Model 994
Dual Counter and Timer
Operating Manual

This manual applies to instruments marked "Rev 00" on rear panel

Printed in U.S.A. EG&G ORTEC Part No. 736780 3802 0287

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for
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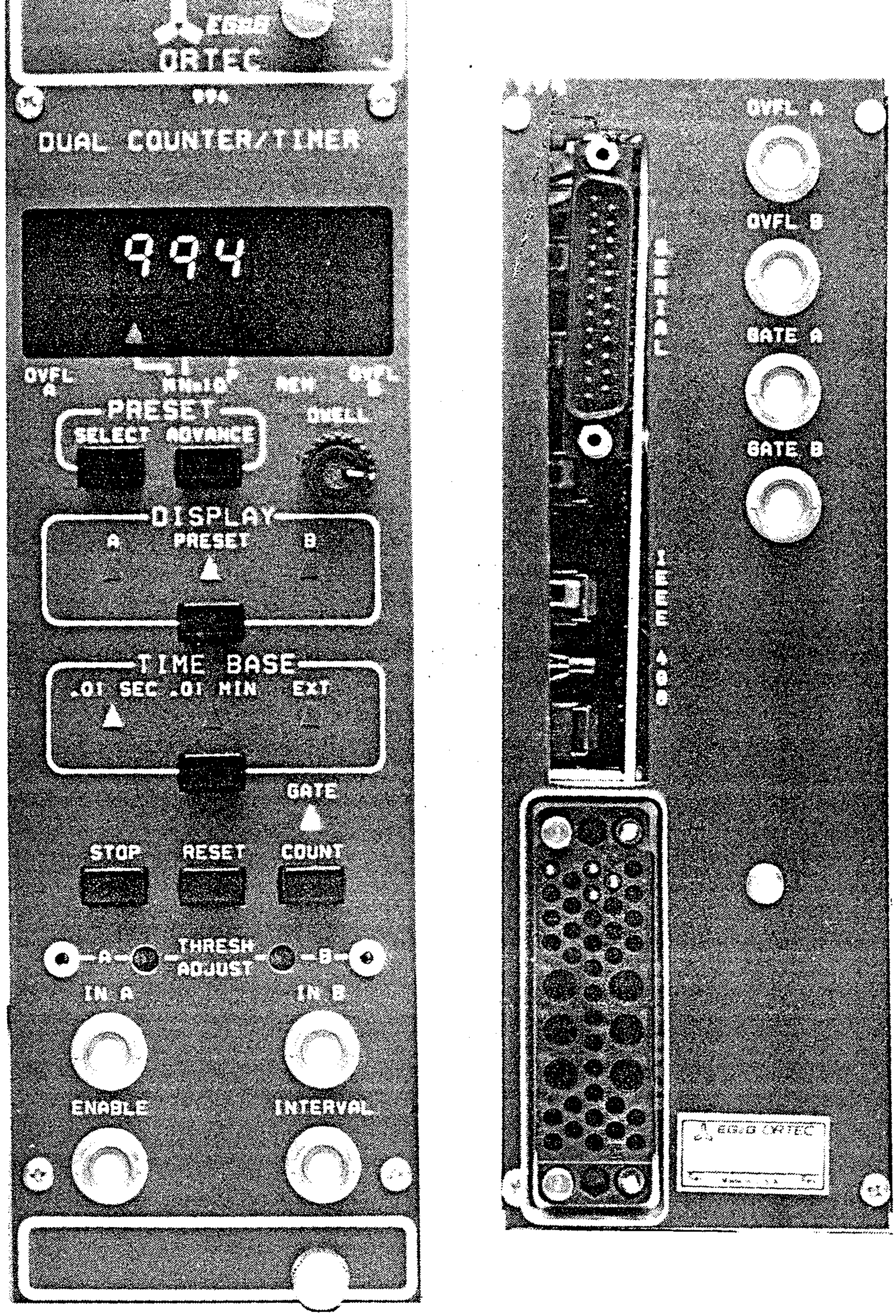
CONTENTS

ILLUSTRATIONS


ORTEC
DUAL COUNTER/TIMER
994
OVFL A
REM
OVFL B
PRESET
SELECT
ADVANCE
DWELL
DISPLAY
A
PRESET
B
TIME BASE
.01 SEC
.01 MIN
EXT
GATE
STOP
RESET
COUNT
A
THRESH ADJUST
B
IN A
IN B
ENABLE
INTERVAL
OVFL A
OVFL B
GATE A
GATE B
SERIAL
IEEE 488
EG&G ORTEC

EG&G ORTEC MODEL 994 DUAL COUNTER AND TIMER

1. DESCRIPTION

The EG&G ORTEC Model 994 Dual Counter and Timer incorporates two 8-decade counters and a blind preset timer. Considerable functional flexibility is designed into the instrument, allowing it to be configured for a variety of measurement tasks. Typically, it can be used as two counters recording separate events under the control of the preset blind timer. When continuous readout of the time is needed, Counter A can be diverted to count the time while Counter B records external events. This provides the function of a counter and a displayed preset timer. In some applications the time taken to count a preset number of events must be measured. For this application Counter A, coupled with the preset blind counter, can be used as a preset counter while Counter B records the time in 0.01-second intervals. In measurements where it is important to correct for the dead time of the detector and its associated electronics, the Gate A input can be switched to also gate the time clock On and Off with a 100-ns time resolution. A positive logic signal which defines the system live time is connected to the Gate A input. This configuration provides a live-time clock (Counter A) and a counter (B).

Excellent flexibility in setting the preset value is offered by the MN $\times 10^P$ selection. The M and N values provide two-digit precision while P selects the decade. Presets can be chosen in the ranges of 0.01 to 990,000 seconds, 0.01 to 990,000 minutes, or 1 to 99,000,000 counts.

The basic Model 994 includes an 8-decade LED display which offers instantaneous visual readout of the full contents of Counter A or B, even in a dimly lighted room. By adding field-installable options, considerably enhanced readout and control capabilities can be incorporated.

The full power of CCNIM™ (Computer-Controlled NIM) can be obtained by adding the IEEE-488 option or the RS-232-C option. These plug-in boards yield computer control of all functions normally selectable from the front panel, including start and stop count, readout, reset, setting the preset value, selecting the displayed counter, and selecting the desired time base. To eliminate accidental operator interference, the computer can disable all front-panel controls in the Remote mode. Computer readout with either of the two CCNIM™ options includes A and B counts, the preset value, and which counter is being displayed. The IEEE-488 option also reads the overflow status for both counters. Implementation of the IEEE-488 interface in the Model 994 is compatible with the NIM/GPIB standard.*

*"STANDARD NIM DIGITAL BUS (NIM/GPIB)", DOE/ER-0173, U.S. NIM committee, August 1983; "IEEE Standard Digital Interface for Programmable Instrumentation," ANSI/IEEE Std 488-1978, The Institute of Electrical and Electronics Engineers, 345 East 47 Street, New York, NY 10017; and "Codes and Format Conventions for Use with ANSI/IEEE Std 488-1978," ANSI/IEEE Std 728-1982, The Institute of Electrical and Electronics Engineers, 345 East 47 Street, New York, NY 10017.

For automated counting applications not requiring computer interfacing, the standard EG&G ORTEC print loop function is available as a field-installable, plug-in board. In conjunction with an EG&G ORTEC Model 777A Printer, this option offers automatic recycling of the counting and printing of all eight digits of the contents of Counters A and B along with other counters in the print loop. Instead of the 777A, the EG&G ORTEC Model 879 Buffered Interface can be used to provide IEEE-488 and RS-232-C interfaces for all the counters in the print loop. The Model 879 has the capability, through the print loop, to start and stop counting, reset, and read the contents of Counters A and B in the Model 994 along with the other counters in the print loop.

The inputs to Counters A and B are individually selectable as either positive or negative sensing inputs by changing the Input Polarity Jumpers on the counter printed wiring board (PWB). The negative input mode is designed to accept standard NIM, fast-negative logic pulses with a fixed threshold of −250 mV on a 50-Ω input impedance. The negative inputs can handle counting rates up to 100 MHz. The positive input mode can accept counting rates up to 25 MHz on a 1000-Ω input impedance. To enhance the flexibility of the positive input mode, precision discriminators are included on both counters. The discriminator thresholds are variable over the range of +100 mV to +9.5 V using front-panel, 25-turn trimpots. The thresholds can be adjusted to suit the amplitude of a specific source of logic pulses or used as precision integral discriminators on analog pulses. For the latter application, the TTL logic outputs of the discriminators are provided as test points on the front panel. These outputs can be used to trigger an oscilloscope while viewing the analog signal at the counter input on the oscilloscope. The oscilloscope trace will show the signals that are being counted by the Model 994, thus permitting a very selective adjustment of the threshold.

All the commonly used functions are conveniently accessible on the front panel. Manual control of the Count, Stop, and Reset functions is via three push buttons. The Gate LED is illuminated when the Model 994 is enabled to count. Selection of the 0.01-second, 0.01-minute, or external time base is made by the Time Base push button. In the external mode the preset counter counts the events at the Counter A input. The Display push button switches the display to show the contents of Counter A, or the preset stop value, or the contents of Counter B. To change the preset value, the Preset mode must first be selected with the Display push button. Subsequently, the Preset Select push button is used to choose M, N, or P for adjustment. Changing the value of M, N, or P is accomplished with the Preset Advance push button. The display contains LED flags to indicate whether M, N, or P has been selected, to warn when overflows have occurred in Counter A or Counter B, and to advise when the front-panel controls are disabled by the computer in the Remote mode. When the Model 994 is used in the automatic recycle mode, the Dwell knob adjusts the dwell time of the display from 1 to 10 seconds.

The counting function of the entire module can be disabled by holding the Enable input below +1.5 V using an external signal source. This condition also turns off the Gate LED. Open circuit or >+3 V at the Enable input allows the instrument to count, if the Count mode has been activated. The Interval output of another EG&G ORTEC timer can perform this function to synchronize the Model 994 counting with the other timer. The Interval outputs on all EG&G ORTEC timers provide nominally +5 V when counting and <+0.5 V when counting is inhibited.

Independent gating of the A and B Counter inputs can be achieved with the Gate A and Gate B inputs on the rear panel. Interface connectors for the IEEE-488, RS-232-C, and print loop options are also located on the rear panel. Each counter has a rear panel output dedicated to signaling overflows. Counting these overflows on another counter extends the counting capacity of the Model 994.

The Model 994 derives its power from the ±12 V and +6 V supplies in a standard NIM bin with power supply. For bins that do not contain a +6 V supply an Internal +6 V Supply option is available. This option is field-installable and derives its power from the 117 V ac lines in the bin.

2. SPECIFICATIONS

2.1. PERFORMANCE

COUNT CAPACITY 8 decades for counts ranging from 0 to 99,999,999 in each of 2 counters.

MAXIMUM COUNTING RATE 100 MHz for negative inputs, 25 MHz for positive inputs.

