary Data Transfers

This mode is only avialable for GPIB transfers.

Sending data in this format is the quickest method: only 1038 bytes are required. In this base the data is not blocked. The format is:

'TRC1A=BLLdddd.....ddddCC‹cr›‹lf›'

Where:

#B is the binary numeric base identifier;

LL is a two-byte byte count of the following data and the checksum. LL is transmitted high byte first.

dddd.....dddd are the 1024 8-bit binary data points.

CC is the two byte checksum transmitted high byte first. The checksum is the sum of all the data bytes ignoring the overflows.

If the transmitted value of LL is incorrect, service request 'length error' is sent and the command terminated. If the checksum is incorrect then the 'checksum error' service request is generated but all the data points will have been loaded into the store.

The following BASIC program builds up a string containing the header, length, data and checksum for a sample waveform, in this case four ramps. Output of the string to the instrument over GPIB has not been included as this is dependent upon the computer used.

```
 10 DIM A$(1038)
 20 C=0                              !initialise the checksum
 30 A$="TRC1A=B"
 40 A$=A$&CHR$(3)&CHR$(250)
 50 !append header, identifier and length
 60 FOR I=1 to 1038                  !1038 data points
 70 X=I MOD 256                      !generate a ramp
 80 A$=A$&CHR$(X)
 90 C=(C+X) MOD 65536                !update the checksum
100 NEXT I
110 A$=A$&CHR$(C DIV 256)            !checksum high byte
120 A$=A$&CHR$(C MOD 256)            !checksum low byte
130 A$=A$&CHR$(13)                   !append ‹cr›
140 A$=A$&CHR$(10)                   !append ‹lf›
150 !now send the string
```

Decimal Data Transfers

In this format numbers are sent in ASCII decimal with leading zeros suppressed. This results in transmissions of variable length. The format is as follows:

1. The appropriate header is followed by 1024 decimal numbers separated by comma or ‹cr›‹lf›.
2. Numbers are in the range −128 to +127 with zero corresponding to the centre of the screen and −128 the bottom.
3. Leading zeros are suppressed on output but are acceptable on input.
4. Leading '+' is suppressed on output but is acceptable on input. Plus is assumed if no sign is present.
5. Decimal points or exponents are not accepted.
6. ‹cr›‹lf› is output to separate blocks.
7. Data can be separated by either ‹cr›‹lf› or commas. Block length is irrelevant when transmitting data to the instrument.
8. Transmission is terminated when either EOI is received, if selected, or 1024 data bytes have been received.

Octal Data Transfers

Octal numbers are transmitted in ASCII coded octal. The format is as follows:

1. The header is followed by 1024 three-character octal numbers separated by commas or ‹cr›‹lf›.
2. The numbers are unsigned and in the range 000 to 377, with 000 corresponding to the bottom of the screen.
3. Leading zeros are transmitted but suppression is acceptable on the input.
4. Notes 6 through 8 under the heading 'Decimal Data Transfers' also apply.

Hexadecimal Data Transfers

Hexadecimal numbers are sent in ASCII as two hex digits. The format is as follows:

1. The header is followed by 1024 two-character hexadecimal numbers separated by commas or ‹cr›‹lf›.
2. The numbers are unsigned and in the range 00 to FF with 00 corresponding to the bottom of the screen.
3. Leading zeros are transmitted but suppression is acceptable on the input.
4. Notes 6 through 8 under the heading 'Decimal Data Transfer' also apply.

GPIB/RS423 Commands

Conventions used in this section

In order to maintain software compatibility with other Gould oscilloscopes, many of the commands or their parameters include an extra character, 'A', which would not at first sight seem to be necessary. For example, TRC1A where TRC1 would be a sufficient abbreviation. The inclusion of the 'A' allows the same software to be used to control both the 1600 and certain other Gould oscilloscopes without the need to reqrite the software. Note that even if this facility is not used, the correct syntax must be adhered to – i.e. the 'A' must be included where shown. Other conventions are as follows:

‹cr›	the carriage return control code.
‹lf›	the line feed control code.
[ ]	denotes one of a set of options.
EOI	stands for End Or Identify.
' '	denotes a reply by the instrument to an interrogative command.
number	Where used this means a number is taken as the argument of the command.

Example:

ADD12=[ON] or [OFF]

Meaning: when you are asserting this command there are two options:

ADD12=ON
or
ADD12=OFF

GPIB/RS423 Command Summary

Key to the Command Summary:

A	Assertive
I	Interrogative
D	Direct Action Assertive

1602 is limited to two channels, reference to all four channels is for 1604.

Command	Parameter	Function	Type
ADD*	ON OFF	Add Traces	A,I
ALL		Machine Status	I
ARM		Arm the Instrument	D
AUTCAL	ENABLE DISABLE FORCE	Enables/disables/forces Autocalibration	A,I
AUTSET		Auto Setup	D
BL	number	Block Length	A,I
BLL	number	Block Length	A,I
CCAL*		Cursor Calculations	I
CH*	ON OFF	Channel Selection	A,I
CSRHP	number	Cursor, Horizontal Position	A,I
CSRTR	1A 2A 3A 4A REFT1 REFT2 OFF	Cursor Trace Selection	A,I
CSRVP	number	Cursor, Vertical Position	I
DATE	number	Set/Read date	A,I
DATMH	number	Hor. Datum Position	A,I
DATMV	number	Vert. Datum Position	A,I
DISPLAY	TRACE MENU*	Display menu or trace	A,I
ECHO	ON OFF	RS423 Echo On/off	A,I
EOI	ON OFF	End Or Identify	A,I
GLDET	OFF MAX MIN MAX/MIN	Glitch Detect	A,I
HE	number	Horizontal Expansion	A,I
HELLO		Hello Message	I
HELP		Command List	I
HOLD	ON OFF	Hold All Channels	A,I
HSA	number	Horizontal Scaling	A,I
INT	DOT DOTJ	Interpolation	A,I
INV*	ON OFF	Channel Invert	A,I
LOCK*	ON OFF	Lock a channel	A,I
MODE	ROLL REFR XY	Acquisition Mode	A,I
MSAV*		Save Machine Setup	D
MSTX*	data field	Transmit Machine Setup	A,I
NB	BIN OCT HEX DEC	Number Base	A,I

Command	Parameter	Function	Type
PBG*	1 10 100	Probe Gain	A,I
PH-		Phase Shift -ve	D
PH+		Phase Shift +ve	D
PLOT		Start Plot	D
PLRT	10 5 1 0.5 0.1 0.05	Plot Rate	A,I
PLTDST	GPIB ANSGL ANQD PRNT SRL	Plot Destination	A,I
PLTGT	ON OFF	Plot Graticule	A,I
PLTMD	AUTO SNGL	Plot Mode	A,I
PLTR	ON OFF	Plot Traces Only	A,I
PROMPT	ON OFF	RS423 Prompt On/Off	A,I
RCLMS	1 2 3 4	Recall Machine Setup	D
REFT*	data field,TR1A data field,TR2A data field,TR3A data field,TR4A	Reference Trace Transfer	A,I
REL		Release	D
RTPL	20 10 2 1 0.2 0.1	Rate of Plot	A,I
SHFT	number	Horizontal Shift	A,I
SRQV		Service Request Value	I
STAT		Acquisition Status	I
STR*		Acquisition Store Transfer	I
TBAND	number	Trigger Band	A,I
TDELA	number	Trigger Delay by Time	A,I
TGAAUT	ON OFF	Auto Trigger On/Off	A,I
TEVNT	number	Trig. Delay by Events Counter	A,I
TIME	number	Set/Read time	A,I
TLA	number	Trigger Level	A,I
TOFR*	ON OFF	Reference Trace On/Off	A,I
TRGCA	DC AC ACLP DCLP TVL TVF	Trigger Coupling	A,I

Command	Parameter	Function	Type
TRGMDA	A	Trigger Mode A,I	
	ADIVN		
	ADELN		
TRC*A	data field	Display Trace Transfer	A,I
	REFM*		
TRHS*	number	Horizontal Trace Scaling	A,I
TRHSR*	number	Ref. Trace Hor. Scaling	A,I
TRVS*	number	Vertical Trace Scaling	A,I
TRVSR*	number	Ref. Trace Vert.Scaling	A,I
TSA	CH1	Trigger Source	A,I
	CH2		
	CH3		
	CH4		
	EXTA		
	LINE		
TSLA	BAND	Trigger Slope	A,I
	MINUS		
	PLUS		
TXT*	"string"	On Screen Text	A,I
VC*	AC	Vertical Coupling	A,I
	DC		
	GND		
VP*	number	Vertical Position	A,I
VPS*	number	Post Storage Shift	A,I
VPSR*	number	Ref. Trace Post Strg Shift	A,I
VS*	[-][›]number[~][ ]	Vertical Scaling	A,I
WIND	number,number	Trace Window	A,I

Function: Add

Type: Assertive, Interrogative

Syntax: ADD12
ADD34
ADD*
ADD12=[ON] or [OFF] ADD34=[ON] or [OFF]
ADD*=[ON] or [OFF]

Explanation: ADD12 will cause the two input channels 1 and 2 to be added together before being displayed. ADD34 will cause input channels 3 and 4 to be added together before being displayed. ADD* is the same as issuing ADD12 as well as ADD34.

Examples: ADD12
'ADD12=ON' (1600 response)

ADD34=OFF

See also: Sections 2.3, 1.2

Function: Complete Machine Status

Type: Interrogative

Syntax: ALL

Explanation: This causes the complete state of the instrument to be output as though the relevant interrogatives had been sent. Its response will be a number of strings each separated by ';'. If the block length is non-zero then each block will be separated by ›cr‹›lf‹. If selected, EOI will be set on the final ‹lf›.

Example: ALL
'ADD12=ON;.....;WIND=0,9999‹cr›‹lf›'

See also: HELP

Function: Arm

Type: Direct Action Assertive

Syntax: ARM

Explanation: This command produces the same effect as pressing the front panel S/Shot button.
Service request 74 will be generated when the trace has been stored. If, for some reason, the trace cannot be captured, service request 100 will be generated.

Notes: *It is not possible to arm the instrument with this command if:*

1. HOLD is on;
2. All the traces are locked;
3. The instrument is in LOCAL;
4. The instrument is in menu mode.

See also: Section 1.5

Function: Channel Selection

Type: Assertive, Interrogative

Syntax: AUTCAL
AUTCAL=[ENABLE], [DISABLE], [FORCE]

Explanation: Enables or disables the auto calibration function in the instrument which balances the DC offsets in the Y preamplifiers. Also a calibration can be forced to ensure the instrument is calibrated.

Examples: AUTCAL
'AUTCAL = ENABLE' (1604 Response).
AUTCAL = FORCE.

Notes: When requesting a calibration, note that the following instrument modes do not allow an autocalibration to occur.
Div by N
Roll at Timebase speeds 50ms/Div
Menu Mode
Armed waiting for Trigger

Function: Auto Setup

Type: Direct Action Assertive

Syntax: AUTSET

Explanation: This command produces the same effect as pressing the Auto Setup button on the front panel.

See also: Section 1.1

Function: Block Length

Type: Assertive, Interrogative

Syntax: BL
BLL
BL=number
BLLnumber

Explanation: This command defines the length of the blocks used during bulk transmissions. Its default state is zero, which selects infinite length blocks. Values from 0 to 256 may be used. Apart from zero these specify the maximum number of characters that will be sent before a ‹cr›‹lf›.

Examples: BLL
'BLL=0' (1600 response)

BL=73

Notes: *The number specified is the maximum number of characters that will be sent before ‹cr›‹lf›. If leading zero suppression (and numeric base = decimal) is used each block may be of different length.*

Function: Cursor Calculations

Type: Interrogative

Syntax: CCAL

Explanation: Forces the instrument to make the voltage and time difference measurements using the cursors. CCAL returns the voltage measurement first, followed by the time measurement.

Example: CCAL
'CCAL="CH1: 12.4E-3 :500.0E-6"'
(1600 response)

Note: *If the cursors are not selected when this command is issued service request 100 will be generated.*

See also: Section 1.6

Function: Channel Selection

Type: Assertive, Interrogative

Syntax: CH1
CH2
CH3
CH4
CH*
CH1=[ON] or [OFF]
CH2=[ON] or [OFF]
CH3=[ON] or [OFF]
CH4=[ON] or [OFF]
CH*=[ON] or [OFF]

Explanation: Switches on or off one or more of the vertical channels. CH* returns the status of all four channels or switches them all on or off. When a channel is switched on, its vertical scaling will default to the value it had prior to the channel being switched off.

Examples: CH1=ON
CH2
'CH2=OFF'(1600 response)

See also: Section 1.2

Function: Cursor, Horizontal Position

Type: Assertive, Interrogative

Syntax: CSRHP
CSRHP=number

Explanation: In its assertive form this command moves the measurement cursor to the specified horizontal position on the screen. The range is 0 to +10, zero being the left-hand edge of the screen and 10 being the right-hand edge.

Examples: CSRHP=5
CSRHP
'CSRHP=3.7' (1600 response)

See also: DATMH, DATMV, CSRVP, Section 1.6

Function: Cursor Trace Selection

Type: Assertive, Interrogative

Syntax: CSRTR
CSRTR=[1A], [2A], [3A], [4A]
[REFT1], [REFT2] or [OFF]

Explanation: This command moves the cursors to the specified trace, or indicates on which trace they will appear when they are selected. If OFF is sent then the cursors will be switched off. REFT1 and REFT2 are the reference traces.

Examples: CSRTR=1A
CSRTR
'CSRTR=4A' (1600 response)

Note: Cursors can only be moved to a trace that is currently being displayed.

See also: Section 1.6

Function: Cursor, Vertical Position

Type: Interrogative

Syntax: CSRVP

Explanation: The vertical position of the measurement cursor is determined by its position on the selected trace. This has a range of ±4.48, zero being the centre of the screen. Resolution is 0.035 divs.

Examples: CSRVP
'CSRVP=4.1' (1600 response)

See also: DATMH, DATMV, CSRHP, Section 1.6

Function: Date

Type: Assertive, Interrogative

Syntax: DATE
DATE=MM,DD,YY

Explanation: This command allows the date held in the machine to be read, or set.

Examples: DATE
'DATE=12-30-87' (1600 response)
DATE=11,21,87

Explanation: In its assertive form this command moves the voltage datum cursor to the specified position on the screen. The range is ±4.48, zero being the centre of the screen.

Function: Horizontal Datum Position

Type: Assertive, Interrogative

Syntax: DATMH
DATMH=number

Explanation: In its assertive form this command moves the time datum cursor to the specified position on the screen. The range is 0 to +10, zero being the left-hand edge of the screen and 10 being the right-hand edge.

