Model 9650A

Digital Delay Generator

Instruction Manual

190168-A-MNL-C

FCC Notice

This equipment generates, uses, and can radiate radio-frequency energy and, if not installed and used in accordance with this manual, may cause interference to radio communications. As temporarily permitted by regulation, operation of this equipment in a residential area is likely to cause interference, in which case the user at his own facility will be required to take whatever measures may be required to correct the interference.

Company Names

SIGNAL RECOVERY is part of Advanced Measurement Technology, Inc, a division of AMETEK, Inc. It includes the businesses formerly trading as EG&G Princeton Applied Research, EG&G Instruments (Signal Recovery), EG&G Signal Recovery and PerkinElmer Instruments (Signal Recovery)

Declaration of Conformity

This product conforms to EC Directives 89/336/EEC Electromagnetic Compatibility Directive, amended by 92/31/EEC and 93/68/EEC, and Low Voltage Directive 73/23/EEC amended by 93/68/EEC.

This product has been designed in conformance with the following IEC/EN standards:

EMC:	BS EN55011 (1991) Group 1, Class A (CSPIR 11:1990)	
	BS EN50082-1 (1992):	
		IEC 801-2:1991
		IEC 801-3:1994
		IEC 801-4:1988
Safety:	BS EN61010-1: 1993 (IEC 1010-1:1990+A1:1992)	

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Introduction

Chapter 1

1.1 How to Use This Manual

This manual gives detailed instructions for setting up and operating the ***SIGNAL RECOVERY*** Model 9650A Four-Channel Digital Delay Generator. It is split into the following chapters:-

Chapter 1 - Introduction
Provides an introduction to the manual, briefly describes what a digital delay generator is, and lists the major specifications of the model 9650A.

Chapter 2 - Installation and Initial Checks
Describes how to install the instrument and gives a simple test procedure which may be used to check that the unit has arrived in full working order.

Chapter 3 - Front and Rear Panels
Describes the connectors, controls and indicators found on the unit and which are referred to in the subsequent chapters.

Chapter 4 - Front Panel Operation
Describes the capabilities of the instrument when used as a manually operated unit, and shows how to operate it using the front panel controls.

Chapter 5 - Computer Operation
This chapter provides detailed information on operating the instrument from a computer over the optional GPIB (IEEE-488) or RS232 interfaces. It includes information on how to establish communications, the functions available, the command syntax and a detailed command listing.

Appendix A
Gives the detailed specifications of the unit.

After unpacking the instrument, users are recommended to carry out the procedure in chapter 2 to check that it is working satisfactorily. They should then make themselves familiar with the information in chapters 3 and 4, even if they intend that the unit will eventually be used under computer control. Only when they are fully conversant with operation from the front panel should they then turn to chapter 5 for information on how to use the instrument remotely.

1.2 What is a Digital Delay Generator?

The model 9650A Four-Channel Digital Delay Generator (DDG) offers unmatched timing flexibility in a single unit. The sophisticated design includes a variable-width “marker” pulse output generated when the unit is triggered and four variable-width delayed pulse outputs. The delay from the marker pulse to each output is independently adjustable from 0 to 99.999ms in 10 ps increments and in addition front panel potentiometers allow the output pulse widths to be set from 30 ns to 1 ms.

If a precisely defined output pulse width is required then two further outputs generate signals which are set after one of the programmed delays and cleared after the other for the AB and CD channel pairs.

The unique patented interruptible ramp technique used in the instrument ensures jitter is as small as 50 ps rms across the entire operating temperature range and without requiring calibration adjustments. The +5V and +10V low impedance outputs are ideal for driving a wide range of loads, including capacitive and inductive loads, while maintaining pulse fidelity. The output circuitry provides automatic overload protection.

The instrument will prove invaluable in any application requiring accurate timing of several triggers to picosecond resolution, such as laser experiments, time-of-flight spectroscopy, electronic device testing and fundamental physics.

1.3 Key Specifications and Benefits

The ***SIGNAL RECOVERY*** Model 9650A includes a number of features not found in other digital delay generators and offers:-

- Four outputs with adjustable delay and width
- Pulse widths independent of delay
- No trigger indeterminacy caused by trigger-to-internal clock retiming
- Scan mode operation
- Burst mode operation
- Bright, easy to read display
- RS232 and GPIB (IEEE-488) interface options

Installation & Initial Checks

Chapter 2

2.1 Installation

2.1.01 Introduction

Installation of the model 9650A in the laboratory or on the production line is very simple. It can be operated on almost any laboratory bench or be rack mounted, using the optional accessory kit, at the user's convenience. With an ambient operating temperature range of 0 °C to 35 °C, it is highly tolerant to environmental variables, needing only to be protected from exposure to corrosive agents and liquids.

The instrument uses forced-air ventilation and as such should be located so that the ventilation holes on the bottom and side panels are not obstructed.

2.1.02 Rack Mounting

An optional accessory kit, part number 9650A/93, is available from ***SIGNAL RECOVERY*** to allow one or two model 9650A's to be mounted in a standard 19-inch rack.

2.1.03 Inspection

Upon receipt the model 9650A Digital Delay Generator should be inspected for shipping damage. If any is noted, ***SIGNAL RECOVERY*** should be notified immediately and a claim filed with the carrier. The shipping container should be saved for inspection by the carrier.

2.1.04 Line Cord Plug

A standard IEC 320 socket is mounted on the rear panel of the instrument and a suitable line cord is supplied.

2.1.05 Line Voltage Selection and Line Fuses

Before plugging in the line cord, ensure that the model 9650A is set to the voltage of the AC power supply to be used.

A detailed discussion of how to check and, if necessary, change the line voltage setting follows.

CAUTION: The model 9650A may be damaged if the line voltage is set for 110 V AC operation and it is turned on with 220 V AC applied to the power input connector.

The Model 9650A can operate from one of four different power-voltage ranges, 90 - 110 V, 110 - 130 V, 180 - 220 V or 220 - 260 VAC, 50/60Hz, 105 W. Range change-over is made by appropriately positioning the circuit-card in the rear-panel Power Input Assembly (Figure 2-1). Instruments are ordinarily shipped for operation from 110 - 130 V AC, unless destined for an area known to use a voltage in the higher range. When that is the case, they are shipped configured for operation from the higher range.

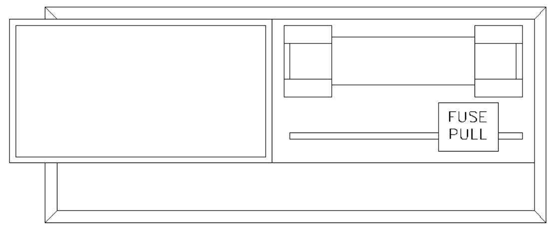


Figure 2-1, Line Power Input Assembly

If necessary, change over can be made in the field, as follows. Observing the instrument from the rear, note the clear-plastic door immediately adjacent to the power cord connector. When the power cord is disconnected from the rear-panel connector, this door is free to slide to the left, giving access to the fuse and to the voltage selector circuit card. The selector card is located at the lower edge of the fuse compartment. A number printed on the upper surface of the selector card is visible without removing the card. This number indicates the nominal line voltage. If the visible number is inappropriate for the intended operating voltage, remove the circuit card and re-insert it oriented so that the correct number will show, as given in table 2-1 below.

VISIBLE #	VOLTAGE RANGE
100	90 - 110 V
120	110 - 130 V
220	180 - 220 V
240	220 - 260 V

Table 2-1, Range vs. Selector Card Position

Next check the fuse rating. For operation from a nominal line voltage of 100 V or 120 V, use a 1¼" slow-blow fuse rated at 1.0 A, 250 V. For operation from a nominal line voltage of 220 V or 240 V, use a 1¼" slow-blow fuse rated at 0.5 A, 250 V.

To change the fuse, first remove the fuse holder by pulling the plastic tab marked with an arrow. Remove the fuse and replace with a slow-blow fuse of the correct voltage and current rating. Install the fuse holder by sliding it into place, making sure the arrow on the plastic tab is pointing downwards. When the proper fuse has been installed, close the plastic door firmly. The correct selected voltage setting should now be showing through the rectangular window. Ensure that only fuses with the required current and voltage ratings and of the specified type are used for replacement. The use of makeshift fuses and the short-circuiting of fuse holders is prohibited and potentially dangerous.

Note that, for user and equipment safety, it is important that the input power connections be properly made. Instruments are supplied with a suitable line power cord. If this ever needs to be replaced then use only one of approved type and compatible design.

2.2 Initial Checks

2.2.01 Introduction

The following procedure checks the performance of the model 9650A. In general, this procedure should be carried out after inspecting the instrument for obvious shipping damage.

NOTE: Any damage must be reported to the carrier and to SIGNAL RECOVERY immediately. In addition the shipping container must be retained for inspection by the carrier.