TIME BASE 10-MHz clock with minimum preset or displayed intervals of 0.01 seconds or 0.01 minutes. Synchronizing error is nominally 100 ns. Also accepts an external input from the Counter A input (In A) when the Ext (External) mode is selected.

TIME BASE INACCURACY $\leq \pm 0.0025\%$ over the 0 to 50° C operating temperature range.

PRESET TIME/COUNTS The module stops counting when the preset value MN x 10^P is reached on the blind preset register. M and N are digits ranging from 0 to 9. P is a digit ranging from 0 to 6. With the 0.01 second time base, preset times from 0.01 to 990,000 seconds can be used. Preset times from 0.01 to 990,000 minutes are available using the 0.01 minute time base. In the Ext time base mode preset counts in the range of 1 to 99,000,000 can be used.

POSITIVE INPUT DISCRIMINATOR Threshold variable from +100 mV to +9.5 V with a 25-turn trimpot.

PULSE PAIR RESOLUTION <10 ns for negative inputs; <40 ns for positive inputs.

2.2. INDICATORS

COUNTER DISPLAY 8-digit, 7-segment LED display with leading zero suppression. When displaying time, 2 digits to the right of a decimal point are included.

OVERFLOW INDICATORS LED indicators labeled Ovfl A and Ovfl B illuminate when the corresponding A or B Counter exceeds its capacity of 8 decades. The indicator remains on until a reset is generated.

M, N, AND P INDICATORS 3 LED indicators aid in the selection of the preset value. When the Preset display function is activated the Select push button selects which of the 3 LEDs is illuminated. When one of these LEDs is On, that digit of the preset value can be incremented using the Advance push button.

DISPLAY 3 LEDs labeled A, B, and Preset indicate the information being displayed in the counter display. Counter A, Counter B, or the Preset value may be displayed by repeatedly pressing the Display push button until the desired LED is illuminated.

TIME BASE 3 LEDs indicate the selected time base source. By repeatedly pressing the Time Base push button, 0.01 Sec, 0.01 Min, or the Ext mode can be chosen.

GATE A single LED indicates that the entire instrument is enabled to count. For the Gate LED to be illuminated the module must be placed in the Count mode (either manually or via the interface option), the Enable input must be above +3 V, and the preset stop condition must not have been reached.

REMOTE A single LED labeled Rem indicates that the 994 is under computer control, and all front-panel controls are disabled. This mode is set by the ENABLE_REMOTE command.

2.3. CONTROLS

DISPLAY Push button selects the contents of Counter A or B, or the Preset value for presentation in the 8-decade display. Repeatedly pushing the button cycles the selection through the three choices as indicated by the A, Preset, and B LEDs.

SELECT Push button chooses the M, N, or P digit in the display of the preset value. Pushing the button advances the selection through the three choices as indicated by the illuminated LED. The Select push button operates only if the Preset mode has been selected by the Display push button.

ADVANCE Push button increments the preset digit selected by the Select push button once each time the Advance button is depressed. The M and N digit ranges are both 0 to 9. The P digit range is from 0 to 6. The Advance push button operates only if the Preset mode has been selected by the Display push button.

TIME BASE Each push on this button advances the selection one step through the three time base choices of 0.01 Sec, 0.01 Min, and Ext to determine the time base source for the preset register.

STOP This push button stops all sections of the instrument from counting.

RESET Depressing this button resets both counters to zero counts and turns off both overflow indicators. It also clears any counts accumulated in the blind preset counter, but does not change the selected preset value. When power is turned on to the module a Reset is automatically generated.

COUNT Pushing this button enables the counting condition for the entire instrument providing the Enable input is not held below +1.5 V and the preset value has not been reached.

THRESH ADJUST (A and B) Front-panel mounted, 25-turn trimpots to adjust the positive input thresholds for Counters A and B. The range is from +100 mV to +9.5 V. Adjacent test points provide the TTL logic signal outputs from the discriminators to facilitate adjustment using an oscilloscope.

DWELL A one-turn potentiometer on the front panel with an On/Off switch at the fully counterclockwise position. Adjusts the display dwell time over the nominal range of 1 to 10 seconds. When the instrument is in the

Recycle mode, dwell time occurs after the preset value has been reached. Turning the switch Off at the fully counter-clockwise position selects the Single Cycle mode. If the print loop option is used, the Dwell control is disabled when the print loop controller is active and controlling the dwell time.

INPUT POLARITY JUMPERS Two jumpers located on the printed wiring board (PWB) separately select the desired input polarities for inputs In A and In B. P = positive, N = negative.

A COUNTER/TIMER JUMPER Two-position jumper located on the PWB. In the Counter position, Counter A always counts and displays the events connected to In A. When set to the Timer position, Counter A counts and displays the time if either the 0.01 Sec or the 0.01 Min time base is selected. If the Ext time base is selected, Counter A will count and display the events from In A.

B COUNTER/TIMER JUMPER Two-position jumper located on the PWB. In the Counter position, Counter B always counts and displays the events from In B. In the Timer position with the Ext time base selected, Counter B counts and displays the time in 0.01 second intervals. With either a 0.01 second or 0.01 minute time base selected, Counter B counts and displays the events from In B.

GATE A (LIVE TIME/NORMAL) JUMPER Two-position jumper mounted on the PWB. In the Normal position, the signals from the rear panel Gate A connector gate the events from the In A connector. In the Live Time position, the signals from the Gate A connector gate the 10-MHz clock to form a live-time clock.

1 CYCLE/RECYCLE Selection of either the 1 Cycle or the Recycle mode can be made via an 8-pin dip switch on the IEEE-488 and the RS-232-C interface boards. The Recycle mode can be used when the computer is able to respond with a data transfer when the 994 reaches the preset value. Upon reaching preset, the 994 latches its data into a buffer, resets the counters, and starts the next counting interval. This process takes ~50 μs. The computer reads the data in the buffer before the next counting interval ends. In the 1 Cycle mode, the 994 simply stops counting and waits for further commands when the preset value is reached.

2.4. INPUTS

IN A Use of this input is affected by the A Counter/Timer Jumper.

Positive Input Front-panel BNC connector for Counter A accepts positive unipolar signals; minimum width above threshold, 20 ns at a 50% duty cycle. The threshold is adjustable from +100 mV to +9.5 V via a front-panel, 25-turn trimpot. Z_{in} = 1000 Ω to ground; dc coupled.

Negative Input Changing the Input Polarity Jumper position on the counter board permits selection of the fast-negative logic input which is designed to accept −600 to −1800 mV pulses with a fixed discriminator threshold of −250 mV. Z_{in} = 50 Ω; dc coupled. Minimum pulse width above threshold is 4 ns.

IN B Identical to In A except that it feeds Counter B. Use of this input is affected by the B Counter/Timer Jumper.

ENABLE Front-panel BNC input connector accepts NIM standard, slow-positive logic pulses to control the counting condition of the entire module. A level of >+3 V or open circuit allows counting provided the instrument is in the Count mode and has not reached the preset value; <+1.5 V inhibits counting. The driving source must be capable of sinking 5 mA of positive current during inhibit; input protected to +25 V.

GATE A Rear-panel BNC input is identical to the Gate B input with the following exception. With the Gate A jumper on the PWB set to the Normal position, the Gate A input controls counting of the In A events in Counter A. By moving the PWB Gate A jumper to the Live Time position, the Gate A input also controls the 10-MHz clock to form a live-time clock with a 100 ns resolution. A level >+3 V or an open circuit allows counting of the clock. A level <+1.5 V is used to inhibit counting of the clock during dead-time intervals.

GATE B Rear-panel BNC connector accepts NIM standard, slow-positive logic signals to control the counting in Counter B. A level >+3 V or open circuit allows counting; <+1.5 V inhibits counting; input protected to +25 V. The driving source must be capable of sinking 5 mA of positive current during inhibit.

2.5. OUTPUTS

INTERVAL Front-panel output BNC connector furnishes a positive level during the counting interval. The level is nominally +5 V when counting is enabled and <+0.5 V when counting is disabled. Z_o ~ 30 Ω.

OVFL A Rear-panel output BNC connector provides a NIM standard, slow-positive logic signal each time Counter A overflows its 8-decade capacity. The signal has a nominal amplitude of +5 V; width ~20 μs.

OVFL B Rear-panel output identical to Ovfl A except that it monitors overflows from Counter B.

2.6. INTERFACES

IEEE-488 When the IEEE-488 option board is plugged in it furnishes a rear-panel, standard, IEEE-488 bus connector. This 24-pin, AMP™CHAMP™ female connector allows the Model 994 to be controlled from a computer via the IEEE-488 bus. The field-installable option provides computer control of the following functions: Count, Stop, Reset, Remote, setting the preset value, selecting the displayed counter, and selecting the desired time base. In the Remote mode the computer can disable all front-panel controls. Computer readout includes: A and B counts, the preset value, which counter is being displayed, and the overflow status for both counters.

™Trademark of AMP Inc.

SERIAL When the RS-232-C option board is plugged in it furnishes a rear-panel, 25-pin, male, D connector containing all signals for standard RS-232-C communications. It also contains connections for 20-mA current loop communications. The field-installable RS-232-C option provides computer control of the following functions: Count, Stop, Reset, Remote, setting the preset value, selecting the displayed counter, and selecting the desired time base. In the Remote mode the computer can disable all front-panel controls. Computer readout includes: A and B counts, the preset value, and which counter is being displayed.

PRINT LOOP When the print loop option board is installed it furnishes a rear-panel, 14-pin, AMP CHAMP™ female connector containing signals for the standard EG&G ORTEC daisy chain print loop operations. This option is field-installable. When connected in a print loop with an EG&G ORTEC Model 777A Printer this option offers automated recycling of the counting and printing of all eight digits of A and B Counters along with any other counters in the print loop. If the Model 777A is replaced with an EG&G ORTEC Model 879 Buffered Interface, the print loop will have IEEE-488 and RS-232-C interface capability allowing the computer to start and stop the counting, reset the module, and read the contents of the A and B Counters.

2.7. ELECTRICAL AND MECHANICAL

DIMENSIONS NIM-standard double-width module, 6.90 x 22.13 cm (2.70 x 8.714 in.) front panel per TID-20893 (Rev).

WEIGHT
Net 2.4 kg (5.2 lb).
Shipping 3.7 kg (8.2 lb).

POWER REQUIRED The basic Model 994 derives its power from a NIM bin furnishing ±12 V and +6 V. For NIM bins that do not provide +6 V, an optional internal +6 V Supply is available. This option is field-installable and draws its power from the 117 V ac lines in the bin. With the Internal +6 V Supply installed, the power requirements are shown in column four below and column three is not applicable.

POWER REQUIREMENTS TABLE

	+12 V	−12 V	Bin Supplied +6 V	Internal +6-V Supply 117 V ac
Basic Model 994	35 mA	115 mA	1300 mA	110 mA
994 plus IEEE-488 option	45 mA	120 mA	1800 mA	145 mA
994 plus RS-232-C option	54 mA	130 mA	1800 mA	145 mA
994 plus Print Loop option	35 mA	115 mA	1425 mA	120 mA

2.8. ORDERING INFORMATION

NOTE: All three interface option boards use the same position in the module. Only one can be plugged in at a given time.