Examples: DATMH=9.4

DATMH
'DATMH=3.7' (1600 response)

See also: DATMV, CSRHP, CSRVP, Section 1.6

Function: Vertical Datum Position

Type: Assertive, Interrogative

Syntax: DATMV
DATMV=number

Explanation: In its assertive form this command moves the voltage datum cursor to the specified position on the screen. The range is ±4.48, zero being the centre of the screen.

Examples: DATMV=0.5

DATMV
'DATMV=1.35' (1600 response)

See also: DATMH, CSRHP, CSRVP, Section 1.6

Function: Display Menus or Traces

Type: Assertive, Interrogative

Syntax: DISPLAY
DISPLAY=[TRACE] or [MENU][number]

Explanation: This command controls whether traces or menus are displayed. If menus are chosen then this is accompanied by the menu number:

MENU0 - Master Menu
MENU1 - Status Menu
MENU2 - Acquisition/Trigger Menu
MENU3 - Display Menu
MENU4 - Save/Recall Setups Menu
MENU5 - Plot Menu
MENU6 - Special Functions Menu
MENU7 - Input/Output Menu (optional)
MENU8 - Option Functions Menu (optional)

The trace display consists of those traces selected by CH* command.

Examples: DISPLAY=MENU4

DISPLAY
'DISPLAY=TRACE' (1600 response)

See also: CH*, Section 2.1

Function: ECHO

Type: Assertive, Interrogative

Syntax: ECHO
ECHO= [ON] or [OFF]

Explanation: Alters the echo mode for RS423, so that the instrument will or will not echo back any inputs received by the instrument.

Example: ECHO
'ECHO=OFF' (1604 Response)
ECHO=ON

Notes: This command is only available in RS423 mode.

Function: End Or Identify

Type: Assertive, Interrogative

Syntax: EOI
EOI=[ON] or [OFF]

Explanation: This command affects only the GPIB interface. When EOI is asserted with ‹lf› this indicates the end of the present transmission. If EOI=OFF then EOI will be ignored if asserted. ON is the default condition.

Examples: EOI=OFF

EOI
'EOI=OFF' (1600 response)

Function: Glitch Detect

Type: Assertive, Interrogative

Syntax: GLDET
GLDET=[OFF], [MAX], [MIN]
or [MAXMIN]

Explanation: This command is used to select the max-min or glitch detect mode. When MAX is selected the acquired data represents all the maximum values captured by the ADC running at 20MHz. When MIN mode is selected the acquired data represents the minimum captured values. When MAXMIN mode is selected the acquired data represents both the maximum and minimum data values captured. In this case adjacent data points comprise the maximum and minimum values for each period. These will be displayed in their correct time order.

Examples: GLDET=MAXMIN

GLDET
'GLDET=OFF' (1600 response)

Function: Horizontal Expansion

Type: Assertive, Interrogative

Syntax: HE
HE=[1], [2], [5], [10], [20], [50], [100] or [200]

Explanation: This command allows the present X magnification to be interrogated or a new value set. This works in the same way as the front panel button X Mag.

Examples: HE=5
HE
'HE=1' (1600 response)

Notes: *In the same way as the front panel button, HE expands the trace around the present centre of the screen.*

See also: HSA, INT, Section 1.3

Function: Hello Message

Type: Interrogative

Syntax: HELLO

Explanation: This command returns the message 'Gould, 1600, 0, Software issue no.'

Function: Command List

Type: Interrogative

Syntax: HELP

Explanation: When this command is issued the 1604 responds with a list of all the allowable commands and their inputs.

See also: ALL

Function: Hold All Channels

Type: Direct Action Assertive

Syntax: HOLD = [ON] or [OFF]

Explanation: When HOLD is asserted all channel traces are held, even if part way through an acquisition. Once the display has been held individual channels may be 'locked' by assertion of the LOCK command. The action of this command is exactly the same as that of the HOLD button on the front panel.

Example: HOLD = ON

See also: LOCK, Section 1.5

Function: Horizontal Scaling

Type: Assertive, Interrogative

Syntax: HSA
HSA=number

Explanation: The horizontal scaling, or timebase, can be set with this command. The range is 50μs per division to 200s per division, in 1, 2, 5 steps, subject of course to the restrictions of dual and normal modes of operation as summarised below:

	Normal	Dual
(Storage)	200s-50μs	200s-100μs

Examples: HSA=5E-3
HSA
'HSA=100E-6' (1600 response)

See also: HE, Sections 1.1,

Function: Interpolation

Type: Assertive, Interrogative

Syntax: INT
INT=[DOT], [DOTJ]

Explanation: There are two choices for interpolation on the displayed traces:

1. DOT — Dots only: when in expanded mode these will be quite visible. This mode is called 'OFF' on the display menu;
2. DOTJ — Dot join: the individual dots are joined by faint straight lines. This mode is called 'NORMAL' on the display menu.

Examples: INT=DOT
INT
'INT=DOTJ' (1600 response)

Notes: *The interpolation modes are particularly useful on expanded traces where the individual samples start to become visible. DOTJ lights up parts of the screen which do not represent part of the captured trace and this should be borne in mind when making measurements on expanded traces.*

See also: HE, Section 2.3

Function: Channel Invert

Type: Assertive, Interrogative

Syntax:
INV1
INV2
INV3
INV4
INV*
INV1=[ON] or [OFF]
INV2=[ON] or [OFF]
INV3=[ON] or [OFF]
INV4=[ON] or [OFF]
INV*=[ON] or [OFF]

Explanation: In its assertive form this command controls whether the channels are displayed in their normal or inverted modes. INV* can be used to control all channels simultaneously, or interrogate them together.

Examples:
INV1=ON
INV*
'INV1=ON
INV2=OFF
INV3=ON
INV4=OFF'

See also: Section 1.2

Function: Channel Lock

Type: Assertive, Interrogative

Syntax:
LOCK1
LOCK2
LOCK3
LOCK4
LOCK*
LOCK1=[ON] or [OFF]
LOCK2=[ON] or [OFF]
LOCK3=[ON] or [OFF]
LOCK4=[ON] or [OFF]
LOCK*=[ON] or [OFF]

Explanation: This command may be used to lock a selected channel in order to prevent subsequent acquisitions from overwriting the store. The command can only be asserted to either lock or release a channel when all channels have been held by a previous assertion of the HOLD command. If this command is asserted without a prior HOLD, a service request 100, indicating a selection failure, will be generated.

Example:
LOCK*=ON
LOCK1
'LOCK1=OFF' (1600 response)

See also: LOCK, Section 1.5

Function: Acquisition Mode

Type: Assertive, Interrogative

Syntax:
MODE
MODE=[ROLL], [REFR] or [XY]

Explanation: There are three capture modes on the 1604:

1. ROLL — Chart recorder mode: the data comes in from the right-hand side of the screen and travels to the left-hand side, even in the absence of a trigger. This is only valid at timebase ranges slower than 50ms/div. At faster ranges REFR and ROLL are indistinguishable.
2. REFR — Refresh mode: data is plotted from left to right across the screen, after a valid trigger is received.
3. XY — XY mode: Channel 1 is displayed as the X or horizontal part of the trace and Channels 2, 3 or 4 as the Y or vertical part.

Examples:
MODE=ROLL
MODE
'MODE=REFR' (1600 response)

See also: Section 2.3.

Function: Save Machine Setup

Type: Direct Action Assertive

Syntax:
MSAV1
MSAV2
MSAV3
MSAV4

Explanation: This command provides the same function as the save part of the Save and Recall Setups Menu. When this command is asserted the present machine setup is saved into the specified memory.

Example: MSAV1

See also: MSTX*, RCLMS

Function: Transmit Machine Setup

Type: Assertive, Interrogative

Syntax:
MSTX1
MSTX2
MSTX3
MSTX4

Explanation: The data sent by this command is a series of numbers. They can be used to extend the number of saved machine setups. The format of the numbers is controlled by NB and BLL.

Example: MSTX3
'**MSTX3**=data field ‹cr›‹lf›'

See also: MSAV*, RCLMS

Function: Number Base

Type: Assertive, Interrogative

Syntax: NB
NB=[BIN], [OCT], [HEX] or [DEC]

Explanation: This command specifies the number base used during bulk data transfers. There are four options:

1. BIN Binary: each byte transferred represents the data for one sample. This is the fastest transfer mode. The range is from 00000000B (bottom of the screen) to 11111111B (top of the screen); the centre is given by 10000000B.
2. OCT Octal: each data sample is sent as three unsigned octal (base 8) digits. The range is 0000 (bottom of the screen) to 3770 (top of the screen); the centre is given by 2000.
3. HEX Hexadecimal: each data sample is sent as two unsigned hex (base 16) digits. The range is 00H (bottom of the screen) to FFH (top of the screen); the centre is given by 80H.
4. DEC Decimal: each data sample is sent as a signed decimal number. The range is -128 (bottom of the screen) to +127 (top of the screen); the centre is given by 0. This is the slowest transfer mode.

Examples: NB=OCT
NB
'NB=DEC' (1600 response)

Notes: *The number base defaults to decimal (DEC) on power up and the selected number base is used for transmitted data. The numeric base for received data is specified in the header of the bulk transfer. Any numbers received outside the range for the chosen number base will generate a service request 103.*

See also: BL, BLL, TRC, REFM*

Function: Probe Gain

Type: Assertive, Interrogative

Syntax: PBG1
PBG2
PBG3
PBG4
PBG*
PBG1=[X1], [X10], [X100]
PBG2=[X1], [X10], [X100]
PBG3=[X1], [X10], [X100]
PBG4=[X1], [X10], [X100]
PBG*=[X1], [X10], [X100]

Explanation: This command sets the gain at the probe input, or reads the currently set value. Probe setting is not automatic: a value must be set using this command unless the default value of x1 is satisfactory.

Examples: PBG3=10
PBG1
'PBG1=100' (1600 response)

Function: Phase Shift

Type: Direct Action Assertive

Syntax: PH-
PH+

Explanation: When the 'divide by N' function is in use, i.e. trigger mode DIVN, these commands cause the phase of the captured signal to be changed. For example, if an input waveform has a repetitive pattern every 17 triggers, divide by N would be set to 17. This would allow the 1600 to capture the same part of the pattern on each acquisition. These commands enable the user to capture other parts of the pattern. PH- takes the previous trigger point and PH+ takes the next one.

Examples: PH-
PH+

See also: TRGMD, Section 2.5

Function: Start Plot

Type: Direct Action Assertive

Syntax: PLOT

Explanation: When this command is received the 1600 will begin a plot on the selected plot output device. In trace mode, the on-screen traces will be plotted. In menu mode, the screen text is plotted, except when analogue plot is selected.

Example: PLOT

Notes: *If the plot destination is GPIB, and the plot was requested from the front panel, or RS423, the instrument transmits data in talk-only mode. GPIB device clear will abort the plot. Service request 74 will be generated when the plot is complete.*

See also: PLTMD, PLTGT, PLTR, PLTDST, PLRT, RTPL, Sections 1.7, 3.3

Function: Plot Rate

Type: Assertive, Interrogative

Syntax: PLRT
PLRT=[0.05], [0.1], [0.5], [1], [5] or [10]

Explanation: The two analogue plot selections, single channel analogue plot and multi-channel analogue plot (quad), are for use with non-digital plotters. On this sort of plotter the drawing rate is not fixed. This command enables the user to set this rate to one of the values given above (these are in divisions per second).

Examples: PLRT=5
PLRT
'PLRT=0.5' (1600 response)

See also: RTPL, Section 1.7

Function: Plot Destination

Type: Assertive, Interrogative

Syntax: PLTDST
PLTDST=[GPIB], [ANSGL], [ANQD], [PRNT] or [SRL]

Explanation: There are five types of plot output on the 1600: GPIB, RS423 (SRL), the internal plotter (PRNT), single channel analogue plot (ANSGL) and quad channel analogue plot (ANQD). This command specifies which device will be used when PLOT is asserted. (For GPIB, RS423 and the internal plotter, optional hardware must be fitted.)

Examples: PLTDST=GPIB
PLTDST
'PLTDST=PRNT (1600 response)

See also: PLOT, Sections 1.7, 3.3

Function: Plot Graticule

Type: Assertive, Interrogative

Syntax: PLTGT
PLTGT=[ON] or [OFF]

Explanation: On the internal plotter and the two external digital plotter modes, GPIB and RS423, it is possible to plot the screen graticule. It will not be drawn on either of the two analogue plot modes. This command does not plot anything: it specifies whether the graticule is plotted when the front panel PLOT button is pressed or plot is asserted.

Examples: PLTGT=ON
PLTGT
'PLTGT=OFF' (1600 response)

See also: PLTR, Sections 1.7, 3.3

Function: Plot Mode

Type: Assertive, Interrogative

Syntax: PLTMD
PLTMD=[AUTO] or [SNGL]

Explanation: On the 1600 there are two plot modes, auto and single. In single mode when plot is asserted, either by the front panel button or by the PLOT command, a hard copy of the screen display is made on the selected plotter. In auto mode when plot is asserted, a hard copy of the screen is made on the selected plotter, the instrument then waits for another capture, makes a further hard copy, etc.

Examples: PLTMD=AUTO
PLTMD
'PLTMD=SNGL' (1600 response)

Note: *There are three ways to stop the instrument once AUTO mode is asserted: send GPIB device clear, press the Plot button, or switch the instrument off.*

See also: Sections 1.7, 3.3

Function: Plot Traces Only

Type: Assertive, Interrogative

PLTR
PLTR=[ON] or [OFF]

Explanation: On the optional internal plotter and in the two optional external digital plot modes (GPIB & RS423) it is possible to plot traces, the graticule and some alphanumerics. When PLTR=ON the graticule and alphanumerics will not be plotted, even if PLTGT=ON. In analogue plot modes PLTR=OFF is an invalid selection. This command determines the format of the plot; it does not plot anything directly.

Examples: PLTR=ON
PLTR
'PLTR=OFF' (1600 response)

See also: PLTGT, Sections 1.7, 3.3

Function: Prompt

Type: Assertive, Interrogative

Syntax: PROMPT
PROMPT= [ON] or [OFF]

Explanation: Alters the Prompt mode in RS423 operation, so that prompts, which indicate a pending SRQ, can be turned on or off.

Example: PROMPT
'PROMPT=ON' (1600 response)
PROMPT=OFF

Notes: This command is only available in RS423 mode.

Function: Recall Machine Setup

Type: Direct Action Assertive

Syntax: RCLMS=[1], [2], [3] or [4]

Explanation: This command recalls one of the optional backed-up memory machine setups. These are setups for all the instrument's controls, i.e. attenuator settings, timebase ranges, trigger source and coupling, etc.