Note that this procedure is intended to demonstrate that the instrument has arrived in good working order, not that it meets specifications. Each instrument receives a careful and thorough checkout before leaving the factory, and normally, if no shipping damage has occurred, will perform within the limits of the quoted specifications. If any problems are encountered in carrying out these checks, contact **SIGNAL RECOVERY** or the nearest authorized representative for assistance.

2.2.02 Procedure

1) Ensure that the model 9650A is set to the line voltage of the power source to be used, as described in section 2.1.05.

2) With the front-panel mounted power switch off, plug in the line cord to an appropriate line source.

3) Turn the model 9650A power switch to the **ON** position.

4) The instrument's alphanumeric display will now light and the **A** (Channel A Delay) menu will be shown.

5) Press the ⇦ cursor key repeatedly until the flashing cursor is as far to the left as it will go.

6) Press the digit keys 0 0 0 0 0 1 0 0 0 0 which will set the display to **A 100.00nS** and hence the channel A delay to 100 ns.

7) Press the upper **FCN** key until the **RATE** menu is displayed.

8) Press the ⇦ cursor key repeatedly until the flashing cursor is as far to the left as it will go.

9) Press the digit keys 0 0 0 1 0 0 0 which will set the display to **RATE 1000.000 Hz** and set the internal rate generator to 1 kHz.

10) Press the upper **FCN** key until the **A +5V B + 5V AB +** menu is displayed and then press the ⇦ cursor key repeatedly until the flashing cursor is as far to the left as it will go.

11) If the **A** output voltage is not already indicated as +5V then set it to this value by repeatedly pressing the **+** key.

12) Press the upper **FCN** key until the **T +5V** menu is displayed.

13) If the $\mathbf{T_0}$ output voltage is not already indicated as +5V then set it to this value by repeatedly pressing the **+** key.

14) Set the switch marked **EXT STOP INT** to **INT**. This sets the trigger mode to internal.

15) Use a dual channel oscilloscope with at least 400 MHz bandwidth to monitor the signals at the $\mathbf{T_0}$ and **A** outputs, with triggering on the $\mathbf{T_0}$ signal. Confirm that the delay between the rising edge of the two pulses is 100 ns and that the pulse widths can be adjusted using the **WIDTH** screwdriver controls mounted beneath the $\mathbf{T_0}$ and **A** output connectors.

This completes the initial checks. Even though the procedure leaves many functions untested, if the indicated results were obtained then the user can be reasonably sure that the unit incurred no hidden damage in shipment and is in good working order.

Front and Rear Panels

Chapter 3

3.1 Front Panel

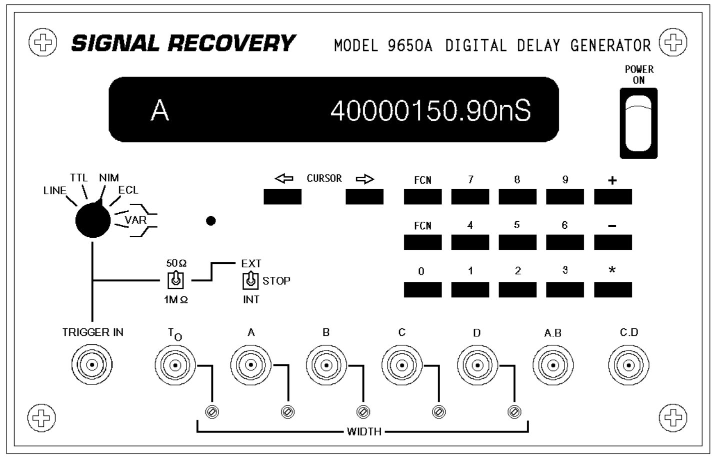


Figure 3-1, Model 9650A Front Panel Layout

As shown in figure 3-1 above the front panel of the Model 9650A follows a logical layout, with the trigger input and controls affecting it on the left-hand side, the keypad on the right and the cold fluorescent display panel across the top. All connections are made to the eight BNC connectors mounted along the bottom edge, thereby ensuring that cables do not obstruct access to the controls.

3.1.01 Power Switch

The power switch is located at the upper right of the front panel. Note that, when the 9650A is turned off, it retains the settings in effect at the moment of power-down. These settings are restored when it is turned on again.

3.1.02 Connectors

There are eight BNC connectors mounted on the front panel that are used for the most common connections to and from the user's experiment. Their purpose is described in the following paragraphs. Connectors used less frequently are mounted on the rear-panel and are described in section 3.3

TRIGGER IN Connector
When the instrument is set to any external trigger mode other than **LINE** then it is triggered by signals applied to this connector.

T_0 Connector
The leading edge of the signal at this connector marks the "time = zero" position with reference to which all the delays generated by the 9650A are specified. The delay between an applied trigger and this pulse is the intrinsic delay of the unit, typically 35 ns. Note that because of the interruptible ramp technique used to generate delays in the instrument, this intrinsic delay does not show any of the trigger indeterminacy caused by trigger-to-internal clock retiming that is typical in conventional digital delay

generators.

The screwdriver adjustable **WIDTH** control beneath the BNC connector changes the $\mathbf{T_0}$ pulse width over the range 30 ns to 1 ms.

A, B, C and D Connectors
The main output pulses which occur after the channel A, B C and D delays respectively are provided at these BNC connectors.

The screwdriver adjustable **WIDTH** control beneath each of these BNC connectors changes the corresponding pulse width over the range 30 ns to 1 ms.

A.B Connector
This output generates a pulse that starts at a time equal to the channel A delay and ends at a time equal to the channel B delay. Hence the pulse width is set by the combination of two digital delays rather than by screwdriver adjustment.

C.D Connector
As with the **A.B** output, this output generates a pulse that starts at a time equal to the channel C delay and ends at a time equal to the channel D delay. Hence the pulse width is set by the combination of two digital delays rather than by screwdriver adjustment.

3.1.03 Trigger Mode Controls

The trigger mode of the 9650A is set by the trigger mode controls on the left-hand side of the front panel, shown below in figure 3-2.

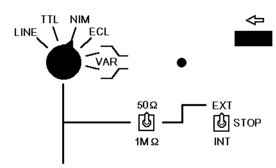


Figure 3-2, Trigger Mode Controls

Trigger Mode Switch
This switch sets the trigger mode, as follows.

Setting	Function
EXT	The 9650A triggers on a signal derived from an external source and applied to the **TRIGGER IN** connector. It triggers from the power input at the line frequency (i.e. nominally 50 or 60 Hz) if **LINE** is selected by the trigger configuration switch.
STOP	Triggering is suppressed.
INT	The 9650A self triggers at the frequency set using the **RATE** menu. Note however that the external trigger input is still active in this mode so that there should not be any connection to the **TRIGGER IN** input

Trigger Input Impedance Switch

This switch sets the input impedance at the **TRIGGER IN** BNC connector to either **1 MΩ** or **50 Ω**

Trigger Configuration Switch

This switch allows the threshold and detection polarity of the trigger circuit to be set to match the available trigger source. It is applicable only when Trigger Mode Switch is set to **EXT**.

Four fixed threshold levels are provided, as follows:

Setting	Function
LINE	Triggers internally at the line frequency.
TTL	Triggers on the positive-going edge of a TTL trigger applied to the **TRIGGER IN** connector.
NIM	Triggers on the negative-going edge of a NIM trigger pulse (-16 mA into 50 Ω, or -0.8V) applied to the **TRIGGER IN** connector.
ECL	Triggers on the positive-going edge of an ECL trigger applied to the **TRIGGER IN** connector.

In addition two variable voltage threshold levels are provided, as follows:

Setting	Function
VAR ╱	Triggers on the positive-going edge of a trigger applied to the **TRIGGER IN** connector as the voltages rises through a threshold voltage of between -3.0 V and + 3.0 V set using the **TRIGGER LEVEL** menu and the keypad.
VAR ╲	Triggers on the negative-going edge of a trigger applied to the **TRIGGER IN** connector as the voltages falls through a threshold voltage of between -3.0 V and + 3.0 V set using the **TRIGGER LEVEL** menu and the keypad.

3.1.04 Trigger Indicator

Immediately to the right of the Trigger Configuration switch is a green LED indicator that flashes briefly each time the 9650A is triggered internally or externally. At high repetition rates the light will appear to glow steadily when triggering is taking place.

3.1.05 Display

The 9650A features a 5 × 7 dot-matrix alphanumeric display. With the exception of pulse width, which is set by the five front-panel screwdriver **WIDTH** adjustments, each control setting can be displayed on this panel and adjusted using the keypad below the display.