994	Basic module without plug in options.
99X-1	RS-232-C Interface option (cable not included).
99X-2	IEEE-488 Interface option (cable not included).
99X-3	Print Loop Interface option. Includes a 772-C1 Print Loop Cable (61 cm long) with a double-ended connector.
99X-4	Internal +6 V Supply option.
C-75	Female-to-female RS-232-C null modem cable (3 meter length).
C-80	Male-to-female RS-232-C extension cable (3 meter length).
C-488-1	IEEE-488 interface cable (1 meter length).
C-488-4	IEEE-488 interface cable (4 meter length).
772-C1-X-S	Print Loop Cable with double-ended connector. Specify the length "X" in feet.

3. INSTALLATION

Before inserting the Model 994 into the bin, set the switches and jumpers for the desired operating conditions. There are several jumpers inside the 994 that allow the operator to select the input polarity and how the time is displayed. The left-side panel must be removed to gain access to these jumpers. Also, if a communications interface is installed, an 8-position dip switch must be set up correctly for the particular system to which it is connected.

3.1. INPUT POLARITY SELECTION

The 994 accepts and counts either fast, negative-logic pulses or slow, positive-logic pulses. Determine the type of input pulses that will be furnished and set the internal PWB jumpers (W5 and W6) to accommodate the type of pulses selected as shown in Fig. 1. The 994 is shipped from the factory with the jumpers set for positive logic pulses.

There are two important points to consider when supplying signals to the 994: (1) A single pulse must cross the threshold level only one time. Signals with overshoot or ringing will be counted more than once if such anomalies cause the signals to cross the threshold level. (2) Single pulses with slow rise and fall times should be as clean as possible to prevent multiple counting. As a slow signal approaches the threshold, a small spurious noise pulse can traverse the threshold level and return, causing an extra count to be added.

When using the negative inputs, the threshold pots should be set at ≥1 V. This prevents any accidental triggering due to high ground currents present at counting rates of 100 MHz.

3.2. COUNTER INPUT SELECT JUMPERS

Two jumpers (W3 and W4) located on the Counter Board (mother board) allow flexibility in selecting the input to Counter A and Counter B with respect to the Time Base Selection (Fig. 1).

W3 is associated with Counter A, and the two positions are labeled Time and Counts. In the Time position, Counter A always counts the time base signals unless the External time base is selected, in which case the signals at Input A are counted. With W3 in the Time position, Counter A always displays the events driving the preset counter. In the Counts position, the signals at Input A are always counted by Counter A, regardless of the time base selection. The preset counter becomes a blind timer in this position unless the External time base is selected.

W4 is associated with Counter B and, like W3, the two positions are labeled Time and Counts. In the Time position, Counter B accepts signals from Input B unless the External time base is selected. In the External position, Counter B counts the time base pulses to give the elapsed time for the counting interval. In the Counts position, Counter B always accepts the signals from Input B.

The 994 is shipped from the factory with W3 set to the Time position and W4 set to the Counts position.

3.3. GENERAL

The Model 994 Dual Counter and Timer operates on power furnished from a NIM-standard bin and power supply such as the EG&G ORTEC 4001/402D Series. If the bin and power supply does not contain a +6-V power supply, an optional, internal +6-V supply is available for the 994 that derives its power from the 117 Vac supply in the bin.

3.4. CONNECTION TO POWER

Always turn off the bin power supply before inserting or removing any modules. The power supply voltages should be checked after all modules have been inserted. The 4001/402D series has test points on the power supply control panel to permit monitoring of the dc voltages.

When power is applied to the 994, an automatic reset function clears the counters to zero and provides a standard set of start-up conditions: (1) display select set to Counter A, (2) preset values of M, N, and P set to zero; (3) time base select set to 0.01 Sec, and (4) counters in the Stop condition.

3.5. SIGNAL CONNECTIONS

COUNTER INPUTS The 994 accepts and counts either fast negative logic pulses or positive pulses with an amplitude from 0.1 to 10 V (see Input Polarity Selection for instructions on how to select polarity). The negative input threshold is fixed at −250 mV. The positive input has a front-panel threshold adjustment which is variable from +100 mV to +9.5 V. A test point is included on the front panel to ease the adjustment process. For positive logic pulses, the threshold should be set well above the noise level of the input. When used with a linear signal as the input, the adjustment should be set just above the amplifier noise level.

ENABLE INPUT A gate input signal or dc level can be connected to the 994 through the Enable input on the front panel. With no input to this BNC, or with a voltage level >+3 V, the 994 is enabled to accept counts through the inputs on the front panel. To disable the counters, the input at this connector must be pulled below +1.5 V. To do this, the driving source must be capable of sinking 5 mA of current from the Enable input circuitry.

GATES A AND B INPUTS The individual A and B Gate inputs (BNCs) are located on the rear panel. The input specifications are the same as for the Enable input, but only affect the inputs of the respective counters.

3.6. OUTPUT CONNECTIONS

INTERVAL OUTPUT A dc level which follows the condition

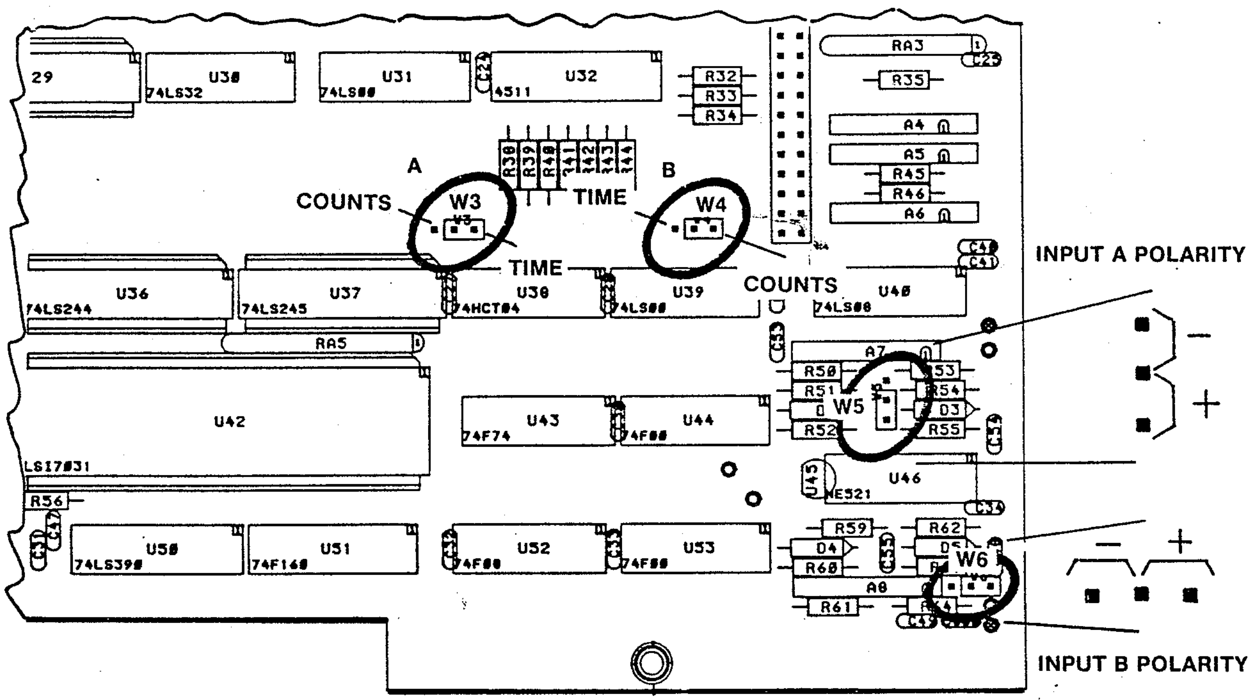


Fig. 1. Selecting Counter Source (W3 and W4) and Setting Input Polarity (W5 and W6).

of the counting gate is available at this front-panel connector. When the counting gate is enabled, the dc level is nominally at +5 V. When counting is inhibited (by gating, by having reached preset, or by being stopped manually or remotely), the dc level is nominally at 0 V. This output can be used to gate other counters.

OVERFLOW OUTPUTS The counter overflow output signals are available through the BNC connectors located on the rear panel. A slow-positive logic signal (nominally +5 V, 20 μs) appears at the connectors each time the contents of the corresponding counter change from 99,999,999 to 0. The output signal can be used as the input to another counter to increase the total counting capacity beyond eight decades.

3.7. PRESET TIME OPERATION

The Model 994 is designed for standard operation as a counter that accumulates counts for a fixed period of time (selected by the operator). At the end of this time interval, it will stop and hold the data until it is reset manually, or it can dwell at the preset stop for an adjustable amount of time in which the data can be read. It then resets automatically and repeats the timing cycle. The use of the Enable and Gate inputs are optional depending on the application.

Determine the time interval required for the collection of counts. If preset time is not desired the preset can be disabled by selecting a value of zero for M and N, and the counting interval can be controlled using the Count and Stop push button switches on the front panel.

There are two internal time bases to select from: 0.01 seconds and 0.01 minutes. The choice is made by pressing the Time Base Select push button until the LED indicator for the desired time base is lighted.

To preset the time interval, select Preset as the displayed value. Press the Select push button until the LED indicator for the M register is lighted. Next, press the Advance push button until the correct value for M appears in the display. Press the Select push button and repeat the above procedure for the values of N and P. The selected value is in the format of MN x 10^P, where MN is a number from 01 to 99 and P represents the power of 10 to which MN is raised. For example, to select a preset time of 15.00 seconds select an M value of 1, an N value of 5, and a value of 2 for P, which represents 15 x 10^2 ticks of the 0.01 second time base.

The dwell period at the end of the preset interval is controlled by the Dwell control. This is a potentiometer with an Off switch at the fully counterclockwise position. In the Off position, the dwell control is disabled and the data collected will be displayed until a manual reset is initiated. As the potentiometer is turned clockwise, the dwell period is varied from ~1 second to ~10 seconds at the full clockwise position. At the end of the selected dwell time an automatic reset is generated, and the counting cycle will be repeated.

To monitor the data collected during a counting cycle, press the Display Select until the LED representing the desired counter is lighted.

To start a counting cycle, press the Stop push button, then press the Reset push button, and then press the Count push button. The counting can be halted at any time by pressing the Stop push button. If desired the cycle can be resumed from the point of interruption by pressing the Count push button without pressing Reset.

3.8. PRESET COUNT OPERATION

To select the preset count mode of operation, press the Time Base Select push button until the LED representing the External mode is lighted. Now the input to the preset counter is taken from the Counter A input. The preset value selection is identical to the selection of the time interval except that the preset value is in units of input counts rather than units of time.

3.9. LIVE-TIME MEASUREMENTS

To use the Model 994 to make live-time measurements, a jumper (Fig. 2) is provided on the Counter PWB which allows the Gate A input to also gate the timer off without affecting the counts into Counter B. The time resolution for this gate is 100 ns. A positive logic signal which defines the system live-time is connected to the Gate A input. This configuration provides a live-time clock (Counter A) and a counter (Counter B). Set jumper W1 to the Live-time position for live-time measurements. Otherwise the W1 jumper should be set to the Normal position.