Example: RCLMS=3

See also:

Function: Reference Trace Transfer

Type: Assertive, Interrogative

Syntax: REFT*
REFT1
REFT2
REFT1=[data field], [TRC1A], [TRC2A], [TRC3A], [TRC4A]
REFT2=[data field], [TRC1A], [TRC2A] [TRC3A], [TRC4A]

Explanation: The reference memories can be transferred to and from the host computer, or set equal to one of the display trace stores. Each store consists of 1024 data samples, the first being for the left-hand edge of the screen and each successive one from one position further right each time.

The format of the data field is dependent on the specified block length. If BLL=0 then this will consist of 1024 numbers in the specified numeric base followed by ‹cr› ‹lf› with EOI on the ‹lf›. If BLL is non-zero then the data field will consist of a number of blocks each separated by ‹cr› ‹lf› with EOI on the last ‹lf›, if asserted.

The command REFT* can only be used interrogatively. It is equivalent to issuing the commands REFT1 and REFT2 respectively, and the instrument responds with the data from each trace.

Examples: REFT1=TRC1A
REFT*
'REFT1=3,20,2,1,0,....,34;
REFT2=3,50,1,2,....,45,6 ‹cr›‹lf›'

See also: EOI, BL, BLL, NB, WIND

Function: Release

Type: Direct Action Assertive

Syntax: REL

Explanation: This command has the same effect as pressing the front panel button Continuous.

Example: REL

See also: ARM, Section 1.5

Function: Rate of Plot

Type: Assertive, Interrogative

Syntax: RTPL
RTPL=[20], [10], [2],
[1], [0.2] or [0.1]

Explanation: The two analogue plot selections, single channel analogue plot and quad channel analogue plot, are for use with non-digital plotters. On this sort of plotter the drawing rate is not fixed. This command enables the user to set the drawing rate in seconds per division.

Examples: RTPL=2
RTPL
'RTPL=0.2' (1600 response)

Notes: *'Rate of Plot' and 'Plot Rate' are reciprocals of each other i.e.*

$$\textit{Rate of Plot} = \frac{1}{\text{Plot Rate}}$$

See also: PLRT, Section 2.6

Function: Horizontal Shift

Type: Assertive, Interrogative

Syntax: SHFT
SHFT=number

Explanation: The horizontal or X position of the traces can be set by this command. The range is ± 6.00 divisions, allowing the ends of the traces to be shifted past the centre of the screen. In its interrogative form a returned value of zero places the traces nominally in the centre of the screen.

Examples: SHFT=-3.14
SHFT
'SHFT=2.71' (1600 response)

Note: *Negative numbers move the traces to the left and positive numbers move them to the right.*

See also: HE, Section 1.3

Function: Service Request's Value

Type: Interrogative

Syntax: SRQV

Explanation: When an error is generated in the instrument, either through an invalid command being issued or for any other reason, a service request is generated. This command allows the user to ascertain what the error is and then determine its cause. The service requests are listed below:

SRQ	Meaning
0	ok
74	completed
96	invalid command
98	SRQ stack overflow
99	command buffer overflow
100	selection failure
101	not allowed when local
102	syntax error in parameter field
103	number out of range
104	length error
105	checksum error

Example: SRQV
'SRQV=74' (1600 response)

Note: *The last two service request numbers, 104 and 105, are only generated by errors in bulk transmissions.*

See also: **Section 1.7**

Function: Acquisition Status

Type: Interrogative

Syntax: STAT

Explanation: This command allows the user to determine which stage the instrument has reached in an acquisition. The four states are given below:

Value	State
ARMD	Armed but not yet triggered
FLSHD	Flushing the acquisition store
TRIGD	Triggered, acquisition in progress
STORD	Stored, trace acquisition complete.

Example: STAT
'STAT=TRIGD' (1600 response)

See also: Section 1.5

Function: Acquisition Store Transfer

Type: Interrogative

Syntax: STR1A
STR2A
STR3A
STR4A
STR*

Explanation: With this command, the acquisition store can be transferred to the host computer. The store consists of 10240 data samples.

The format of the data field is dependent on the specified block length. If BLL=0 then it will consist of 10240 numbers in the specified numeric base followed by ‹cr›‹lf› with EOI on the last ‹lf›. If BLL is non-zero then the data field will consist of a number of blocks each separated by ‹cr›‹lf› with EOI on the last ‹lf›, if asserted.

Example: STR2A
'STR2A=4,96,...,12‹cr›‹lf›'

See also: EOI, BL, BLL, NB, WIND

Function: Trigger Band

Type: Assertive, Interrogative

Syntax: TBAND
TBAND=number

Explanation: This function allows the value of the trigger band to be set or changed. The range of values for the width of the band is from 0.5 to 8.

Examples: TBAND=3.7
TBAND
'TBAND=0.5' (1600 response)

See also: TLA

Function: Trigger Delay by Time

Type: Assertive, Interrogative

Syntax: TDELA
TDELA=number

Explanation: This command allows the present value of the trigger 'delay by time' function to be read or changed. Negative time delays capture events prior to the trigger point (this is called pre-trigger). The amount of pre-trigger is expressed as a percentage, i.e. -100.0 (100% pre-trigger) places the trigger point on the right-hand edge of the screen and 0.0 (0% pre-trigger) places it on the left-hand edge. Positive time delay settings capture events after the trigger point, and are expressed in seconds. The minimum time delay is minus 100%, the maximum is over 2000 screen divisions. Before using this command, the trigger mode should be set to 'A'.

Max. Delay	Timebase range
1000s	200ms - 200s
10s	5ms - 100ms
100ms	50ms - 1ms

Examples: TDELA=-50
TDELA
'TDELA=0.0' (1600 response)

See also: TRGMD, TEVNT, Section 1.4

Function: Set Trigger Event Counter

Type: Assertive, Interrogative

Syntax: TEVNT
TEVNT=number

Explanation: This command is used to set the trigger event counter. If the trigger mode is ADIVN the incoming triggers are divided by the value in this counter e.g. if the value is set to 5 the acquisition circuit will trigger on each fifth event. If the trigger mode is ADELN the value set in this counter represents the number of trigger events that are to be counted before the acquisition circuit is triggered e.g. if the value in this counter is 5 then the acquisition circuit will trigger on the sixth event. The range that may be selected is from 1 to 16383 with ADELN or 2 to 16385 with ADIVN.

Examples: TEVNT=951
TEVNT
'TEVNT=3' (1600 response)

Note: *A trigger event is a valid trigger as determined by the trigger source, coupling, LEVEL, BAND and slope controls.*

See also: TDELA, TRGMD, Section 1.4

Function: Time

Type: Assertive, Interrogative

Syntax: TIME
TIME=HH,MM,SS

Explanation: This command gives the option of reading the time held in the 1600, or setting the time.

Example: TIME
'TIME=10:51.43 (1600 response)
TIME=1,13,51

Function: Auto Triggering On/Off

Type: Assertive, Interrogative

Syntax: TGAAUT
TGAAUT=[ON] or [OFF]

Explanation: This command is used to select either auto or manual triggering.

Examples: TGAAUT=ON

TGAAUT
'TGAUT=OFF' (1600 response)

Function: Trigger Level

Type: Assertive, Interrogative

Syntax: TLA
TLA=number

Explanation: The level controls of the trigger channel can be set or read with this command. The range is -7 to +7 Divs.

Examples: TLA=3.73

TLA
'TLA=1.45' (1600 response)

Note: *It is not necessarily possible to relate the trigger level to a particular vertical position on the screen display. This is due to the effects of pre- and post-storage shift and the selected trigger coupling.*

See also: TBAND, TRGCA, TS, TSL, Section 1.4

Function: Reference Trace On/Off

Type: Assertive, Interrogative

Syntax: TOFR1
TOFR2
TOFR*
TOFR1=[ON] or [OFF]
TOFR2=[ON] or [OFF]
TOFR*=[ON] or [OFF]

Explanation: The reference traces R1 and R2 can be activated or deactivated with this command.

Examples: TOFR1=ON

TOFR1
'TOFR1=OFF'

Function: Trigger Coupling

Type: Assertive, Interrogative

Syntax: TRGCA
TRGCA=[DC], [AC], [ACLP], [DCLP], [TVL] or [TVF]

Explanation: On the 1600 there are six different types of trigger coupling:

Value	Meaning
DC	Direct Coupling
AC	AC coupling
ACLP	AC low pass
DCLP	DC low pass
TVL	TV line
TVF	TV frame

Examples: TRGCA=TVF

TRGCA
'TRGCA=ACLP' (1600 response)

See also: TBAND, TLA, TS, TSL, Section 1.4

Function: Trigger mode

Type: Assertive, Interrogative

Syntax: TRGMDA
TRGMDA=[A], [ADIVN], [ADELN]

Explanation: On the 1600 there are three different trigger modes. These represent different ways in which the trigger signals can be processed before they initiate a capture. The options are given below:

Value	Meaning
A	Normal triggering or delay by time
ADIVN	Triggers divided by events
ADELN	Triggers delayed by events

A detailed explanation of the action of these trigger modes can be found in Section 2.5

Examples: TRGMDA=ADIVN

TRGMDA
'TRGMDA=ADELN' (1600 response)

See also: TDELA, TEVNT, Sections 1.4, 2.5

Function: Display Trace Transfer

Type: Assertive, Interrogative

Syntax: TRC*A
TRC1A
TRC2A
TRC3A
TRC4A

TRC1A=data field
TRC2A=data field
TRC3A=data field
TRC4A=data field

Explanation: The display trace stores can be transferred to and from the host computer. Each store consists of 1024 data samples, the first being for the left-hand edge of the screen and each successive one for one position further right each time.

The format of the data field is dependent on the specified block length. If BLL=0 then this will consist of 1024 numbers in the specified numeric base followed by ‹cr› ‹lf› with EOI on the last ‹lf›. If BLL is non-zero then the data field will consist of a number of blocks each separated by ‹cr› ‹lf› with EOI on the last ‹lf›, if asserted.

TRC*A can only be used interrogatively. It is equivalent to issuing the commands TRC1A, TRC2A, TRC3A, and TRC4A respectively. The instrument responds with the data from each trace.

Example: TRC*A
'TRC1A=3,20,2,1,0,....,34;
TRC2A=3,50,1,2,....,45,6;
TRC3A=3,12,.....,5,12;
TRC4A=3,28,.....,7,11 ‹cr›‹lf›'
(1604 response)

See also: EOI, BL, BLL, NB, WIND

Function: Horizontal Trace Scaling

Type: Assertive, Interrogative

Syntax: TRHS1A
TRHS2A
TRHS3A
TRHS4A
TRHS*A
TRHS*A=number
TRHS1A=number
TRHS2A=number
TRHS3A=number
TRHS4A=number

Explanation: When a display trace is stored the horizontal scaling (timebase) is also stored. This value can be changed or interrogated with this command. The range is 50μs per division to 200s per division in 1, 2, 5 steps. TRHS*A interrogates the scaling of all four timebase traces.

Examples: TRHS1A=200E-3

TRHS2B
'TRHS2B=5E-9' (1600 response)

Note: *When the scaling has been changed the results of any cursor calculation will be based on the new value.*

See also: HSA, Section 1.3

Function: Reference Trace Horizontal Scaling

Type: Assertive, Interrogative

Syntax: TRHSR1
TRHSR2
TRHSR*
TRHSR*=number
TRHSR1=number
TRHSR2=number

Explanation: When a reference trace is stored the horizontal scaling (timebase) is also stored. This value can be changed or interrogated with this command. The range is 50μs per division to 200s per division in 1, 2, 5 steps. TRHSR* interrogates both reference traces.

Examples: TRHSR1=50E-6

TRHSR1
'TRHSR1=5E-6' (1600 response)

Function: Vertical Trace Scaling

Type: Assertive, Interrogative

Syntax: TRVS1A
TRVS2A
TRVS3A
TRVS4A
TRVS*A
TRVS*=[-][›]number[~][ ]
TRVS1A=[-][›]number[~][ ]
TRVS2A=[-][›]number[~][ ]
TRVS3A=[-][›]number[~][ ]
TRVS4A=[-][›]number[~][ ]

Explanation: When a display trace is stored the vertical scaling is also stored. This value can be changed or interrogated with this command. The range is 2mV per division to 10V per division in 1, 2, 5 steps. In addition to the scaling there are four other pieces of information that may be specified:

- `-` Trace invert
- `›` Uncalibrated
- `~` AC coupled
- Ground

Examples: TRVS1A=5

TRVS2A
'TRVS2A=2E-3' (1600 response)

-0.5~ means the trace is AC coupled and invert is on.
›10 means the trace is uncalibrated and the sensitivity is greater than 10V per division.

Note: *When the scaling has been changed the results of any cursor calculation will be based on the new value.*

See also: VS*, Section 1.2

Function: Reference Trace Vertical Scaling

Type: Assertive, Interrogative

Syntax:
TRVSR1
TRVSR2
TRVSR*
TRVSR*=[-][›]number[~]
TRVSR1=[-][›]number[~]
TRVSR2=[-][›]number[~]

Explanation: When a reference trace is stored the vertical scaling is also stored. This value can be changed or interrogated with this command. The range is 2mV to 10V per division in 1, 2, 5 steps. In addition to the scaling there are four other pieces of information that may be specified:

- `-` Trace invert
- `›` Uncalibrated
- `~` AC coupled
  Ground

Examples: TRVSR1=5

TRVSR1
'TRVSR1=2E-3' (1600 response)

-0.5~ means the trace is AC coupled and invert is on.
›10 means the trace is uncalibrated and the sensitivity is greater than 10V per division.

Note: *When the scaling has been changed the results of any cursor calculation will be based on the new value.*

Function: Trigger Source

Type: Assertive, Interrogative

Syntax:
TSA
TSA=[CH1], [CH2], [CH3], [CH4], [EXTA] or [LINE]

Explanation: On the 1604 there are six different sources for the trigger channels,: the four input channels, the external input and LINE.

Examples: TSA=EXTA

TSA
'TSA=LINE' (1600 response)

See also: TB, TLA, TRGCA, TSL, Section 1.4

Function: Trigger Slope

Type: Assertive, Interrogative

Syntax:
TSLA
TSLA=[MINUS], [PLUS] or [BAND]

Explanation: The trigger slope determines whether the trigger points are generated on the rising (PLUS) edge, the falling (MINUS) edge or either (BAND) edge of the trigger source.