The display shows one of the following seventeen menus at any one time:

A (Channel A Delay)
B (Channel B Delay)
C (Channel C Delay)
D (Channel D Delay)
RATE
TRIGGER LEVEL
KEY * TO SAVE AT ##
KEY * TO RECALL ##
SCAN I DEL
SCAN STEP
TRIGGERS/STEP
STEPS/SCAN
RUN SCAN
A +5V B + 5V AB +
C +5V D + 5V CD +
T +5V
GPIB ADDRESS

The purpose of each of these menus is described later in section 3.2

3.1.06 Keypad

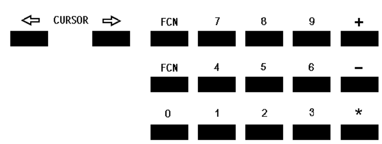


Figure 3-3, Keypad

As shown in figure 3-3, there are seventeen keys on the front panel of the model 9650A, which operate as follows:

⇦ and ⇨ CURSOR Keys
In the menus requiring numerical entry of values, such as the four menus used to set the delays, a cursor in the form of a flashing digit is displayed at one of the digit positions of the value to be adjusted. The position of this cursor can be set using the two white keys marked **CURSOR** located below the main display and to the left of the numeric keypad. Pressing the right hand key once causes the cursor (i.e. the flashing digit position) to move one place to the right and pressing the left hand key once causes the cursor to move one place the to left.

When entering a value these keys must be used to position the cursor at the required starting location before entering the value using the numerical keypad. For example, if a control setting of “400”is to be entered then the cursor must first be located at the third place to the left of the decimal point before keying the number. When a multi-digit number is entered, the cursor automatically shifts to the right as each digit is keyed so that after entering “400” the cursor would finish on the units digit, in this case a zero.

NOTE: If the currently displayed value has a greater number of digits than the new value to be entered then it is necessary to move the cursor to the digit furthest from the decimal point and enter a zero at each point until the cursor reaches the desired position. For example if the display is showing "2345" when the value "400" is to be entered, move the cursor left until it is over the "2" and then enter a zero. The cursor will move one place right and "400" can then be entered. The leading zero has no significance and will not be displayed.

FCN (function) Keys

The two white function keys marked **FCN** are used to cycle through the seventeen menu choices; pressing the upper **FCN** key moves to the next menu and the lower **FCN** key moves to the previous menu. The menu selections "wrap" from bottom to top, so that, for example, pressing the upper **FCN** key when the **GPIB ADDRESS** menu is displayed moves to the **A** (Channel A Delay) menu.

Numeric (0 to 9) Keys

These keys set the value of the displayed number at the cursor position. For example, if the number displayed at the cursor (blinking) position is "4" and is to be change to "9", then it is only necessary to press the "9" key. The new value is implemented immediately; there is no separate "Enter" key.

Each digit entered moves the current cursor position one place to the right.

+ and - Keys

These keys increment or decrement the number at the cursor position by one each time they are pressed.

*** Key**

The effect of this key, which has a red button, depends on the menu displayed on the main display, as follows:

KEY * TO SAVE AT ##

Pressing the ***** key causes all the instrument settings to be stored to the location specified by the numbers ##. On completion the channel A delay selection menu is shown.

KEY * TO RECALL ##

Pressing the ***** key loads all the instrument settings from the location specified by the numbers ##. On completion the channel A delay selection menu is shown.

RUN SCAN

Pressing the ***** key once initiates repetitively scanned operation. Scans will only start if the trigger requirements are satisfied for the selected trigger settings. Pressing the ***** key simply arms the trigger circuit to allow one trigger from the selected source to initiate a scan.

SCAN I DEL
SCAN STEP
TRIGGERS/STEP
STEPS/SCAN
Pressing * once initiates a single scan. The scan will only start if the trigger requirements are satisfied for the selected trigger settings. Pressing the * key simply arms the trigger circuit to allow one trigger from the selected source to initiate a scan.

A (Channel A Delay)
B (Channel B Delay)
C (Channel C Delay)
D (Channel D Delay)
RATE
TRIGGER LEVEL
GPIB ADDRESS
Pressing the * key generates a one-shot trigger when any of these menus are displayed, the Trigger Mode switch is set to **EXT**, no trigger source is connected and the Trigger Configuration Switch is set to **TTL**

3.2 Front Panel Menu Reference

3.2.01 Introduction

The sections that follow describe the function of each of the seventeen possible menus and the effect of changing the settings. As mentioned above, menus are selected by pressing the **FCN** keys.

3.2.02 A (Channel A Delay)

```
A        100000.00nS
```

Figure 3-4, A (Channel A Delay) Menu

In fixed-delay operation, sets the delay between the leading edge of the $\mathbf{T_0}$ Output pulse and the leading edge of the **A** output pulse.

NOTE: In scanned operation, the delay is set by the scan controls.

3.2.03 B (Channel B Delay)

```
B        100000.00nS
```

Figure 3-5, B (Channel B Delay) Menu

In fixed-delay operation, sets the delay between the leading edge of the $\mathbf{T_0}$ Output pulse and the leading edge of the **B** output pulse.

NOTE: In scanned operation, the delay is set by the scan controls.

3.2.04 C (Channel C Delay)

```
C       100000.00nS
```

Figure 3-6, C (Channel C Delay) Menu

In fixed-delay operation, sets the delay between the leading edge of the $\mathbf{T_0}$ Output pulse and the leading edge of the **C** output pulse.

NOTE: In scanned operation, the delay is set by the scan controls.

3.2.05 D (Channel D Delay)

```
D       100000.00nS
```

Figure 3-7, D (Channel D Delay) Menu

In fixed-delay operation, sets the delay between the leading edge of the $\mathbf{T_0}$ Output pulse and the leading edge of the **D** output pulse.

NOTE: In scanned operation, the delay is set by the scan controls.

3.2.06 RATE (Set Internal Trigger Frequency)

```
RATE   10000.000 Hz
```

Figure 3-8, RATE Menu

The **RATE** menu is used to set the frequency of the oscillator that generates internal triggers when the 9650A is set to the **INT** triggering mode.

3.2.07 TRIGGER LEVEL (Set Trigger Threshold)

```
TRIGGER LEVEL +1.2V
```

Figure 3-9, TRIGGER LEVEL Menu

The **TRIGGER LEVEL** menu is used to set the input trigger threshold voltage when operating in the **EXT** trigger mode with either the **VAR** or **VAR** trigger configurations selected. The range is - 3.0 V to + 3.0 V and the level can be adjusted by using the **+** and **-** keys. Each keypress changes the threshold by 200 mV.

3.2.08 KEY * TO SAVE AT ## (Save Settings)

KEY * TO SAVE AT 10

Figure 3-10, KEY * TO SAVE AT ## (Save Settings) Menu

The model 9650A can save up to 30 complete instrument set-ups in memories numbered “00” to “29”. If the desired memory is entered then pressing the red ***** key saves the present setting in that location. The display then changes to the **A** (Channel A Delay) menu.

Settings are recalled by using the **KEY * TO RECALL** ## menu (section 3.2.09).

3.2.09 KEY * TO RECALL ## (Recall Saved Settings)

KEY * TO RECALL 10

Figure 3-11, KEY * TO RECALL ## (Recall Saved Settings) Menu

This menu is used to recall a saved instrument setup from memory. The required memory location in the range “00” to “29” is entered and then the red ***** key is pressed to recall the setup.

3.2.10 SCAN I DEL (Scan Initial Delay)

SCAN I DEL 10000

Figure 3-12, SCAN I DEL (Scan Initial Delay) Menu

This menu sets the initial delay of the **A** output in scanned mode. It has no effect in normal non-scanned mode.

3.2.11 SCAN STEP

SCAN STEP 1020

Figure 3-13, SCAN STEP Menu

This menu sets the number of nanoseconds for each step within a scan. It is only operative in scanned mode. Note that setting this control to 0 establishes the burst mode of operation, which is a special form of the scanned mode (see section 4.5).

3.2.12 TRIGGERS/STEP

```
TRIGGERS/STEP     10
```

Figure 3-14, TRIGGERS/STEP Menu

This menu specifies the number of times the unit triggers at each delay value in scanned operation. After the specified number of triggers have occurred, the delay increments by the value specified in the **SCAN STEP** menu (section 3.2.11), and the cycle repeats. The value is set using the keypad. The menu has no effect in non-scanned operation.

3.2.13 STEPS/SCAN

```
STEPS/SCAN    10
```

Figure 5-15, STEPS/SCAN Menu

This menu specifies the number of steps for a complete scan. The **A** channel delay at the end of the scan is simply the **SCAN I DEL** delay value plus the product of the **SCAN STEP** value (which is in nanoseconds) and the **STEPS/SCAN** value. The value is set using the keypad. **STEPS/SCAN** has no effect in non-scanned operation.

3.2.14 RUN SCAN

```
RUN SCAN
```

Figure 3-16, RUN SCAN Menu

When this menu is displayed, pressing the red * key starts repetitive scans. Once scanning is active, pressing any key other than the * key will stop it.