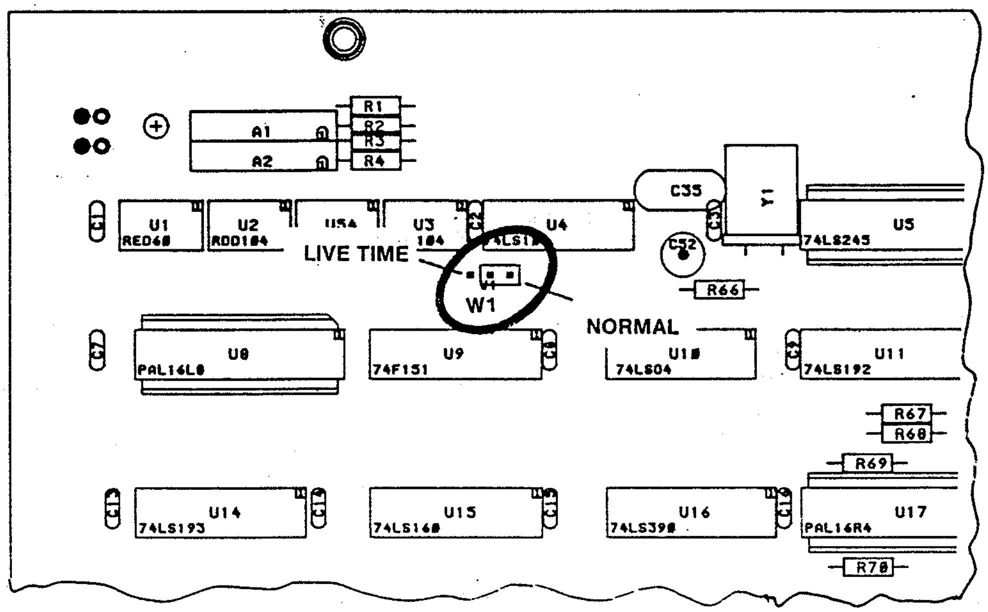


Fig. 2. Selecting Live Time or Normal Mode of Operation.

4. OPTIONS FOR THE MODEL 994

There are three interfaces available for the Model 994 to facilitate the integration into a system environment: (1) the RS-232-C Serial interface which includes a 20-mA current loop circuit, (2) the IEEE-488 (GPIB) interface (1978 standard digital interface bus), and (3) the EG&G ORTEC standard print loop interface. Each of these interfaces is a separate plug-in card which is easily installed in the field.

For bin and power supplies that do not provide the +6 V needed for the logic circuitry used in the 994, an internal +6 V supply is available. This option is field installable, and delivers regulated +5 V directly to the integrated circuits on the PWB.

4.1. RS-232-C INTERFACE (MODEL 99X-1)

This Serial Communications Interface conforms to the EIA RS-232-C Standard and contains all the circuitry needed to communicate with most ASCII terminals and with most computers equipped with a Serial Communications Port. The connection is made with a standard 25-pin, male "D" connector mounted directly to the interface printed wiring board (PWB). The connector is accessible through a slot in the rear panel of the 994. This connector is wired as a DTE (data terminal equipment) device as defined in the RS-232-C standard. The 20-mA current signals are also included on this connector.

The signal connections are shown in Table 1. The signal names in upper case are the 20-mA current connections and the RS-232-C signal names are shown in lower case.

When this interface is connected to another DTE device such as a computer or terminal, a null Modem cable must be used to match the proper signals between the two devices. These cables are available at most computer equipment suppliers or directly from EG&G ORTEC. (See Appendix D, Optional Parts List.) The connections of the null modem cable are given in Table 2.

The serial option is a full-duplex, asynchronous communications interface with a selectable baud rate from 50 to 19,200. The baud rate selection is made via a 4-position dipswitch located on the PWB (Fig. 3). The baud rate selected must match exactly the baud rate of the device to which the 994 is connected. The switch settings are given in Table 3.

In addition to the baud rate selection, the format of the data bits (ASCII characters) must also be set to match the device to which the 994 is connected. To accomplish this, an 8-position dipswitch (Fig. 3) is provided to allow the operator to select the number of data bits, parity enable or disable, odd or even parity if enabled, and either one or two stop bits. These must match the device to which the 994 is connected. Table 4 defines these selections.

Table 1. RS-232-C Connections.

Pin No.	Signal	Pin No.	Signal
1	protective ground	14	
2	transmit data	15	
3	receive data	16	
4	request to send	17	POSITIVE TRANSMIT
5	clear to send	18	
6	data set ready	19	
7	signal ground	20	data terminal ready
8		21	
9		22	
10		23	POSITIVE RECEIVE
11		24	NEGATIVE TRANSMIT
12		25	NEGATIVE RECEIVE
13			

Table 2. Null Modem Cable Connections.

Computer	Pin No.		Pin No.	994
Protective ground	1	<---->	1	Protective ground
Signal ground	7	<---->	7	Signal ground
Transmit data	2	<---->	3	Receive data
Receive data	3	<---->	2	Transmit data
Request to send	4	<---->	5	Clear to send
Clear to send	5	<---->	4	Request to send
Data set ready	6	<---->	20	Data terminal ready
Data terminal ready	20	<---->	6	Data set ready

Table 3. Baud Rate Selection

Baud Rate	S1	S2	S3	S4
50	On	On	Off	On
75	On	On	Off	Off
110	Off	Off	Off	Off
134.5	On	Off	On	On
150	Off	Off	Off	On
200	On	Off	On	Off
300	Off	Off	On	Off
600	On	Off	Off	On
1200	Off	On	Off	Off
1800	Off	On	Off	On
2400	On	Off	Off	Off
4800	Off	On	On	Off
9600	Off	On	On	On
19,200	On	On	On	On
19,200	On	On	On	Off

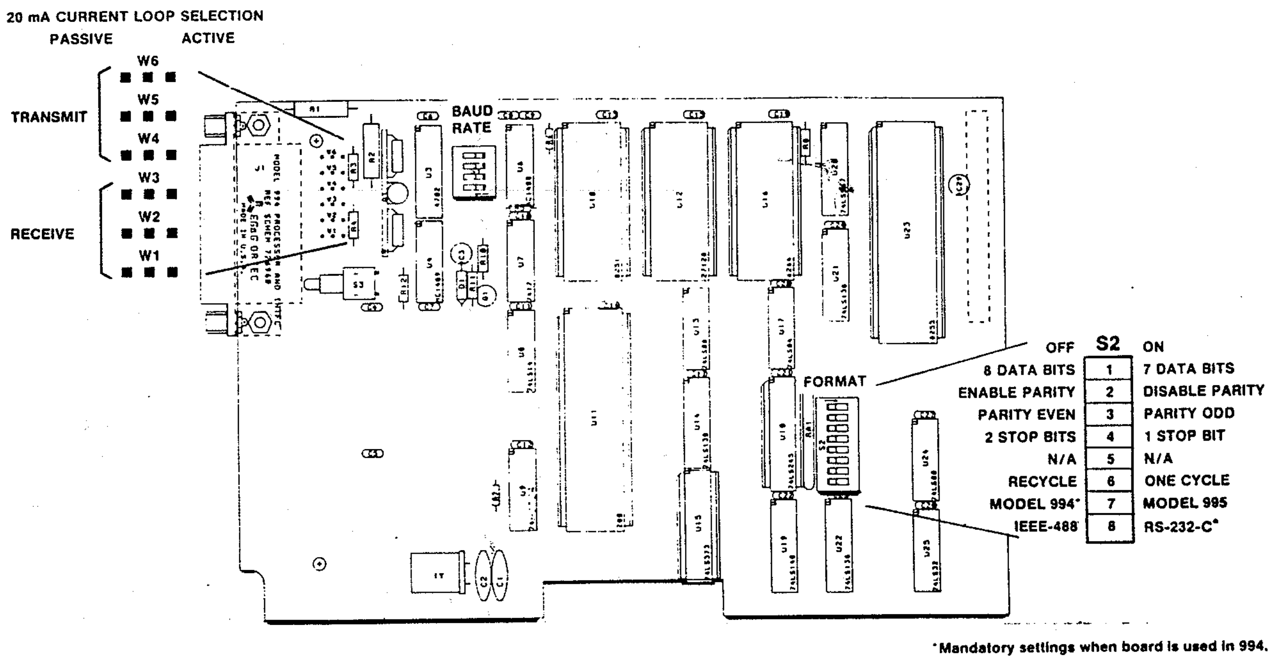


Fig. 3. Changing Jumpers on the 99X-1 RS-232-C Interface Board.

Table 4. Data Format.

Switch Position	Off	On
1	8 Data Bits	7 Data Bits
2	Enable Parity	Disable Parity
3	Even Parity	Odd Parity
4	2-Stop Bits	1 Stop Bit
5		
6	Recycle Mode	One-Cycle Mode
7	Model 994*	Model 995
8	IEEE-488 (GPIB)	RS-232-C*

*Mandatory settings.

The 99X-1 option is shipped from the factory with the following settings:

1. Character length set to 8 bits.
2. Parity check and generation disabled.
3. Parity selection set to even.
4. Stop bit selection set for 1.
5. Baud rate set for 9600.
6. One-cycle mode selected.
7. Model 994 selected.
8. RS-232-C interface selected.

4.1.1. 20-mA CURRENT LOOP OUTPUT

The 20-mA current loop operates in exactly the same way as the RS-232-C. All switch selections apply equally to the 20-mA current loop communications. The major difference in the two modes is the electrical characteristics of the signals. The RS-232-C uses a change in voltage to transmit and receive data, and the 20-mA current loop uses a change in current to transmit and receive data. The current loop is optically coupled to the 994 and can be made to be either active (current for the loop supplied by the 994) or passive (current for the loop supplied by the connected device) by changing a set of jumpers on the interface board (Fig. 3). The transmit and receive loops can be individually selected to be active or passive. The Model 994 is factory-set at shipment with both the transmit and receive loops set for active. The transmit and receive signals are included in the RS-232-C connector. A special cable is needed when using the 20-mA current loop to connect the 994 to a computer or terminal. This cable is available from EG&G ORTEC (Appendix C, Optional Parts List).

4.1.2. INSTALLATION INSTRUCTIONS

To install the RS-232-C interface follow the steps listed below:

1. Remove the left side plate from the module. If the optional power supply is not already installed skip to step 5.
2. Remove the right side panel.
3. Remove the two screws holding the optional power supply to the bottom right module bar.
4. Remove the two screws on the top of the power supply chassis which secure it to the bracket mounted on the bottom left module bar and move the power supply chassis out of the module.

5. On the interface board, set the switches to the desired positions using Tables 3 and 4 to match the device to which it will be connected.

6. Install the interface board into the module, sliding the RS-232-C connector through the slot in the rear panel of the module first and align the 40-pin connector on the back of the board with the pins provided on the counter board. Use care to insure proper match-up of connector and pins.