Examples: TSLA=MINUS

TSLA
'TSLA=PLUS' (1600 response)

See also: TB, TLA, TRGCA, TSA, Section 1.4

Function: On Screen Text

Type: Assertive, Interrogative

Syntax:
TXT*
TXTnumber
TXTnumber="string"

Explanation: The 1600 has 16 lines of 32 characters on the screen. Line 0 is the top of the screen and line 15 the bottom. In addition, it is possible to use inverse video characters. These appear on lines 16 to 31 which are overlayed with lines 0 to 15. Line 16 places inverse characters in the same screen position as line 0 text and line 31 places them in the same position as line 15 text. TXT* is interrogative only and returns all the text presently on the screen. TXTnumber returns the text on line 'number' only. In its interrogative form the string returned always consists of 32 characters. When asserted the string may have any number of characters up to and including 32.

Examples: TXT1="Gould 1604"

TXT4
'TXT4="TEST NUMBER 8"

Note: *If the screen text line is empty then a string of 32 spaces will be transmitted.*

Function: Vertical Coupling

Type: Assertive, Interrogative

Syntax:
VC1
VC2
VC3
VC4
VC*
VC1=[AC], [DC] or [GND]
VC2=[AC], [DC] or [GND]
VC3=[AC], [DC] or [GND]
VC4=[AC], [DC] or [GND]
VC*=[AC], [DC] or [GND]

Explanation: This command allows the input coupling of the four input channels to be interrogated or changed. VC1 controls Channel 1, VC2 controls Channel 2, etc. VC* allows all channels to be interrogated or changed together.

Examples: VC2=AC

VC*
'VC1=GND ‹cr› ‹lf›
VC2=DC ‹cr› ‹lf›
VC3=±AC ‹cr› ‹lf›
VC4=AC' (1600 response)

See also: VP*, VS*, Section 1.2

Function: Vertical Position

Type: Assertive, Interrogative

Syntax:
VP1
VP2
VP3
VP4
VP*
VP1=number
VP2=number
VP3=number
VP4=number
VP*=number

Explanation: The vertical position of traces on the instrument can be controlled in two ways: pre-storage shift and post-storage shift. This command controls pre-storage shift. The input range is ± 16 screen divisions, where zero is nominally the centre of the screen.

VP* sets or returns the values of the shift for all four input channels.

Examples:
VP1=7.65
VP2
'VP2=-4.67' (1600 response)

See also: VPS, Section 1.2

Function: Post Storage Shift

Type:

Syntax:
VPS1A
VPS2A
VPS3A
VPS4A
VPS*A
VPS1A=number
VPS2A=number
VPS3A=number
VPS4A=number

Explanation: The vertical position of traces on the instrument can be controlled in two ways: pre-storage shift and post-storage shift. This command controls post-storage shift; see VP* for pre-storage shift. The input range is ±8.9 screen divisions, where zero is nominally the centre of the screen.

VPS* returns the values of the shift for all four traces, its action being the same as issuing the four commands VPS1A, VPS2A, VPS3A and VPS4A.

Examples:
VPS2A=-3.8
VPS1A
'VPS1A=4.2' (1600 response)

See also: VP, Section 1.2

Function: Reference Trace Post Storage Shift

Type: Assertive, Interrogative

Syntax:
VPSR1
VPSR2
VPSR*
VPSR1=number
VPSR2=number

Explanation: The vertical position of the reference traces can be controlled by this command. The input range is ±8.9 screen divisions, where zero is nominally the centre of the screen. VPSR* returns the values of the shift for both reference traces, its action being the same as issuing the two commands VPSR1 and VPSR2.

Examples:
VPSR1=-3.8
VPSR1
'VPSR1=2.8' (1600 response)

Function: Vertical Scaling

Type: Assertive, Interrogative

Syntax:
VS1
VS2
VS3
VS4
VS*
VS1=[-][›]number[~][ ]
VS2=[-][›]number[~][ ]
VS3=[-][›]number[~][ ]
VS4=[-][›]number[~][ ]
VS*=[-][›]number[~][ ]

Explanation: This command allows the attenuator settings of the input channels to be interrogated or set. The range of inputs is 2mV per division to 10V per division in 1, 2, 5 steps. In addition to the attenuator settings there are three other pieces of information that may be specified:

- `-` Trace invert
- `›` Uncalibrated
- `~` AC coupled
- ` ` Ground

Examples:
VS1=5
VS2
'VS2=2E-3' (1600 response)

-0.5~ means the trace is AC coupled and invert is on.
›5 means the trace is un-calibrated and the sensitivity is greater than 5V per division.

See also: TRVS*, Section 1.2

Function: **Trace Window**

Type: Assertive, Interrogative

Syntax: WIND
WIND=number1, number2

Explanation: This command is used in conjunction with the block transfer commands. It specifies a window on the trace that will be transmitted next time a block transfer is requested. The range for number1 is 0 to 10240 and for number2 is 1 to 10239; number2 must always be greater than number1. Only data samples between the two numbers will be transferred, inclusive.

Examples: WIND=1,58

WIND
'WIND=0,1023' (1600 response)

Note: *The REFT* and TRC* block transfer commands apply to the 1024 byte stores and consequently an error will be returned if these commands are issued without previously selecting a trace window of less than 1024. (Default window is 0,1023.)*

See also: REFT*, TRC*, STR*

3.2 RS423 Input/Output Interface

The RS423 commands are identical to the GPIB commands given in alphabetical order in Section 3.1.

When interfaced to a computer, RS423 operates in the same way the GPIB bus. Apart from the introductory paragraphs, Section 3.1 on GPIB is equally applicable to RS423. Differences between the two systems are noted in the GPIB text.

RS423

RS423 is an upgrade from RS232. Provided cabling and handshaking are correctly set then there should be no problems interfacing the 1604 RS423 to any RS232 or RS423 equipment.

Interface 1 is the RS423 interface to an HPGL plotter (talk only). Interface 2 is the interface to control the instrument (bidirectional).

One major problem encountered in using RS423/RS232 is that of the direction of the data and handshake lines.

The instrument is fitted with the interface in the following configuration:

Table 3.2.1 The RS423 connector

Interface 1			Interface 2
Pin No.	**Name**	**Description**	**Pin No.**
1	0VL	0V Logic	1
2	TX	Transmit Data	3
3	RX	Receive Data	2
4	RTS	Request To Send	4
5	CTS	Clear To Send	5
6	DSR	Data Set Ready	6
7	0VL	0V Logic	7
8	DCD	Data Carrier Detect	8
9	True	RS423 Logic True	9
14	True	RS423 Logic True	14
20	DTR	Data Terminal Ready	20

The I/O Interface Menu

The instrument is supplied with the following set-up: 9600 baud, eight bits, no parity and two stop bits. Once changed through the menu system the new setting will be the power-on default set-up.

The I/O Interfaces menu allows the user to set a number of standard parameters for the GPIB and RS423 interfaces:

GPIB Address This is discussed in Section 3.1.

All the other options on this menu are for the RS423 interface:

Speed With this option the user can set the I/O baud rate to one of 50, 110, 300, 600, 1200, 2400, 4800, or 9600 baud, using successive presses of the number 3 button. The presently selected choice is indicated by the inverse video characters.

Handshake There are three forms of handshaking available: none at all (i.e. 'Off'), 'XON-XOFF' giving software handshaking and the hardware handshake 'CTS-RTS'. If 'CTS-RTS' is selected see also Section 1.7. The choices are made by successive presses of the number 4 button, with the present selection being indicated by the inverse video characters.

Echo & Prompt All characters sent to the oscilloscope will be echoed back to the transmitting device should the user choose 'On'. When the 'scope is ready to receive the next command it will issue a prompt. If the selection is 'Off' pressing button 5 will switch it on, a further press will switch it off again.

Parity There are three choices: 'SPACE' i.e. no parity, 'EVEN' or 'ODD'. The selections are made by repeated pressings of the number 6 button, the present choice being indicated by the inverse video characters.

RS423 Syntax

The RS423 commands are identical to the GPIB commands given in alphabetical order in Section 3.1.

3.3 WAVEFORM PROCESSOR TYPE 160 (Option)

OPERATION

General

The Waveform Processor 160 is for use with the Gould 1600 to capture and manipulate waveforms.

Connection

Disconnect the 1600 from the AC supply.

Connect the 160 Waveform Processor interface to the rear panel connector, tighten the thumbscrew until the interface is securely fixed to the rear panel.

The 160 Waveform Processor is connected to the interface.

To check, switch on and the on-screen alpha numerics will display the message "Version X.xx + Keypad X.xx". This ensures that the 160 Waveform Processor is connected correctly to the 1600. This message may be cleared by operating any front panel control.

Check the waveform processor is operating by selecting the cursors pressing the 'Select Trace' button. The cursor and datum will be at the extreme left of the display and the reading will be CH1 x.xmV 0.00ms; the units are dependant on the input ranges selected.

F(function)
Blue 2nd level key is used to select the corresponding coded functions.

Initialize
Initializes the Waveform Processor Functions. Resets averaging and filtering to zero, cancels TV mode triggering, clears any limits traces, and resets cursor to voltage and time.
NOTE:– It is advisable to press initialize prior to switching off the 1600, because the 1600 will store any 160 functions in non-volatile memory even if you remove the keypad.

Time and Voltage Measurements

The 1600 has three on-screen lines for measurements:-

1. CURSOR. This is a short line which can only be moved horizontally to follow the trace. The display gives voltages measured with respect to the voltage datum and the time measured with respect to the time datum.

2. VOLTAGE DATUM. This is a horizontal dashed line, which can be moved over the height of the screen. Cursor voltages are measured with respect to this datum.

3. TIME DATUM. This is a vertical dashed line, which can be moved over the width of the screen. Cursor times are measured with respect to this datum.

Select Trace
Operation of this button turns on the cursor and datum.
Subsequent key presses step though the displayed traces and the off position.
Waveforms to be measured,or processed are identified by the measuring cursor.

Datum
After pressing 'Datum' the four arrow keys control the position of the voltage and time datums.
A second operation, while the Alpha-numerics call for it, will set the datum point to the cursor on the trace.

Cursor
Operating the 'cursor' controls enables the cursor to be positioned on the trace to make a measurement. The cursor can be moved in X and will follow the trace in Y.

Acquisition Functions

The following functions affect what traces will be captured by the 1600.

Capture
Pressing the "Capture" key will arm the 1600 to complete a capture after the next received trigger. Holding down the key will continually re-arm the 1600 up-dating the display at each trigger.
If averaging is selected pressing capture will result in the set number of traces being captured and averaged. For example if averaging of 8 traces is

selected then pressing 'Capture' will cause 8 traces to be acquired and the running average will be displayed.

Capture & Repeat

Pressing the "Capture and Repeat" Key, will arm the 1600 to complete a capture after the next received trigger and then action the last selected post-storage function.

NOTE:– To enter a function it is advisable to press "Initialize" to reset the waveform processor prior to selecting the required post-storage function. When using Capture and Repeat a measurement function will follow a post storage function (e.g. Filter, Integration).

TV Mode

Pressing the 'TV Mode' will set up the 1600 trigger system to acquire TV lines from the TV standard selected in the TV and Special functions menu. 'TV line' may then be used to select the required line. Pressing 'Initialize' will return the trigger system to the settings prior to 'TV Mode' being pressed.

TV Line

Enables the current TV line to be changed by using the INC (Increment) or DEC (Decrement) push buttons. The Inc,Dec, controls have three speeds of operation: single step, first step slow, fully depressed fast.

Limits Testing:

This function enables the user to compare an incoming waveform with a pre-defined testband.

The testband consists of an upper and a lower limit which are displayed as an alternating sequence of data points. During testing the testband is displayed on the Reference 1 trace.

The testband can be derived from an incoming signal or a reference store loaded via IEEE. The trace can be positioned, using the 'Position' control on the 160, and used to define the upper or lower limit by pressing either the 'Save Upper Limit' or 'Save Lower Limit' buttons.

The limits will be held in the 160 until either the 1604 is switched off or another trace is placed in the reference 1 trace.

When both limits are set, the testband is shown as a bright band on the trace.

NOTE:– It is advisable to use the "Position" control on the 160 keypad to reposition the trace rather than the individual channel "Position" control on the 1604. This is because the channel "Position" control acts on pre-storage and post-storage values.

When both limits are set then press "Test Limit". The screen will momentarily display the message 'PRESS AGAIN TO HALT ON FAIL'.

If the 'Test Limit' key is pressed again, the 1600 will capture waveforms until the signal deviates outside the testband when it will stop.

If AUTOPLOT has been selected on the 1604, the captured trace will be plotted and then the 1604 will continue testing.

If a key is not pressed, the 1600 will continuously test the selected trace and display the message "LIMITS TEST: PASS". If the signal leaves the testband it will display the message "LIMITS TEST: FAIL", but it will not stop testing traces.

NOTE: In both cases the testband is defined as that section of the trace between the time datum and cursor.

Set Average

Pressing the 'Set Average' will initially display the current averaging factor selected; repeated presses will step through the available selection of averaging factors and display this number on the screen. The selections available are: no averaging, 4, 8, 16, 32, 64, 128, 256, 512 and 1024, returning to the beginning. In continuous capture the average will be running with the weighting factor selected. If a single capture is selected from the waveform processor, the number of triggered acquisitions is dependant on the number of averages selected.

'Capture' initiates the averaging process, and it will be continuous or single shot depending on whether single shot or continuous is set on the front panel.

Post-storage Functions

The following functions will only operate once a trace has been captured or is held. For automatic operation use 'Capture and Repeat'. The trace on which the function is to be performed is selected using the cursor on the waveform processor using the 'Select Trace' button.

Y Mag

Selecting Y Mag allocates the Inc (increment) and Dec (Decrement) Buttons to magnify or reduce the waveform identified by the cursor. The range is from x4.0 to x0.062. The magnification value is indicated using the alpha-numeric display on the 1600 for a limited time after selection. After magnification is applied all voltage measurements on the magnified trace will be displayed in divisions.

Inc

Increment button will increase one step of magnification or TV line for a single push. The button has two positions and if held in the first, the increments will be applied slowly; with the button pushed fully down the increments will be fast.

Dec

Decrement button will decrease one step of magnification or TV line for a single push. The button has two positions, the first step will decrement slowly, with the button pushed fully down the decrements will be fast.

Filter

Operating the filter button for the first time will select filtering. Subsequent presses will step the filter through the 6 stages, returning to the 'no filtering' position. There are 6 stages of filter for each timebase range.

The filter is a single pole low pass filter, where the alpha numeric display indicates the 3dB point.

$$\text{Cut-off frequency} = \frac{15.92}{T} \ln\left(1 + \frac{1}{2^n}\right)$$

T = timebase in secs.
n = filter step

Position

The trace identified by the cursor can be moved in X and Y using the position controls. The trace, when moved in X, will roll round, disappearing at one end and reappearing at the other.

Integration

Pressing this button will calculate and display the integrated waveform of the controlled trace.

The voltage datum is taken as zero for integration. The cursor reads out the value in Vs (Volts - seconds or similar units).