3.2.15 A xx B xx AB x (Configure A, B and A.B Outputs)

```
A +5V B +5V AB +
```

Figure 5-17, A xx B xx AB x (Configure A, B and A.B Outputs) Menu

This menu is used to independently set the levels for the **A** and **B** outputs. Standard units offer the option of **+5V**, **+10V**, and **NIM** (-16 mA into 50 Ω load, or -0.8 V) for these outputs, but units fitted with the 9650A/98 15 V output option offer **+5V**, **+15V**, and **NIM** instead.

The derived output, **A.B**, always has 0 V and +5 V output levels, but the polarity can be set so that it is active low (a 0 V pulse with +5 V baseline) or active high (+5 V pulse with 0 V baseline). Active low operation is indicated by a “ **-** ”(a minus sign) next to the menu item **AB** while active high operation is shown by a “ **+** ”.

The cursor keys are used to choose one of the three controls and the **+** and **-** keys are then used to change the setting.

3.2.16 C xx D xx CD x (Configure C, D and C.D Outputs)

`C +5V D +5V CD +`

Figure 5-18, C xx D xx CD x (Configure C, D and C.D Outputs) Menu

This menu is used to independently set the levels for the **C** and **D** outputs. Standard units offer the option of **+5V**, **+10V**, and **NIM** (-16 mA into 50 Ω load, or -0.8 V) for these outputs, but units fitted with the 9650A/98 15 V output option offer **+5V**, **+15V**, and **NIM** instead.

The derived output, **C.D**, always has 0 V and +5 V output levels, but the polarity can be set so that it is active low (a 0 V pulse with +5 V baseline) or active high (+5 V pulse with 0 V baseline). Active low operation is indicated by a " **-** "(a minus sign) next to the menu item **CD** while active high operation is shown by a " **+** ".

The cursor keys are used to choose one of the three controls and the **+** and **-** keys are then used to change the setting.

3.2.17 T xx (Configure T_0 Output)

`T +5V`

Figure 5-19, T xx (Configure T_0 Output) Menu

This menu is used to set the level for the $\mathbf{T_0}$ output. Standard units offer the option of **+5V**, **+10V**, and **NIM** (-16 mA into 50 Ω load, or -0.8 V) for this output, but units fitted with the 9650A/98 15 V output option offer **+5V**, **+15V**, and **NIM** instead.

The setting is changed using the **+** and **-** keys.

3.2.18 GPIB ADDRESS

`GPIB ADDRESS 29`

Figure 5-20, GPIB ADDRESS Menu

This menu is used to set the GPIB address on units equipped with the 9650A/97 GPIB interface option. If the address is changed the power must be cycled in order for the new address to take effect.

3.3 Rear Panel

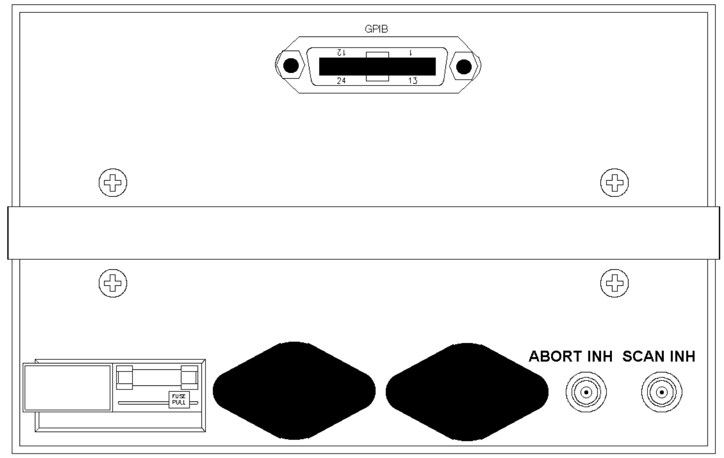


Figure 3-21, Model 9650A Rear Panel Layout (With -/97 GPIB Option)

As shown in figure 3-21, the line power input assembly, two BNC connectors and, for units fitted with either the GPIB or RS232 communications interfaces, the interface connector, are mounted on the rear panel of the instrument. Brief descriptions of these are given in the following sections.

3.3.01 Line Power Input Assembly

This houses the line voltage selector and line input fuse. To check, and if necessary change, the fuse or line voltage see the procedure in section 2.1.05.

3.3.02 RS232 Connector (Units with option /96)

This 25-pin D type RS232 interface connector implements pins 1, 2, 3, 5 and 7 (Earth Ground, Receive Data, Transmit Data, Request to Send and Logic Ground) of a standard DCE interface. To make a connection to a PC-compatible computer, it is normally sufficient to use a three-wire cable connecting Transmit Data to Receive Data, Receive Data to Transmit Data, and Logic Ground to Logic Ground. Figures 5-2 and 5-3 show the connection diagrams of cables suitable for computers with 9-pin and 25-pin serial connectors. Pinouts for this connector are given in figure 5-1.

The 9650A RS232 parameter settings are factory set to 19200 baud, 8 data bits, 1 stop bit and no parity check and cannot be changed.

3.3.03 GPIB Connector (Units with option /97)

The GPIB interface connector conforms to the IEEE-488.1 1978 Instrument Bus Standard. The standard defines all voltage and current levels, connector specifications, timing and handshake requirements.

3.3.04 ABORT INH Connector

Triggering of the 9650A is inhibited whenever this TTL compatible input is pulled to logic “0” level. If left disconnected then an internal pull-up resistor allows triggering to occur.

3.3.05 SCAN INH Connector

This input is active in scanned operation only. It is an active low TTL input that prevents further triggering on completion of the present scan, if one is in progress. If it is asserted (i.e. pulled to logic “0” level), it must go high for at least 100 ns to restart the scan.

In the specialized burst mode of operation, this input acts as a soft trigger to start a burst of output pulses. In this case it should normally be held at logic “0” level, with the burst of pulses being initiated when it goes to logic 1 (TTL high) level.

If left disconnected then an internal pull-up resistor allows scans to occur.

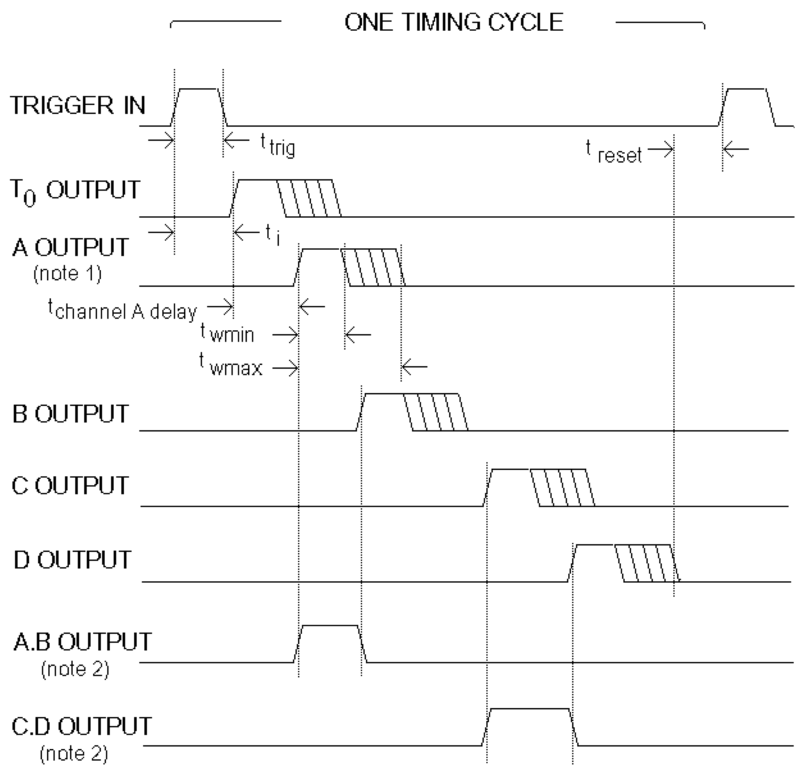
Front Panel Operation

Chapter 4

4.1 Introduction

The model 9650A is very easy to set up and use manually. Operation consists of attaching a suitable trigger source or setting the internal generator so that the instrument is triggered, and then establishing the required delays for each of the four main and two derived outputs. The following sections describe these actions in more detail.

4.2 Timing Diagram



t_{trig}	External Input Pulse Width; 10 ns minimum
t_i	Insertion Delay; 35 ns typical
t_w	Output Pulse Width **T_0**, **A**, **B**, **C** & **D**; 30 ns to 1 ms
t_d	Delay **T_0** to **A**, **B**, **C** & **D**; 0 to 100 ms
t_{reset}	Time between last output and new trigger acceptance; 350 ns maximum

Note 1: **A**, **B**, **C** and **D** may be in any order. They are identical with one constraint. A cycle completes 100 ns after the leading edge of the **B**, **C** & **D** delay and after the trailing edge of the **A** delay. As a result, if a pulse width greater than 100 ns is required from the output channel having the longest delay, it is necessary to use channel **A** as the longest delay channel. Note that **T_0** will be truncated if its width is set to complete after all other outputs have completed.