7. Install the two mounting screws into the standoffs provided on the counter board.

8. Reinstall the power supply chassis if one is present.

9. Replace side panels and installation is complete.

4.2. IEEE-488 (GPIB) INTERFACE (MODEL 99X-2)

The IEEE-488-1978 standard bus is a byte-serial, bit parallel interface system established primarily for the transfer of data and commands between the components of an instrumentation network. The system is defined for no more than 15 devices, interconnected by passive cabling, whose total transmission length does not exceed 20 meters. Data rates through any of the 16 signal lines that comprise the bus must be <1M-byte/s and consist of digital data only. The bus is connected in parallel to all components of the system and is designed to ensure reliable data transfer throughout the network.

Eight lines of (DIO1-DIO8) are used for the transfer of data between the components of the system. Three lines (DAV, NRFD, and NDAC) are used as transfer control. The remaining five lines (IFC, ATN, SRW, REN, and EOI) are for bus management. These lines may employ either open-collector or tri-state drivers as defined by the IEEE-488-1978 standard.

Information is transmitted over the eight data lines under direct supervision of the three transfer control lines. Transfer proceeds as fast as the components of the system can respond, but no faster than the slowest device currently addressed by the bus. This permits multiple data transfers to more than one device on the bus at a time.

Active devices connected into the system may be talkers, listeners, controllers, or a combination of the three, but no more than one device may be designated as a talker at any given time. The controller determines the role of each of the devices by sending out an address of the device to be defined. Addresses of the devices are set at the time of system configuration (before power is applied) by means of an 8-position dipswitch. Sections 1 thru 5 of switch 1 are used for the address selection (Table 5).

The following are descriptions for the 16 bus lines defined in the IEEE-488 bus.

DIO 1 THROUGH DIO 8 (DATA INPUT/OUTPUT) These bi-directional lines are used to transfer data between devices. Data is asynchronous and generally bi-directional. The lines carry either data or address information, depending on the state of the ATN line.

DAV (Data Valid) One of the three transfer control lines used to indicate that data is available on the DIO lines.

NRFD (Not Ready For Data) Another transfer control line used to indicate that all devices are ready to accept data.

NDAC (Not Data Accepted) The third transfer control line that indicates the acceptance of data by all devices.

ATN (Attention) A bus management line used to indicate the type of data on the data lines. When the ATN line is asserted, DIO 1-8 carry address or commands. When ATN is false, the data lines carry only data.

IFC (Interface Clear) A bus management line which is used to place the system in a known state for system initialization.

SRQ (Service Request) A bus management line used to indicate a need for service by a device in the system.

REN (Remote Enable) A bus management line used to select either local or remote control of each device.

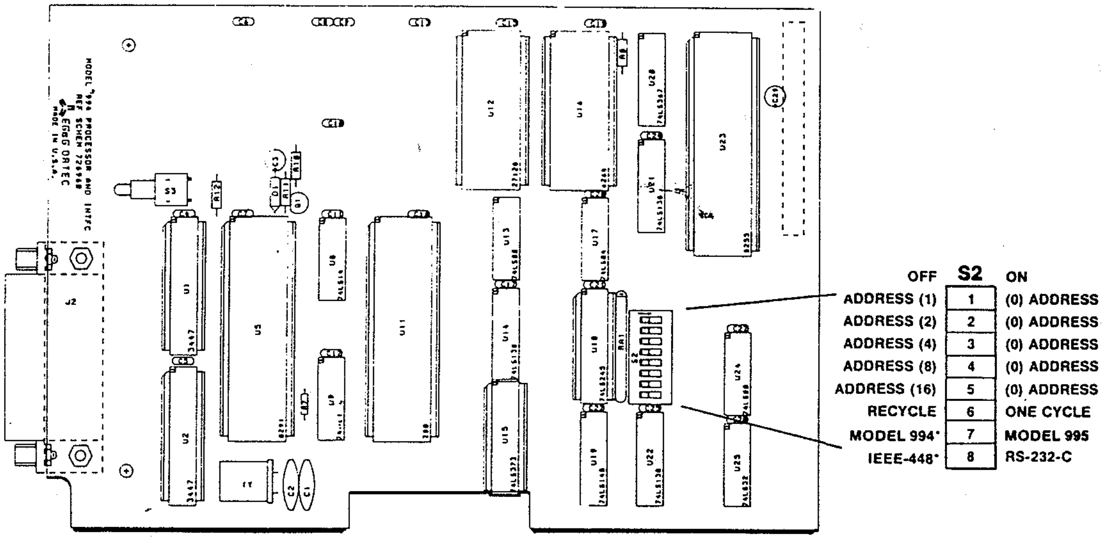
EOI (End Or Identify) The fifth bus management line used to indicate the end of a multiple-byte transfer sequence. This line is asserted with the last byte of a data record.

The IEEE-488 (GPIB) interface is a separate PWB that plugs into the 994 counter board and is held in place with two screws. The connector containing the signals for bus communications is mounted to the board and is accessible through the rear panel of the 994. The placement of the connector is in accordance with the Standard NIM Digital Bus (NIM/GPIB) with pin 1 of the connector to the top of the module.

When power is applied to the 994, a series of self-test routines are executed to test certain parts of the module. A response record is created to show the results of the tests. This response record must be read by the bus controller before the 994 will accept any command. A service request (SRQ) is issued to notify the controller that service is required before commands can be accepted. Commands sent to the 994 must be terminated with ASCII (carriage return and line feed) characters. For every command received by the 994, a response record is returned and must be accepted by the controller before another command can be issued. In case of a SHOW command to the 994, two response records must be read by the controller. All response records from the 994 will be terminated with a carriage return-line feed sequence with the EOI line asserted along with the line feed character.

Table 5 shows the switch configuration for address selection of the device on the bus (Fig. 4).

The address selected is the total of the switches set to the Off position. For example, to select an address of 25, switches 1 (1), 4 (8), and 5 (16) should be set to the Off position. The One Cycle/Recycle switch determines the action that occurs when the counters reach a preset condition. In the One Cycle mode, the counters will stop at preset and hold the data until reset manually or remotely. In the Recycle mode, the contents of the counters will be transferred to a buffer, the



*Mandatory settings when board is used in 994.

Fig. 4. Address Selection of Dip Switch on the 99X-2 IEEE-488 Interface Board.

Table 5. Address Configuration.

Switch Position	Off	On
1	Address (1)	Address (0)
2	Address (2)	Address (0)
3	Address (4)	Address (0)
4	Address (8)	Address (0)
5	Address (16)	Address (0)
6	Recycle Mode	One Cycle Mode
7	Model 994*	Model 995
8	~~IEEE-488*~~	~~RS-232-C~~ normal

*Mandatory settings. Print only

counters will be reset, and another counting interval will be started immediately.

4.2.1. INSTALLATION INSTRUCTIONS

To install the IEEE-488 (GPIB) interface follow the steps listed below:

1. Remove the left side plate from the module. If the optional power supply is not already installed skip to step 5.
2. Remove the right side panel.
3. Remove the two screws holding the optional power supply to the bottom right module bar.
4. Remove the two screws on the top of the power supply chassis which secure it to the bracket mounted on the bottom left module bar and move the power supply chassis out of the module.
5. On the interface board, set the switches to the desired positions using Table 5. Set switch 7 to Model 994.
6. Install the interface board into the module, sliding the IEEE-488 (GPIB) connector through the slot in the rear panel of the module first and align the 40-pin connector on the back of the board with the pins provided on the counter board. Use care to insure proper match-up of connector and pins.
7. Install the two mounting screws into the standoffs provided on the counter board.
8. Reinstall the power supply chassis if one is present.
9. Replace side panels and installation is complete.

4.3. PRINT LOOP INTERFACE (MODEL 99X-3)

With this interface the 994 can be included in a print loop with the other counters and timers from EG&G ORTEC. Up to 50 counters can be included in a counting system with one controller, such as the Model 879 Buffered Interface, providing the interface from the loop to a computer or printout device.

A three-position slide switch (Fig. 5) is located on the PWB to select one of the three operating modes: Master, Slave, or Normal. This switch determines the role of the individual modules when contained in a counting system. As a Master, the 994 drives the system gate and the system reset lines but does not respond to a system gate driven by another device. As a Slave, the 994 does not drive the system gate or the system reset signals but does respond to both. In the Normal position, the 994 does not drive or respond to the system gate or system reset signals. When used with a Model 879 controller module the usual operating mode would be the Slave mode.

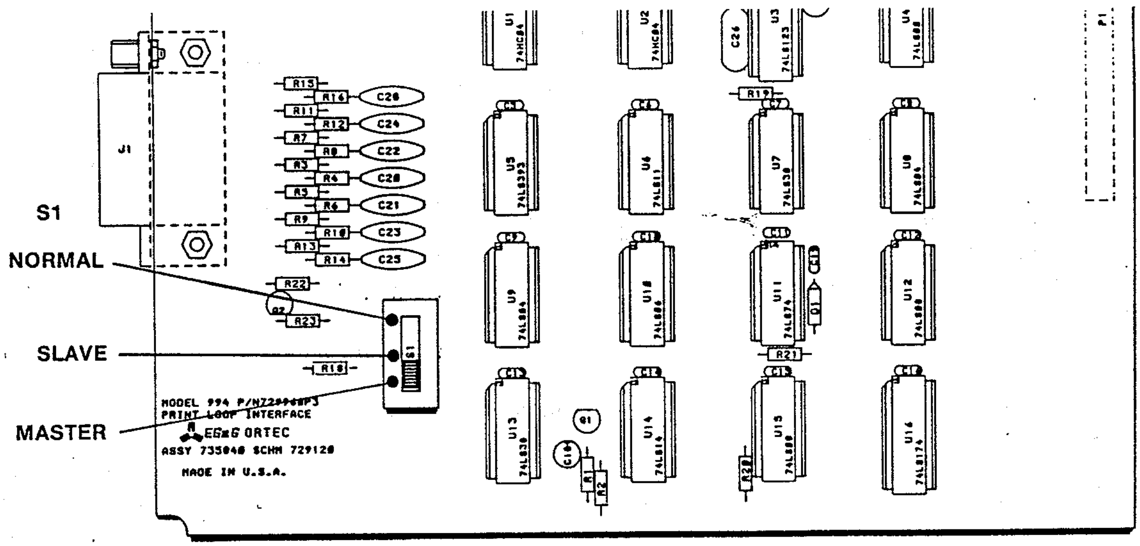


Fig. 5. Selecting Operating Modes on the 99X-3 Print Loop Interface PWB.

Table 6. Print Loop Signals.

Pin No.	Signal Name
1	Data 1
2	Data 2
3	Data 4
4	Data 8
5	Print
6	Print Advance
7	Previous Module Finished
8	System Gate
9	System Preset
10	System Reset
11	Ground
12	Control
13	This Module Finished
14	This Module Printing

The Print Loop Connection is made through a 14-pin connector accessible through the rear panel of the 994. A standard print loop cable (EG&G ORTEC Model 772-C1) is used to connect the 994 to the other modules in the data acquisition system. The connections in the cable are listed in Table 6.