Restore

Restore cancels the last post storage function. The previous trace is re-displayed.

Waveform Measurements

For all the following functions the 160 will continuously calculate the results until either another waveform measurement is selected or 'Initialize' is pressed. The measurements are made on the trace selected by the cursor, between the time datum and the cursor. If the cursors are not displayed then measurements will be made on the last trace selected across the entire trace, and the voltage datum is assumed to be at the center of the screen.

Rise/Fall

The point where the cursor and time datum cross the trace set the 0 and 100% points. The 160 calculates the rise/fall time between the 10 and 90% points.

O/Shoot

The point where the cursor and time datum cross the trace sets the 0 and 100% points. The 160 calculates the overshoot as a percentage of the voltage difference between the 0 and 100% points.

Pulse Width

The 160 measures the time between the 50% points of the pulse. The time datum and cursor need to be either side of the pulse to be measured. Positive or negative pulses can be measured in this way.

If the leading edge of the pulse is noisy, the 1600 could read the value of the noise pulse.

Frequency

The 1600 will display three results:
Frequency, Period and Duty Cycle.
The voltage datum sets the zero crossing voltage. If this datum is outside the waveform, the 160 calculates the mean of the trace between the time datum and the cursor and uses this as the zero level. If the cursor is not displayed, the 160 will calculate the result for the entire waveform taking the center of the screen as the voltage datum.

Cursor and time datum must enclose at least three zero crossings (One complete cycle) or a warning 'Trace invalid' will be displayed.

Period

Inverse of the frequency as above.

Duty Cycle

Ratio of mark to whole pulse period expressed as a percentage.

Max/Min

The cursor and time datum set the part of the trace to be measured. The display reads the maximum positive point and minimum negative point of the waveform. Voltages are measured with respect to voltage datum. If no cursors are displayed it will calculate the Max/Min point of the entire trace with respect to the center of the screen.

Pk/Pk

The cursor and time datum set the part of the trace to be measured. The display reads the voltage difference between the most positive and negative points.

RMS

The display reads two values:
RMS – This is the RMS voltage with respect to the voltage datum.
AC – This is the RMS voltage with respect to the mean of the trace.
If no cursors are displayed, it will calculate the RMS voltage of the entire trace. The RMS voltage will be with respect to the center of the screen.

Area

Calculates the area under the curve bounded by the trace, cursor, voltage datum and time datum. If no cursors are displayed, the area will be that bounded by the left and right of the screen and the center of the screen.

160 assumes that if the trace goes below the horizontal datum, as in the example shown in Fig. 1, the area is negative.

Area B is added algebraically to Area A and the result displayed.

If Area B is greater than Area A the result is a negative area. The result is in Vs (Volt-seconds) or similar units.

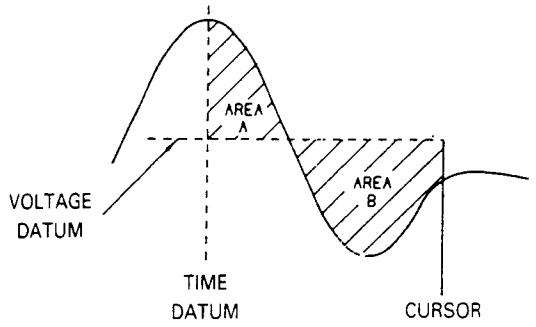


Fig. 1. Definition of Area under curve

```
SAVE CH2 TO MEMORY 01  . . . . 1
(Trace selected by cursor)
RECALL MEMORY 01 TO REF 1  . . 2

RECALL MEMORY 01 TO REF 2  . . 3

                  50 <UNUSED>   ▲
SELECTED MEMORY: 01 06/04/64
                  02 09/22/63   ▼

AUTO CAPTURE & SAVE: OFF On  . 6

MEMORY SIZE:  50x1K 5x10k  . . 7

CLEAR MEMORY 01  . . . . . . . 8
    <<REFERENCE WAVEFORMS>>
```

Fig. 2. Option Menu

Option Functions Menu

This menu allows the user to access the reference memories in the WP option pod.

Save Trace to Memory

To save the currently selected trace to the reference memory shown press button 1. The word "saving" will appear briefly on the menu screen. Upon completion the selected memory display line will increment, as will all other reference memory indicators on the menu.

Recall Memory to Ref 1

To recall a previously stored reference memory to reference trace 1 press button 2. The word "recalling" will appear briefly on the menu screen. Upon completion the selected memory display line will increment, as will all other reference memory indicators on the menu.

When recalling a 10K reference memory, the current settings of X mag and X shift are taken into account before transferring the data to the display.

Recall Memory to Ref 2

To recall a previously stored reference memory to reference trace 2 press button 3. The word "recalling" will appear briefly on the menu screen. Upon completion the selected memory display line will increment, as will all other reference memory indicators on the menu.

When recalling a 10K reference memory, the current settings of X mag and X shift are taken into account before transferring the data to the display.

Selected Memory

This display line shows the current selected reference memory that will be used by all other functions on the menu screen. The next available selections are also shown above and below the current line. The selected memory can be altered by moving in either direction by pressing button 4 to decrement or button 5 to increment.

Auto Capture & Save

Pressing button 6 will toggle this menu function to ON. The current state is shown in reverse video flashing. When ON, the function is started by a second press of button 6 while the message "PRESS AGAIN TO START" is displayed. This causes the following sequence of events to occur, starting at the currently selected reference memory number:

a) Instrument armed.
b) Wait till stored.
c) Transfer selected trace to current reference memory.
d) Increment the selected memory number.

The above sequence is repeated until the upper limit of the available reference memories is used (i.e. 5 or 50). The function is cancelled by operating a menu selection.

Memory Size

This allows the user to swap between the two types of memory configuration either 50 x 1K or 5 x 10K.

Pressing button 7 will briefly display the message "PRESS AGAIN", if button 7 is pressed again the configuration will change from current to alternative selection. The repeated push for operation is a safeguard against accidental usage.

Clear Memory

This allows the user to clear the currently selected memory. Pressing button 8 will briefly display the message "PRESS AGAIN", if button 8 is pressed again the currently selected memory will be cleared and the date stamp on the selected memory display line will show "‹UNUSED›". The selected memory number will not update. The repeated push for operation is a safeguard against accidental operation.

GPIB/RS423 CONTROL

The type 160 Waveform Processor adds a range of additional commands to the GPIB/RS423 command set of the 1604 and 1602.

GPIB/RS423 COMMAND SUMMARY

Command	Parameter	Function	Type
ACRMS		RMS value about mean of waveform	I
AREA		Area under trace	I
DUTY		Duty cycle about voltage datum	I
FILTER	1,2,3,4,5,6	Filter trace with one of 6 filters	D
FREQ		Frequency about voltage datum	I
HELLOWP		Waveform processor hello message	I
HPS	number	Horizontal post storage shift	A,I
INIT		Initialize keypad	D
INTG		Integrate about voltage datum	D
INVPS		Invert trace after storage	D
LIM	CONT HALT OFF	Test limits	A,I
LIMST	PASS FAIL	Limit status	I
LOWLIM		Save lower limit	D
MAX		Maximum measured from datum	I
MEAN		Average voltage of trace	I
MIN		Minimum measured from datum	I
OVER		Overshoot	I
PEAK		Peak to Peak value	I
PERIOD		Period at datum level	I
REFM		Reference Memory transfer	A,I
REFT		Reference Trace transfer	A,I
RISE		Rise time at 10%, 90% points	I
RMHS		Reference memory horizontal scaling	A,I
RMVS		Reference memory vertical scaling	A,I
RMS		RMS value measured from datum	I
RMTYPE		Reference memory type	A,I
RESTORE		Recover from last function	D
(VPS)		Vertical position post storage (see 4070 operating manual)	
TVLINE	number	TV line number	A,I
TVSTD	PAL NTSC SECAM	TV standard	A,I
TVMODE	ON OFF	TV mode triggering	A,I
UPLIM		Save upper limit	D
WIDTH		Pulse width at 50% points	I
YCAL	CAL UNCAL	Vertical calibration	A,I
YMAG	number	Post storage Y magnification	A,I
YSCALE	number	Vertical scaling factor	I

General

Key to the command summary:
A Assertive
I Interrogative
D Direct action assertive

The IEEE/RS423 commands are designed to allow access to the functions of the 160 waveform processor, they operate in the same way as pressing the buttons on the keypad. All the measurement functions which return a value (ie. those which are interrogative only) work on data bracketed between the time datum and the cursor. The cursor must be selected for the trace on which the measurements are being made (see the CSRTR command in the main operating manual). If the cursors are switched off then measurements will be made on the last selected trace between the first and last data point taking the center of the screen as the voltage datum. With the exception of rise and fall measurements, it does not matter which way round the cursor and time datum are positioned for selecting the measurement window.

Note that if the selection fails, for example in the case of the DUTY command if no zero crossings are found, then the function will return a value of −1, as well as generating a service request of 100.

The convention used in this manual is the voltage datum is displayed as a horizontal line on the screen and is the reference for voltage measurements, and the time datum is displayed as a vertical line on the screen and is the reference for time measurements.

If required, the measurements of duty cycle, frequency, and period can be made about the center of the trace. This is done by first using either the MEAN or MAX/MIN functions to determine the centerpoint, and then setting the voltage datum to this level. For example to measure the frequency of trace 1A:

CSRTR=1A	Select trace 1A
DATMH=0	set datum to left of screen
CRSHP=10	set cursor to right of screen
MEAN	request mean of trace 1A
input mean value	
DATMV=mean value	set datum to center of trace
FREQ	request frequency of trace 1A
input result	

Function: RMS value about mean of waveform

Type: Interrogative

Syntax: ACRMS

Explanation: The RMS value of the selected waveform between the time datum and cursor is measured by first calculating the mean of the waveform. The difference between this level and the waveform for each point, is then squared and the average of these values is then square rooted and returned.

Example: ACRMS
'ACRMS=2.34' (1600 response) (RMS voltage is 2.34 Volts)

Note: If the peak value of the trace between the time datum and cursor lies outside the range of the A/D converter, ie., if it is off screen, the routine will return a service request 103 as well as a result using the maximum allowable value.

See also: RMS

Function Area under trace

Type Interrogative

Syntax AREA

Explanation: The area under the selected waveform between the time datum and cursor by summing the voltage differences between the trace and the voltage datum. The result is then rescaled into units of Volts Seconds.

Example AREA
'AREA=2.34E-6' (1600 response) (RMS voltage is 2.34μVs)

Note: If the peak value of the trace between the time datum and cursor lies outside the range of the A/D converter, ie., if it is off screen, the routine will return a service request 103 as well as a result of zero.

See also INTG

Function: Duty cycle about voltage datum

Type: Interrogative

Syntax: DUTY

Explanation: The duty cycle of a waveform is the ratio of the time the waveform is positive to the period of the waveform. This function notes the positions where the waveform crosses the voltage datum and so calculates the duty cycle as a percentage of the period.

Examples: DUTY
'DUTY=39.1' (1600 response) (Duty cycle is 39.1%)

Note: If no cross over points are found then service request 100 will be generated and the value −1 will be returned.

See also: PERIOD

Function: Filter waveform

Type: Direct

Syntax: FILTER=[1] or [2] or [3] or [4] or [5] or [6]

Explanation: The selected waveform is filtered by one of six digital low pass filters. The effective cutoff frequency of each filter is determined by the timebase setting.

Example: FILTER=3

Note: When the filtering operation is completed a service request 74 will be generated. A copy of the data is taken so the RESTORE command will recover the original waveform. If the trace is not stored or held a service request 100 will be generated and no action will be taken.

Function: Frequency about voltage datum

Type: Interrogative

Syntax: FREQ

Explanation: The frequency of the selected waveform between the time datum and cursor is measured by looking for points at which the waveform crosses the voltage datum, from these points the period and hence the frequency of the waveform is calculated.

Example: FREQ
'FREQ=15.1E+3' (1600 response (Frequency is 15.1 kHz)

Note: If no cross-over points are found then service request 100 will be generated and the value −1 will be returned.

See also: PERIOD

Function: Waveform processor hello message

Type: Interrogative

Syntax: HELLOWP

Explanation: This command is used to check the keypad version.

Example: HELLOWP
'HELLOWP=WP160version 1.21' (1600 response)

See also: HELLO in the 1600 operating manual

Function: Horizontal post storage shift

Type: Assertive, Interrogative

Syntax: HPS
HPS=number

Explanation: After data has been stored or is held, an individual trace can be moved horizontally. This is done by rotating the data through the store, so there will be a discontinuity at the point where the first and last acquisition are placed next to one another. The number in the command is the shift in divisions relative to its

initial position, and so it can lie in the range +10.23 to −10.23. Positive numbers indicate a shift to the right, and negative numbers a move to the left. The value read back when the command is used interrogatively is the total shift from the captured position, and so the trace can be restored to its original position by applying equal and opposite shift.

Example: HPS=2.3

HPS
'HPS=−3.9' (1600 response)
(Currently selected trace is shifted 3.9 divs to the left)

Note: Since the position before the shift is remembered the RESTORE command will reset the trace to its previous position, ie. HPS=0. If the shift required is outside the allowable range a service request 103 will be generated. When the shifting is completed a service request 74 will be generated.

See also: VPS,SHFT in the 1600 operating manual

Function: Initialise keypad

Type: Direct

Syntax: INIT

Explanation: This command is equivalent to pressing the Initialize button on the keypad, and it resets the internal variables to their default settings.

Example: INIT

Note: When the initialisation is complete a service request 74 will be generated.

Function: Integrate trace

Type: Direct

Syntax: INTG

Explanation: The selected trace is integrated with respect to time, the voltage zero is taken to be the voltage datum. The result is automatically scaled and the scaling factor is retained so that the cursors read correctly. This factor can be read out using the YSCALE command.

Example: INTG

Note: When the integration is completed a service request 74 will be generated. A copy of the data is taken so the RESTORE command will recover the previous trace. If the trace is not stored or held a service request 100 will be generated and no action will be taken.

See also: YSCALE

Function: Invert trace post storage

Type: Direct

Syntax: INVPS

Explanation: This command inverts the trace about the voltage datum and is equivalent to pressing the invert button on the keypad. A record of the original trace is taken and so the RESTORE command will recover the last action of this function. The sign of YSCALE is changed to record the fact that the trace has been inverted.

Example: INVPS

Note: When the invert is complete a service request 74 will be generated. If the trace is not stored or held a service request 100 will be generated and no action will be taken.

Function: Limit test mode

Type: Assertive, Interrogative

Syntax: LIM
LIM= [OFF] or [CONT] or [HALT]

Explanation: The limit testing works by comparing the trace in one channel with reference trace 1.