Note 2: **A.B** and **C.D** are selectable difference outputs. The illustrated waveforms or their complements may be selected.

Figure 4-1, Model 9650A Timing Diagram

Operation of the instrument is best understood by reference to the timing diagram, shown in figure 4-1. Each timing cycle is initiated by an external or internal trigger, which after the intrinsic delay of the unit generates the leading edge of the $\mathbf{T_0}$ marker pulse output. The four main outputs then generate pulses at the preset delays; only after all four pulses and a reset time in the unit ready to be triggered again.

The diagram also shows how the derived outputs, **A.B** and **C.D,** are related to the four main outputs.

In the fixed delay mode each timing cycle is the same as the previous one, but the 9650A also includes a scan mode that allows it to generate a single output delay that increases with each trigger or groups of triggers. A version of this mode, the burst mode, can generate a fixed number out output pulses as the same delay after each trigger. Both scan and burst modes may be initiated by front panel or external logic signals.

NOTE: On units equipped with the 9650A/94 5 MHz option, the cycle always completes on the trailing edge of the Channel A output. Hence, Channel A should always be used for the longest required delay. Also, the reset time is reduced from 350 ns to <125 ns in units equipped with this option.

4.3 Triggering

The model 9650A features a very flexible input trigger circuit, allowing almost any external waveform to be used as a source of triggers. In addition it includes an internal trigger generator so that it can act as the master source of experimental triggers, as well as the ability to be triggered at the line power frequency. This last mode can be used to eliminate problems of trigger jitter that can occur in some systems due to line power RFI pick-up.

When setting up the unit, first use the Trigger Mode Switch to set the basic trigger mode to **EXT** (external) or **INT** (internal). Triggering can also be suspended by setting the switch to **STOP**.

If using the internal triggering mode, next set the required trigger rate using the **RATE** menu (section 3.2.06), and finally check that the unit is triggering by checking that the green “triggered” LED is lit or flashing.

NOTE: When using the internal triggering mode, make sure that no connection is made to the TRIGGER IN input, since the triggers at this input are OR’ed with the internal trigger generator output.

To select triggering at the line power frequency, set the Trigger Mode Switch to **EXT** and set the Trigger Configuration Switch to **LINE**.

If using external triggers, apply the trigger signal to the **TRIGGER IN** connector. Next, select the required input impedance using the Trigger Input Impedance Switch and then the required threshold using the Trigger Configuration Switch. If one of the preset thresholds, **ECL**, **NIM**, or **TTL** are not suitable, or if triggering on the other edge to that implied by these settings is required then select either the **VAR ⌐** or **VAR ⌙** settings and adjust the threshold using the **TRIGGER LEVEL** menu (section 3.2.07). Again, proper triggering can be checked by observing the “triggered” LED.

The maximum external trigger rate for standard units is 2 MHz while for units fitted with the 9650A/94 option it is 5 MHz. Triggers at up to these frequencies are accepted in normal operation as long as the period between triggers is greater than the longest delay setting plus the reset time of 350 ns.

In the scan mode, triggers are accepted at rates of up to 20 kHz. If triggers are applied at a faster rate, the counter will miss some of them. As a result, there will be a larger number of output pulses per step than the programmed value. Accuracy of output pulse delays will not, however, be affected. There is a deadtime between scan steps of approximately 30 ms during which no triggers are accepted.

In addition to external, line frequency and internal triggering, the 9650A can also be manually triggered in a one-shot mode. In order to use this mode, set the Trigger Mode switch to **EXT**, remove any connection to the **TRIGGER IN** input, set the Trigger Configuration Switch to **TTL** and use the **FCN** keys to select one of the following menus:

A (Channel A Delay)
B (Channel B Delay)
C (Channel C Delay)
D (Channel D Delay)
RATE
TRIGGER LEVEL
GPIB ADDRESS

The one-shot cycle can then be started by pressing the red * key once.

4.4 Fixed Delay Operation

In the normal, fixed delay, mode of operation from the front panel, each trigger (external, internal, line or one-shot) generates one delay cycle, resulting in a $\mathbf{T_0}$ pulse, an **A** pulse, a **B** pulse, an **A.B** pulse, a **C** pulse, a **D** pulse, and a **C.D** pulse. The **A.B** output is defined by the leading edges of the **A** and **B** outputs. Similarly, the **C.D** pulse is defined by the leading edges of the **C** and **D** outputs.

The delay of each of the four outputs **A, B**, **C** and **D** with respect to $\mathbf{T_0}$ are set using the relevant **A** (Channel A Delay), **B** (Channel B Delay), **C** (Channel C Delay) and **D** (Channel D Delay) menus. The output pulse amplitudes and polarity of the derived **A.B** and **C.D** outputs are set with the **A xx B xx AB x** (Configure A, B and A.B Outputs), **C xx D xx CD x** (Configure C, D and C.D Outputs) and the **T x** (Configure T0 Output) menus.

In fixed delay operation, the setting of the **SCAN I DEL**, **SCAN STEP**, **TRIGGERS/STEP**, and **STEPS/SCAN** controls have no effect.

4.5 Scanned Delay Operation

In scanned delay operation, all four outputs **A**, **B**, **C** and **D** all generate the same delay, although the pulse width and output voltage can still be independently set. The **A.B** and **C.D** outputs are not available. The delay is not fixed with respect to the $\mathbf{T_0}$ output but instead is stepped, starting at an initial value and incrementing in equally spaced steps. The effect is that the delay sweeps over a range specified by the scanned delay controls.

The initial delay is set in nanoseconds by the **SCAN I DEL** control while the scan step, also in nanoseconds, is specified using the **SCAN STEP** menu.

Each scan consists of a number of steps, specified by the **STEPS/SCAN** menu, at each of which a number of triggers, the **TRIGGERS/STEP** setting, will be accepted.

Hence the overall number of triggers required to complete the scan is:
TRIGGERS/STEP × **STEPS/SCAN**;

the initial delay is:
SCAN I DEL nanoseconds

and the maximum, or final, delay is:
SCAN I DEL + (**SCAN STEP** × **STEPS/SCAN**) nanoseconds

giving a range over which the delays is swept of:
(**SCAN STEP** × **STEPS/SCAN**) nanoseconds

Note that the maximum delay is 80 µs. If settings are chosen that would exceed this then the main display shows **SCAN DELAY ERROR** when an attempt is made to initiate a scan.

Scans can be generated in a one-shot or continuous mode. To generate a one-shot scan use the **FCN** keys to select any one of the following menus:-

SCAN I DEL
SCAN STEP
TRIGGERS/STEP
STEPS/SCAN

Pressing the red * key once initiates a single scan.

To generate a continuous series of scans, use the **FCN** keys to select the **RUN SCAN** menu. Pressing the red * key once then starts the continuous scan mode after a delay that can range from approximately 70 ms to 5 s depending primarily on the setting of the **STEPS/SCAN** control. Scans may be stopped by pressing either of the two **FCN** keys.

The rear panel active-low **SCAN INH** input allows outputs to be inhibited on completion of the current scan by applying TTL logic zero (0 V). The input must then go positive for at least 100 ns to allow another scan can be initiated. Note that this same input serves as a soft-trigger input when using burst-mode operation (see section 4.6).

When a scan is terminated or completed, no further triggering occurs unless a new scan is initiated or fixed delay operation is restored. To restore fixed-delay operation, simply use the **FCN** keys to select any one of the output delay-setting menus.

Example
A series of output pulses are needed that scan repetitively from a delay of 5 µs to 25 µs with a 1 kHz trigger rate. This range of delay, 20 µs, is to be made up of 50 steps of 400 ns and at each step 20 pulses are to be output.

Start with the unit set to fixed delay operation, set the Trigger Mode switch to **INT** and use the **RATE** menu to set the internal trigger generator to 1000.000 Hz. Next adjust the **A** output pulse width as required with the aid of small screwdriver and an oscilloscope. Then set the individual scan controls as follows:

SCAN I DEL	5000 (ns)
SCAN STEP	400 (ns)
TRIGGERS/STEP	20
STEPS/SCAN	50

Repetitive scanning as programmed can then be initiated by selecting the **RUN SCAN** menu and pressing the red * key.

If the **A** output is monitored with an oscilloscope triggered from the leading edge of the $\mathbf{T_0}$ output then a pulse will be seen to move smoothly and repetitively across the oscilloscope screen from a point 5 µs after the leading edge of $\mathbf{T_0}$ to a point 25 µs after the leading edge of $\mathbf{T_0}$. Scanning continues until terminated by pressing either of the two **FCN** keys.

4.6 Burst Mode Operation

Burst mode is a special form of the scanned mode of operation established by simply setting the **SCAN STEP** control to 0. Assuming the **STEPS/SCAN** control is set to 2 or greater then a burst of pulses will be generated each time a scan is initiated.