The print loop signals are included in the 14-pin connector on the Print Loop Interface board and in each of the other units in the printing loop system. All of the signals except one are in parallel to all units in the system. The exception is Previous Module Finished, as an input to the module, and This Module Finished, as an output to the next module. This signal ripples through the printing loop to indicate to each module when its turn to transfer data has occurred. The order in which modules transfer data is determined by the cables and their relative positions in the loop.

DATA LINES (1, 2, 4, 8) transfer the four bits of BCD data from the assigned module to the Controller module. Each module drives these lines only during its turn for printing.

PRINT prepares the modules in the loop for data transfer.

PRINT ADVANCE advances the module through its digits during data transfer. It starts with the most significant digit and scans sequentially to the lowest significant digit.

PREVIOUS MODULE FINISHED starts the actual data transfer from an instrument when its turn has occurred.

SYSTEM GATE carries a signal to all modules set for Slave operation in the system loop. This signal can be used to synchronize the data collection time for all modules in the loop.

SYSTEM PRESET carries a signal to all modules in the system loop. A preset condition stops data collection in all modules in the loop.

SYSTEM RESET carries a Reset signal to all modules in the loop except any that may be set for Normal. This signal originates in the Master module or in the Controller module.

GROUND provides a common ground reference to all modules in the system loop.

CONTROL carries a signal to indicate when the controller is in charge of the loop. This signal is used to disable the Dwell function in any module in the loop that contains this function.

THIS MODULE FINISHED carries a signal to the next module in the loop (arrives as PREVIOUS MODULE FINISHED) to indicate its turn to transfer data has occurred.

THIS MODULE PRINTING carries a signal to the controller to indicate to the controller that the module presently transferring data has a number other than six decades of data to transfer to the controller. This line is only driven during the module's turn to transfer data.

4.3.1. INSTALLATION INSTRUCTIONS

To install the PRINT LOOP interface follow the steps listed below:

1. Remove the left side plate from the module. If the optional power supply is not already installed skip to step 5.
2. Remove the right side panel.
3. Remove the two screws holding the optional power supply to the bottom right module bar.
4. Remove the two screws on the top of the power supply chassis which secure it to the bracket mounted on the bottom left module bar and move the power supply chassis out of the module.
5. On the interface board, set the switch to the desired position, Master, Slave, or Normal.
6. Install the interface board into the module, sliding the PRINT LOOP connector through the slot in the rear panel of the module first and align the 40-pin connector on the back of the board with the pins provided on the counter board. Use care to insure proper match-up of connector and pins.
7. Install the two mounting screws into the standoffs provided on the counter board.
8. Reinstall the power supply chassis if one is present.
9. Replace side panels and installation is complete.

4.4. INTERNAL +6 V SUPPLY OPTION (MODEL 99X-4)

This option is available for systems that do not have a bin and power supply containing a +6 V supply. It contains a transformer, bridge rectifier, and filter capacitor and uses the 117 Vac available in the bin to generate the voltage and power needed for the logic circuitry contained in the 994. Although it replaces the function of the external +6 V supply, it actually feeds +5 V power directly to the logic circuits on the PWB.

4.4.1. INSTALLATION INSTRUCTIONS

To install the optional Internal +6 V Supply, follow the steps listed below:

1. Remove both side panels.
2. Mount the small L-shaped bracket to the left lower module bar with two flat head screws provided. Use the third and fifth holes in the module bar, counting from the rear of the module.
3. Unplug the connector going to the Transistor mounted on the rear panel.
4. Slide the Power Supply chassis into the module and align the two holes in the top of the chassis with the two holes on the mounting bracket. Insert the two round head screws provided to secure the chassis to the mounting bracket.
5. Using the remaining two flathead screws, secure the chassis to the right module bar through holes three and five counting from the rear.
6. Connect the power supply to the module using the connector that previously went to the power transistor on the PWB side of the rear panel.
7. The connector to the power transistor can be left disconnected or the power transistor and connector can be removed from the module.
8. Replace the side panels and the installation is complete.

5. PROGRAMMING THE 994

5.1. RS-232-C INTERFACE

To become familiar with the 994 commands and response records it is suggested that a terminal be used. This allows the operator to exercise the unit and view on the terminal display exactly what must be done inside a computer program to communicate with the 994 effectively. A complete list of commands and responses is given in Appendix A of this manual.

5.1.1. TERMINAL OPERATION

The first step, whether interfacing to a terminal or computer, is to ensure that the proper cables are available and that the data format and baud rate switches are set correctly (Tables 3 and 4). The actual settings are not as important as ensuring that the 994 and the device to which it is connected are set to exactly the same conditions. These conditions include the baud rate, number of data bits, parity conditions, and number of stop bits. Also, set the 994 to the Recycle mode. When these conditions have been satisfied, connect the terminal to the 994 and apply power to the terminal. Next apply power to the 994. A % response record should appear on the terminal screen showing the results of the self-test at power-up. If all is well, the response record should be %001000070.

Since the 994 powers up in the Computer mode, the first command to the 994 should be to change to the Terminal mode. This is done by typing TERMINAL and a return on the keyboard. These characters will not appear on the screen, but the % response record (%000000069) and prompt (>) should appear after the return. Now, any characters typed on the keyboard will be echoed to the terminal display.

Now that communication has been established, try the following commands:

SHOW_VERSION $F0994-001 %000000069 >	This command shows the version of firmware installed in the 994.
SHOW_COUNTS 00000000;00000000; %000000069 >	This command shows the contents of Counters A and B separated by a semicolon.
SET_COUNT_PRESET 35,4 %000000069 >	This command loads the M, N, and P registers with the data values included. The format is <MN,P> where MN is any number from 0 to 99 and P is any value from 0 to 6.
SHOW_COUNT_PRESET $B035004CCC >	In this command, the $B response record shows the value loaded in the preset registers. 035 is the MN value, 004 is the P value, and CCC is the checksum.
SET_DISPLAY 2 %000000069 >	This command selects the preset value to be displayed. The display should show 354 for M, N, and P, respectively.
SET_DISPLAY 0 %000000069 >	This command selects Counter A, and the display should read 0.00 if the internal time base is selected.

Set up the 994 for automatic data collection:

ENABLE_ALARM %000000069 >	Enable data transfer at end of preset.
SET_COUNT_PRESET 10,1 %000000069 >	Set preset time for 1 second.
START %000000069 >	Start data collection.

At the end of a 1-second interval, and continuing at 1-second intervals, the contents of the counters will be displayed on the terminal screen:

```
00000100;00000000
00000100;00000000
00000100;00000000
```

This sequence will continue until a STOP command is sent to the 994.

```
STOP
%000000069
>
```

Refer to Appendix A and exercise the remainder of the commands until you are familiar with the actions and responses. This will prove valuable when using the commands in a computer program. Remember that for every SHOW command, two response commands must be read.

5.1.2. BASIC PROGRAMMING

Connect the 994 to the computer via the RS-232-C cable (refer to Section 4 for proper cable connections). The following BASIC program for the IBM-PC and compatible computers shows some of the programming methods between the 994 and the computer:

```
10 REM   SAMPLE PROGRAM FOR THE IBM-PC AND COMPATIBLES
20 REM   OPEN SERIAL PORT FOR COMMUNICATIONS
30 REM   SET PORT FOR 9600 BAUD, NO PARITY, AND 8 DATA BITS
40 OPEN   "COM1:9600,N,8" AS #1
50 REM   DEFINE SUCCESS RESPONSE FROM THE 994
60 OK$ = "%000000069"
70 REM   INITIALIZE THE 994 TO A POWER-UP CONDITION
80 PRINT #1, "INIT"
90 REM   READ RESPONSE RECORD FROM THE 994 AND STOP IF NOT OK
100 INPUT #1, RESP$
110 IF RESP$ <> OK$ THEN PRINT RESP$: STOP
120 REM   TEST M AND N REGISTERS FOR PROPER LOADING
130 FOR MN = 1 TO 99 STEP 1
140 MSG$ = "SET_COUNT_PRESET" + STR$(MN) + ",1"
150 PRINT #1, MSG$
160 REM   READ RESPONSE RECORD FROM 994
170 INPUT #1,RESP$
180 REM   CHECK FOR CORRECT EXECUTION OF COMMAND
190 IF RESP$ <> OK$ THEN PRINT RESP$: STOP
200 REM   READ VALUE BACK AND CHECK IT
210 PRINT #1, "SHOW_COUNT_PRESET"
220 INPUT #1, ANS$
230 INPUT #1, RESP$: REM  TWO RESPONSE RECORDS FOR A SHOW COMMAND
240 A$ = MID$(ANS$,3,3)
250 A = VAL(A$) IF A <> MN THEN PRINT MN,A$: STOP
260 NEXT MN: REM   LOOP UNTIL ALL VALUES HAVE BEEN TESTED
270 REM   CHECK FOR CORRECT LOADING OF P VALUES
280 FOR P = 0 TO 6 STEP 1
290 REM   LOAD P VALUES
300 PRINT #1, "SET_COUNT_PRESET 01,";P
310 REM   READ RESPONSE RECORD
```

```
320 INPUT #1, RESP$
330 REM   CHECK FOR CORRECT EXECUTION
340 IF RESP$ <> OK$ THEN PRINT RESP$: STOP
350 REM   READ VALUE BACK FROM 994 AND CHECK FOR PROPER LOADING
360 PRINT #1, "SHOW_COUNT_PRESET"
370 INPUT #1, ANS$: REM   READ VALUE
380 INPUT #1, RESP$: REM   READ RESPONSE RECORD
390 P$ = MID$(ANS$ 6,3)
400 IF P <> VAL(P$) THEN PRINT ANS$: STOP
410 NEXT P
420 REM   EXERCISE A FEW OF THE COMMANDS
430 PRINT #1, "CLEAR_COUNT_PRESET"
440 INPUT #1, RESP$
450 IF RESP$ <>1 OK$ THEN PRINT RESP$: STOP
460 REM   READ COUNTER VALUE
470 PRINT #1, "SHOW_COUNTS"
480 INPUT #1, CNT$
490 INPUT #1, RESP$
500 IF RESP$ <>1 OK$ THEN PRINT RESP$: STOP
510 REM   LOAD DISPLAY SELECT AND READ IT BACK
520 PRINT #1, "SET_DISPLAY 1"
530 INPUT #1, RESP$: REM   READ RESPONSE RECORD
540 PRINT #1, "SHOW_DISP"
550 INPUT #1, ANS$: REM   READ VALUE BACK
560 INPUT #1, RESP$: REM   READ RESPONSE RECORD
570 D$ = MID$(ANS$ 3,3)
580 IF VAL(D$) <> THEN PRINT ANS$: STOP
590 END
```

5.2. INTERFACING TO THE IEEE-488 BUS

Of the three choices of interface, the IEEE-488 interface holds the greatest potential for misunderstandings. This section on programming the IEEE-488 will hopefully help smooth the interfacing. The two computer systems discussed in this section are the Hewlett-Packard and the IBM-PC compatibles. For other computers, there should be enough information included to allow interfacing to the Model 994. The major difference between the Hewlett-Packard computers and the IBM-PC compatibles is the fact that Hewlett-Packard includes software drivers in the high-level languages, but on the IBM compatibles the interface circuitry and the software drivers to interface to the IEEE-488 bus must be installed in order to complete the working system.