The referencec trace memory 1 holds both the upper and lower limits by using alternate sample points. For example if the test waveform in trace 1A must lie between a data value of 50 and 110, then reference trace 1 should contain the data:

50,110,50,110,50,110 . . . .

The limit waveform can be transferred to and from the computer (see the sending and receiving stores section of the 1604 operating manual). If required, the upper and lower limits can be set from the corresponding sweep (see LOWLIM and UPLIM).

The channel to be tested is selected using the cursors. The section of the waveform on which the limit test is performed is defined by the time datum and cursor.

The LIM command is used to select the operating mode for limits testing. There are two possible modes:

Continuous: Data is continuously acquired and tested The result is displayed or read out as PASS or FAIL

Halt: Data is acquired and tested
When the test is failed acquisition stops

The result of the test can be read out using the LIMST command.

Example: LIM=CONT
LIM=OFF

LIM
'LIM=HALT' (1600 response)
(Acquisition will stop if selected trace falls outside limit)

See also: LIMST,LOWLIM,UPLIM

Function: Limit test status

Type: Interrogative

Syntax: LIMST

Explanation: This command is used to read the result of the limit test. The response will be PASS if the trace under test is within the limits defined by the limit waveform and the time datum and cursor, and it will be FAIL if any data point lies outside these limits. If the limit test mode is HALT the response will be PASS until a trace has failed and been stored, when the response will be FAIL.

Example: LIMST
'LIMST=PASS' (1600 response)
(trace is within limit)

Note: If no limits testing has been selected using the LIM command a service request 100 will be generated.

See also: LIM,LOWLIM,UPLIM

Function: Save lower limit

Type: Direct

Syntax: LOWLIM

Explanation: This command is equivalent to pressing the Save Lower Limit button on the keypad and is used to set up the lower limit for limits testing. This is held in reference trace 1. LOWLIM will save the selected trace in the correct form for limits testing.

Example: LOWLIM

Note: When the transfer is complete a service request 74 will be generated.

See also: UPLIM,LIM,LIMST,HMOD

Function: Maximum measured from datum

Type: Interrogative

Syntax: MAX

Explanation: This command returns the maximum value of the trace in volts measured from the voltage datum. If the section of the waveform selected by the time datum and cursor is below the voltage datum then the result will be negative.

Example: MAX
'MAX=54E−2' (1600 response)
(Maximum value is 54 mVolts)

Note: If the peak value of the trace between the time datum and cursor lies outside the range of the A/D converter, ie., if it is off screen, the routine will return a service request 103 as well as a result using the maximum allowable value.

See also: MIN

Function: Mean of trace

Type: Interrogative

Syntax: MEAN

Explanation: This command returns the mean value of the trace between the time datum and cursor in divisions. It can be used to find the center of an ac waveform prior to measuring duty cycle, period or frequency.

Example: MEAN
'MEAN=2.4' (1600 response)
(Mean value is 2.4 divisions)

Note: If the peak value of the trace between the time datum and cursor lies outside the range of the A/D converter, ie., if it is off screen, the routine will return a service request 103 as well as a result using the maximum allowable value.

See also: MAX

Function: Minimum relative to datum

Type: Interrogative

Syntax: MIN

Explanation: This command returns the minimum value of the waveform in volts measured from the voltage datum. If the section of the waveform selected by the time datum and cursor is above the voltage datum then the result will be negative.

Example: MIN
'MIN=55.4E−3' (1600 response)
(Maximum value is 55.4mVolts)

Note: If the peak value of the trace between the time datum and cursor lies outside the range of the A/D converter, ie., if it is off screen, the routine will return a service request 103 as well as a result using the maximum allowable value.

See also: MAX

Function: Overshoot

Type: Interrogative

Syntax: OVER

Explanation: The overshoot of an edge is measured between the time datum and the cursor. The 100% and 0% points are taken as the points where the time datum and the cursor cross the waveform. The overshoot is the ratio of the maximum point between the time datum and cursor and the voltage difference between the time datum and cursor expressed as a percentage.

There are a number of different possible measurements which can be made, depending on the relative positions of the time datum and cursor:

Condition	Measurement
1: Rising edge, datum to left of cursor	Overshoot
2: Falling edge, datum to left of cursor	Undershoot

Example: OVER
'OVER=21.9' (1600 response)
(Overshoot is 21.9%)

Note: If the peak value of the waveform between the time datum and cursor lies outside the range of the A/D converter, ie., if it is off screen, the routine will return a service request 103 and return a result of 100%.

See also: RISE,MAX,MIN,PEAK

Function: Period at voltage datum

Type: Interrogative

Syntax: PERIOD

Explanation: The period of the selected waveform between the time datum and cursor is measured by looking for points at which the waveform crosses the voltage datum, and then calculating the period allowing for incomplete cycles.

Example: PERIOD
'PERIOD=53.4E−6' (1600 response)
(Period is
53.4 μsec)

Note: If no cross-over points are found then service request 100 will be generated and the value −1 will be returned.

See also: FREQ

Function: Reference memory transfer

Type: Assertive, Interrogative

Syntax: REFM*
REFM(number)
REFM(number) = [data field], [TRC1A], [TRC2A], [TRC3A], [TRC4A]

Explanation: The command takes one basic interrogative form which allows the transfer of a reference memory to the host computer. The number of the reference memory depends upon the current mode. The two modes are 50 x 1K or 5 x 10K reference memories. Consequently the two valid ranges are REFM(1-50) or REFM(1-5). The REFM* form of this command will transfer all reference memories in the current mode.

The two basic assertive forms will again operate with any valid reference memory number for the current mode.

The format of the data field is dependent on the specified block length. If BLL = 0 then this will consist of 1024 numbers in the specified base followed by ‹cr› ‹lf› with EOI on the ‹lf›. If BLL is non zero then the data field will consist of a number of blocks, each separated by a ‹cr› ‹lf› with EOI on the last ‹lf› if asserted.

Examples: REFM*
REFM5
REFM17
REFM23 = TRC3A

See also: EOI, BL, BLL, NB, WIND in the 1604 operating manual.

Note: Service request 103 will be generated if the number is out of range. Service request 102 will be generated for a syntax error.

Function: Reference trace transfer

Type: Assertive, Interrogative

Syntax: REFT*
REFT1
REFT2
REFT1 = [data field], [reference memory number], [TRC1A], [TRC2A], [TRC3A], [TRC4A]

Explanation: The operation of this command will supercede the same command existing in the GPIB option. The command takes three interrogative forms (REFT*, REFT1, REFT2) these will transfer the data from either both or one reference trace to the host computer. Each reference trace store consists of 1024 data samples, the first being for the left-hand edge of the screen and the next successive one for the position further right, each time.
There are three assertive forms of the command which will operate with either reference trace. These allow bulk transfer of data from the host to a reference trace, transfer of a reference memory to a reference trace and transfer of a trace to a reference memory.

The format of the data field is dependent on the specified block length. If BLL = 0 then this will consit of 1024 numbers in the specified base followed by ‹cr› ‹lf› with EOI on the ‹lf›. If BLL is non zero then the data field will consist of a number of blocks each separated by a ‹cr› ‹lf› with EOI on the last ‹lf› if asserted.

The range of the reference memory numbers is dependent on the current modes. The two modes are 50 x 1K or 50 x 10K reference memories. Consequently the two valid ranges are REFM(1-50) or REFM(1-5).

Examples: REFT1 = TRC1A
REFT*
REFT2 = REFM7

See also: EOI, BL, BLL,NB, WIND.

Note: Service request 103 will be generated if the number is out of range. Service request 102 will be generated for a syntax error.

Function: Rise time between 10%, 90% points

Type: Interrogative

Syntax: RISE

Explanation: The rise time is measured between the 10% and 90% points. The 0% point is defined by the point where the time datum crosses the trace, and the 100% point is defined by the value at the cursor position. Working from the time datum, the routine will accept the first points at which the waveform crosses the 10% and 90% levels.
If the 0% is greater than the 100% level then the fall time is calculated in the same way as the rise time.

Example:
```
RISE
'RISE=832E-9'   (1600 response)
                 (Fall time is 832 nsec)

RISE
'RISE=532E-6'   (1600 response)
                 (Fall time is 532 μsec)
```

Function: Reference memory horizontal scaling

Type: Assertive, Interrogative

Syntax:
```
RM(number)HS
RM*HS
RM(Number)HS = [timebase range]
```

Explanation: The command takes one basic interrogative form which gives the timebase value that was valid when the trace was stored. The number of the reference memory depends upon the current mode. The two modes are 50 x 1K or 5 x 10K reference memories. Consequently the two valid ranges are (1-50) or (1-5). The RM*HS form of this command will give all the associated timebase values for each reference memory in the current mode. The assertive form of this command allows a particular reference memory's timebase value to be altered. The timebase range is 50μs to 200s per division in 1,2,5 steps.

Examples:
```
RM3HS
RM*HS
RM7HS = 100E-6
```
NOTE: Service request 102 will be generated for a syntax error.

Function: Reference memory vertical setting

Type: Assertive, Interrogative

Syntax:
```
RM(number)VS
RM*VS
RM(number)VS = [vertical setting]
```

Explanation: The command takes one basic interrogative form which gives the vertical settings that were valid when the trace was stored. The number on the reference memory depends on the current mode. The two modes are 50 x 1K or 5 x 10K reference memories. Consequently the two valid ranges are (1-50) or (1-5). The RM*VS form of this command will give all the associated vertical settings for each reference memory in the current mode. The assertive form of this command allows a particular reference memory's vertical settings to be altered.
The vertical setting takes the form of:-

- Trace Inverted
- › Variable, uncalibrated
- ~ AC coupled

Trace inverted, variable and ac coupled are optional. The vertical range is 2mV to 10V per division in 1,2,5 steps.

Example:
```
RM23VS
RM*VS
RM43VS = -10E-2~     set to inverted
                     100mV/DIV ac
                     coupled.
```

Function: RMS value about voltage datum

Type: Interrogative

Syntax: RMS

Explanation: The RMS value of the selected waveform between the time datum and cursor is measured taking the voltage datum as the zero level. The difference between this level and the waveform, for each point is squared and the average of these values is then square rooted and returned as the result.

Example:
```
RMS
'RMS=12.34'   (1600 response)
               (RMS Voltage is
                12.34 Volts)
```

Note: If the peak value of the trace between the time datum and cursor lies outside the range of the A/D converter, ie., if it is off screen the routine will return a service request 103 as well as a result using the maximum allowable value.

See also: ACRMS

Function: Reference memory type

Type: Assertive, Interrogative

Syntax:
```
RMTYPE
RMTYPE = [5] or [50]
```

Explanation: This command takes one basic interrogative form which gives the current reference memory type. There are two configurations of reference memories, either 50 x 1K or 50 x 10K. The reference memory type is 5 for 5 x 10K memories or 50 for 50 x 1K memories. The assertive form of this command allows the reference memory configuration to be altered between types.

Example:
```
RMTYPE = 50
RMTYPE
RMTYPE = 5'  (1600 response)
```

Note: Service request 103 will be generated for numbers out of range.

Function: Restore original trace

Type: Direct

Syntax: RESTORE

Explanation: This command is equivalent to pressing the Restore button on the keypad. It returns the trace to the condition it was in before the last waveform manipulation. The functions which can be recovered in this way are:
HPS,INT,INVPS,YMAG,FILTER

Example: RESTORE

Function: Select TV line number

Type: Assertive, Interrogative

Syntax: TVLINE
TVLINE=number

Explanation: This command is used to select the number of the line to be acquired when in TV capture mode. the maximum value of the number of lines will be determined by the setting of TVSTD.

Example: TVLINE=123
TVLINE
'TVLINE=367' (1604 response)
(line 367 currently selected)

Note: If the line number selected falls outside the allowable range then a service request 103 will be generated and the command will be ignored.

See also: TVSTD,TVMODE

Function: Select TV standard

Type: Assertive, Interrogative

Syntax: TVSTD
TVSTD=[PAL] or [NTSC] or [SECAM]

Explanation: This command selects the TV standard which will be used for the acquisition of TV lines

Example: TVSTD=PAL

See also: TVMODE,TVLINE

Function: Select TV triggering

Type: Assertive, Interrogative

Syntax: TVMODE
TVMODE=[ON] or [OFF]

Explanation: This command sets up the triggering correctly for capturing TV lines. It is equivalent to pressing the TV MODE button on the keypad. Once TVMODE has been set to ON then setting TVMODE to OFF will return the trigger system to its state before the TVMODE=ON was issued.

Example: TVMODE=ON
TVMODE
'TVMODE=OFF' (1600 response)
(TV trigger mode not selected)

See also: TVSTD,TVLINE

Function: Save upper limit

Type: Direct

Syntax: UPLIM

Explanation: This command is equivalent to pressing the Save Upper Limit button on the keypad and is used to set up the upper limit for limits testing. The upper limit is held in the reference trace 1 UPLIM will save the selected trace in the correct form for limits testing.

Example: UPLIM

Note: When the transfer is complete a service request 74 will be generated.

See also: LOWLIM,LIM,LIMST,HMOD

Function: Pulse width at 50%

Type: Interrogative

Syntax: WIDTH

Explanation: The pulse width of the selected waveform between the time datum and cursor is measured by first performing a max/min function on the waveform. The 50% level is then calculated and the time between the two points at which the waveform crosses this level is measured.

Example: WIDTH
'WIDTH=57.6E−6' (1600 response)
(Pulse width is 57.6 μsec)

Note: If no cross over points are found then service request 100 will be generated and the value −1 will be returned.

Function: Vertical calibration

Type: Interrogative

Syntax: YCAL

Explanation: This command is used to determine if a trace is calibrated or uncalibrated. The two possible responses which can be returned are CAL and UNCAL. If the trace was captured using the variable gain or if the trace has been magnified after storage the response will be UNCAL, otherwise the response will be CAL. If the trace is CAL then the results measurements will be in Volts, and if the trace is UNCAL the results will be in divisions.

Example: YCAL
'YCAL=CAL' (1600 response)
(Trace is calibrated)

See also: YMAG,VG*

Function: Post storage Y magnification

Type: Assertive, Interrogative

Syntax: YMAG
YMAG=number

Explanation: After data has been stored or held, an individual trace can be expanded or reduced vertically about the voltage datum. The maximum allowable range for magnification is 0.062 to 4.0 and this is achieved in 63 steps so the resolution of the magnification factor is 0.06. A copy of the original trace is retained when each magnification is performed, so all magnification factors are relative to the previous trace and not the currently displayed one. For example, requesting a YMAG of 2 followed by a YMAG of 3 on a trace which was 1 division peak to peak, will result in a trace which is 6 divisions peak to peak. The RESTORE command will reset the trace to its original magnification, ie., YMAG=1. The total magnification can be read out using the YSCALE command.