Both one-shot and continuous burst operation from the front panel are possible. It is also possible to initiate a burst on the rising edge of a TTL pulse to the rear-panel **SCAN INH** connector. Note, however, that this is a soft trigger in that the burst does not begin immediately but rather at an indeterminate time after the edge that can range over an interval equal to the trigger period.

Burst operation varies according to the selected mode as follows.

One-Shot Operation
Number of Pulses per Burst = (**TRIGGERS/STEP** - 1)

Number of Bursts per Shot = (**STEPS/SCAN** - 1)

Interpulse Interval within each Burst
As appropriate for the trigger rate. In **EXT** Trigger operation, it equals the interval between the applied triggers. In **INT** Trigger operation, it is set by the **RATE** control.

Continuous Operation
Number of Pulses per Burst = (**TRIGGERS/STEP** - 1)

Interburst Interval
An indeterminate interval somewhere in the range of 16 ms to 32 ms depending on the trigger rate. For any particular trigger rate, the separation remains constant.

Interpulse Interval within each Burst
As appropriate for the trigger rate. In **EXT** Trigger operation, it equals the interval between the applied triggers. In **INT** Trigger operation, it is set by the **RATE** control.

Note that the **STEPS/SCAN** control has no effect in continuous burst operation.

SCAN INH (Scan Inhibit) Operation
As for one-shot operation except that the burst is triggered on the rising edge of a TTL pulse applied to the to the rear panel **SCAN INH** connector. For proper operation, the pulse applied to this input must be narrower than the total burst width.

Example
A burst of twenty 10 µs wide pulses, each separated by 1 ms, are required when a TTL signal goes "high".

Start with the unit set to fixed delay operation, set the Trigger Mode switch to **INT** and use the **RATE** menu to set the internal trigger generator to 1000.000 Hz. This will set the time between each pulse to 1 ms. Next adjust the **A** output pulse width to the required setting of 10 µs with the aid of small screwdriver and an oscilloscope. Then set the individual scan controls as follows:

SCAN STEP	0
TRIGGERS/STEP	21
STEPS/SCAN	2

With these settings, a single burst of twenty 10 µs wide pulses 1 ms are generated on each rising edge of the TTL signal applied to the rear-panel **SCAN INH** input. Note however that there is no synchronization between this edge and the start of the bursts, so that the first pulse of the burst will occur at any time in the 1 ms interval (determined by trigger rate) following the edge. Note also that the signal at the **SCAN INH** input must not be wider that 20 ms, the total burst width, if only one burst is required.

4.7 Storage & Recall of Settings

The current settings are saved each time a front-panel push-button or the cursor key is moved and will be retained indefinitely when power is removed.

Settings can also be saved to any one of the thirty available memories, numbered 00 to 29, using the **KEY * TO SAVE AT ##** (Save Settings) menu. Settings are restored from these memories using the **KEY * TO RECALL ##** (Recall Saved Settings) menu.

If the **KEY * TO RECALL ##** menu is used with the memory set to "30" then the default settings are reloaded. This facility can also be used if, for any reason, loss of data in the nonvolatile memory causes a menu to be displayed without a cursor.

Computer Operation

Chapter 5

5.1 Introduction

The model 9650A can be fitted with optional GPIB (9650A/97) or RS232 (9650A/96) computer control interfaces. This chapter describes the capabilities of the instrument when fitted with one of these options and operated remotely, and discusses how this is done.

5.2 Capabilities

Units fitted with one of the computer interfaces allow remote control of the internal trigger generator frequency, the four output **A**, **B**, **C** and **D** delays (and hence the behavior of the **A.B** and **C.D** outputs) and the scan mode controls (**SCAN I DEL**, **SCAN STEP**, **TRIGGERS/STEP** and **STEPS/SCAN**). In addition fixed delay, single scan and burst scan modes may be selected and activated.

The interfaces are unidirectional in that the instrument functions only in the “listen” mode, there being no facility for the controlling computer to read the present setting of a control. However with an instrument as relatively simple, from a control point of view, as the 9650A this is unlikely to cause any problems.

5.3 RS232 and GPIB Operation

5.3.01 Introduction

Control of the delay generator from a computer is accomplished by means of communications over the RS232 or GPIB interfaces, with the communication activity consisting of the computer sending commands to instrument. All commands are encoded in standard 8-bit ASCII format, with one or more additional bits as required by the interface (see below).

The interface, either GPIB or RS232, is always active. In the case of the GPIB interface, the only adjustment required is the setting of the GPIB address using the **GPIB ADDRESS** menu (see section 3.2.18) so that it matches that expected by the controller. Units fitted with the RS232 control option have no user-settable controls and require that the controlling computer be set to transmit at 19,200 baud, 8 data bits, 1 stop and with no parity checking.

5.3.02 RS232 Interface - General Features

The RS232 interface in the model 9650A technically requires only two wires, a ground and a data line to carry digital transmissions from the computer to the instrument. In practice, however, three wire connections are often used if this type of cable is to hand although the third wire, which would normally carry digital transmissions instrument to the computer to the instrument, is not used. The logic levels are ±12 V referred to Logic Ground, and the connection may be a standard RS232 one-to-one cable or, alternatively, may be made up from low-cost general purpose cable. The pinout of the

RS232 connector is shown below in figure 5-1.

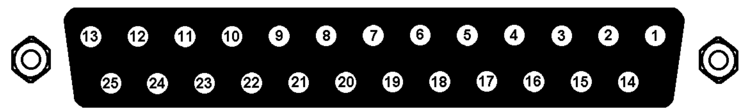


Figure 5-1, Model 9650A/96 RS232 Control Option - Connector Pinout - Female

Pin	Function	Description
1	Earth Ground	Ties the chassis of the model 9650A to that of the computer
2	Receive Data	The 9650A receives data on this line
3	Transmit Data	Not used
5	Request to Send	Constantly asserted
7	Logic Ground	Data signals are referenced with respect to the voltage at this pin

Cables suitable for coupling the 9650A to PC style computers fitted with 9 and 25 pin serial port connectors are shown in figures 5-2 and 5-3.

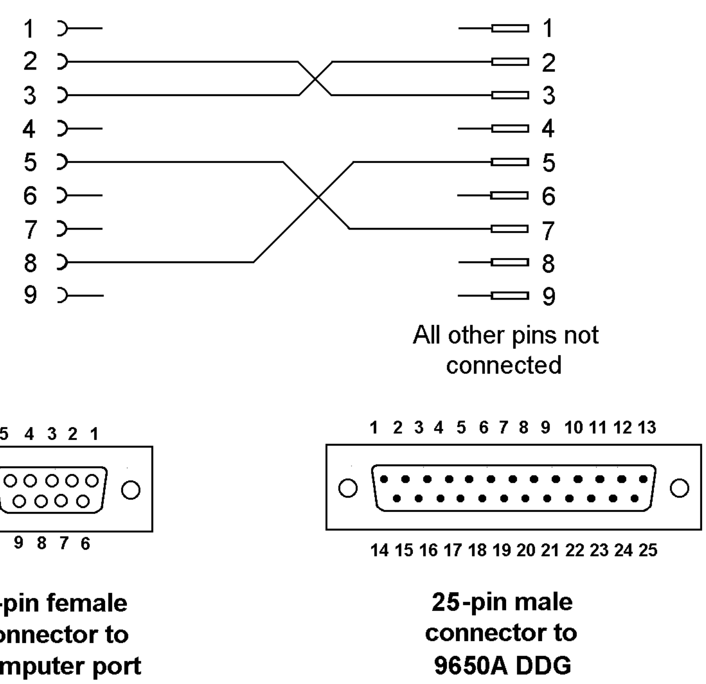


Figure 5-2, Interconnecting Cable for 9-Pin PC Serial Port

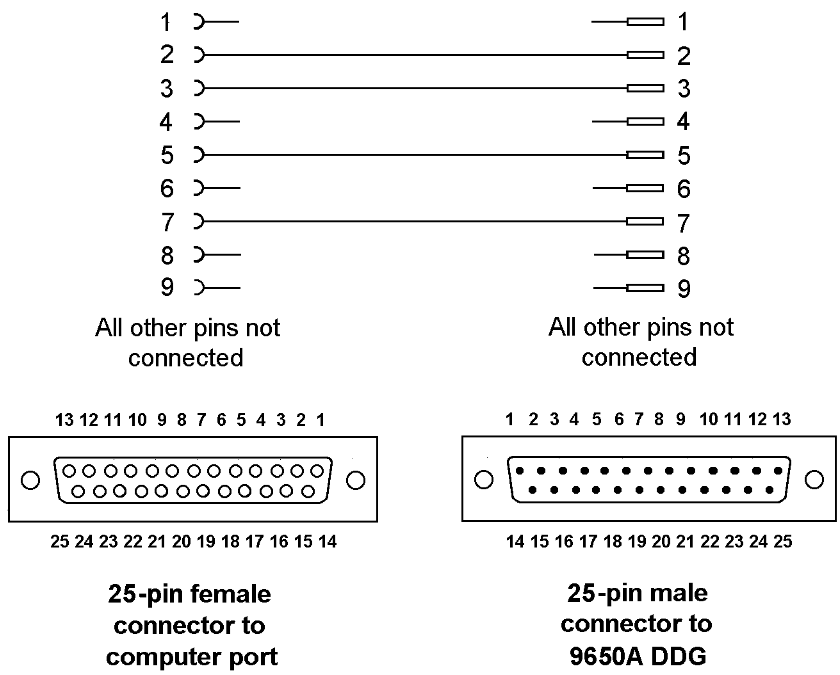


Figure 5-3, Interconnecting Cable for 25-Pin PC Serial Port

The main advantages of the RS232 interface are:

1) It communicates via a serial port which is present as standard equipment on nearly all computers, using leads and connectors which are available from suppliers of computer accessories or can be constructed at minimal cost in the user's workshop.