The most important aspect of interfacing to the IEEE-488 bus is ensuring that the address switches in the 994 are set correctly and that the correct address is used when accessing the 994 in a program statement (Section 4). The other important consideration is to always read the response records from a previous command before trying to send another command; otherwise, the 994 will not respond. Also, when the 994 is powered up, a series of self-tests are performed, and the results of these tests are included in a power-up response record that must be read by the Bus Controller before any other commands are sent to the 994.

Before attempting to connect the 994 to the computer, the address switches should be checked to ensure that the proper address is selected and does not conflict with another module connected to the bus. The 99X-2 option is shipped from the factory with the address switches set for 4. If more than one 99X-2 is connected to the bus, the addresses of all but one will have to be changed. The address may be set for any number from 0 to 31; however, 0 is usually used for the controller in charge, and 31 is used as the untalk and unlisten commands (Section 4.2, Table 5).

Another important point to consider when communicating with the 994 is the fact that the 994 always asserts the Service Request (SRQ) signal line on the bus when information is available for transfer. This will be reset by conducting a serial poll or by reading the response record from the 994. When a serial poll is conducted, a serial poll status byte is transferred to the computer. This byte contains information about the status of the 994 and is defined in Fig. 6.

The 994 will not accept another command until the response record is read. The ready condition will be indicated by a serial poll status byte with only bit 4 asserted.

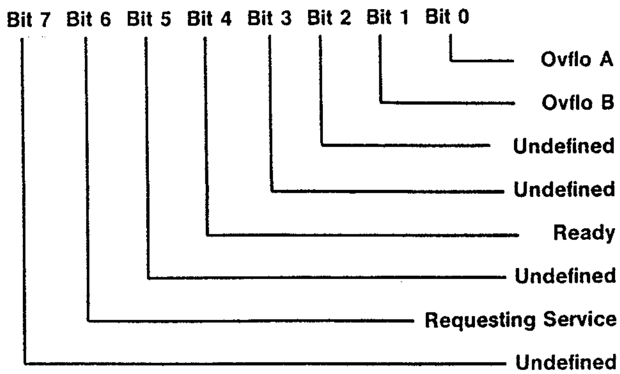


Fig. 6. Serial Poll Status Byte.

Install the Model 994 in the bin and connect the IEEE-488 bus cable to the connector on the rear panel of the 994. Turn On the power to the bin. The easiest way to become familiar with programming the 994 via the IEEE-488 bus is to use the immediate mode of communications, whereas the computer can be used as a terminal to exercise the commands. This method can be used to become familiar with the protocol of the GPIB and the 994 communications structure. The following examples for the Hewlett-Packard and the IBM-PC compatibles will show the command formats and responses from the 994.

5.2.1. HEWLETT-PACKARD COMPUTER EXAMPLES

The first computer system discussed will be the Hewlett-Packard, which should apply to the HP-85 family and the 9816, 9826, and the 9836 computers. The computer should be set to terminate each data transfer with a line feed character. Refer to the operating manual for set-up procedures.

Since the Model 994 has just been powered up there will be a response record waiting to be transferred to the computer. This response record must be read before the 994 will accept commands. First a serial poll will be performed to show the service request bit set. With the computer operating under BASIC, execute the following commands.

```
A = SPOLL (704)
DISP A
64
```

In the above statement, 7 selects the GPIB interface in the computer and 04 is the address of the 994 on the bus. This automatically conducts a serial poll of the 994 and assigns the status byte, which is an 8-bit binary value, to the variable A. When the variable A is displayed, the value 64 is printed which is the decimal value of the 8-bit binary status byte.

Next, the power-up response record must be read before any commands will be accepted by the 994.

```
ENTER 704; A$
DISP A$
%001000070
```

The ENTER statement reads the response record and assigns the input characters to the string variable A$, and the DISP statement prints the string to the screen.

In the following statements a command is sent to the 994, and the resulting responses from the 994 are read.

```
OUTPUT 704; "SHOW_VERSION"
ENTER 704; A$
DISP A$
$F0994-001
ENTER 704; A$
DISP A$
%000000069
```

In the above commands, the firmware version installed in the 994 is asked for, the string is assigned to A$ and displayed to the screen, and the response record is read, which indicates that everything is O.K. Remember for every SHOW command, two records must be read.

The next statement shows a command to the 994 which includes parameters along with the command.

```
OUTPUT 704; "SET_COUNT_PRESET 25,6"
ENTER 704; A$
DISP A$
%000000069
```

The above command should have loaded the preset count to a value of 25 x 10^6. Press the Display Select pushbutton until the preset value is displayed. The display should read 256.

```
OUTPUT 704; "CLEAR_COUNT_PRESET"
ENTER 704; A$
DISP A$
%000000069
```

The display should now read 000. Select Counter A for display. The display should now read 0.00.

```
OUTPUT 704; "START"
ENTER 704; A$
DISP A$
%000000069
```

The Gate light should now be On and the counter display should be accumulating counts.

```
OUTPUT 704; "STOP"
ENTER 704; A$
DISP A$
%000000069
```

The Gate light should go Off and the counting should stop.

```
OUTPUT 704; "SHOW_COUNTS"
ENTER 704, A$
DISP A$
XXXXXXXX;00000000;
ENTER 704; A$
%000000069
```

The XXXXXXXX in the first counter value should match the value shown in the display of the 994. Remember that for every SHOW command two records must be read.

Using the above examples and the information in Appendix A, exercise the remaining commands to become familiar with the commands and response records. The following is a sample BASIC program to demonstrate the commands and responses in a program.

```
10 REM   EXAMPLE PROGRAM FOR COMMUNICATING WITH THE 994 FROM
11 REM   HP COMPUTER. IT IS ASSUMED THAT AN ADDRESS OF 4 IS
12 REM   SELECTED FOR THE 994 AND 7 IS THE NUMBER OF THE GPIB
13 REM   INTERFACE IN THE COMPUTER
14 CLEAR !REM CLEAR DISPLAY
15 DIM A$[25]
20 REM   USE A SERIAL POLL TO FIND OUT IF THE 994 IS STARTING FROM
21 REM   A POWER-UP CONDITION
22 = SPOLL(704)
23 REM   SKIP RESPONSE RECORD IF SERVICE REQUEST BIT NOT SET
24 IF A < 64 THEN GOTO 30
25 ENTER 704; A$ !REM READ POWER—UP RESPONSE RECORD.
26 IF A$ <> "%00100007" THEN GOTO 30! REM TEST FOR POWER-UP
27 DISP "STARTING FROM POWER UP"
28 REM   IF POWER-UP, THEN SKIP INIT COMMAND
29 GOTO 40
30 REM   IF NOT POWER-UP INITIALIZE 994
31 OUPTUT 704;"INIT"
32 REM   WAIT FOR INIT COMMAND TO COMPLETE
33 FOR I = 1 TO 200 @ NEXT I! REM WAIT LOOP
34 REM   READ RESPONSE RECORD FROM 994
35 ENTER 704; A$
36 REM
40 REM   TEST COMMUNICATIONS FOR LOAD AND READ OPERATIONS OF MN VAL
41 FOR I = 1 TO 99
42 A$ = "SET_COUNT_PRESET"& VAL$(I) & ",1"
43 OUTPUT 704;A$
43 ENTER 704; A$! REM   READ RESPONSE RECORD
44 REM   READ VALUE BACK TO INSURE PROPER LOADING
45 OUTPUT 704; "SHOW_COUNT_PRESET"
46 ENTER 704; A$! REM   READ VALUE RECORD
47 A = VAL(A$[3,5])! REM   EXTRACT MN VALUE FROM RECORD
48 IF A <> I THEN DISP "ERROR LOADING MN."@ STOP
50 REM   READ SECOND RESPONSE RECORD FROM SHOW COMMAND
51 ENTER 704; A$
52 REM   COMPLETE LOOP FOR REMAINING VALUES
53 NEXT I
54 DISP "MN VALUES LOAD OK"
55 REM
60 REM   NOW TEST FOR PROPER LOADING OF P VALUES
61 FOR I = 1 TO 6
62 OUTPUT 704; "SET_COUNT_PRESET 10,";I! REM   LOAD P VALUE
63 ENTER 704; A$! REM   READ RESPONSE RECORD
64 REM   READ P VALUE BACK AND CHECK FOR PROPER LOADING
65 OUTPUT 704; "SHOW_COUNT_PRESET"
66 ENTER 704; A$! REM   READ VALUE FROM 994
67 REM   EXTRACT P VALUE FROM RECORD AND CHECK
68 P = VAL(A$[6,8])
70 IF A <> I THEN PRINT "ERROR LOADING P VALUE"@ STOP
71 REM   READ SECOND RESPONSE RECORD FROM SHOW COMMAND
72 ENTER 704; A$
73 REM   COMPLETE LOOP FOR REMAINING VALUES
74 NEXT I
```

```
75 PRINT "P VALUES LOADING PROPERLY:
76 REM
80 REM   NOW TEST START AND STOP OPERATION
81 C$ = "%000000069": REM   CORRECT RESPONSE RECORD
82 OUTPUT 704; "START"! REM   SEND START COMMAND
83 ENTER 704; A$! REM   READ RESPONSE RECORD
85 REM   DELAY LOOP TO ALLOW COUNTS TO ACCUMULATE
86 FOR I = 1 TO 200 @ NEXT I
87 OUTPUT 704; "STOP"! REM   SEND STOP COMMAND
88 ENTER 704; A$! REM   READ RESPONSE COMMAND
89 IF A$ <> C$ THEN DISP "ERROR IN STOP COMMAND"@ STOP
90 REM   NOW READ ACCUMULATED COUNTS
91 OUTPUT 704; "SHOW_COUNTS"! REM   ASK FOR COUNT VALUE FROM 994
92 ENTER 704; A$! REM   READ COUNT VALUE
93 DISP A$! REM   VALUE PRINTED SHOULD MATCH COUNTER DISPLAY
94 REM   READ SECOND RESPONSE RECORD FROM SHOW COMMAND
95 ENTER 704; A$
96 REM   END OF COMMUNICATIONS TEST
97 DISP "END OF COMMUNICATIONS TEST"
98 END
```

ibdev 0:4:0:13:0:0 (no colons)

5.2.2. IBM-PC PROGRAMMING EXAMPLES

Before connecting the 994 to the IBM interface there are some important considerations regarding the setup of the software drivers which must be done before attempting to communicate with the 994. These are described in the installation and users guide which comes with the interface. These include the creation or editing of a file called CONFIG.SYS to let the DOS know that the interface is installed. Also there are modifications which may have to be made to a file called GPIB.COM. This is done by running a program called IBCONF. This allows the selection of the device number and address of the 994 on the bus. These programs are described in detail in the Users Guide.