Example: YMAG=2
YMAG
'YMAG=0.5' (1600 response)
(Currently selected trace is reduced by a factor of 2)

Note: If a magnification is requested outside the allowable range a service request 103 will be generated. If the trace is not stored or held a service request 100 will be generated and no action will be taken.

Function: Vertical scaling factor

Type: Interrogative

Syntax: YSCALE

Explanation: This command is used to read out the overall scaling of the trace after various waveform processing functions have been performed. It is the number by which the current trace must be multiplied to return to the original. If no functions have been performed then YSCALE=1, so this can be used to check whether the results of the measurement are in divisions or Volts. The functions which affect YSCALE are INTG, YMAG and INVPS.

Example: YSCALE
'YSCALE=1.76' (1600 response)
(Trace has been reduced by 1.76)

See also: INTG,YMAG,YCAL,INVPS

APPLICATIONS

Showing the button sequence on the Waveform Processor 160.

1. To capture a waveform or waveforms:

Set-up the 1600 with no overall lock or hold on stores.

☐	F:	Select function
☐	Initialize:	To reset average and filter if necessary.
☐	Capture:	To arm 1600.
☐	Capture:	Press again to re-arm or hold down to continuously arm 1604.

2. To capture A TV waveform:

☐	TV Mode:	Select TV mode triggering
☐	F:	Select function.
☐	TV Line:	Alpha Numerics will display line number and standard.
☐	INC:	Increases line no.
☐	DEC:	Decreases line no.
☐	CAPTURE:	To arm 1600.

3. LIMITS TESTING

Limits testing is a powerful signal capture feature of the 160 waveform processor. It enables the user to establish a testband and the 1600 will either acquire the waveform or signal the operator if the waveform leaves the testband.

a. SETTING TESTBAND

The testband can be set using a waveform from either a computer or a captured signal. This example assumes that the testband is derived from a captured signal.

☐	Initialize:	To reset average and filter if necessary.
☐	Capture:	To arm 1600.
☐	Select Trace:	To mark a trace for subsequent movement.
☐	F:	Select Function.
☐ ☐ ☐ ☐	Position:	To select trace movement.
☐		Move trace to upper limit position.
☐	Save Upper Limit: Sets trace as upper limit.	

☐ Move trace to lower limit position.

☐ Save Lower Limit: Sets trace as lower limit.

NOTE: If the upper and lower trace are different signals, to capture lower limit trace, press "Capture" after "Save Upper Limit".

b. LIMITS TESTING

Set the signal to be tested between the upper and lower limits.

☐ Test Limit: Starts limits testing.

The 1604 will momentarily display the message "Press again to halt on fail".

If the 160 Test Limit key is pressed again, then the 1604 will acquire waveforms until the signal deviates outside the testband and then it will stop.

To continue testing:–

Press the "Test Limit" key.

if AUTOPLOT has been selected on the 1600 the captured trace and testband will be plotted and the 1604 will continue testing.

If Test Limit key is not pressed again, the 1600 will acquire waveforms and display the message "LIMITS TEST: PASS". If the signal leaves the testband it will display the message "LIMITS TEST: FAIL", but it will not stop acquiring waveforms.

4. FILTERING

The basic function of the filter is to remove progressively high frequency signals from the waveform. The filter cut-off frequency is linked to the timebase range and the operator selects the appropriate timebase range.

H.F. Reject Filter.

☐ Capture: Store.

☐ Filter: Calls for Filter.

☐ Filter: Subsequent presses step filter.

If operating in filter mode reselection of the filter key will step on to the next stage.

INSTALLATION

The upgrade kit comprises a 160 Waveform Processor Interface and 160 Waveform Processor.

INSTRUCTIONS:

a. Disconnect the mains power from the 1604.

b. Connect to two mounting lugs on the processor into the holes on the rear panel.

c. Rotate the module until the connectors mate.

d. Use the thumbscrew to connect the module securely to the rear panel.

e. Connect the 160 Waveform Processor to the module using the connector.

f. Reconnect the mains power and switch on.

g. The message during the self test routine should be "Version X.xx + Keypad X.xx".

4. PERFORMANCE CHECKING

The aim of this section is to allow the user of a 1600 to verify the major analogue performance parameters. Should any of these fail to be within specification then it is recommended that the instrument be re-calibrated. A skilled technician with the aid of the service manual will be able to perform this task; alternatively return the instrument to your Gould distributor.

Bandwidth

Equipment required:

Levelled signal generator: Tektronix SG503 or similar;
50 Ohm coaxial cable;
50 Ohm terminator.

Connect the signal generator to a channel input through the coax cable and the terminator, which should be at the 1600 end of the cable.

1. Select 5mV per division on the input channel and set the timebase to 50μs per division.
2. Set the amplitude of the signal generator to give six divisions at 50kHz or similar reference frequency.
3. Change the timebase range to 200ns per division.
4. Increase the frequency on the signal generator until the peak to peak amplitude reduces to 4.2 divisions.

The measured frequency should be greater than 20MHz in non-storage mode and 5MHz in storage mode.

Trigger Sensitivity

Equipment required:

Signal generator: Tektronix SG503 or similar;
50 Ohm coaxial cable;
50 Ohm terminator.

Connect the signal generator to a channel input through the coax cable and the terminator, which should be at the 1600 end of the cable.

1. Select 100mV per division on the input channel and set the timebase to 50μs per division.
2. Select **Auto** trigger.
3. Set the signal generator to 50kHz or similar reference frequency and adjust the amplitude to give one fifth of a division peak to peak.
4. Select **AC Coupling** and **Norm** on the trigger controls.

It should be possible to find a suitable trigger level to obtain a stable picture.

Trigger Bandwidth

Equipment required:

Levelled signal generator: Tektronix SG503 or similar;
50 Ohm coaxial cable;
50 Ohm terminator.

Connect the signal generator to a channel input through the coax cable and the terminator, which should be at the 1600 end of the cable.

1. Select 100mV per division on the input channel and 50μs per division on the timebase.
2. Set the signal generator to give six divisions at 50kHz or similar reference frequency.
3. Select **AC Coupling** and **Norm** on the trigger controls.
4. Without adjusting the amplitude set the signal generator to 20MHz.
5. Change the timebase to 200ns per division.

It should be possible to adjust the trigger level to give a stable trace.

Timebase Calibration

Equipment required:

Time calibrator: Bradley oscilloscope calibrator type 192 or Tektronix TG501 or similar;
50 Ohm coaxial cable;
50 Ohm terminator.

Connect the calibrator to a channel input through the coax cable and the terminator, which should be at the 1604 end of the cable.

NON STORAGE MODE

1. Select a suitable timebase range to view the signal and set the channel attenuator to give between two and five vertical divisions of signal.
2. Select **DC** Coupling and **Norm** on the trigger controls.
3. Adjust the trigger level to give a stable trace.
4. Change the timebase to 500ns per division.
5. Set the calibrator to produce markers every 500ns.

It should be possible to align the markers with the vertical graticule lines to within 3%.

Note: *In non-storage mode, should the instrument fail on this specification point it is indicative of a major system fault and it should be serviced immediately.*

Vertical Calibration

Equipment required:

Oscilloscope calibrator: Bradley type 192 or similar;
Coaxial cable.

Connect the vertical calibration output of the oscilloscope calibrator to the 1604 through the coax cable.

1. Set the timebase to 500μs per division and select 5mV per division for the input channel.
2. Set the calibrator to give 25mV peak to peak, i.e. 5 screen divisions.
3. Adjust the trigger level to give a stable picture.
4. Switch the cursors on.

The peak to peak measurement should be 25mV to within 2% and the trace should be 5 divisions high to ± 0.1 divisions.

These measurements should be repeated on all the attenuator ranges, each time setting the calibrator to 5 screen divisions for the selected range.

Glitch Detect (Alias Detector)

Equipment required:

Signal generator: Tektronix SG503 or similar;
50 Ohm coaxial cable;
50 Ohm terminator.

Connect the signal generator to an input channel through the coax and the terminator, which should be at the 1600 end of the cable.

1. Set the timebase to 100μs per division and select 100mV per division on the input channel.
2. Set the generator to give approximately 5 divisions at 10kHz and adjust the trigger level to give a stable trace.

3. Select 10ms per division on the timebase. You should notice that the screen picture will change considerably with small changes in input frequency.

4. Carefully adjust the frequency of the signal generator to produce a sine wave of approximately 2 to 5 cycles. This is an alias.

If Glitch Detect is functioning correctly then two roughly horizontal lines will be displayed. These will be at the peak levels of the input signal. Note that Glitch Detect may have to be selected in both the Display menu and the Acquisition/Trigger menu and Display MAX/MIN in the Display Menu.

5. ALPHABETICAL SUMMARY OF THE BUTTONS

AC This is used to remove the DC component from input signals. Suitable input signals (i.e. the bandwidth) are from 2Hz to 20MHz in non-storage mode (2Hz to 5MHz in storage mode) with a x1 probe or direct input, and 0.2Hz to 20MHz (0.2Hz to 5MHz) with a x10 probe.

Add Displays the sum/difference of Channels 1 and 2 (left button) or Channels 3 and 4 (right button 1604). The original traces disappear and the resultant traces are placed in either Channel 1 or Channel 3 respectively. The addition is performed prior to any Max-Min operations.

Alpha Intens This is used to control the brightness of the characters displayed on the screen.

Arm'd This light illuminates after the S/Shot button has been pressed; it will stay lit until either a valid trigger has been received or until the Continuous button is pressed.

Auto/Norm This button selects which trigger mode the instrument is operating in. The current mode is indicated by the light above the button. If Auto is selected then one push will select Normal and a further push will re-select Auto.

Auto Setup will always attempt to arrange the display so that two to five complete cycles appear, with the amplitude set so that the height of the trace is between two to five screen divisions. Also, it selects Auto trigger to ensure that the screen is frequently updated and a trace of some sort will be visible.

BAND This paddle allows a range of adjacent trigger levels to be selected, the paddle controlling the extent of the range.

CH1 This is one of four channel signal input sockets, this one being for the connection of signals to Channel 1.

Continuous This button puts the 1600 in continuous capture mode (i.e. its default state). The instrument will automatically re-arm itself after each capture is completed; this enables the displayed traces to be updated as frequently as possible.

CURSOR This paddle moves the minor cursor to the right and left along the trace. It is a five-position paddle, with the settings fast left, slow left, no movement, slow right and fast right.

DC The input signal is directly coupled to the instrument so all frequency components of the input signal will be displayed. The bandwidth will be from 0Hz(DC) to 20MHz in non-storage mode or DC to 5MHz in storage mode.

DATUM These five-position paddles move the two datum cursors. The left-hand paddle moves the horizontal datum cursor up and down, and the left-hand paddle moves the vertical datum cursor to the right and left.

DELAY The function of this paddle depends on the setting of the trigger mode in the Acquisition/Trigger menu. If 'Pretrig' is selected, this paddle will set the amount of pre-trigger in 0.1% steps between 0% and 100%. If 'Trig Delay' is set in the menu, then the paddle will control either delay by time or delay by events. If 'Div by N' is selected, then this paddle will control either the value of N, i.e. the number of valid triggers to be received before acquiring another trace, or it will control the phase - e.g. allowing the next or previous TV line to be acquired instead, those options being selected on the Acquisition/Trigger menu.

Focus Controls the focus of the display.

Gnd The input signal is internally disconnected from the inputs and the amplifier grounded. 0V reference signal is displayed.

HOLD This button freezes the display the moment it is pressed. To release hold simply press the button again.

Inv The input signal is inverted before being displayed. If there is any DC component in the signal this will also be inverted and could cause the trace to disappear from the screen. If DC coupling is in use, see below.

LEVEL This paddle adjusts the trigger level, the trigger bars on the screen showing a representation of the level set relative to the trace.

LOCK These buttons lock the selected channel when in hold mode so that when hold is released that channel remains frozen.

Non/Store This button allows the user to select non-storage or storage (realtime or digital) mode. If storage mode is selected, a press of the button will select non-storage mode. Another press would re-select storage mode.

Norm The trace is a true representation of the input signal.

Off The channel is deactivated.

Off/Norm/Inv Controls channel activation:

Off The channel is deactivated.

Norm The trace is a true representation of the input signal.

Inv The input signal is inverted before being displayed. If there is any DC component in the signal this will also be inverted and could cause the trace to disappear from the screen.

PLOT Pressing this button causes the chosen plotter to make a copy of the screen display. A further press aborts the plot.

Posn (Horizontal) This paddle moves the trace right or left. It is a five-position paddle, having the settings fast right, slow right, no shift, slow left and fast left.

Posn (Vertical) These move their respective traces up and down on the display. They have the following settings: fast up, slow up, no shift, slow down and fast

down. In addition, after a few moments in the fast modes the moving trace will accelerate.

Pre Trig Used to set 10% or 50% pre-trigger by successive presses of the button. If 'Var' is selected then the **DELAY** paddle is used to set the level of time delay provided 'Pretrig' has been selected in the Acquisition/Trigger menu. A fourth press of the button will switch this option off.

Refr This is the usual oscilloscope mode, whereby even if the 1600 is in storage (i.e. digital) mode, it will imitate the style of a conventional realtime 'scope: the display is plotted from left to right as it is acquired.

from right to left until a trace has been acquired. The scrolling effect is most noticable on the slower timebase ranges; on the faster ranges there is no discernable difference between Roll and Refreshed. Roll is only available in storage mode.

Scale Illum The gratiicule on the screen can be illuminated using this control.

Select Trace One press of this button activates the cursors and places them on the trace of the lowest numbered active channel. Successive presses move the cursors onto successive active channels, until a final press deactivates the cursors.

Stor'd This light illuminates on completion of a single-shot acquisition. This is after the instrument has been Arm'd, triggered and a trace acquired. The light will stay illuminated until the instrument is re-armed or Continuous is pressed.

S/Shot This button arms the instrument for a single-shot capture. The Arm'd light will be illuminated to show that the button has been pressed.

TIME/DIV This is a five position paddle which controls the sweep rate of the trace. A gentle push causes a small change in the sweep rate, whilst a firmer push will cause a large change in the sweep rate.

Trace Intens This controls the brightness of the 'trace', i.e. the part of the display used to show waveforms.

Trace Rotate If the trace is not properly horizontal relative to the scale, then adjustment of this control with a small screwdriver will provide correction.

Trig'd This lights up when the 1600 is receiving valid trigger signals at a rate greater than one every 30ms.

TRIGGER The left button steps through the available options of trigger source. These are CH1, CH2 (CH3, CH4, 1604) Ext and LIne. After Line has been selected, a further press of the button returns the selection to CH1. The button next to this is for selecting the trigger coupling. It steps through the available options: DC, DCLP (DCLow Pass), AC, ACLP (AC Low Pass), TVL (TV Line) and TVF (TV Frame). After TVF has been selected, a further press of the button returns the selection to DC. All the couplings can be used with any source except Line. On LINE, the input coupling is not selectable.