2) It requires no more software support than is normally supplied with the computer, for example Microsoft's Windows HyperTerminal program.

A single RS232 transmission consists of a start bit followed by 8 data bits, no parity bit, and 1 stop bit. The rate of data transfer depends on the number of bits per second sent over the interface, usually called the baud rate, which as mentioned above is fixed at 19200 baud in the model 9650A, corresponding to a minimum time of less than 0.5 ms for a single character. However the 9650A takes some time to process each character received on the RS232 interface. Hence any controlling program should not send a complete command to the instrument by simply writing it as a single string to the relevant serial port. Rather, the command should be sent character-by-character with a program delay between each character. A value of 25 ms has been found to give satisfactory results.

NOTE: In order to achieve satisfactory operation, the RS232 settings must be set to exactly the same values in the terminal or computer as in the 9650A.

5.3.03 GPIB Interface - General Features

The GPIB is a parallel digital interface with 8 bi-directional data lines, and 8 further lines which implement additional control and communication functions. Communication is through 24-wire cables (including 8 ground connections) with special-purpose connectors which are constructed in such a way that they can be stacked on top of one another to enable numerous instruments to be connected in parallel. By means of internal hardware or software switches, each instrument is set to a different address on the bus, usually a number in the range 0 to 31. In the model 9650A the address is set using the **GPIB ADDRESS** menu.

An important aspect of the GPIB is that its operation is defined in minute detail by the IEEE-488 standard, usually implemented by special-purpose semiconductor devices that are present in each instrument and communicate with the instrument's microprocessor. The existence of this standard greatly simplifies the problem of programming the bus controller, i.e. the computer, to implement complex measurement and test systems involving the interaction of numerous instruments.

The operation of the GPIB requires the computer to be equipped with special-purpose hardware, usually in the form of a plug-in card, and associated software which enable it to act as a bus controller. The control program is written in a high-level language, usually BASIC or C, containing additional subroutines implemented by software supplied by the manufacturer of the interface card.

Because of the parallel nature of the GPIB and its very effective use of the control lines, including the implementation of a three-wire handshake, comparatively high data rates, up to a few hundred thousand bytes per second, are possible. In typical setups the data rate of the GPIB itself is not the factor that limits the rate of operation of the control program.

5.3.04 Terminators

In order for communications to be successfully established between the computer and the delay generator, it is essential that each transmission or command is terminated in a way which is recognizable by the delay generator as signifying the end of that transmission.

In the model 9650A the required terminator is the line feed character, (ASCII 10)

5.3.05 Serial Poll Status Byte and Service Requests

The model 9650A does not use or support the serial poll status byte as described in the GPIB (IEEE-488) standard. However the lack of this support has no effect on other instruments that may be present on the bus and which may use it.

Consequently it has no way of generating GPIB service requests

5.3.06 REMOTE Indicator

When the model 9650A is being operated remotely via either the GPIB or RS232 interfaces, the display shows the word “remote”, as shown in figure 5-3.

REMOTE

Figure 5-3, REMOTE Indicator

This is useful since it warns the user that the unit is under remote control and should not therefore be adjusted manually. However, the unit can quickly be returned to manual control when the word **REMOTE** is displayed simply by pressing one of the two **FCN** keys.

5.4 Command Descriptions

5.4.01 Syntax

The model 9650A recognizes ten ASCII commands that are listed in the following section. Each command consists of a single uppercase letter in the range A to K, with up to ten digits that are used to specify the settings of the relevant control. In addition, line feed characters have to be sent to allow the command to be correctly interpreted.

Although the basic syntax is similar for GPIB are RS232 interfaces, there are slight differences. These are highlighted in the following command descriptions, which use the following syntax:

<LF>	The line feed character, ASC10
<d0>...<d9>	A single ASCII digit in the range 0 to 9

5.4.02 Command Listings

Set Channel A Delay

GPIB:
A<LF>A<d0><d1><d2><d3><d4><d5><d6><d7><d8><d9><LF>
RS232:
A<LF>A<d0><d1><d2><d3><d4><d5><d6><d7><d8><d9><LF>A<LF>

Sets the delay at the **A** output with respect to the $\mathbf{T_0}$ output to:
<d0><d1><d2><d3><d4><d5><d6><d7>.<d8><d9> ns.
Note all ten digits <d0>...<d9> must be sent, with leading zeros used where necessary.

This command also returns the 9650A to fixed delay operation and, if a suitable trigger is present, allows it to start triggering.

Set Channel B Delay

GPIB:

B<LF>B<d0><d1><d2><d3><d4><d5><d6><d7><d8><d9><LF>

RS232:

B<LF>B<d0><d1><d2><d3><d4><d5><d6><d7><d8><d9><LF>B<LF>

Sets the delay at the **B** output with respect to the $\mathbf{T_0}$ output to:
<d0><d1><d2><d3><d4><d5><d6><d7>.<d8><d9> ns.
Note all ten digits <d0>...<d9> must be sent, with leading zeros used where necessary.

This command also returns the 9650A to fixed delay operation and, if a suitable trigger is present, allows it to start triggering.

Set Channel C Delay

GPIB:

C<LF>C<d0><d1><d2><d3><d4><d5><d6><d7><d8><d9><LF>

RS232:

C<LF>C<d0><d1><d2><d3><d4><d5><d6><d7><d8><d9><LF>C<LF>

Sets the delay at the **C** output with respect to the $\mathbf{T_0}$ output to:
<d0><d1><d2><d3><d4><d5><d6><d7>.<d8><d9> ns.
Note all ten digits <d0>...<d9> must be sent, with leading zeros used where necessary.

This command also returns the 9650A to fixed delay operation and, if a suitable trigger is present, allows it to start triggering.

Set Channel D Delay

GPIB:

D<LF>D<d0><d1><d2><d3><d4><d5><d6><d7><d8><d9><LF>

RS232:

D<LF>D<d0><d1><d2><d3><d4><d5><d6><d7><d8><d9><LF>D<LF>

Sets the delay at the **D** output with respect to the $\mathbf{T_0}$ output to:
<d0><d1><d2><d3><d4><d5><d6><d7>.<d8><d9> ns.
Note all ten digits <d0>...<d9> must be sent, with leading zeros used where necessary.

This command also returns the 9650A to fixed delay operation and, if a suitable trigger is present, allows it to start triggering.

Set Internal Trigger Generator Frequency

GPIB:

E<LF>E<d0><d1><d2><d3><d4><d5><d6><d7><d8><d9><LF>

RS232:

E<LF>E<d0><d1><d2><d3><d4><d5><d6><d7><d8><d9><LF>E<LF>

Sets the internal trigger generator frequency to:
<d0><d1><d2><d3><d4><d5><d6>.<d7><d8><d9> Hz.
Note all ten digits <d0>...<d9> must be sent, with leading zeros used where necessary.

This command also returns the 9650A to fixed delay operation and, if a suitable trigger is present, allows it to start triggering.

Set Scan Initial Delay (**SCAN I DEL**)

GPIB:
F<LF>F<d0><d1><d2><d3><d4><d5><d6><d7><LF>
RS232:
F<LF>F<d0><d1><d2><d3><d4><d5><d6><d7><LF>F<LF>

Sets the **SCAN I DEL** control to:
<d0><d1><d2><d3><d4><d5><d6><d7> ns.
Note all eight digits <d0>...<d7> must be sent, with leading zeros used where necessary.

This command also switches the 9650A to scanned mode operation and suspends triggering until a Start Scan command is applied.

Set Scan Step (**SCAN STEP**)

GPIB:
G<LF>G<d0><d1><d2><d3><d4><d5><d6><d7><LF>
RS232:
G<LF>G<d0><d1><d2><d3><d4><d5><d6><d7><LF>G<LF>

Sets the **SCAN STEP** control to:
<d0><d1><d2><d3><d4><d5><d6><d7> ns.
Note all eight digits <d0>...<d7> must be sent, with leading zeros used where necessary.

This command also switches the 9650A to scanned mode operation and suspends triggering until a Start Scan command is applied.