When these initial setup procedures have been completed, connect the 994 to the computer and apply power to the 994. As with the H-P computer, it is much easier to become familiar with the command format and response records by using the computer in an immediate mode. To do this with the IBM, a program called IBIC must be run. Type IBIC to start the program, and follow instructions when the logo appears. The following is a step-by-step example of communicating with the 994. The test appearing in upper case letters is generated by the computer; commands typed by the operator are in lower case letters.

```
PRESS F1 FOR HELP

GPIBO: set dev4
DEV4:
```

Commands to the 994 are only sent when the prompt DEV4: is present. Because the 994 has just been powered up, a power-up response record will be waiting to be read. A serial poll (ibrsp) command should confirm that the 994 is asserting the service request (SRQ) line on the bus.

```
DEV4: ibrsp
[100] ( CMPL )
POLL: 0X40

DEV4:
```

The second line shows the contents of the status registers. In this case, it shows that the command was completed by the interface adapter. The results of the poll (0X40) show that the service request was being asserted by the 994 (40 hex is bit 6 of the serial poll status byte set to a 1).

Next, read the power-up response record from the 994. This is done with the command ibrd [xx], where xx is the number of bytes to be read. This number must be as large as, or larger than, the number of bytes expected. Most response records from the 994 will be 11 bytes long including the line feed terminator. One exception is the contents of the counters in the SHOW_COUNTS command, which is 19 bytes long. Others may be shorter than the 11 bytes (Appendix B).

```
DEV4: ibrd 12
[2100] ( END CMPL )
COUNT: 11
25 30 30 31 30 30 30 30                 % 0 0 1 0 0 0 0
37 30 0A                                7 0 .

DEV4:
```

In the above example, the second line is the status register contents, the third line is the number of bytes transferred by the 994 module to the computer, the fourth and fifth lines show the characters transferred with the hexadecimal value on the left and the ASCII characters on the right.

Now the 994 is ready to accept commands from the computer. The next example sends a SHOW_VERSION command to the 994 that will cause the 994 to send the version of firmware installed in the module. The \n characters in the command cause the computer to send a line feed (new line) character along with the command. This must be included before the 994 will execute the command.

```
DEV4: ibwrt "show_version\n"
[100] ( CMPL )
COUNT: 13
```

DEV4:

Now read the version number.

```
DEV4: ibrd 12
[2100] ( END CMPL )
COUNT: 11
24 46 30 39 39 34 2D 30        $ F 0 9 9 4 - 0
30 31 0A                       0 1 .
```

DEV4:

Now read the response record:

```
DEV4: ibrd 12
[2100] ( END CMPL )
25 30 30 30 30 30 30 30        % 0 0 0 0 0 0 0
36 39 0A                       6 9 .
```

DEV4:

The next command will load a preset value to the 994. This is an example of a command that must include parameters.

```
DEV4: ibwrt "set_count_preset 25,6\n"
[100] ( CMPL )
COUNT: 22
```

```
DEV4: ibrd 12
[2100] ( END CMPL )
COUNT: 11
25 30 30 30 30 30 30 30        % 0 0 0 0 0 0 0
36 39 0A                       6 9 .
```

DEV4:

The above command should have loaded a preset value of 25 X 10^6. Press the Display Select push button until Preset is selected for display. The display should show 256.

The next command should reset the preset value to zero.

```
DEV4: ibwrt "clear_count_preset\n"
[100] ( CMPL )
COUNT: 19
```

DEV4:

The display should now read 000. Press the Display Select until Counter A is selected for display. The display should read 0.00.

```
DEV4: ibwrt "start\n"
[100] ( CMPL )
COUNT: 6
```

```
DEV4: ibrd 12
[2100] ( END CMPL )
COUNT: 11
```

DEV4:

The Gate light should be On and the counter display should be advancing.

```
DEV4: ibwrt "stop\n"
[100] ( CMPL )
COUNT: 5
```

```
DEV4: ibrd 12
[2100] ( END CMPL )
COUNT: 11
25 30 30 30 30 30 30 30        % 0 0 0 0 0 0 0
36 39 0A                       6 9 .
```

DEV4:

The counting should be stopped and the Gate light should be Off. The next command asks for the counter contents with the SHOW_COUNTS command.

```
DEV4: ibwrt "show_counts\n"
[100] ( CMPL )
COUNT: 12
```

```
DEV4: ibrd 20
[2100] ( END CMPL )
COUNT: 19
30 30 30 3X 3X 3X 3X 3X        0 0 0 X X X X X
3B 30 30 30 30 30 30 30        ; 0 0 0 0 0 0 0
30 3B 0A                       0 ; .
```

```
DEV4: ibrd 12
[2100] ( END CMPL )
COUNT: 11
25 30 30 30 30 30 30 30        % 0 0 0 0 0 0 0
36 39 0A                       6 9 .
```

DEV4:

The numbers represented by the Xs in the first record should match the numbers showing in the display of the 994. Remember that two response records must be read for every SHOW command. Using the above examples, refer to Appendix A and exercise the remaining commands to become familiar with the commands and the response records.

The following is a sample program written in BASIC to show how some of the commands may be used in a program. The same format holds for any programming language used. The following program must be preceded by steps 1 through 99 of the program DECL.BAS (see Installation Instructions in the IBM Interface Manual).

```
100 REM   THIS PROGRAM MUST BE APPENDED TO DECL.BAS PROVIDED
101 REM   BY THE INTERFACE MANUFACTURER.
102 REM
103 REM   MAKE SOME ASSIGNMENTS :
104 LF$ = CHR$(&HOA): REM   LINEFEED CHARACTER
105 COUNTER$ = "DEV4": REM   REFER TO DEV3 AS COUNTER IN PROGRAM
106 GPIB0$ = "GPIB0": REM   GPIB0 REMAINS GPIB0
107 CALL IBFIND (GPIB0$,GPIB0%)
108 CALL IBFIND (COUNTER$,COUNTER%)
109 OK$ = "%000000069": REM   RESPONSE GENERATED IF EVERYTHING OK
110 REM   THIS PROGRAM TESTS THE COMMUNICATIONS BETWEEN THE 994
111 REM   AND THE COMPUTER.
112 REM
120 REM   FIRST TEST THE SERVICE REQUEST TO SEE IF STARTING FROM
121 REM   A POWER-UP.
122 REM
130 CALL IBRSP (COUNTER%,SPR%): REM   SERIAL POLL TO 994
131 S% = (SPR% AND &H40): REM   TEST SERVICE REQUEST BIT
132 IF S% = 0 THEN GOTO 140 ELSE PRINT "STARTING FROM POWER-UP"
133 CALL IBRD (COUNTER%,RD$): REM   READ POWER-UP RESPONSE
134 REM
135 REM   SKIP INIT COMMAND IF STARTING FROM POWER-UP
136 GOTO 150
137 REM
140 REM   SEND INIT COMMAND TO 994
141 WRT$ = "INIT" + LF$: REM   ALL COMMANDS MUST TERMINATE WITH LF$
142 CALL IBWRT (COUNTER%,WRT$): REM   SEND COMMAND
143 REM   WAIT FOR COMMAND TO BE EXECUTED
144 FOR I = 1 TO 100 : NEXT I
145 REM   READ RESPONSE RECORD FROM INIT COMMAND
146 CALL IBRD (COUNTER%,RD$)
147 REM
150 REM   TEST MN REGISTERS FOR LOADING AND READING
152 FOR I = 11 TO 99 STEP 11
153 WRT$ = "SET_COUNT_PRESET" + STR(I) + ",1" + LF$
154 CALL IBWRT (COUNTER%,WRT$): REM   SEND COMMAND
155 CALL IBRD (COUNTER%,RD$): REM   READ RESPONSE RECORD
156 REM
157 REM   READ BACK VALUES LOADED AND CHECK FOR CORRECT VALUE
158 WRT$ = "SHOW_COUNT_PRESET" + LF$
159 CALL IBWRT (COUNTER%,WRT$)
160 CALL IBRD (COUNTER%,RD$): REM   READ VALUE
161 MN$ = MID$(RD$,3,3): REM   EXTRACT THE MN VALUE FROM RESPONSE
162 IF VAL(MN$) <> I THEN PRINT "ERROR LOADING MN": STOP
163 REM   READ SECOND RESPONSE RECORD FROM SHOW COMMAND
164 CALL IBRD (COUNTER%,RD$)
165 NEXT I: REM   COMPLETE LOOP
170 REM   TEST P REGISTER FOR LOADING AND READING
172 FOR I = 1 TO 6 STEP 1
173 WRT$ = "SET_COUNT_PRESET 1," + STR(I) + LF$
174 CALL IBWRT (COUNTER%,WRT$): REM   SEND COMMAND
175 CALL IBRD (COUNTER%,RD$): REM   READ RESPONSE RECORD
176 REM   READ BACK VALUES LOADED AND CHECK FOR CORRECT VALUE
177 WRT$ = "SHOW_COUNT_PRESET" + LF$
178 CALL IBWRT (COUNTER%,WRT$)
179 CALL IBRD (COUNTER%,RD$): REM   READ VALUE
180 P$ = MID$(RD$,6,3): REM   EXTRACT THE P VALUE FROM RESPONSE
```

```
181 IF VAL(P$) <> I THEN PRINT "ERROR LOADING MN": STOP
182 REM   READ SECOND RESPONSE FROM SHOW COMMAND
183 CALL IBRD (COUNTER%,RD$)
184 NEXT I: REM   COMPLETE LOOP
190 REM   TEST START AND STOP COMMANDS
191 WRT$ = "START" + LF$
192 CALL IBWRT (COUNTER%,WRT$): REM   SEND START COMMAND
193 CALL IBRD (COUNTER%,RD$): REM   READ RESPONSE RECORD
195 REM   ALLOW TIME FOR SOME COUNTS TO ACCUMULATE
196 FOR I = 1 TO 200: NEXT I: REM   DELAY LOOP
197 REM   NOW STOP COUNTER AND READ COUNTS
198 WRT$ = "STOP" + LF$
199 CALL IBWRT (COUNTER%,WRT$): REM   SEND STOP COMMAND
200 REM   READ RESPONSE RECORD
201 CALL IBRD (COUNTER%, RD$)
203 REM
210 REM   READ COUNTS FROM 994 COUNTER
211 WRT$ = "SHOW_COUNTS" = LF$
212 CALL IBWRT (COUNTER%,WRT$): REM   SEND COMMAND
213 REM   READ CONTENTS OF THE COUNTER AND DISPLAY THE VALUE
214 CALL IBRD (COUNTER%,RD$): REM   READ VALUE
215 PRINT RD$: REM   DISPLAY VALUE
216 REM   READ SECOND RESPONSE FROM SHOW COMMAND
217 CALL IBRD (COUNTER%,RD$)
218 REM
220 REM   THIS CONCLUDES THE COMMUNICATIONS TEST
221 PRINT "COMMUNICATIONS TEST COMPLETE"
222 END
```