Variable (Horizontal) When not set to 'Cal', this control imposes a reduction of the timebase from 1 down to about 0.4. This control, unlike the vertical Variable controls, is only effective in non-storage mode.

Variable (Vertical) When this is not set to 'Cal', the coarse setting of the attenuator remains unchanged, but a variable gain is applied to the input signal. This gain has a range of 1 to about 0.4. Thus, with an initial setting of 1V, the actual sensitivity of the channel could be set by this control to anywhere between 1V and 2.5V per division.

V/DIV This paddle steps the attenuator through the discrete calibrated ranges from 2mV to 10V per screen division in 1, 2, 5 steps. With a x10 probe the ranges are 20mV to 100V per division at the probe input.

X Mag Selects X magnification; in storage mode the expansion factor is selected on the Display menu and the **X Mag** button toggles the expansion on and off. In non-storage mode only x5 is available. The timebase range reflects the amount of expansion selected if **X Mag** is on.

X-Y This mode allows you to use the CH1 (X) socket input to control the X (horizontal) component of the trace, and any or all of the CH2, (CH3 and CH4 1604) sockets for the Y (vertical) component.

± + −This button selects positive (+), negative (9), or either (±) slope triggers. The current selection is indicated by the light above the button and is changed by successive presses of the button.

0 to 9 are used in conjunction with the menu system to provide a large number of extra functions not otherwise available directly from the front panel. The menu system is activated with the two buttons **9** and **0**, labelled **Master Menu** and **Menu/Trace** respectively.

1604 – CH1, CH2, CH3, CH4 apply.
1602 – CH1, CH2 only.

DISPLAY

CRT 8 x 10cm rectangular.
Internally Illuminated Graticule with 8 x 10cm divisions and 2mm sub-divisions.

Accelerating Potential 10kV.

Graticule Continuously variable illumination.

Trace Rotation By front panel preset.

Intensity Separate controls for traces and alpha-numerics.

ALPHA NUMERIC DISPLAY

Display of input voltage range, timebase range, measurement cursors and results.

VERTICAL DEFLECTION

Four identical input channels, CH1, CH2, CH3, CH4 (Invert provided for all channels).

Sensitivity 2mV/div to 10V/div in 1-2-5 sequence. Programmable.

Accuracy ±2% of full scale. (Non-Storage)

Variable Sensitivity >2.5:1 (allows continuous adjustment of sensitivity between ranges).

Input Impedance 1MΩ/30pF.

Input Coupling DC-GND-AC Programmable.

Input Protection 400V DC or pk AC.

Vertical Position ±8 div Programmable.

HORIZONTAL DEFLECTION

NON-STORAGE

Sweep Rate 0.2μs/div to 10ms/div. 15 ranges in 1,2,5 sequence. Programmable.

Accuracy ±3% of full scale.

Expansion x5 gives fastest range sweep speed of 40ns/div.

STORAGE

Sweep Rate 50μs/div-200sec/div. 21 ranges in 1-2-5 sequence. Programmable.

Accuracy ±3% of full scale (display accuracy).

Horizontal Position Programmable.

Horizontal Expansion x1, x2, x5, x10, x20, x50, x100, x200.

TRIGGER

Variable level control with Auto/Normal Facility, with resolution of at least 1mm. In Auto the timebase free runs when insufficient signal (20Hz-20MHz) is present or when the selected level is outside the range of the input signal.

Source Internal CH1, CH2, CH3, CH4, Ext, Line. Programmable.

Slope +ve or −ve. Programmable.

Band Trigger 0.5 to 8 Programmable.

Coupling DC, DCLP, AC, ACLP, TV Frame, TV Line. Programmable. LP Filter attenuates signals >15kHz.

Post-Trigger Delay

Time Timebase range	Max. Delay
5μs – 1ns	100ns (non storage)
50μs – 1ms	100ms
2ms – 100ms	10s
200ms – 200s	1000s

Events 1 to 16383 trigger events.

Trigger divide by N (N=2 to 16383).

Post-Trigger Delay cannot be used for sweep speeds faster than 5μs/div in the Non-Storage Mode.

Pre-Trigger Programmable. 0-100% in 0.1% steps.

Trigger Sensitivity

Internal	DC Coupled	<0.3 div to 2MHz
		<1.5 div to 20MHz
	AC Coupled	<0.3 div 10Hz to 2MHz
		<1.5 div 4Hz to 20MHz.
External	DC Coupled	<150mV to 2MHz
		<600mV to 20MHz
	AC Coupled	<150mV 10Hz to 2MHz
		<600mV 4Hz to 20MHz

External Input Impedance 100kΩ/10pF approx.

External Input Protection 250V DC or pk AC.

NON-STORAGE DISPLAY MODES

All Programmable

Bandwidth DC, DC-20MHz (-3dB)
AC, 2Hz-20MHz (-3dB).

Single Trace CH1 or CH2, or CH3 or CH4.

Multi-Trace Any combination of the four available channels. In normal non-storage, Chopped or Alternate Modes, are automatically selected by the Timebase.

Add CH1 + CH2 and/or CH3 + CH4.

Invert Any channel may be inverted. When used in conjunction with ADD Mode, it gives the algebraic difference of the two channels.

X-Y CH1 gives X, CH2, CH3 and CH4 give Y deflections.

STORAGE FACILITIES

ACQUISITION SYSTEM

Acquisition Memory 10k words per channel.

Maximum Sample Rate 20M samples/sec per channel when operating in single channel mode or CH1 and CH3 or CH2 and CH4 at 50μs/div. timebase range. 10M samples/sec per channel when operating at 100μs/div timebase range. Reducing with timebase range to 5 samples/sec at 200sec/div.

Vertical Resolution 8 Bits (1 in 256).

A-D Conversion Linearity Less than ±½ LSB error. Monotonic.

Single/Shot Acquisition Freezes memory at the end of triggered sweep. Programmable.

Peak Detection (Glitch Capture). Capture of positive and/or negative glitches 50ns pulse width when operating in single channel mode or CH1 and CH3 or CH2 and CH4 captures 100ns pulse width in three and four channels operation.
100% probability of capture.

Bandwidth DC, DC-7MHz.
AC, 2Hz-7MHz.

STORAGE DISPLAY MODES

All Programmable.

Roll Stored data and display updated continually.

Refreshed Stored data and display updated by triggered sweep.

X-Y Display As Non-Storage. 8 bit x 8 bit (256 x 256).

Interpolation Linear.

Display Resolution 8-Bits x 1k per channel (256 x 1024).

Display Hold Freezes total store.

Channel Hold Freezes individual selected channel.

Datum Cursors Independent vertical and horizontal cursor lines.

Measurement Cursor Assigned to trace.

Cursor Measurement Display △V and △T displayed on screen.

Cursor Accuracy
Voltage ±2% ±1L.S.B., resolution 0.4%
Time ±0.1%, resolution 0.01%
0.02% using expansion.

Trigger Indication Trigger level indication on-screen. On-trace trigger point bright-up indication.

MEMORY

Waveforms Two 1k reference traces can be stored and displayed in addition to input channel displays.

Set-ups A total of 4 set-ups can be stored in non-volatile memory.

Retention Time The memory support battery is trickle charged and will retain information for 3 months after power-down.

INTERNAL SCREEN PLOTTER

Direct digital screen copy of waveforms with annotation of range scales, labels and graticule selected by menu.

Plot Size 89mm wide by 102mm long (approx.)

No. of Pens 4 color automatically selected.

Speed 50sec per trace (approx.)

ANALOG OUTPUT

Analog output of the stored displays for plotters and recorders.

Y Output Parallel output of up to 4 channels selected by channel ON/OFF controls. Serial output CH1 through CH4.
Amplitude 100mV/div via bnc connectors.
Accuracy ±5%.

X Output X ramp output.
Amplitude 100mV/div via bnc connector.
Accuracy ±5%.

Output Impedance 100Ω.

Output Sweep Rate Selected via Menu.
0.1 div/sec, 1.0 div/sec, 10 div/sec ranges.

Pen Lift isolated single pole contact closes from start of plot to the end of plot cycle.

Plot Mode Manual or Auto. Auto initiates a plot at the end of acquisition and re-arms the instrument at the end of the plot cycle.

DIGITAL PLOTTER OUTPUT

(Available with an Interface Option). The instrument can directly output to HPGL format plotters via the IEEE or RS423 Interface Ports.

Plot Mode Manual or Automatic after acquisition.

Colors Color pens automatically selected when available.

Labels Range scaling, measurements, labels and graticule information selected by menu.

MISCELLANEOUS

Calibrator 1V pk-pk ±1% approx. 1kHz.

POWER REQUIREMENTS

Voltage 100V, 120V, 220V and 240V.

Frequency 45-400Hz.

Power 70VA approx.

Weight 8kg approx. (17 lb. 9 oz. approx.).

Dimensions See Drawing

ENVIRONMENTAL

Temperature

Operating	0°C to 50°C
Full Specification	+15°C to +35°C
Storage Temperature	−10°C to +70°C

Humidity Tested to IEC 62-2-Ca operating at 45°C at 95%RH.
Tested to IEC 68-2-Db cycling.
Non-operating 25°C to 45°C, 95%RH.
6 cycles (144 hours)

Safety Designed for IEC 348 Cat 1 Standards.

ACCESSORIES SUPPLIED

Operating Manual
Line Cord.

OPTIONAL ACCESSORIES

Probe Kit PB12 A passive probe kit with switched x1 and x10 attenuators.
Input impedance: 10MΩ/11.5pF (x10).

Probe Kit PB17 A x100 passive probe with 1.5m of cable.
Input impedance: 100MΩ/4.5pF.
Working voltage: 1.2kV pl AC.

Probe Kit PB20 A 250MHz modular probe kit with a x1 and x10 switched head.
Input impedance: 10MΩ/18pF (x10)
Working voltage: 600V pk.

Rack Mount Kit PN4091631.

Rack Mount Tray with slides PN04091632.

Cart TR7 General-Purpose Cart.

Protective Carrying Case PN04101176. (A strong padded case, enclosing the oscilloscope for transportation.)

Front Panel Cover PN04101177.

WAVEFORM PROCESSOR TYPE 160 (Optional)

Introduction

The 160 Waveform Processor adds a range of functions to the 1600, which increases the power of the instrument in terms of both capture and post-storage analysis and measurement functions.

SPECIFICATION

SIGNAL CAPTURE FUNCTIONS

Initialise Clears the repeat buffer and sets cursors to normal mode.

Signal Averaging Steps selectable from 1,2,4,8,16,32,64, 128,256,512 or 1024.

Capture & Repeat Arms the scope for a capture and automatically applies the post-storage functions of shift, magnification, filtering or integration, that have been selected since the last initialisation of the keypad.

TV Steup TV Line Configure the instrument to acquire a selected TV line. (Dependent on Transmission System).

Capture Arms the scope for a single capture.

Limits Testing The scope will either hold, or display a "TEST FAILED" message if the acquired signal goes outside a pre-defined test band.

POST STORAGE ANALYSIS FUNCTIONS

Filter 6 selectable stages of low pass filtering per timebase range.

$$\text{Cut-off Frequency} = \frac{15.92}{t} \ln\left(1 + \frac{1}{2^n}\right)$$

t = Timebase range in sec/div.
n = Selected by filter step.

Restore Effectively "undoes" the *last* post-storage trace manipulation.

Vertical Trace Magnification/Attenuation Multiplies trace from 0.06 to 4.00 times in 63 steps selectable by increment/decrement controls.

Invert Inverts the trace about the centre line.

Position Moves trace and datum in X and Y planes and cursor in X plane.

Integration Calculates the indefinite integral and displays the resultant waveform. The trace is auto-scaled.

Area Calculates the area under a curve with limits defined by the cursor and datum.

POST-STORAGE MEASUREMENTS

Rise/Fall Time Calculates rise/fall time of a signal; the 0% anmd 100% points are set by cursor and datum.

Overshoot Calculates overshoot of a signal as a percent of 100 point. 0% and 100% are set by cursor and datum.

Duty Cycle Calculates a duty cycle (ratio of mark to pulse period) as a percentage. Also calculates the average frequency and period of signal. Vertical datum defines the zero crossing or uses the mean of the waveform. Cursor and datum set measurement limits.

Pulse Width Calculates time between 50% points (or voltage datum if required). With the pulse "bracketed" between the time datum and cursor.

Max. Min Display maximum and minimum voltage excursion of a waveform relative to the vertical datum position. The cursor and datum "bracket" the waveform of interest.

Peak-Peak Calculates peak-to-peak voltage of the waveform bracketed between the cursor and datum.

RMS Calculates the root mean square (RMS) voltage of a waveform bracketed between the cursor and datum. The values are calculated with respect to both the vertical datum and the mean of the waveform.

Reference Memory Additional reference memories are available with the waveform processor module. Up to 50 x 1k or 5 x 10k, configured from menu.

Retention Time The module can be detached without losing the waveform data for at least 3 months.

Realtime Clock 24 hour and date set via menu. Stored with reference traces and plotted with digital output plots for record of acquisition time. The time is retained for at least 3 months with the power disconnected.

OPTION 103 – IEEE-488 INTERFACE

Read and Write Functions
All front panel controls with the exception of:
- Variable Timebase Non-Storage
- Variable Input Attenuation
- Power On/Off
- Trace Intensity
- Scale Illumination
- Trace Rotation
- Alpha-Numeric Intensity.

All menu selections are programmable.
Memory data is programmable.
On-screen alpha-numerics can be read.
Alpha-numeric 16 line x 32 characters are programmable for display messages.

OPTION 102 – RS423 (RS232) SERIAL INTERFACE

Two Ports are provided:
1. Input/Output for control as IEEE specification.
2. Output only, e.g. for plotter or printer.

Baud Rate Selectable via menu. 300 to 9600.

ORDERING INFORMATION

1604 4 Channel Digital Storage Oscilloscope.
104 Plotter Option for 1602
102 RS423 (RS232) Serial Interface.
103 IEEE-488 Interface.
1602 2 Channel Digital Storage Oscilloscope.
160 Type 160 Waveform Processor.
105 Type 105 Waveform storage module.
PN04091631 – Rack Mount Kit
PN04091632 – Rack Mount Kit with slides.
PN04101176 – Protective carrying case.
PN04101177 – Front Panel cover.
Type TR7 – General Purpose cart.

INTERNAL PLOTTER CONSUMABLES

PN04101175 – Pack of 4 replacement pens, one of each color.
PN04101165 – Pack of 8 rolls of paper.

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