Set Triggers per Step (**TRIGGERS/STEP**)

GPIB:
H<LF>H<d0><d1><d2><d3><d4><LF>
RS232:
H<LF>H<d0><d1><d2><d3><d4><LF>H<LF>

Sets the **TRIGGERS/STEP** control to:
<d0><d1><d2><d3><d4>
Note all five digits <d0>...<d4> must be sent, with leading zeros used where necessary.

This command also switches the 9650A to scanned mode operation and suspends triggering until a Start Scan command is applied.

Set Steps per Scan (**STEPS/SCAN**)

GPIB:
I<LF>I<d0><d1><d2><d3><d4><LF>
RS232:
I<LF>I<d0><d1><d2><d3><d4><LF>I<LF>

Sets the **STEPS/SCAN** control to:
<d0><d1><d2>
Note all three digits <d0>...<d2> must be sent, with leading zeros used where necessary.

This command also switches the 9650A to scanned mode operation and suspends triggering until a Start Scan command is applied.

Start Single Scan

GPIB:
K<LF>
RS232:
K<LF>

Starts a single scan. Note that there is a pause before the scan starts when the Start Single Scan command is applied after making a parameter change. The length of the pause is typically in the range of 70 ms to 5 s, depending primarily on the setting of the **STEPS/SCAN** control. If no manual or remote command change has been made since the last time a Start Single Scan command was applied, the scan will begin within 60 ms of applying the command.

On completion, triggering is suspended until a further Start Single Scan command is applied or the unit is switched back to fixed delay mode operation by sending one of the Set Channel Delay commands or the Set Internal Trigger Generator Frequency command.

5.4.03 Repeating Commands

If the same command is repeated, the initial command designator may be omitted after the first command. For example, to repeatedly control the Channel A delay via the GPIB interface it is possible to send:

A<LF>A<d0><d1><d2><d3><d4><d5><d6><d7><d8><d9><LF>
A<d0><d1><d2><d3><d4><d5><d6><d7><d8><d9><LF>
A<d0><d1><d2><d3><d4><d5><d6><d7><d8><d9><LF>
A<d0><d1><d2><d3><d4><d5><d6><d7><d8><d9><LF>
etc.

As shown, the first time the command is sent, the command character is sent twice. The second and subsequent times, it is only sent once and is directly followed by the operand. This, of course, only applies if the command is directly repeated. If another command is interposed between repetitions, then the full syntax requirements must be observed.

5.4.04 Program Example

The following listing sets the 9650A's A, B, C and D delays to 100 ns, 200 ns, 300 ns and 400 ns respectively and the internal trigger generator to 1000 Hz. It also sets the **SCAN I DEL** control to 50 ns, the **SCAN STEP** control to 400 ns, the **TRIGGERS/STEP** control to 20 and the **STEPS/SCAN** to 100. Commands are suitable for the GPIB interface.

Commands	Notes
A<LF>A0000010000<LF>	Channel A delay = 100 ns
B<LF>B0000020000<LF>	Channel B delay = 200 ns
C<LF>C0000030000<LF>	Channel C delay = 300 ns
D<LF>D0000040000<LF>	Channel D delay = 400 ns
E<LF>D0001000000<LF>	Trigger generator Frequency = 1000 Hz
F<LF>F00000050<LF>	**SCAN I DEL** = 50 ns
G<LF>G00000400<LF>	**SCAN STEP** = 400 ns
H<LF>H00020<LF>	**TRIGGERS/STEP** = 20
I<LF>I100<LF>	**STEPS/SCAN** = 100

Specifications

Appendix **A**

General

Four channel digital delay generator using interruptible ramp technique to generate precise delays without the normal errors associated with trigger to internal clock synchronization. Adjustable output pulse widths. RS232 and GPIB control options. LabVIEW driver available.

External Trigger

0 to 2 MHz. Threshold variable from -2.8 V to +3.0 V in 200 mV steps, positive or negative slope. Preset TTL, NIM and ECL switch selectable.

Input Impedance	50 Ω or 1 MΩ in parallel with 15 pF

Internal Trigger

Single Shot or 0.001 Hz to 999 kHz. Three digit resolution from 1 Hz to 999 kHz, 0.001 Hz resolution below 1 Hz

Accuracy	±0.1 %
Jitter	< 0.2 % over 90 % of range
Settling time	< 2 seconds over 90 % of range.

Triggers (general)

External or internal trigger rate should be < 1/(longest delay + 330 ns + output pulse width) for delays up to 80 µs and < 1/(longest delay + 500 µs) for delays longer than 80 µs

Trigger Inhibit	Rear panel active low TTL input inhibits internal and external triggers
Insertion Delay	35 ns typical (from input trigger to T_0)
Delays	Four independent delays adjustable with respect to T_0 in the range 0 to 100 ms.

Internal Timebase

Stability	±20 ppm (0 to 50 °C)
Delay Accuracy	(delay) × (timebase stability) ±0.3 ns
Jitter	Between the trigger or any output and the succeeding output< 50 ps + ((1 × 10-8) × delay)

Output Pulse Widths

T_0, A, B, C and D	30 ns to 1 ms (screwdriver adjustable)

A.B and C.D Minimum settable width for valid output:

5 ns. Pulse starts on rising edge of A (or C) and stops on rising edge of B (or D), with edges typically 1 ns later than A (C) and B (D) leading edges when the latter are set to 5 V output levels.

Output Levels

T_0, A, B, C and D

Low impedance outputs which generate +5 V, +10 V or -0.8 V into 50 Ω loads, with higher levels when terminated in higher impedances.

Typical pulse transition times when driving a 50 Ω load:

+5 V and +10 V	1 ns/V risetime, 2.5 ns/V falltime, < 5 % under/overshoot;
-0.8 V	+300 mV undershoot, 200 mV overshoot

A.B and C.D

Low impedance outputs which generate TTL levels into low or high impedance loads. Typical pulse transition times for a 0.7 V to 2.7 V swing: 5 ns risetime, 5 ns falltime for a 50 Ω load; 3 ns risetime, 4 ns falltime for a 100 Ω load.

Output Protection

Outputs are short circuit and overload protected and limit if the maximum aggregate current of all outputs averaged over 5 ms exceeds 0.7 A

Scan Mode

Channel A delay scans with the delay controlled by the following parameters:-

Initial Delay	0 to 80 μs in 1 ns steps
Triggers/ Step	1 to 49,999
Delay Step Size	0 to 80 μs in 1 ns steps
Delay Steps/Scan	1 to 899 subject to the overall restriction that the max delay in scan mode is 80 μs
Max trigger rate	20 kHz. (external or internal)

Scan Inhibit

Rear panel active low TTL input inhibits outputs on completion of current scan.

Burst Mode

Special case of scan mode where Delay Step Size = 0. Allows the generation of 1 to 49,999 pulses using external or internal triggers at up to 20 kHz. Use of scan inhibit input and internal triggers allows the unit to generate “n” pulses on receipt of a single trigger pulse.

Display

5 × 7 dot-matrix alphanumeric vacuum fluorescent.

Setup Storage

The model 9650A automatically stores the current setup when power is removed and restores it when power is reapplied. Up to 30 additional setups may be saved for future use.

Computer Interface

The optional RS232 (-/96) or GPIB (IEEE- 488) (-/97) interfaces allow remote setting of the A, B, C and D channel delays, the internal rate generator and the scan settings.

Options

9650A/93	Rack Mounting Shelf (for one or two units)
9650A/94	5 MHz External Trigger Option
9650A/96	RS232 Serial Interface (cannot be installed with 9650A/97)
9650A/97	GPIB (IEEE-488) Interface (cannot be installed with 9650A/96)
9650A/98	+15 V Outputs (Increases +10 V output pulse amplitude setting to +15 V)

Software Support

A LabVIEW driver software suitable for version 4.01 and later of LabVIEW is available by download from our website at **www.signalrecovery.com**

General

Power Requirements	
Voltage	110/120/220/240 VAC
Frequency	50/60 Hz
Power	105 VA max
Dimensions	
Width	8¼" (210 mm)
Depth	13¾" (350 mm)
Height	5¼" (135 mm)
Weight	10lb (4.5 kg)

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SHOULD YOUR EQUIPMENT REQUIRE SERVICE

A. Contact your local AMETEK SIGNAL RECOVERY office, agent, representative or distributor to discuss the problem. In many cases it may be possible to expedite servicing by localizing the problem to a particular unit or cable.

B. We will need the following information, a copy of which should also be attached to any equipment which is returned for service.

1. Model number and serial number of instrument
2. Your name (instrument user)
3. Your address
4. Address to which the instrument should be returned
5. Your telephone number and extension
6. Symptoms (in detail, including control settings)
7. Your purchase order number for repair charges (does not apply to repairs in warranty)
8. Shipping instructions (if you wish to authorize shipment by any method other than normal surface transportation)

C. If you experience any difficulties in obtaining service please contact:

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Oak Ridge
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